The Effects of Mandatory Transparency in Financial Market Design: Evidence from the Corporate Bond Market[1]

Paul Asquith Thomas R. Covert Parag A. Pathak[2]

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Abstract. In July 2002, FINRA began mandatory dissemination of price and volume information for corporate bond trades. This paper, using recently released data, measures transparency's effect on trading activity and costs for the entire corporate bond market. Even though trading costs decrease significantly across all types of bonds, trading activity does not increase and, by one measure, decreases. Transparency affects the high-yield market differently than the investment grade market since high-yield bonds have the largest decrease in trading activity, 71.1%, and the largest decrease in trading costs, 22.9%. High-yield bonds also disproportionately contribute to the reduction in estimated trading costs of $600 million a year.

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[2] Asquith: MIT Sloan School of Management, Cambridge, MA 02142 and NBER, email: pasquith@mit.edu; Covert: Chicago Booth School of Business, Chicago, IL 60637, email: Thomas.Covert@ChicagoBooth.edu; Pathak: MIT Economics, Cambridge, MA 02142 and NBER, email: ppathak@mit.edu.

I. Introduction

Many financial markets have recently become subject to new regulations requiring transparency. This paper studies how transparency affects trading in the US corporate bond market. In July 2002, FINRA began requiring the timely public dissemination of post-trade price and volume information for the $4.4 trillion-a-year U.S. corporate bond market through TRACE (FINRA's Trade Reporting and Compliance Engine). Dissemination took place in Phases over two-and-a-half years. Actively traded, investment grade bonds became transparent before thinly traded, high-yield bonds. TRACE has become the template for increased transparency in other over-the-counter financial markets.[3] The increase in information due to TRACE was so significant that it has been likened to the early 20th century introduction of stock market tickers for equities and electronic screens for Treasuries (Vames 2003).

When market participants have timely information about transaction prices and quantities, it may lower search costs and alter bargaining between customers and dealers. Several models suggest that post-trade transparency reduces trading costs and improve market performance. In Duffie, Garleanu, and Pedersen (2005)'s search-and-matching model, bid-ask spreads decrease when investors have greater bargaining power. In models with information differences, a reduction in information asymmetries also reduces transaction costs (e.g., Glosten and Milgrom 1985). FINRA's (then NASD) stated rationale for TRACE emphasized that more information would level the playing field between institutional and retail market participants. TRACE proponents anticipated that everyone, including dealers, would benefit from increased market participation. For instance, SEC commissioner Arthur Levitt (1999) remarked, "This participation means more trading, more market liquidity, and perhaps even new business for bond dealers."

In this paper, we use previously unreleased data to examine the effects of TRACE on trading activity and costs over all four Phases of its introduction. The new data includes anonymized dealer identifiers. These identifiers allow us to directly measure trading costs by measuring the cost of round-trip trades for all bonds. The data also include transaction information on bond trades that were collected by TRACE, but not publicly disseminated. The non-disseminated trades allow us to exploit TRACE's four distinct Phases to estimate difference-in-differences models of TRACE's effect. This provides complete coverage across all segments of the bond market for the first time. In addition, our research design, which exploits the introduction of TRACE in Phases, isolates the effect of transparency from other elements of market design since bonds continued to be traded over-the-counter in a dealer market afterwards.

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[3] Title VII of the Dodd-Frank Wall Street Reform and Consumer Protection Act (Dodd-Frank) (2010) required that swaps (including credit default swaps, interest rate swaps, collateralized debt obligations, and other derivatives) adopt TRACE-like post-trade transparency beginning in 2011. In addition, FINRA has expanded TRACE to several other asset classes, including Agency-Backed Securities, Asset-Backed Securities, and 144a bonds. TRACE was expanded in March 2010 to include Agency-Backed Securities and in May 2011 to include Asset-Backed Securities. FINRA started publicly disseminating 144A transactions on June 30, 2014. European MiFID II/R regulations mimic TRACE for European corporate bonds and were implemented starting January 3, 2018.

Bonds differ substantially between the Phases as does trading activity and trading costs. For example, bonds in the last Phase (3B) are far more likely to be lower rated high yield bonds than bonds in the first two Phases (1 and 2), which are all investment grade. In addition, bonds in Phase 3B trade less frequently than bonds in Phases 1, 2, and 3A. At the same time, Phase 3B bonds have the largest average trade size and the highest trading-cost per round-trip trade.

These differences in bonds across Phases allow us to show that TRACE has significantly different effects on the investment-grade and high-yield segments of the bond market. Using a difference-in-differences methodology, we find that TRACE results in an 11.7% reduction in the number of trades overall.[4] This result is driven by Phase 3B bonds. TRACE significantly reduces the number of Phase 3B trades by 71.1% from the mean number of trades prior to dissemination.[5] These findings are robust across variations of our difference-in-differences research design.

TRACE does not significantly change trading volume for any Phase, however. Even though the number of trades for Phase 3B bonds decrease, TRACE increases the average trade size for Phase 3B bonds significantly increases by 4.3% or $50,101. Moreover, the reduction in the number of trades in Phase 3B is driven by trades less than 100,000. These are exactly the small retail trades that proponents of TRACE predicted would increase the most, yet the data show that they decrease the most.

There is no effect on trading volume even though TRACE reduces round-trip trading costs significantly in each Phase. A round-trip trade is one where a given quantity of a bond is bought and sold by the same dealer within a certain amount of time. There is a reduction in round-trip trading costs, both by trade and by bond traded for each Phase. TRACE reduces round-trip trading costs across all Phases by 18.5% per round-trip trade and 4.9% per round-trip bond traded. The effects on trading costs are largest, at 22.9% per round-trip trade and 10.9% per round-trip bond traded, for Phase 3B bonds. These significant effects are present even though Phase 3B occurs more than two-and-a-half years following the introduction of transparency in segment of the bond market.

We also investigate differences between dealer and customer trading. We divide round-trip trades between those with a customer on both ends and a dealer in between ("CDC"), which we refer to as customer round trips, and those with no customers ("DDD"), which we refer to as dealer round trips. The customer trading cost per round-trip trade is larger than for dealers at $2,562 for CDCs versus $1,035 for DDDs. This fact is consistent with dealers having market power or more information than customers. TRACE has the largest negative effect on customer round-trip trades, and reduces the dealer cost advantage, but it does not eliminate it. There is a significant reduction in trading cost per round-trip trade of $454 for CDCs and a $225 for DDDs. On a percentage basis, however, these effects are similar, showing that TRACE does not level the playing field between customers and dealers.

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[4] Since there is no systematic data on corporate bond trading prior to TRACE's introduction, we cannot use our research design to study Phase 1. Following Bessembinder, et. al. (2005), we use data from the National Association of Insurance Commissioners together with our difference-in-differences research design to measure Phase 1 effects on trading activity and costs. Appendix A details these results.

Finally, we estimate that the aggregate reduction in trading costs across all Phases is $605 million per year. We also estimate TRACE's effect on trading revenues per dealer and find that dealer's revenue dropped approximately by $695 million a year from transparency. Moreover, the high-yield and infrequently traded bonds in Phase 3B account for 21.8% of the reduction in trading cost per round-trip trade and 34.4% of the reduction in dealer revenues, even though they represent only 5.1% of the trades.

Our results extend the existing literature on TRACE, written before it was fully implemented. Bessembinder, Maxwell, and Venkataraman (2006), focusing on Phase 1 only, which covered investment grade and large issue bonds, and using data from the National Association of Insurance Commissioners (but not TRACE), document a reduction in trade execution costs, estimated using a structural model. Edwards, Harris, and Piwowar (2007) and Hotchkiss, Goldstein, and Sirri (2007) both using investment-grade bonds in Phase 2 TRACE data report no effect on trading activity and a decline in transaction costs.

None of these studies consider the last two Phases of TRACE, which cover primarily smaller issue size bonds and high-yield bonds. Bonds in these segments trade less frequently and were the subject of the most vocal concerns of TRACE opponents. It was because of these concerns that FINRA phased-in TRACE over four Phases, and even delayed disseminating certain transactions in the last Phase of TRACE. Prior work has also focused on model-based estimates of trading costs or reported round-trip measures of trading costs for small subsamples of bonds. These estimates may not be representative of TRACE's overall impact.

The rest of this paper is organized as follows. Section 2 presents additional background on TRACE and reviews the related literature. Section 3 describes the Academic TRACE database and presents descriptive statistics. Section 4 describes our research design. Section 5 reports on trading activity, while Section 6 reports on trading costs. Section 7 investigates trade sizes and trading partner (either dealer or customers). Section 8 examines dealer revenue and the aggregate effect of TRACE. The last section states our conclusions and discusses the implications of our findings.

II. TRACE and the Corporate Bond Market

II.A History and Implementation of TRACE

The Trade Reporting and Compliance Engine (TRACE) was launched in July 2002, but it has its origins in the late 1990s when the Securities and Exchange Commission (SEC) reviewed issues related to price transparency in U.S. debt markets. After this review, the SEC asked the National Association of Security Dealers (NASD) to take three steps to enhance the transparency and integrity of the corporate debt market: 1) adopt rules to report all transactions in U.S. corporate bonds to NASD and develop systems to receive and distribute transaction prices on an immediate basis; 2) create a database of transactions in corporate bonds to enable NASD and other regulators to take a proactive role in supervising the corporate debt market; and 3) create a surveillance program to better detect misconduct and foster investor confidence in the corporate debt market. NASD changed its name to the Financial Industry Regulatory Authority (FINRA) in 2007.[6]

The SEC and NASD's stated rationale was to level the playing between institutional and retail participants in the corporate bond market. Advocates of transparency claimed that almost everyone, including dealers, would benefit because of increased market participation. As mentioned above, SEC commissioner Arthur Levitt (1999) remarked, "This participation means more trading, more market liquidity, and perhaps even new business for bond dealers."

The anticipated benefits of TRACE and the absence of harm contrasts sharply with the opinions of many market participants. TRACE opponents argued that "transparency would add little or no value" to highly liquid and investment grade bonds since these issues often trade based on widely known US Treasury benchmarks (NASD 2006). Furthermore, the Bond Market Association warned that there would be negative effects for lower-rated and less frequently traded bonds (Mullen 2004). Dealers may be less willing to hold inventory because bid-ask spreads subsidize holding costs and TRACE may reduce these spreads, particularly for less frequently traded securities. Moreover, opponents saw TRACE as imposing heavy compliance costs, particularly for small firms (Jamieson 2006). Lastly, there was a concern that dealers who buy large quantities may be particularly disadvantaged since dissemination would affect the resale price. Not surprisingly, similar arguments for and against transparency resurfaced in response to the introduction of the Dodd-Frank's post-trade transparency requirements for swaps (Economist 2011).

By January 2001, the SEC approved rules requiring NASD members to report all over-the-counter (OTC) market transactions in eligible fixed income securities to the NASD and mandating that certain market transactions be disseminated. NASD developed a platform, TRACE, to facilitate this mandatory reporting. The rules, referred to as the "TRACE Rules," are contained in the new Rule 6200 Series that replaced the old Rule 6200 Series, which governed the Fixed Income Pricing System (FIPS). FIPS, which reported transactions information on approximately 50 high-yield bonds, started in April 1994.

On July 1, 2002, FINRA implemented TRACE, requiring dealers to report all bond transactions on TRACE-eligible securities within 75 minutes. As described in Table 1, FINRA began disseminating price and volume data for trades in selected investment-grade bonds with an initial issue of $1 billion or greater (i.e., Phase 1 bonds). FINRA's dissemination occurred immediately upon reporting for these bonds. FINRA censored trade size reports at $1,000,000 for high-yield bonds and $5,000,000 for investment grade bonds, due to the concerns about TRACE's impact on large trades discussed above (Vames 2003).[7]

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[6] http://www.finra.org/Industry/Compliance/MarketTransparency/TRACE/FAQ/P085430, Last accessed: July 14, 2012.

[7] Duffie (2012) states that censoring trade information may "reduce inventory imbalances stemming from large trades with less concern that the size of a trade or their reservation price will be used to the bargaining advantage of their next counterparties."

A "TRACE-eligible security" is any US dollar-denominated debt security that is depository-eligible and registered by the SEC, or issued pursuant to Section 4(2) of the Securities Act of 1933 and purchased or sold pursuant to Rule 144a.[8] Additionally, the 50 high-yield securities disseminated under FIPS were transferred to TRACE, which now disseminated their trades.[9] We denote these bonds as the FINRA50. 520 securities had their information disseminated by the end of 2002.

At the start of Phase 1, it was not certain when and to what extent TRACE would be expanded. After all, the FIPS program had existed without expansion for eight years. Initially, a bond transactions reporting committee comprised of NASD and the Bond Market Association members was established to study TRACE's impact. Their mandate was to focus not on the largest, highest quality credit and actively traded issues, but rather on the rest of the market (Vames 2003). Their recommendation was to expand TRACE's coverage. The NASD approved the expansion of TRACE on November 21, 2002 and the SEC approved it on February 28, 2003.

Phase 2 of TRACE was implemented on March 3, 2003, and it expanded dissemination to include smaller investment grade issues. The new dissemination requirements included securities with at least $100 million par value or greater and ratings of A- or higher. In addition, dissemination began on April 14, 2003 for a group of 120 Investment-Grade securities rated BBB. We denote these BBB bonds as the FINRA120.[10] After Phase 2 was implemented, the number of disseminated bonds increased to approximately 4,650 bonds.[11]

Finally, on April 22, 2004, after TRACE had been in effect for some bonds for almost two years, the NASD approved the expansion of TRACE to almost all bonds. The last Phase came in two parts, which FINRA designates as Phase 3A and Phase 3B. The distinction between Phase 3A and 3B was in response to concerns about the adverse effects of immediately disseminating information on large trades. Phase 3B bonds are eligible for delayed dissemination. Specifically, Rule 6250(b)(2)(A) states that transactions greater than $1 million on BB bonds that trade an average of less than one time per day will be disseminated two business days from the time of execution. Rule 6250(b)(2)(B) states that transactions greater than $1 million on bonds rated B or lower that trade an average of less than one

[8] The list of eligible security types is: (1) Investment-grade debt, including Rule 144A/DTCC eligible securities, (2) High-yield and unrated debt of U.S. companies and foreign private companies, (3) Medium-term notes, (4) Convertible debt and other equity-linked corporate debt not listed on a national securities exchange, (5) Capital trust securities, (6) Equipment trust securities, (7) Floating rate notes, (8) Global bonds issued by U.S. companies and foreign private companies, and (9) Risk-linked debt securities (e.g., "catastrophe bonds"). TRACE-eligible securities exclude debt that is not depository-eligible, sovereign debt, development bank debt, mortgage- and asset-backed securities, collateralized mortgage obligations, and money market instruments.

[9] Alexander, Edwards, and Ferri (2000) examine the liquidity of the bonds in the FIPS dataset.

[10] The FINRA120 sample was selected by FINRA to study the impact of dissemination on market behavior and has been studied by Goldstein, Hotchkiss, and Sirri (2007).

[11] The FINRA50 subset did not remain constant over our time period. On July 13, 2003, the FINRA50 list was updated, and the list was then updated quarterly for the next 5 quarters. The FINRA50 list was updated on July 13, 2003, October 15, 2003, January 15, 2004, April 14, 2004, and July 14, 2004.

time per day will be disseminated four business days from the time of execution.[12] TRACE eliminated delayed dissemination on January 9, 2006.

In Phase 3A, effective on October 1, 2004, 9,558 new bonds started having their trade information disseminated. In Phase 3B, effective on February 7, 2005, an additional 3,016 bonds started dissemination, though sometimes with delay. According to the NASD at that point, there was "real-time dissemination of transaction and price data for 99 percent of corporate bond trades" (NASD 2005).

In an effort parallel to increasing the number of bonds with disseminated trade information, FINRA began reporting transactions (except for delayed disseminations discussed above) more quickly: the time-lag between the dealer's report to FINRA and its public release was reduced from 75 minutes on July 1, 2002, to 45 minutes on October 1, 2003, to 30 minutes on October 1, 2004, and to 15 minutes on July 1, 2005. On January 9, 2006, the same day that delayed dissemination was eliminated, the time-lag for public release was eliminated and trades were disseminated immediately.

II.B Related Literature

There are three early studies of TRACE which focus on Phase 1 or Phase 2. The first, Bessembinder, Maxwell, and Venkataraman (2006), studies the impact of Phase 1 of TRACE using the National Association of Insurance Commissioners (NAIC) database, before and after the start of Phase 1. That database contains insurance company transactions of corporate bonds. Bessembinder et al. estimate a structural model in which changes in bond prices are regressed on customer buy/sell dummies and other factors to estimate trade execution costs. They estimate a 4.9-7.9 basis point reduction in trade execution costs for Phase 1 bonds in a before-and-after comparison. They also estimate that after Phase 1, transaction costs for bonds not covered in Phase 1 decline by 3.5 basis points, and that there is a decline in the share of trading activity performed by the 12 largest dealers. In light of the decline in trade execution costs for non-Phase 1 bonds, they argue that the implementation of TRACE on the large and high credit quality bonds in Phase 1 had spillover effects on other bonds whose trades were not disseminated.

Two other studies examine transaction costs for Phase 2 bonds. Edwards, Harris, and Piwowar (2007) estimate imputed transaction costs using a structural model, similar to the one used in Bessembinder et al. They find that disseminated bonds have lower estimated transaction costs. Since this result may be due to bond characteristics rather than the effect of transparency, they also report a difference-in-differences analysis, which compares the transaction costs of bonds which are newly disseminated to three distinct control groups of bonds that do not change dissemination status. The transaction costs of newly disseminated bonds decrease relative to each control group across the entire

[12] In addition, dissemination is delayed for the first two days for newly issued BBB rated TRACE-eligible securities for trades that are executed in the first two days after pricing (all trades for the first two days are reported on the third day). Similarly, dissemination is delayed for the first ten days for newly issued BB or lower rated TRACE-eligible securities for trades that are executed in the first ten days after pricing (all trades for the first ten days are reported on the eleventh). Note our sample is restricted to bonds that trade at least 90 days before the start of any Phase and therefore these types of delayed dissemination are not present in our sample.

range of trade sizes. Both Bessembinder et al. and Edwards et al. estimate that investors could have saved a minimum of $1 billion per year if trades were transparent.

Hotchkiss, Goldstein, and Sirri (2007) report on a controlled experiment, commissioned by the NASD, of 120 BBB bonds, 90 of which are actively traded and 30 of which are relatively inactive. Through cooperation with the NASD, they construct a matched sample of the 90 actively traded bonds based on industry, average trades per day, bond age, and time to maturity. When the 90 actively traded bonds were disseminated on April 14, 2003, the matched bond was not. To increase power, they also compare the disseminated sample to a larger portfolio of non-disseminated bonds. For the 90 actively traded bonds, they find declines in transaction costs for all but the group with the smallest trade size. There is no evidence of a reduction in transaction costs for inactively traded bonds. In subsequent work, Goldstein and Hotchkiss (2012) study new issues of corporate bonds, and find a secular decline in price dispersion, measured as the difference between high and low prices charged by the same dealer on the same day, from July 2002 through February 2007, for newly issued bonds. This fall in price dispersion does not, however, coincide with the start of any of the TRACE phases.

While these studies provide evidence that TRACE reduces transaction costs for Phase 1 and Phase 2 bonds, there is little evidence about actual reductions in trading costs and no evidence about TRACE's effect on trading activity or trading costs in Phases 3A or 3B. These last two Phases cover 13,940 bonds (or 82.7% of all bonds) and 55.7% of trading activity from July 2002 – December 2006. The SEC, and others, saw the evidence above as inconclusive, stating that concerns about liquidity were not rejected.[13] Duffie (2012) concludes "the empirical evidence does not generally support prior concerns by dealers that the introduction of TRACE would reduce market liquidity." More recently, Dugalic (2017) studies the behavior of core and peripheral dealers in the period surrounding the introduction of TRACE. Following our research design, he finds that transparency influences trading between the core and peripheral dealers.

The absence of any adverse effect on trading activity is surprising considering the negative reaction to TRACE from many market participants. For instance, Bessembinder and Maxwell (2008) survey dealers and report that bond dealers almost universally perceive that trading became more difficult after TRACE. (See also Jamieson 2006 and Decker 2007).[14] This may be a consequence of the earlier studies' focus on Phase 1 and Phase 2 since our paper finds a reduction in trading activity for bonds in Phase 3B.

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[13] The SEC's Director of Market Regulation Nazareth (2004) stated "the NASD commissioned two studies to address this issue [the impact of TRACE on liquidity]. Neither study provided significant evidence that transparency harms liquidity. However, neither study was extensive enough to address all concerns raised by dealers and other market participants." The industry group, the Bond Market Association, described these studies as largely inconclusive (Mullen 2004).

[14] Bessembinder and Maxwell (2008) are skeptical of these claims given that there was an upward trend in aggregate corporate bond trading from 2002-2007. This increase in aggregate bond trading does not imply TRACE increased trading activity, however, since there was also an upward trend in the amount of corporate debt outstanding due to new issues. When we hold the number of bonds constant by examining bonds newly disseminated in TRACE's four Phases, there is a downward trend in the number of trades (see Figure 1).

A set of studies on municipal bonds is also relevant to the TRACE experiment. On January 31, 2005, the Municipal Securities Rulemaking Board (MSRB) started requiring that information about trades in municipal bonds be reported within 15 minutes, similar to TRACE. Prior to that dissemination, Green, Hollifield, and Schurhoff (2007a) find significant price dispersion in new issues of municipal bonds, which they attribute to the decentralized and opaque market design. Green, Hollified, and Schurhoff (2007b) analyze broker-dealer and customer trades, and report that dealers exercise substantial market power. Schultz (2012) compares price dispersion at offering date for municipal bonds before and after this change and finds that it falls sharply. Brancaccio, Li, and Schurhoff (2018) show that the MSRB transparency rule reduced trading volume in uninsured bonds, but not in insured bonds.

Other more recent papers use TRACE data to examine aspects of corporate bond trading but are not directly related to transparency. Bessembinder et al. (2017) study the time series of dealer margins and capital commitment between 2006 and 2016. They find that while transaction costs (inferred from their estimates of a structural model) have been relatively stable, some measures of dealer capital commitment have fallen. Goldstein and Hotchkiss (2017) show that dealers unwind most corporate bond trades within a day, especially in infrequently-traded or high-yield bonds. Di Maggio, Kermani, and Song (2017) use TRACE data to estimate trading relationships between corporate bond dealers. They find that dealers who frequently transact with each other do so at lower margins, and that central dealers charge higher markups when transacting with peripheral dealers.

Finally, the theoretical work on the impact of transparency highlights various mechanisms through which post-trade transparency can impact trading behavior. (See Biais, Glosten, and Spatt (2005) for a review of the literature on the impact of transparency on financial markets). Madhavan (1995) demonstrates that dealers may prefer not to disclose trades because they benefit from the reduction in information. Pagano and Roell (1996) argue that well-informed dealers may be able to extract rents from less well-informed customers in an opaque market, but that transparency may result in more uninformed traders entering the market. Bloomfield and O'Hara (1999) show that transparency can reduce market-makers incentives to supply liquidity, if market makers have more difficulty unwinding inventory following large trades. On the other hand, Naik, Neuberger, and Viswanathan (1999) show that transparency can improve dealers' ability to share risks, which decreases their inventory costs and therefore customers' costs of trading.

III. Data and Descriptive Statistics

III.A Academic TRACE data and Phase identification

Beginning in July 2002, TRACE publicly provided price and volume data for disseminated trades for Phase 1 bonds.[15] Simultaneously, FINRA also collected non-disseminated trade data on all trades in

[15] During our sample period, FINRA censored reported trading volume at $1 million for high-yield bonds and $5 million for investment-grade bonds. That is, for trades greater than this amount, the actual trading volume was not

corporate bonds in the period before public dissemination. In March 2010, FINRA released a "Historical" TRACE dataset, which includes both disseminated and non-disseminated transaction records, starting from TRACE's initiation in July 2002. In February 2017, FINRA appended anonymized dealer identifiers to the Historical TRACE dataset (now available as the Academic Corporate Bond TRACE dataset).

We use a cleaned version of the Academic Corporate Bond TRACE dataset, "Academic TRACE", to examine the period from July 1, 2002 through December 31, 2006. Within this database, we identify which bonds FINRA began disseminating trade data on at the beginning of the four Phases. Since Phase 3B, the last major Phase of TRACE, concluded in February 2005, our time period covers all four TRACE Phases.

Cleaning this raw data requires a number of steps to process Academic TRACE into our analysis dataset. The nature of the reporting process makes cleaning the database an essential task. The raw FINRA database contains self-reported information by bond dealers who are FINRA members. Dealers are required to report the bond's CUSIP, the trade's execution time and date, the transaction price ($100 = par), and the volume traded (in dollars of par). Since every dealer involved in the trade must, under FINRA regulations, report a trade ticket, many trades are reported more than once. In addition, dealers must indicate whether they were the buyer or the seller, the identity of the counterparty to the trade, whether they were acting as a principal or agent, and whether the counterparty to the trade was a dealer or a customer. Unlike the Public TRACE database, the Academic TRACE does not censor volume at $1 million or $5 million. Finally, dealers are required to correct errors in previously reported trades with flags corresponding to trade cancels, modifies, or reversals.

The cleaning steps and their rationale are described in detail in the Data Appendix and outlined in Table B1. We began the cleaning process by first dropping all bonds not contained in the Mergent Fixed Income Securities Database (FISD), and all bonds with an equity-like component (since partial price information may be available from the stock market). Then we eliminate self-reported errors in the trade reports. These are reports for trades that do not actually take place and they are later modified, cancelled, or reversed.

Next, trade reports are eliminated that are reported more than once. This occurs either as part of agency or interdealer principal transactions. Finally, we correct or eliminate trades based on timing, price, and volume issues. The appendix and Table B1 enumerate the number of bonds and trade reports affected by each step.[16] After applying the filters described in Table B1, there are 22,582,689 trades, corresponding to 30,814 CUSIPs, remaining in the "Cleaned Academic TRACE Sample".

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reported and TRACE only reported that the trade size exceeded the cap. As of 2018, FINRA continues to censor trades in high-yield bonds over $1 million and investment-grade bonds over $5 million. The actual trade amounts are made public after 6 months.

[16] We do not exclude bond trades that occurred on the NYSE's Automated Bond System. Even though they take place on an exchange with publicly available price and quantity, they constitute a tiny fraction of the market. For instance, Hotchkiss, Goldstein, and Sirri (2007) state that 99.9% of corporate bond trading in 2004 takes place over-the-counter.

Phase Identification

FINRA's criterion for a bond's dissemination Phase is presented in Table 1. The main criteria are the bond issue size and credit rating. FINRA does not indicate a bond's Phase designation in the Academic TRACE dataset. As a result, we contacted FINRA and obtained their listings of the bonds included at the start of Phases 2, 3A, and 3B. We obtained the list of bonds that are in the FINRA50 or FINRA120 directly from the FINRA website.[17]

Since FINRA did not provide us a list of bonds in Phase 1 we constructed the Phase 1 list by first requiring a bond to have a publicly disseminated trade before the start of Phase 2.[18] Bonds which are in either the FINRA50 or FINRA120 are excluded from our Phase lists. The Data Appendix and Table B2 further describe the steps involved in matching the Phase lists to the Cleaned Academic TRACE database.

Table B2 shows that after cleaning, there are 388 Phase 1 bonds, 2,526 Phase 2 bonds, 11,081 Phase 3A bonds, and 2,859 Phase 3B bonds. We designate these 16,854 bonds and 15,952,736 trades as the "Phase Analysis Sample." The remaining bonds in the Cleaned Academic TRACE database are not associated with any Phase because either they did not exist at the beginning of their Phases, they were not present for the entire 90 days before and after the start of the Phase, they were either issued after the Phase began or they were called before the start of what would have been their Phase. Finally, 107 bonds are not included in our Phases Analysis Sample because they were at some point a part of FINRA50 or FINRA120.

III.B Bond Characteristics

Table 2 shows the distribution of issue size, credit rating, coupon rate, and maturity for our sample of bonds by Phases. As mentioned above, when assigning bonds to Phases, FINRA uses issue size and rating as criteria. Table 2 shows the mean bond issue size decreases from Phase 1 to Phase 3A, consistent with the rules set by FINRA outlined in Table 1. Phase 1 bonds have by far the largest issue size with a mean of $1.463 billion and Phase 3A bonds are the smallest with mean issue sizes of $86 million. Phase 3B bonds have a mean issue size of $184 million.

We also report the quartiles of the issue size distribution as well as the 5th, 10th, 90th, and 95th percentiles. These quantiles show that there is an overlap in issue size between Phases 2, 3A, and 3B. For example, the median of Phase 3B bonds equals the 25th percentile of Phase 2 bonds and the 75th percentile of Phase 3A bonds is close to the 25th percentile of Phase 3B bonds. These overlapping intervals will later allow us to compare bonds with similar issue sizes across Phases 2, 3A, and 3B.

Data on credit ratings comes from two sources. We first use rating information from S&P RatingsXpress if it is available. This covers 75.2% of bonds for the four Phases. If ratings are not available in S&P RatingsXpress, we use ratings from FISD.[19,20] FISD includes ratings from S&P, Moody's,

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[17] The FINRA50 and FINRA120 samples are defined in the appendix.
[18] This approach will not capture bonds that are classified by FINRA as Phase 1, but do not trade before Phase 2.
[19] Akins (2018) states that the S&P RatingsXpress database is more complete than FISD's S&P ratings database.

Fitch and Duff and Phelps. To assign a FISD rating, we first use the S&P value if it exists, otherwise, the Moody's value, otherwise the Fitch value, and otherwise the Duff and Phelps value. If FISD does not have a rating from any of the four, we classify the bond as unrated. Using both sources, there are ratings for 99.3% of bonds, and only 126 bonds are classified as unrated.

Table 2 shows the distribution of credit ratings at the start of each Phase. The average rating at the beginning of the Phase is similar between Phases 1, 2, and 3A, at A, A+, and A-, respectively. Bonds in Phase 3B have a significantly lower average credit rating of B. The distribution of credit ratings shows considerable overlap between the ratings in Phases 1, 2, and 3A and far less overlap in ratings between Phase 3B and the other Phases. For example, the 10th percentile rating in Phase 3B is a BB+, while the 90th percentile ratings in Phase 1, 2, and 3A are BBB, A-, and BBB-, respectively.

Table 2 also describes bond characteristics not used by FINRA when assigning Phases. For example, most bonds, about 90% in each Phase, have fixed coupon rates. Consistent with its lower ratings, Phase 3B bonds have the highest coupon rates. In addition, Phase 1 bonds have the lowest maturity at issue with a mean of 9.2 years and a median of 6.0 years. Bonds from all three other Phases have a mean maturity of at least 11.8 years and a median maturity of at least 9.7 years.

FINRA's definition of the Phases suggests that the major difference between the Phases 1, 2 and 3A is issue size. Phase 3B differs primarily from the other three Phases because of credit rating. If the market for high-yield bonds behave differently than that for investment-grade bonds, or more generally bond market trading differs by credit rating, then FINRA's definition of Phases captures this segmentation. Any such differences must be accounted for in our later analysis of trading activity and costs.

III.C Measuring Trading Activity and Trading Costs

Trading Activity

We measure trading activity in several ways. Since most bonds trade infrequently, we use one day as the minimum unit of time. (In our Phase Analysis Sample, the average number of trades per day for a bond is 1.03). Figure 1 plots the average daily number of trades per bond averaged by week for the bonds in Phases 1, 2, 3A, and 3B from July 2002 through December 2006 (note: the graph is on a log scale).[21] The four vertical lines correspond to the starting date for each of the four Phases. For all four Phases, the average number of trades per bond averaged by week fell by about a half over the entire period from July 2002 to December 2006. While this decrease in trading may be due to TRACE, we cannot, at this point, exclude the possibility that there is a pre-existing downward trend independent of TRACE.

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[20] FINRA does not rely exclusively on S&P ratings. It also uses ratings from other nationally recognized statistical rating organizations. If a bond is unrated or split rated, FINRA has specific rules determining the bond's rating for Phase classification.

[21] Figure 1 does not include trading days that SIFMA recommends that bond dealers take off or operate for less than a full day. Additionally, Figure 1 does not include the two weeks spanning Christmas and New Year's Day for each year due to significantly reduced volume.

Table 3 reports summary statistics trading activity and trading costs for each Phase in the window surrounding dissemination. The upper left panel reports the mean number of trades per bond-day for the period 90 days before and 90 days after the beginning of each Phase.[22] Phase 1 bonds trade most often, averaging over 15.5 trades per day in the 90 days after dissemination. Phase 3B bonds trade most infrequently, both before and after dissemination, averaging less than 1/3 trade per day. Table 3 also reports the mean trading volume per day. Here, too, trading activity in Phase 1 swamps that in the other Phases.

Differences in trading volume across Phases may be due to a difference in bond issue sizes. A larger bond issue may generate more after-market trading simply because there are more bonds to trade. As shown in Table 2, the mean issue size of Phase 1 bonds is 5.5 times greater than those in Phase 2 and Phase 2 bonds' mean issue size is three times that of bonds in Phase 3A. To examine whether the difference in volume across Phases is driven by differences in issue size, Table 3 also shows trading volume per day divided by issue size. Normalizing by issue size reduces the skewness in comparisons across Phases but doesn't eliminate it. Trading volume per day divided by issue size in Phase 1 is now five times that of Phase 3B.

Going forward, we will use the number of trades as our primary measure of trading activity. We focus on the number of trades first because that is where we find the strongest and most robust effects of transparency on trading activity. We also report on volume and volume divided by issue size in Table 5.

Trading Costs

We primarily measure trading costs by computing trading cost per round-trip trade and per round-trip bond traded. A round trip is defined as two trades of the same size in a particular bond where the buyer in one trade is the seller in the second trade or vice versa.[23] For example, if a dealer purchases a quantity of a particular bond and then later sells the same quantity of the same bond, we define the two trades as a round trip. The trading cost per round-trip trade is defined as the difference in the total cost, which is the price times quantity of the trade, between the second and first trade. The trading cost per round-trip bond traded is defined as the difference in price between the second and first trade. We report both trading cost per round-trip trade and per round-trip bond traded because trading costs vary with the number of bonds transacted. Both measures correspond to trading costs associated with the total round trip; that is, the sum of the trading costs for two consecutive trades.

The definition of a round trip requires setting a time interval between the two trades. The period over which the two trades take place can be an hour, a day, or longer. What is important for identifying a round trip is that one party participates in both transactions, once as a buyer and once as a seller, and that the amount traded of a particular bond is the same. We classify round trips over several

[22] Since bonds trade infrequently, we use a 90-day window to capture changes in trading behavior. In Table 4, we also look at 60-, and 180-day windows.

[23] Round-trip trading costs are commonly used to measure transaction costs in studies of the over the counter markets, when trade data include dealer identifiers (see, e.g., Goldstein et. al, 2007).

time intervals, including 1, 7, and 14 days. Most round-trip trades occur within one day, but we identify 17.8% more round trips by using the 7-day definition. We focus on 7-day round trips, but also report findings for 1 and 14 days with no substantial differences. For any given interval, when the first trade can be paired with multiple second trades, we match it to the trade that is closest in execution time.

It should be noted that round-trip trades are a subset of all trades. As a result, the number of bonds used for analysis of trading costs, shown in Table 3's sample counts, is lower than the number used for analysis of trading activity. For example, in Phase 1, there are 364,429 trades in the 90 days following dissemination. 143,458 (39.4 percent), or 71,729 round trips, of them are 7-day round-trip trades. We can construct 7-day round-trip trading cost estimates in the 90-day window around dissemination, where there is at least one round-trip observation before and after dissemination, for 78% of Phase 2, 56% of Phase 3A, and 39% of Phase 3B bonds.

Figure 2 plots 7-day trading cost per round-trip trade averaged by week from July 2002 through December 2006.[24] The figure shows that there is a reduction in trading cost per round-trip trade over the entire time period for every Phase. The decline in trading cost per round-trip trade seems to begin at TRACE's launch and continues through 2006. Trading cost per round-trip trade are highest for Phase 3B bonds and decline the most of any Phase. Although we do not show it, trading cost per round-trip bond traded also decline over the time period. Trading cost per round-trip bond traded are usually highest for Phase 3A bonds and lowest for Phase 1 over the entire period.

Table 3 reports the mean 7-day trading cost per round-trip trade over a 7-day interval for the 90-day window around Phase start dates. The day associated with the 7-day interval is the day of the first trade in the round trip. We do not include round-trip trades for which one trade occurs before the Phase start date and the other occurs after it. Trading cost per round-trip trade is lower after dissemination for Phases 2, 3A, and 3B.

Table 3 also shows trading cost per round-trip bond traded. Trading cost per round-trip bond traded are lowest in Phase 3B, but trading cost per round-trip trade are highest in Phase 3B. The reason for this difference is that Phase 3B trades are larger than the trades in the other Phases, a fact we investigate later. As with trading cost per round-trip trade, trading cost per round-trip bond traded are lower after dissemination for Phases 2, 3A, and 3B.

Since round-trip trading cost measures are only computed for 36.8 percent of all trades for the 90-day windows around each Phase start, we also calculate the daily price standard deviation. This measures price dispersion for a larger percentage of trades than just round-trip trades. Daily price standard deviation measured in dollars is defined for bond i on day t as

$$\sigma_{it} = (\sum_j (p_{ijt} - p_{it})^2)^{½}, \quad (1)$$

where p_{ijt} is the price of bond i for trade j on day t and p_{it} is the average price of bond i on day t.

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[24] As with Figure 1, Figure 2 does not include trading days on which SIFMA reports that dealers take off or operate for less than a full day. It also does not include the two weeks spanning Christmas and New Year's Day.

Like round-trip trading cost measures, price standard deviation requires that there are at least two bond trades. Unlike round-trip trading cost measures, these two trades do not have to be of identical size or have a common buyer/seller. Thus, price standard deviation can be computed on a larger fraction, 97.1%, of the trades. The number of bonds for which we are able to compute daily price standard deviation is also higher than the number of bonds for which we are able to compute round-trip trading costs, but not by as much as the number of trades.

The bottom right panel of Table 3 reports on price standard deviation in the 90-day window around when a bond changes its dissemination status. There is a reduction in price standard deviation, measured in dollars, for bonds in all three Phases. The average Phase 2 bond's price standard deviation falls from $0.88 to $0.86 per $100 par. The reduction in price standard deviation is greater for Phase 3A and 3B bonds. The average Phase 3A bond's price standard deviation falls by $0.05, from $0.86 to $0.81 which is a 6.4% decrease, while the average Phase 3B standard deviation falls from $0.55 by $0.07, which is a 13.4% decrease.

A key assumption for studying the effect of transparency on our trading cost measures is that the probability of a round trip is not affected by dissemination. That is, if the probability of a round trip rises or falls after dissemination, then the measured effects of dissemination are confounded by changes in the composition of bonds for which we can measure trading cost. If the bonds that would have traded without dissemination substantially differ from the bonds that do trade with dissemination, then it may be difficult to attribute changes in round-trip trading costs to dissemination. This appears to not to be an issue for our sample.[25] To further address the role of bond sample composition for our round-trip trading cost findings, in our analysis, we will construct a matched sample of bonds which holds the observable characteristics of bonds constant before and after dissemination.

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[25] The probability that any of the Phase 2, 3A, or 3B bonds has a trade that is part of a round-trip trade in the 90 days before dissemination is 9.13%. To test whether this probability changes after dissemination, we estimate the effect of dissemination on the probability that a bond has a trade that is part of a round-trip trade. The estimates come from a difference-in-differences regression similar to those estimated in Table 4, where the dependent variable is an indicator for whether a bond has a trade that is part of a round-trip trade on a given day. (The next section introduces our difference-in-differences methodology.) There is a statistically significant 2.2% reduction in the probability of having a trade that is part of a round-trip trade for treated bonds across all three Phases.

Assuming that the likelihood of trading is independent across days, this 2.2% reduction implies that TRACE causes a negligible reduction in the probability that a bond's round-trip trading costs can be measured in the 90-day window. The estimated probability that a bond is no longer in the round-trip trading cost sample due to dissemination is less than 0.01%. This is calculated as follows: the probability that in any day among the 90 calendar days before there is a trade that is part of a round trip and that in any day among the 90 calendar days after dissemination there is a trade that is part of a round trip is equal (1-(1-Pr(at least one trade that is part of a round trip))^64) * (1-(1-Pr(at least one trade that is part of a round trip))^64), where 64 is the average number of trading days among 90 calendar days. The 2.2% reduction in the probability of having a trade that is part of a round-trip of 9.13% yields a 0.01% reduction in the probability that a bond will be in round-trip trading cost sample due to dissemination.

IV. Difference-in-Differences Research Design

The before-and-after comparisons in Table 3 do not establish that dissemination affected trading activity and trading costs because they are contemporaneous with the market-wide downward trends that we see in Figures 1 and 2. We, therefore, adjust for potential market trends by comparing the changes in the sample of newly disseminated bonds (the treated sample) to those who do not change dissemination status (the control sample) by estimating difference-in-differences models of the form:

$$y_{it} = \alpha_i + \gamma_0 \text{ Disseminate}_i + \gamma_1 \text{ Post}_t + \lambda \text{ Disseminate}_i \times \text{Post}_t + \varepsilon_{it,} \quad (2)$$

where y_{it} is bond i's outcome (i.e., measures of trading activity or trading costs) on day t, α_i is a bond-specific effect, Disseminate_i is an indicator for whether the bond changes dissemination status (i.e., is in the treated group) and Post_t is an indicator for the trade outcomes on days after the dissemination period. Since there are repeated observations per bond, in all estimates, the standard errors are clustered by bond. We include bond fixed effects to adjust for the fact that not all bonds may have an outcome in the 90 days before and in the 90 days after changes in dissemination.[26] Further, for trading costs, we require that there is at least one round-trip trading cost observation both in the 90 days before and in the 90 days after each Phase date for all treated and control bonds.

In equation (2), any pre-existing difference between bonds that change dissemination status and those that do not are captured by γ_0. Any effects of dissemination that accrue to all bonds – that is, effects that are not limited to only bonds that change their dissemination status in the Phase – are absorbed by time effects γ_1. The coefficient of interest is λ, which estimates the direct effect of transparency on a bond's trading outcome. The coefficient λ reflects the change in trading outcomes for bonds that change dissemination status compared to the change in trading outcomes for bonds that do not change dissemination status. Estimates of λ, therefore, net out aggregate changes in bond trading outcomes.

It is possible that changes in dissemination will also affect bonds that do not change dissemination if the market impounds trading information on newly disseminated bonds into all bond trading. Indeed, the overall downward trend in the number of trades and trading cost per round-trip trade in Figures 1 and 2 may be the consequence of TRACE's introduction in July 2002. However, we cannot assert that TRACE caused this decrease because we do not observe trading activity before Phase 1. The overall downward trend could instead be due to macroeconomic factors affecting the corporate bond market. For example, the Federal Reserve raised interest rates 17 times from June 2004 through

[26] For many of our trading activity measures (number of trades, volume, volume / issue size), we observe the level of trading activity, or its absence, for every bond on every day. For average trade size and all of the trading cost measures, we only observe a value for a bond in a day if there is enough data to compute it. For example, a bond must trade on a given day to compute the average trade size. Moreover, we must observe a round-trip transaction to measure a round-trip trading cost, and we must observe two transactions on a day to compute price standard deviation.

June 2006 (NASD 2006). In our regression equation, the time effects incorporate all these potential factors, and therefore we cannot interpret the estimates of γ_1 as a causal effect of dissemination.

Our estimate of λ isolates the effect of transparency from other elements of market design since bonds continued to be traded over-the-counter in a dealer market afterwards. That is, λ does not confound the effect of transparency with other reforms such as changes in trading protocols from over-the-counter to exchange trading. However, for λ to provide unbiased estimates of the causal effect of transparency there are several important necessary assumptions. First, transparency and its consequences must not have been fully anticipated by market participants; to the degree that impacts were foreseen by traders and dealers, the impacts on trading activity and costs would appear before the actual change in dissemination status. If all trade outcomes responded immediately at Phase 1, our TRACE results for Phases 2, 3A, and 3B would only measure the incremental impact of later Phases of TRACE. Bessembinder, Maxwell, and Venkataraman (2006) first emphasized this point when they argued that TRACE's initiation affected all bonds, not only those in Phase 1. In this case, our estimates understate the true impact of TRACE. (In Appendix A, we investigate Phase 1 using a separate data set from the National Association of Insurance Commissioners. That appendix shows that the NAIC data is not representative of the entire market.)

It seems unlikely that the effects of TRACE occurred in their entirety at the beginning of Phase 1. Even though TRACE started collecting information on trade activity for all bonds from July 1, 2002, the schedule of when transaction data would be disseminated remained uncertain. The timing of the expansions was not initially known and took place incrementally, depending on both FINRA and SEC approval. For example, FINRA approved Phase 2 on November 21, 2002, but the SEC did not approve it until February 28, 2003. Phase 2 was implemented on March 3, 2003. Thus, participants knew in advance that dissemination would expand, but they did not know its exact timing until shortly before it occurred.

The second assumption for λ to be a causal estimate is that there are no other changes simultaneous with the Phase start date that affects the trading activity for those bonds changing dissemination status. That is, in equation (2), the interaction between Disseminate and Post is uncorrelated with other unmeasured factors that affect trade activity that change at the same time as the change in dissemination status (but are not caused by the change in dissemination status). There are trends in bond market trading during our time period, but we are unaware of any changes to bond market trading that coincide with the Phase start dates.

Finally, a third assumption is that we can measure the counterfactual difference in bond trading with the bonds that do not change dissemination status. That is, we assume that the change over time in control bonds' behavior reveals what would have occurred to treated bonds if there had been no change in their dissemination status. Note this assumption does not mean that control bonds must have the same characteristics as treated bonds, but rather that the change in their behavior captures the counterfactual time path. This is important because our treated bonds have different attributes than our control bonds by definition. FINRA selected bonds for Phases based on characteristics such as ratings and issue size. For instance, Phase 2 bonds are investment grade and have an original issue size of at least $100 million. Hence, our third assumption will be violated if bond trading activity varies substantially over time due to different bond characteristics. We examine the sensitivity of our results to these three assumptions in the next section.

To estimate equation (2), there are two implementation decisions. First, it is necessary to specify the estimation window. Since bonds trade infrequently, a longer time window may be needed to observe changes in trading activity. A longer time window, however, may undermine the assumption that the time path of the control group represents the time path of the treatment group absent a change in dissemination status. Moreover, if dissemination only has a short-run effect, it will be harder to detect with a longer time window. For these reasons, we calculate estimates of equation (2) for three different estimation windows covering 60, 90, and 180 days surrounding the Phase start dates.

The second implementation decision is how to define the control bonds for any Phase for these regressions. Because of the four distinct TRACE Phases, there are several possibilities for defining control bonds. Control bonds can be defined as bonds that were already disseminated before the Phase begins. Alternatively, a control group can be defined as bonds that are disseminated in a later Phase.

At first, the control bonds for Phase 2 are the disseminated bonds in Phase 1, and the non-disseminated bonds in Phase 3A and Phase 3B. For Phase 3A and Phase 3B, the control bonds are the disseminated bonds in Phase 1 and Phase 2. Phase 3A bonds are not a control for Phase 3B and vice versa because Phase 3A and Phase 3B occur just over four months apart, on October 1, 2004 and February 7, 2005, respectively. If we use a 90 or 180-day window before and after a Phase to capture the effects of dissemination, the post-dissemination trading of Phase 3A overlaps with the pre-dissemination trading of Phase 3B. We examine variations on the control group definition, including dropping Phase 1 bonds as a control for each Phase.

Finally, we conduct our analysis for three samples: the sample described above, truncating the outliers, and winsorizing the outliers. We truncate and winsorize our bond-day data for the entire sample period (July 2002 – December 2006) for all our trading activity and trading cost outcomes separately i.e. a trade that is truncated for one measure does not necessarily get excluded in another measure.[27] The statistical significance of our results and their interpretation does not change across these three samples. We report the results for the truncated samples because we feel they provide a more accurate representation of the effects of dissemination. This is particularly true since TRACE is a self-reported dataset that covers an initiation period. We found several obvious data entry errors, particularly when TRACE first started, and FINRA did not yet screen the data entries.

[27] For trading activity measures, number of trades, volume, volume/issue size and trade size, we truncate and winsorize at the right tail at 99.99 percentile. For example, for our 90-day number of trades measure, truncating for the entire sample period by bond-day eliminates 613 bond-days out of 3,421,687 bond-days across treatment and control groups. For the trading cost measures, trading cost per round-trip trade, trading cost per round-trip bond traded, and daily price standard deviation, we truncate and winsorize our bond-day data at 0.01 and 99.99 percentiles. For dealer revenue outcomes in Table 10, we truncate and winsorize at again 0.01 and 99.99 percentiles, but at the dealer-day level.

V. Estimates on Trading Activity

V.A Number of Trades

Table 4 reports estimates of equation (2) for 60, 90, and 180-day windows for bonds in Phases 2, 3A, and 3B, separately. It also reports pooled estimates, based on equation (2), with data stacked across the three Phases. In the pooled estimates, α_i, γ_0 and γ_1 vary by Phase, but λ does not.

The estimate of the effect of TRACE on the number of trades per day, pooled across all three Phases, is negative and significant for all three estimation windows. For example, across all Phases, the number of trades drops by 0.088 in the 90-day window around dissemination, which is significant at the 1% level. This is a 11.7% reduction from 0.754, the average level before dissemination.

Across Phases, the reduction in number of trades is driven by Phase 3B, where it is largest and significant for all estimation windows at the 1% level. In the 90-day window, TRACE reduces the average number of trades for Phase 3B bonds by 0.236. This represents a 71.1% drop from the average level before dissemination. The results are similar for the 60-day and 180-day windows.

The estimates in Table 4 do not tell us how long it takes for the market to react, if at all, to a change in dissemination. Changes may be immediate or even prior if market participants anticipate the effects of dissemination in advance of Phase start dates. On the other hand, changes due to dissemination may occur with delay because of adjustment costs, e.g., rebalancing inventories, faced by market participants. Delays may also occur if participants require time to utilize the newly available data. Moreover, the relative infrequency of bond trading may make it difficult to detect the effects of dissemination in short estimation periods.

To examine when the effects of dissemination begin, we next estimate an "event-study" version of the regression model that allows the effects to differ by one-week intervals:

$$y_{it} = \alpha_i + \gamma_0 \text{ Disseminate}_i + \gamma_w \text{ One-Week Interval}_t + \lambda_w \text{ Disseminate}_i \, x \text{ One-Week Interval}_t + \varepsilon_{it,} \qquad (3)$$

where the One-Week Interval$_t$ is an indicator of whether day t is in week w. Equation (3) is estimated for each Phase separately. γ_0 captures any pre-existing difference between disseminated and non-disseminated bonds, while γ_w captures the overall trend in trading outcome in week w.

The estimate of λ_w is the amount by which the average newly disseminated bond deviates in trading outcomes (either number of trades or trading cost per round-trip trade) from control bonds during the one-week interval w. If there is a trend in the market that only affects bonds that change dissemination status, it should be reflected in the relative levels of λ_w. For example, if number of trades in newly disseminated bonds is trending down in the time period before a change in dissemination, the λ_w's will be higher before than after. Since the estimates of λ_w are based on one-week contrasts, they will be estimated less precisely than models which impose a common effect for the period before and a separate common effect for the period after as in equation (2).

Figure 3 plots values of λ_w for number of trades for each week by Phase. We adopt the convention that week 0 includes the dissemination date and the six calendar days following it. We normalize λ_w to be zero in the week before the change in dissemination (i.e., week -1) and we add a vertical line to the plot for that week.[28] The horizontal dotted lines before and after the vertical line at week -1 represent the average value of λ_w in the 90 days before and after dissemination, respectively. The patterns in Figure 3 for Phase 2 and 3A are consistent with the results in Table 4, i.e. dissemination has little effect on the number of trades for these bonds since there is only a small change in the horizontal line after dissemination in Figure 3.

Phase 3B bonds, however, experience a sharp and significant drop in number of trades from the period preceding dissemination to the period after it (as shown by the dotted horizontal lines) in Figure 3. The horizontal line after dissemination is substantially below that of the line prior. The plot of week-by-week estimates shows that the reduction in the number of trades does not appear immediately, but it occurs approximately five weeks after Phase 3B begins. In addition, for Phase 3B, the level of trading activity remains lower for the 13 weeks after dissemination begins. This persistent reduction is consistent with Table 4 which shows a significant reduction in Phase 3B difference-in-differences estimates for 60, 90, and 180–day windows. The lack of any pre-trend in number of trades for all Phases provides support for our identification assumption of incomplete anticipation. Moreover, because the weekly results for trading activity occur only after five weeks, we focus on estimates for the 90-day window.[29]

V.B. Robustness Checks: Time Trends and Control Groups

An assumption underlying the difference-in-differences methodology is common parallel trends. That is, we assume that if treated bonds had not changed their dissemination status, their trading behavior would follow the same trajectory as the control bonds. However, it is possible that trading outcomes for newly transparent bonds follow different trajectories than control bonds, even in the absence of transparency. As discussed above in Section IV, one reason for this possibility is that the control bonds have different characteristics than treated bonds, particularly since FINRA uses size and credit ratings to determine Phase classifications.

In column (5) of Table 4, we relax the common parallel trends assumption by estimating specifications that allow the trade outcomes for bonds to evolve over time depending on whether they are investment-grade or not. Specifically, we estimate models with linear and quadratic time trends by including Phase- and credit-rating-specific quadratic functions of time in equation (2) as follows:

$$y_{it} = \alpha_i + \gamma_0 \text{ Disseminate}_i + \gamma_{01i}\, t + \gamma_{02i}\, t^2 \qquad (4)$$
$$+ \gamma_{11i} \text{ High Yield}_i\, t + \gamma_{12i} \text{ High Yield}_i\, t^2 + \gamma_1 \text{ Post}_t + \lambda \text{ Disseminate}_i \, x \, \text{Post}_t + \varepsilon_{it,}$$

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[28] Since the event study includes the period from 90 days before and 90 days after day 0, there is one fewer calendar day in week -13.

[29] Although not shown, results in Table 4 column (6)-(8) and Table 5 with a 60 and 180-day window are similar to those from a 90-day window.

where High Yield$_i$ is an indicator for bond ratings of BB+ and below. For each Phase, the variable t starts at zero at the beginning of the time window. For the pooled estimate, we estimate separate Phase-specific trends.

With these flexible time trends, the large and negative 90-day estimate on number of trades for Phase 3B remains significant at the 1% level. However, the pooled estimate is no longer significant.

Finally**,** we address the robustness of the Table 4 results by considering two variations on the control group. The adequacy of the control group is a substantial concern in any difference-in-differences research design and may be particularly worrisome in our setting since bonds in each Phase have different attributes by definition. In particular, high-yield bonds are concentrated in Phase 3B, so if the high-yield bond market is unrelated to the investment-grade market, there may be no appropriate control for Phase 3B. However, the necessary assumption is that the time-path of control bonds represents the time-path that treated bonds would have been on had they not been disseminated, not that control bonds have the same characteristics as treated bonds.

We first examine the sensitivity of our estimates to the definition of control bonds by eliminating Phase 1 bonds from the control group. As discussed above, Phase 1 bonds are larger and more actively traded than bonds in any other Phase. It is, therefore, possible that the change in trading behavior of Phase 1 bonds does not provide an adequate counterfactual for non-Phase 1 bonds that change their dissemination status. In column (6) of Table 4, we report estimates for trading activity where Phase 1 bonds are not used as controls. This means that for Phase 2, the control bonds are from Phase 3A and 3B. For Phase 3A and 3B, the control bonds are from Phase 2.

For the number of trades, our estimate for Phase 3B is sensitive to using Phase 1 as a control, as shown by comparing column (6) to column (3). The significant decline for the pooled sample and for Phase 3B disappears.

Second, we construct a matched sample, restricting the treated sample to bonds for which there is a suitable control bond with similar pre-treatment characteristics. The pre-treatment bond characteristics we use to construct the matched sample are issue size, time to maturity at Phase start, and years since issue at Phase start. To construct the matched sample, we divide the sample (which includes Phase 1 bonds) by issue size into four quartiles. For the other two characteristics, we construct two groups: above and below the median time to maturity, and above and below the median years since issue. This results in 16 potential cells for each Phase. We exclude a cell if there are either fewer than 5 treated bonds or fewer than 5 control bonds. The match for Phase 3A bonds is not as comprehensive because of their smaller issue size. Our matched sample covers close to 100.0% of Phase 2 and Phase 3B bonds in our trading activity sample, but only 39.9% of Phase 3A bonds. For round-trip trading costs, we cover 100% of Phase 2 and 3B bonds in our round-trip trading costs sample, but only 45.3% of Phase 3A bonds.

The estimates for the matched-sample difference-in-differences regression are in column (7) of Table 4. To control for bond attributes, we add a dummy variable for each cell to equation (2) and interact the cell dummy with Post and treated. Their inclusion means that our estimates are a weighted average of the within-cell difference-in-differences estimates. For the matched sample, the number of trade estimates in column (7) for the pooled sample and Phase 3B remain negative and significant.

In summary, bonds in Phase 3B experience a large and economically significant decline in the number of trades following dissemination. This result is robust to alternative specifications which allow for more flexible trends and when the sample is matched on size, time to maturity, and years since issuance. There is also a reduction in the number of trades for the sample pooled across Phases. This result is sensitive to the assumptions on common trends and the set of control bonds and is primarily driven by Phase 3B bonds. We do not detect significant changes in trading activity for Phase 2 and 3A bonds.

V.C. Other Measures of Trading Activity

We next examine several other measures of trading activity: volume, volume divided by issue size, and average trade size. The first two measures are zero when there is no trade. Average trade size is only observed when there is a trade.

Table 5 shows that dissemination causes no reduction in trading volume pooled across Phases, or for Phases 3A and 3B. There is a slight reduction in trading volume for Phase 2 bonds, but this result is marginally significant. The decrease in the number of trades shown in Table 4 is therefore not associated with a corresponding large change in volume. That is, as measured by trading volume, we do not find that dissemination systematically reduced trading activity.

We find some weak evidence that TRACE reduced trading activity as measured by volume/issue size. For the pooled sample, volume/issue size drops by -0.012, which is a 6.5% reduction from the mean volume/issue size of 0.186. This effect is driven by Phase 2 bonds only. Bonds in Phase 3A and 3B do not experience a reduction in volume/issue size.

The last two columns of Table 5 reports on trade size. The number of trades per day for Phase 3B bonds (shown in Table 3) is about one-fifth that number in Phase 2. However, when a Phase 3B trades, the average trade size is much larger than that in any other Phase. The average trade size for a Phase 3B bond is 1,178,134, compared to 709,546 for Phase 2 and 541,930 for Phase 3A.

Tables 4 and 5 together show that the significant decrease in the number of trades in Phase 3B is not associated with a corresponding decline in volume. Therefore, it must be the case that there is an increase in trade size for Phase 3B. In fact, there is a significant increase in trade size for Phase 3B bonds of 50,101, which is equivalent to 4.3%.[30]

In summary, for Phase 3B bonds, we have fewer trades but of larger size, resulting in no significant effect on volume or volume divided by issue size. These results are noteworthy because of the aforementioned TRACE provision that Phase 3B bonds are subject to delayed dissemination if their

[30] Since trade size is only observed when a bond trades, it is possible that this result confounds changes in trade size with changes in the sample of bonds that trade. We therefore estimate trade size effects for the sample of bonds that trades at least three or at least 10 times in the 90 days before the Phase, and we find similar effects.

transaction size is $1 million or greater, they are infrequently traded, and they are high-yield. Thus, it appears that TRACE induced a change in trading behavior because of the delayed dissemination provision since Phase 3B bonds are both less frequently traded but when traded are larger trades. We will investigate this issue further below.

VI. Estimates for Trading Costs

VI.A Trading cost per round-trip

We next study the effect of TRACE on trading costs as we did for trading activity by deploying the same methodology. Table 6 reports estimates of equation (2) for 60, 90, and 180-day windows for bonds in Phases 2, 3A, and 3B, separately, and pooled together, where the outcome variable is 7-day trading cost per round-trip trade.

There is a robust decline in trading cost per round-trip trade due to TRACE. In the 90-day window, the pooled estimate of the reduction in 7-day round-trip trading cost per round-trip trade is $241 (18.5%) and is highly significant. When divided by Phase, there is a decline for all three Phases. For Phase 2, there is a significant 17.7% reduction in trading costs, measured with the 90-day window. For Phase 3A, the estimate is negative for 60, 90, and 180-day windows, but it is only significant for the 180-day window. For Phase 3B, the estimate is significantly negative for all the estimation windows. The percentage reduction is also the largest for Phase 3B compared to the other Phases. For example, in the 90-day window, the largest drop in trading cost per round-trip trade is $924 for Phase 3B which is 22.9% drop from the mean of $4,030.

The event study plots in Figure 4 show a clear drop in week-by-week estimates at dissemination for round-trip trading costs for all three Phases. This is similar to the difference-in-differences results in Table 6 where the estimate is strongest for Phase 3B bonds, and the reaction to TRACE is most immediate. As with trading activity, the lack of any pre-trend in round-trip trading costs for all Phases supports for our identification assumption of incomplete anticipation.

Table 6 also reports several specifications paralleling those in Table 4 which allow for differential time trends and control groups. With trends, the estimates of TRACE on round-trip trading costs remain significant in the pooled sample, but slightly smaller in magnitude (a reduction of $141 vs. a reduction of $241). The estimates for Phase 2 and 3B are still significant, but smaller.

Unlike our estimates for trading activity, the estimates on round-trip trading costs are very similar when we exclude Phase 1 bonds from the control set. The 90-day estimates reported in column (6) are similar to our base results in column (5) both in magnitude and significance. These estimates are also quite similar when we use the matched sample of control bonds, shown in column (8).

Therefore, there is strong evidence that TRACE reduced trading cost per round-trip trade, with most pronounced effects for Phase 3B bonds. The results for Phase 3B appear in all time windows and are negative and significant in all the alternative specifications. The results for Phase 2 bonds are similarly robust, but not as large in magnitude. The point estimates for Phase 3A bonds are negative, but we cannot definitely assert that dissemination reduced trading cost per round-trip trade.

VI.B Other Measures of Trading Costs

Table 7 presents several alternative measures of trading costs as robustness tests for the 7-day trading cost per round-trip trade reported in Table 6. First, we consider two additional windows for trading cost per round-trip trade: 1 day and 14 days. We then examine trading cost per round-trip bond traded for 1-day and 7-day windows. Finally, we examine daily price standard deviation per bond. Compared to the 7-day window in Table 4, there are fewer round-trip trades defined over a 1-day window and more round-trip trades defined over a 14-day window.

Our conclusions about the effect of TRACE on trading cost per round-trip trade are similar when we consider 1-day and 14-day windows. The pooled estimate of TRACE on trading cost per round-trip trade for 1-day and 14-day round-trips are -$267 (20.6%) and -$273 (20.3%) respectively, both of which are statistically significant. For Phase 3B bonds, the pattern of estimates and significance levels for 1-day and 14-day windows is similar to that using the 7-day round-trip measure.

We next examine trading cost per round-trip bond traded in columns (5)-(8). The mean round-trip trading cost per round-trip bond traded is lowest in Phase 3B, and highest in Phase 3A pre-TRACE. In contrast, the mean trading cost per round-trip trade is highest in Phase 3B, and lowest in Phase 3A. The reason for this difference is the larger average trade size in Phase 3B. Pooling across the three Phases, the 1-day trading cost per round-trip bond traded decrease significantly by -0.033 after dissemination, which is equivalent to a 3.9% reduction. The pooled 7-day round-trip trading cost per trade also decreases significantly by -0.047 or 4.9%.

Closer examination shows that the decline in trading cost per round-trip bond traded are largest for Phase 3B bonds. The total trading cost per round-trip bond traded drop by -0.075 and -0.061 over 1-day or 7-day round-trip windows or 14.1% and 10.9%, respectively. The effects for Phase 3A bonds are also negative, while the effects for Phase 2 bonds are negative for 7-day round trips but not for 1-day round trips.

A limitation of the round-trip trading cost measures, either computed per bond or per trade, is that it can only be computed for a subset of bonds with round-trip trades. To expand the sample, we therefore also report estimates on the price-standard deviation. Standard deviation still requires at least 2 trades per bond but does not require the stronger restrictions of a round trip. As with round-trip trading costs, we restrict the sample to bonds which have at least one measured price standard deviation observation in the 90 days before and after each Phase date. The sample for standard deviation has 589,716 bond-days compared to the sample size for 7-day round trips of 415,993 bond-days. Dissemination significantly reduces price standard deviation for the pooled sample, and for Phase 3A and Phase 3B.

To summarize, the results on alternative measures of trading costs shown in Table 7 support the fact that TRACE reduced overall trading costs, in particular for Phase 3B bonds. Phase 3B bonds experience a significant and large reduction in round-trip trading cost per bond and per trade. The percentage decrease in trading costs is between 10.9% and 29.0% depending on the measure.

VII. Additional Results

VII.A Trading Activity and Trading Costs by Trade Size

The difference between trading cost per round-trip trade and trading cost per round-trip bond traded suggests that trade size must be considered in measuring the effects of dissemination. Moreover, Table 4 suggested that Phase 3B bonds are more likely to trade in larger quantities because TRACE regulations allow for some large Phase 3B trades to be disseminated with delay. Finally, a major motivation for TRACE was to encourage participation by retail investors, who transact in smaller quantities. For all these reasons, we next consider how trading activity and costs differ by trade size.

Table 8 reports 90-day difference-in-differences estimates on trading activity and costs pooled and by Phases for three categories of trade sizes: < $100K (small), $100-$1M (medium), and $1M+ (large). We chose these categories because trades under $100K are often associated with retail trades, and as discussed above, TRACE had dissemination provisions specific to trades greater than $1M+.

Panel A of Table 8 shows that roughly two-thirds of all trades are small. In the 90 days before dissemination, 67.7% of all trades are small, and in the 90 days after dissemination, 68.9% are. In contrast, most of the volume is accounted for by large trades, with 89.8% and 89.6% before and after dissemination, respectively.

Panel B shows the effect of dissemination on the number of trades is significantly negative for all three trade size categories, when pooled across Phases. The estimates range from -0.066 to -0.012, or -12.2% to -8.6% for the three size categories. Although not shown in the Table, aggregating this result across the size categories results in a decrease in the total number of trades of -0.096 which is similar to the pooled effect on the number of trades reported in Table 4 of -0.088.

When split by Phase in Panel C, TRACE appears to have reduced the number of trades differentially across Phases. Large trades drop significantly for Phase 2, medium-size trades drop for Phase 2 and 3A, and small trades drop for Phase 3B. TRACE did not increase the number of trades for any size and Phase combination.

The largest reduction in trading activity occurs for small trades in Phase 3B. In fact, almost the entire reduction in the number of trades for Phase 3B is due to fewer small trades. Returning to the question of the effect of the delayed dissemination provision for Phase 3B trades, we find that there is not an increase in the number of large Phase 3B trades, even though there is an increase in average trade size. The reason average trade size in Phase 3B increases is because small trades are taking place less frequently, raising the average trade size. Thus, traders did not appear to increase their number of large trades to avoid immediate dissemination.

Finally, these results in Table 9 mean that TRACE did not increase the number of small (retail) trades as anticipated for any of the Phases, and significantly decreased it for Phase 3B.

Turning now to trading costs, the 7-day trading cost per round-trip trade for the three different size categories are shown in columns (7) through (12). The 7-day trading cost per round-trip trade is $209 for small trades and $6,276 for large trades. Pooling across Phases, TRACE reduced trading costs significantly.

When split by Phase, trading costs decrease for each size and Phase combination, but not all are significant. Trading costs decrease significantly for all size trades in Phase 3B. The largest reduction in 7-day trading cost per round-trip trade is for medium size trades in Phase 3B, where the reduction is 26.9%.

VII.B Round-Trip Trading Costs by Trading Partner

Our analysis so far has not distinguished trades by customers from those by dealers. Customers and dealers may trade for different reasons. Customers typically trade bonds for portfolio and life-cycle reasons. Dealers may trade bonds for portfolio reasons, but also to intermediate between customers, e.g., make a market. The effects of transparency on customers and dealers may also differ. For example, the dissemination of transaction information may provide more new information to customers than to dealers both because dealers typically transact more frequently and because active traders will see many trade inquiries that are ultimately executed by other dealers. In this section, we will investigate the effects of dissemination on Customer (C) and Dealer (D) trades separately.

The TRACE database only reports trades where one of the two parties is a dealer. These trades can be between two dealers or between a customer and a dealer.[31] Although not reported in a table, Dealer-to-Dealer trades represents 28% of all trades and 24% of total volume. Trades in which a customer sell to a dealer, Customer-to-Dealer, represent 31% of all trades (37% of total volume) and trades in which a dealer sells to a customer, Dealer-to-Customer, trades are 40% of trades (39% of volume).

Table 9 reports on round-trip trades, which we use to measure trading costs based on the counterparties. In particular, a round trip can be one of three types: (1) Customer-Dealer-Customer (CDC), (2) Dealer-Dealer-Dealer (DDD), and (3) Customer-Dealer-Dealer (CDD) or Dealer-Dealer-Customer (DDC). The first two types of round-trip trade involve intermediation by a dealer since a dealer need not hold inventory outside the round-trip time window. The other two categories imply that a dealer is bearing risk outside the round-trip time window because some securities are held by that dealer in inventory either before or after the trade.

Panel A of Table 9 shows that CDC trades represent roughly 25% of all round-trip trades, DDD trades represent about 16% of all round-trip trades, and CDD/DDC trades are 59% of all round-trip trades. We will use CDC trades as a proxy for customer trading costs and DDD trades as a proxy for dealer trading costs.

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[31] FINRA members must report all trades in which they are involved. Trades between two parties, who are not FINRA members, are possible, but not recorded.

Panel B of Table 9 shows that trading costs for CDC round trips are substantially larger than for DDD round trips, either pooled across Phases or by Phase. For example, pooled across Phases, the mean CDC trading cost per round-trip trade is $2,562, while the mean DDD trading cost per round-trip trade is $1,035.

We next examine the effect that dissemination had on customer and dealer trading costs. Table 9 also shows that both types of round trips become significantly cheaper after TRACE, with a greater percentage reduction for DDD round-trip trades than CDC round-trip trades (-21.7% vs. -17.7%). When split by Phase, trading cost per round-trip trade for DDD fall significantly for each Phase. CDCs, however, only decrease significantly for Phase 3B trades, by $1,589 or 25.3%.

Therefore, once again, bonds in Phase 3B react differently to dissemination than bonds in other Phases. Table 8 showed that small trades fell substantially for Phase 3B bonds, while Table 9 shows that the cost of customer round-trip trades only falls significantly for Phase 3B. In particular, the number of small size trades in Phase 3B bonds decreases, even though the cost of customer trades for these Phase 3B bonds go down the most.

VIII. Dealer Revenue and Aggregate Trading Costs

VIII.A Dealer Revenue

In the last section we saw that, in the pooled sample, trading costs for both CDC and DDD round-trip trades decreased following dissemination. For a CDC round-trip trade, when the trading costs decrease, the amount customers pay to dealers decreases, and therefore the intermediating dealer earns less. That is, when the round-trip trading costs for a CDC trade decreases, the revenue earned by the intermediating dealer decreases. However, in DDD round-trip trades, dealers can benefit when round-trip trades become cheaper if they are not the intermediating dealer. Just as a customer obtains better terms in a CDC trade, the dealer who initiates or ends the round trip may obtain better terms. Since a dealer may work in different capacities, we cannot reach definitive conclusions from the results in Table 9 on the effects of transparency on dealer trading costs.

To obtain a measure of dealer performance, we compute the total revenue a dealer makes on round-trip trades. This is not a measure of a dealer's total revenue from trading, since dealers also generate revenue from changes in the value of their inventory. That is, a dealer's total revenue is the amount they earn from trading costs plus the amount they earn from holding inventory. For trades that are not part of round-trip trades, we do not know the initial buy or sell price of these trades. It's worth noting that we also do not directly observe a dealer's holding costs.

Our estimation approach for dealer trading revenue builds on equation (3). The outcome is the total revenue from round-trip trades. It differs from equation (3) because all specifications include a dealer fixed effect. This means our comparisons are a within-dealer contrast of trading revenue for newly disseminated bonds compared to bonds traded by that dealer whose dissemination status does not change. To implement this approach, we only consider active dealers who have at least 1,000 bond trades from July 2002 – December 2006 or are in the top 20% of dealers (ranked by the number of trades) in a Phase. A dealer that trades at least 1000 times or is in the top 20% for one Phase is included as a dealer in all other Phases if they trade at least once in the other phases.[32]

Table 10 shows that, on average, across the three Phases a dealer's revenue for round-trip trades is $1,749. As with round-trip trading costs, the round-trip revenue is greatest in Phase 3B at $3,789. This is partly a consequence of the fact that the average trade size is largest for Phase 3B bonds. When comparing revenue per round-trip per bond traded, the revenue per bond traded is largest for Phase 3A.

Dissemination causes a statistically significant reduction in dealer revenue per round-trip trade pooled across Phases. This effect is driven by a large, statistically significant $1,246 reduction for Phase 3B bonds. This is equivalent to a 32.9% reduction in dealer trading revenue per trade. When measured by revenue per round-trip bond traded, dealers also have a significant decrease of -0.845, or 12.7%, for Phase 3B. None of the results for either round-trip per trade or round-trip per bond traded are significant for Phase 2 or Phase 3A.

The large and significant effect on dealer revenue in Phase 3B with no effects in Phase 2 and 3A are not surprising, given that dealer revenue on round-trip trades is closely related to round-trip trading costs.

VIII.B Aggregate Economic Effects of TRACE

How economically large are the effects of TRACE estimated above? We have seen that TRACE reduces the number of trades, particularly for Phase 3B bonds, but does not have a significant effect on overall trading volume. TRACE also has a large and significant effect on trading costs and dealer revenues. We next investigate the aggregate effects of TRACE by focusing on its effects on overall trading costs and dealer revenues.

We benchmark our estimates against the overall level of transaction costs and revenues in the corporate bond market. For this exercise, it is necessary to extrapolate our estimates of dissemination effects along three dimensions. First, our research design does not allow us to construct an estimate of the effect on bonds in Phase 1 or bonds that are not in any Phase. In particular, our research design does not allow us to conclude much about the first Phase of TRACE.[33] Second, our research design

[32] Most members of FINRA are not active corporate bond dealers. There are 2,639 unique hashcodes for dealers from July 2002 – December 2006 in our data. The mean number of trades for a dealer is 7,751 and the median is 74. Using our definition above, we are left with 599 unique dealers that trade 98.6% of all trades and 99.4% of all volume in our data.

[33] Using a sample of NAIC bonds, Bessembinder, Maxwell, and Venkataraman (2006) argue TRACE reduced transaction costs [they use the term trade execution costs] for Phase 1 bonds. It is possible to measure bond trading activity for NAIC bonds before Phase 1 of TRACE. In Appendix A, we use data from the NAIC together with our difference-in-differences methodology to examine Phase 1 effects. Unlike our TRACE sample, we are not able to construct a round-trip cost estimate. The Appendix shows two main facts. First, NAIC bond trading has different characteristics than TRACE trading. NAIC bonds are larger and transact less frequently. They also contain very few Phase 3B bonds. Second, using our research design, there is no evidence that TRACE influenced NAIC trading activity or costs for Phase 1 bonds.

focuses on the 180 days surrounding dissemination, while our sample period covers 4.5 years from July 2002 through December 2006. Finally, since round-trip trades only represent about 35% of all trading activity, we need to apply our estimate to the remaining trades that are not part of round-trip trades.

Panel A of Table 11 first uses our estimate of pooled trading cost per round-trip trade as the basis for extrapolation. If we assume that the mean round trip in the 90 days prior to dissemination pooled across Phases represents the average trading cost per round-trip trade for the 22.6 million trades during our time period, the total costs of trading bonds is $14.7 billion. Pooled across Phases, TRACE reduced the average trading cost per round-trip trade by -$241, which would amount to a $2.7 billion reduction in trading costs. Since our time period covers 4.5 years, this translates to a reduction in trading costs of $605 million per year.

We have also seen that TRACE has different effects across Phases. A second estimate of the reduction in trading costs takes the average trade cost and dissemination estimates by Phase and applies it to trading activity specific to each Phase. To implement this approach, we still need to ascribe a value of trading costs and the effect of TRACE to bonds in Phase 1 and bonds that do not have a Phase. Table 11 reports aggregate estimates broken down by Phase which use values from Phase 2 for Phase 1, and the pooled estimate for bonds that are not in a Phase. The total reduction in trading costs per year from this more refined comparison is $538 million per year. Importantly, trading in Phase 3B bonds contributes to a 21.8% share of this aggregate reduction, even though Phase 3B only accounts for 5.1% of all trades. This fact further highlights that studies of TRACE without Phase 3B bonds miss a large part of the aggregate picture.

Table 11 also aggregates the reduction in dealer revenue from round-trip trades, using the estimate from Table 10. The results for this outcome are shown in Panel B. When the pooled estimate is applied to all trades, we find a $695 million per year reduction in dealer revenue due to TRACE. When split by Phase in the same way as in Panel A, the estimated reduction in dealer revenue per year is $460 million. The reason the estimate is smaller by Phase is that when split by Phase, a large decrease in dealer revenue only appears for Phase 3B. As with trading costs, Phase 3B stands out as contributing an outsize share of the reduction in dealer revenue of 34.5% compared to the number of trades in Phase 3B bonds.

Since our estimates show little overall effect on trading volume, the reduction in dealer revenues is largely a transfer from dealers to customers. That is, customers pay less to transact at the expense of dealers but experience no overall reduction in trading activity as measured by volume.

It’s worth emphasizing that the interpretation of the effect on trading activity is not straightforward absent a view on why corporate bonds trade. First, we find a decrease in the number of trades. This might influence how quickly prices reflect new information. Moreover, trading activity outcomes are a consequence of the demand and supply for trades: they do not directly speak to whether trading has become more difficult, say if dealers are less willing to hold inventory because of the cut in their margins.

VIII. Conclusion

The introduction of TRACE, which was implemented in four Phases over a three-and-a-half-year period, combined with the availability trading records before and after dissemination for three of the Phases, provides a unique opportunity to study how previously opaque over-the-counter financial markets respond to transparency. We use a difference-in-differences research design to isolate the effect of post-trade transparency from underlying market trends, holding fixed all other institutional aspects of corporate bond trading. Our study is distinguished by the fact that we examine all Phases of TRACE, including the less frequently-traded bonds in the last two Phases of TRACE, which have small issue sizes and low-credit quality, respectively. It also directly measures round-trip trading costs for all bonds across all four Phases.

Our main finding is that TRACE causes trading costs to decline significantly for the entire bond market and for both dealers and customers. In addition, we find the impact on trading activity and trading costs are largest and most significant for Phase 3B bonds. After transparency, there is a significant decline in the number of trades for Phase 3B bonds, and a large significant reduction in trading costs. These results stand out because at the time of Phase 3B, TRACE's dissemination provisions had already been implemented for three previous Phases covering a majority of bonds issued. Bonds in Phase 3B also play an outsized role in our estimates of the aggregate effect of transparency on total trading costs. Thus, studies of TRACE and transparency that do not examine this segment of the market are incomplete.

The results also confirm that transparency has a limited impact on trading activity of investment grade bonds and the most frequently-traded bonds. There is no significant decrease in trading activity, either measured by number of trades or trading volume for this segment of the market. On the other hand, TRACE does not increase overall trading activity, as many proponents anticipated. This is noteworthy given the significant reduction in trading costs.

These findings have several other implications. The sharp pervasive reduction in trading costs may be a consequence of the fact that trading information changes the relative bargaining positions of investors and dealers, allowing investors to benefit at the expense of dealers. Our best estimate is that TRACE transferred about $600 million a year from dealers to customers. Since transparency has negative effects for some trading partners, our result may suggest why transparency reforms need to be mandated rather than voluntarily adopted.

These results are also relevant for current and planned expansions of mandated market transparency. The implicit assumption underlying the use of TRACE as a template for regulations such as Dodd-Frank is that transparency affects all segments of a market the same way. Our results show that transparency effects are not uniform across different segments of the bond market. Many of the securities markets that are newly subject to transparency are akin to Phase 3B bonds. That is, they are infrequently traded and may not be widely held across dealers. As a consequence, our results support the view that not every segment of a security market should be subject to the same degree of mandated transparency.

Figure 1. Weekly Number of Trades by Phase

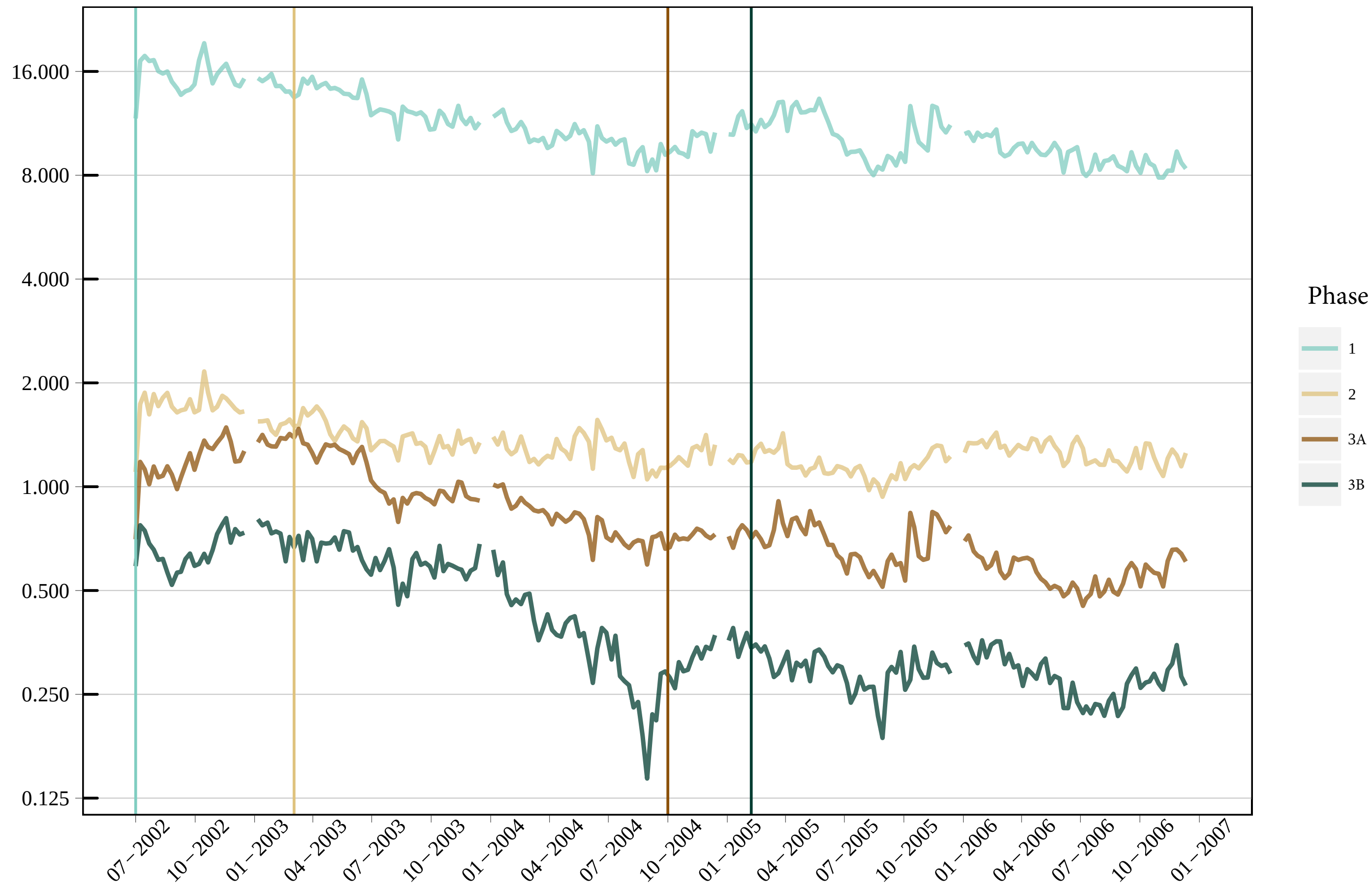

Figure does not include trading days that SIFMA recommends that bond dealers take off or operate for less than a full day. Figure also does not include the two weeks spanning Christmas and New Year's Day.

Figure 2. Weekly 7-Day Trading Cost per Round-trip Trade by Phase

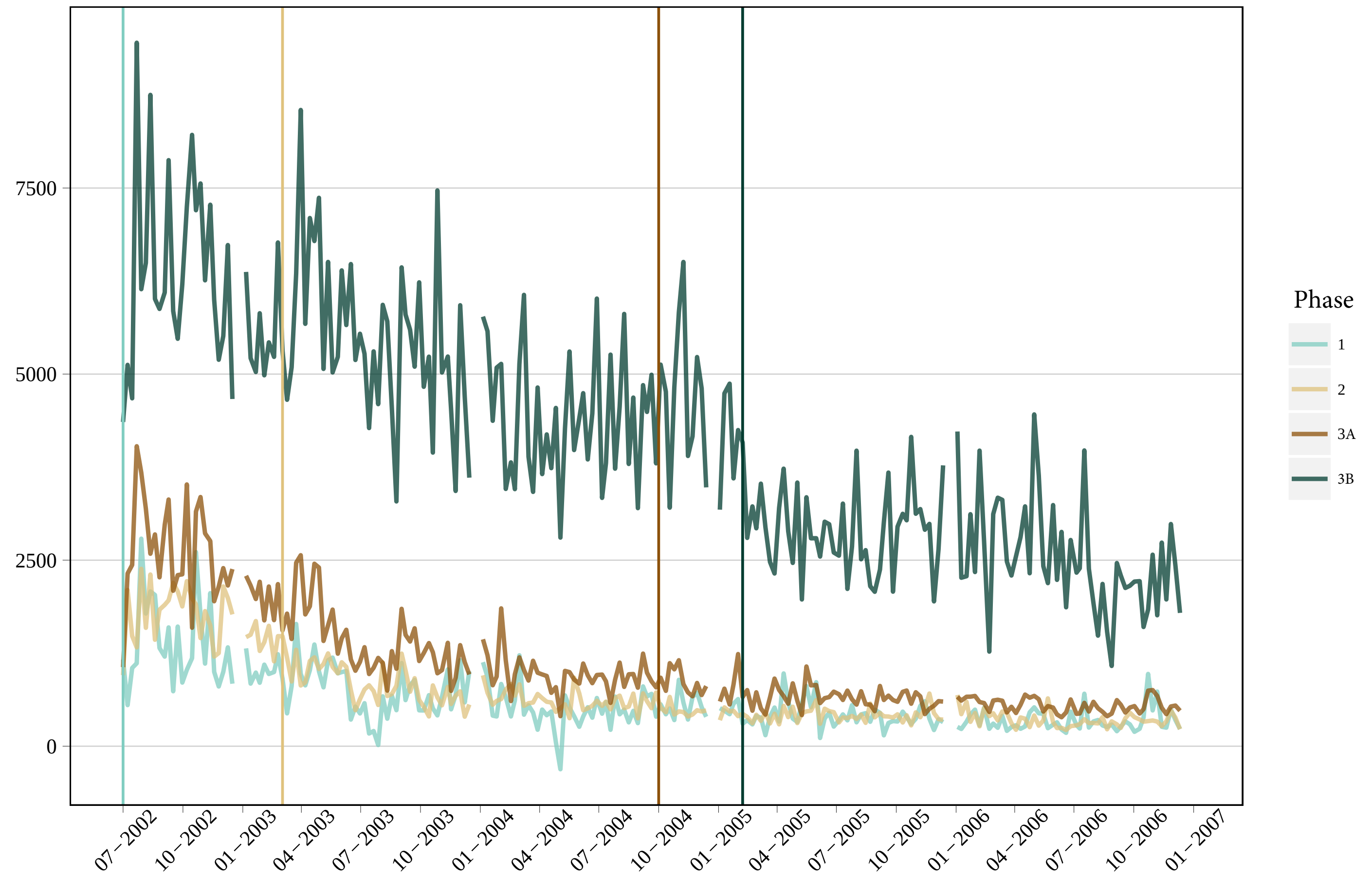

Figure does not include trading days that SIFMA recommends that bond dealers take off or operate for less than a full day. Figure also does not include the two weeks spanning Christmas and New Year's Day.

2

Figure 3. Event Study for Number of Trades

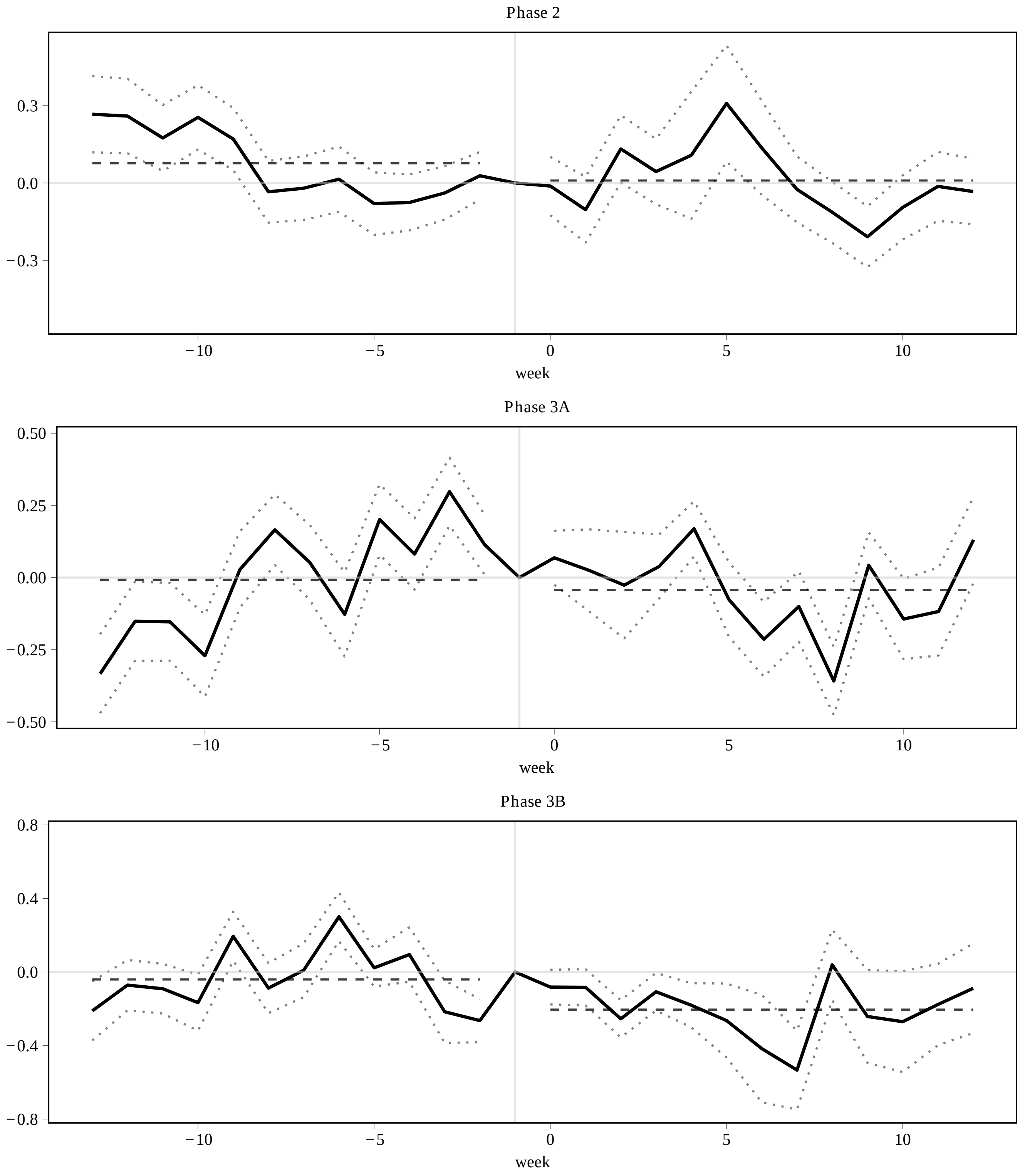

Figure plots coefficients on Disseminate x Week variables from event study regressions where the dependent variable is weekly number of trades. Disseminate is an indicator for a bond that becomes disseminated in the Phase. The x-axes represent weeks, where, 0 is week of March 3, 2003 for Phase 2, 0 is week of October 1, 2004 for Phase 3A, and 0 is week of February 7, 2005 for Phase 3B.

Figure 4. Event Study for 7-Day Trading Cost per Round-trip Trade by Phase

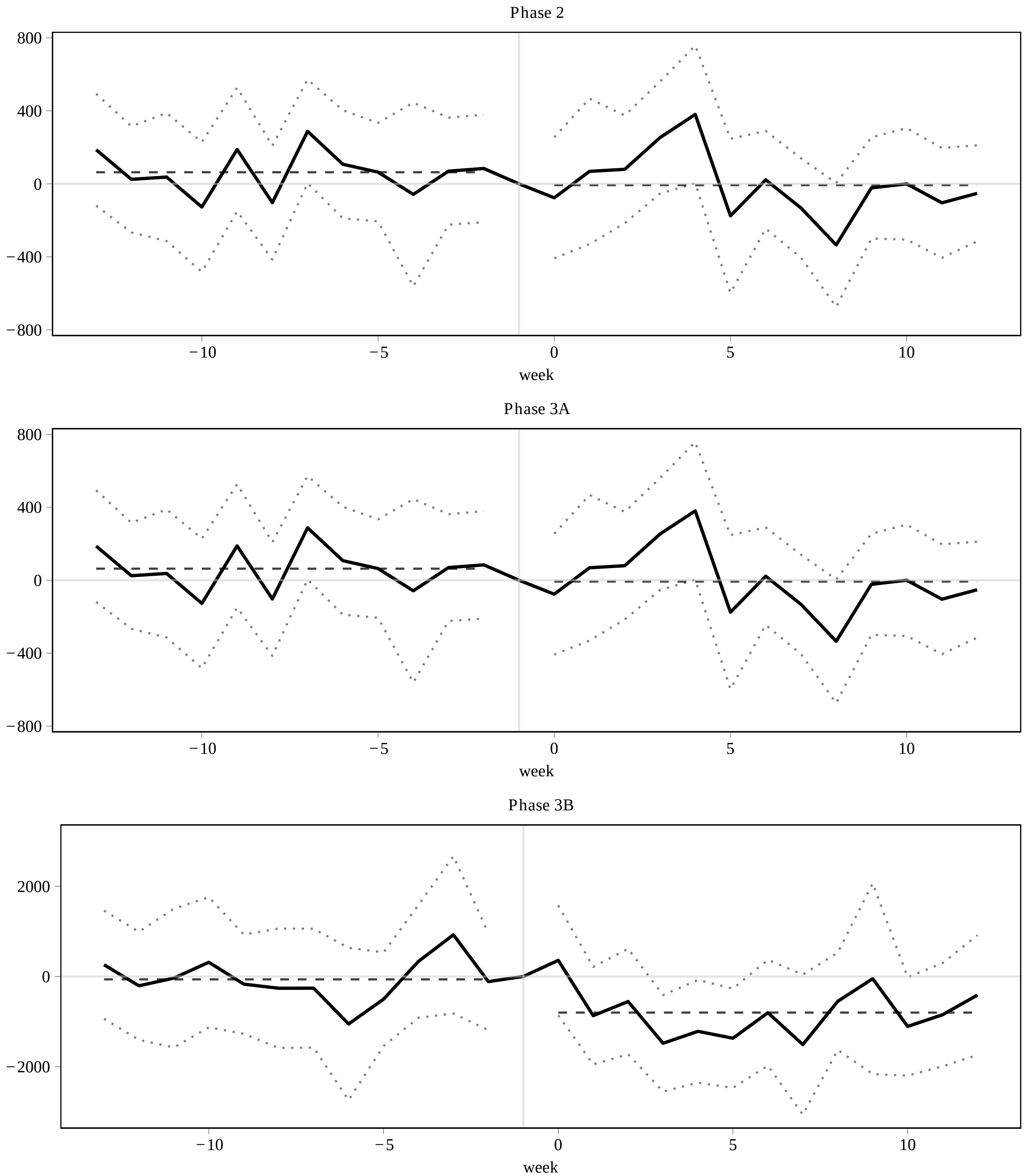

Figure plots coefficients on Disseminate x Week variables from event study regressions where the dependent variable is weekly trading cost per round-trip trade. Disseminate is an indicator for a bond that becomes disseminated in the Phase. The x-axes represent weeks, where, 0 is week of March 3, 2003 for Phase 2, 0 is week of October 1, 2004 for Phase 3A, and 0 is week of February 7, 2005 for Phase 3B.

Table 1. Timeline of Major TRACE Regulatory Changes

Sample	Date	Bonds affected	Time to report
Phase 1	July 1, 2002	Investment Grade TRACE-eligible bonds having an initial issue of $1 billion or greater	75 Minutes
FINRA50	July 1, 2002	50 Non-Investment Grade (High-Yield) bonds disseminated under Fixed Income Pricing System (FIPS). First day is 7/1/02, last day is 7/14/04	75 Minutes
Phase 2	March 3, 2003	All Investment Grade TRACE-eligible bonds of at least $100 million par value (original issue size) or greater rated A- or higher; and 50 Non-Investment Grade bonds	75 Minutes
FINRA120	April 14, 2003	120 Investment Grade TRACE-eligible bonds rated BBB	75 Minutes
n/a	October 1, 2003	All currently disseminated bonds	45 Minutes
Phase 3A	October 1, 2004	All bonds that are not eligible for delayed dissemination (bonds with rating of BBB- or higher)	30 Minutes
Phase 3B	February 7, 2005	All bonds potentially subject to delayed dissemination (bonds with ratings BB+ or lower)[1]	30 Minutes
n/a	July 1, 2005	All currently disseminated bonds	15 Minutes
n/a	January 9, 2006	End of delayed dissemination. All trades immediately disseminated	Immediate

Notes: Information from FINRA press releases available at finra.org. Time to report is the amount of time the dealer has to report the transaction to FINRA. FINRA collected information on all TRACE-eligible securities on July 1, 2002. A TRACE-eligible security means all US dollar-denominated debt securities that are depository-eligible and registered by the SEC or issued pursuant to Section 4(2) of the Securities Act of 1933 and purchased or sold pursued to Rule 144a. FINRA disseminates the transaction for Bonds Affected immediately after the report, except for bonds subject to delayed dissemination. (1) Bonds subject to delayed dissemination must meet certain trading, size, and rating criteria described by Rule 6250(b). Transactions that are greater than one million dollars (par value) in BB-rated TRACE eligible securities that trade on average less than one time per day are disseminated two business days from the time of execution. See Rule 6250(b)(2)(A). Transactions that are greater than one million (par value) rated B or lower that trade on average less than one time per day are disseminated four business days from the time of execution. See Rule 6250(b)(2)(B).

Table 2. Bond Characteristics by Phase

	Phase 1 (1)	Phase 2 (2)	Phase 3A (3)	Phase 3B (4)
Number of bonds	388	2,526	11,081	2,859
Size at issue ($M)				
mean	1,463	264	86	184
p5	750	100	1	2
p10	1,000	100	1	8
p25	1,000	150	3	87
median	1,250	200	12	150
p75	1,750	300	80	238
p90	2,500	500	300	350
p95	3,000	600	425	470
Rating at phase start				
mean	A	A+	A-	B
p5	AAA	AAA	AAA	BBB-
p10	AA-	AA	AA	BB+
p25	A+	A+	A	BB-
median	A	A+	A-	B
p75	BBB+	A	BBB	CCC
p90	BBB	A-	BBB-	D
p95	BBB-	A-	BB+	D
# with rating information at phase start	388	2,524	11,046	2,770
# where rating is from S&P RatingsXpress	366	2,182	7,754	2,283
# where rating is from FISD	22	342	3,292	487
Fixed coupon rate				
mean	6.7	6.9	5.8	9.0
median	6.8	6.9	5.9	8.8
number fixed coupon	346	2,149	10,153	2,638
Maturity at issue (years)				
mean	9.2	15.0	11.8	12.4
median	6.0	10.0	10.0	9.7
Years since issue (at phase start)				
mean	1.9	5.5	3.3	5.9
median	1.4	5.1	1.9	5.7

Notes: Bond issue size, coupon, maturity, and issue date characteristics are from FISD. Bond rating are the most recent rating before the Phase starts. Bond rating characteristics are from S&P RatingsXPress database. If ratings are not available in S&P RatingsXpress, we use ratings from FISD. To assign a FISD rating, we first use the S&P value if it exists, otherwise the Moody's value, otherwise the Fitch value, and otherwise the Duff and Phelps value. Mean ratings are computed by first converting each rating to a number (AAA=1, AA+=2, AA=3, …, and D=22) and then converting the number back to a letter rating.

Table 3. Trading Activity and Trading Cost around Phase Start

	Trading activity			Trading cost	
	90 days before	90 days after		90 days before	90 days after
	(1)	(2)		(3)	(4)
	Number of trades per bond-day			7-day trading cost per round-trip trade ($)	
Phase 1 (N=388)	-	15.527	Phase 1 (N=381)	-	1,682
Phase 2 (N=2,526)	1.502	1.538	Phase 2 (N=1,967)	1,413	1,053
Phase 3A (N=11,081)	0.696	0.691	Phase 3A (N=6,151)	947	822
Phase 3B (N=2,859)	0.332	0.315	Phase 3B (N=1,106)	4,030	2,920
	Volume per day ($)			7-day trading cost per round-trip bond traded ($)	
Phase 1 (N=388)	-	12,440,080	Phase 1 (N=381)	-	0.568
Phase 2 (N=2,526)	952,667	876,079	Phase 2 (N=1,967)	0.806	0.790
Phase 3A (N=11,081)	377,875	354,424	Phase 3A (N=6,151)	1.087	1.007
Phase 3B (N=2,859)	387,815	376,500	Phase 3B (N=1,106)	0.561	0.434
	Volume/Issue size per day			Price standard deviation ($)	
Phase 1 (N=388)	...	0.902	Phase 1 (N=388)	...	0.988
Phase 2 (N=2,526)	0.297	0.273	Phase 2 (N=2,042)	0.875	0.861
Phase 3A (N=11,081)	0.163	0.164	Phase 3A (N=6,369)	0.862	0.806
Phase 3B (N=2,859)	0.187	0.169	Phase 3B (N=1,206)	0.554	0.480

Notes: Sample for number of trades is restricted to bonds in either the 90 calendar days before or after the Phase start. If a bond does not trade, it contributes to zero trades for that day. The mean reported above is the average daily number of trades in the 90-day window. The sample for average daily volume is constructed like that of trades and the daily volume is averaged over all bond-days in the 90-day window. Average daily volume/issue size is the average of daily volume/issue size calculated in the same manner as average daily volume. For round-trip trading cost measures, we measure the price difference between the two trades in a chain that span at most 7 calendar days (including the day of the first trade). The sample of bonds is restricted to bonds where there is at least one day in the 90 days before the Phase start with at least one chain and at least one chain after. The trading cost per round-trip bond traded is the difference in price per bond between the second and the first trade in the chain (in $100 par). The trading cost per round-trip trade is the difference in price per bond times the number of bonds. The reported average for the round-trip measures is average of bond-day mean over all bond-days in the 90-day window. The sample for daily price standard deviation is constructed as the round-trip measures but with the additional requirement of having at least two trades both before and after the start of the Phase. After computing the within-day price standard deviation for each bond for all days with at least two trades, we average across these days during either the 90 days before or after the Phase start. Price standard deviation is the average daily price standard deviation across these bonds. There is no transaction information for Phase 1 bonds in the 90 days before Phase 1 starts. N refers to the number of bonds in the sample that change dissemination status in the Phase.

Table 4. Difference-in-Difference Estimates for Number of Trades

		Alternative time windows			Alternative specifications (90-day window)		
	90-day mean for disseminated before phase start	60 days	90 days	180 days	With linear and quadratic trends specific to investment grade for each Phase	Without Phase 1 bonds as controls	Sample matched on size, time to maturity, and years since issuance
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				A. Pooled			
All three phases	0.754	-0.069***	-0.088***	-0.092***	-0.033	-0.030	-0.094***
		(0.027)	(0.026)	(0.028)	(0.026)	(0.021)	(0.033)
		-9.1%	-11.7%	-12.2%	-4.4%	-4.0%	-12.5%
				B. By phase			
Phase 2	1.502	0.094**	-0.033	-0.093**	0.005	-0.069*	-0.054
		(0.047)	(0.041)	(0.041)	(0.045)	(0.038)	(0.059)
		6.3%	-2.2%	-6.2%	0.3%	-4.6%	-3.6%
Phase 3A	0.696	-0.132***	-0.048	-0.041	-0.029	-0.004	-0.109**
		(0.044)	(0.038)	(0.045)	(0.037)	(0.036)	(0.055)
		-19.0%	-6.9%	-5.9%	-4.2%	-0.6%	-15.7%
Phase 3B	0.332	-0.238***	-0.236***	-0.169***	-0.194***	-0.001	-0.140***
		(0.042)	(0.062)	(0.065)	(0.034)	(0.022)	(0.046)
		-71.7%	-71.1%	-50.9%	-58.4%	-0.3%	-42.2%
H_0: Phase effects equal (p-val)		0.000	0.017	0.269	0.000	0.000	0.000
# of Phase 2 bonds		2,526	2,526	2,526	2,524	2,526	2,524
# of Phase 3A bonds		11,081	11,081	11,081	11,044	11,081	4,421
# of Phase 3B bonds		2,859	2,859	2,859	2,768	2,859	2,859
# of trades for Phase 2		1,496,633	2,116,395	4,132,239	2,105,872	1,503,471	2,046,291
# of trades for Phase 3A		1,022,128	1,530,186	3,174,160	1,525,675	1,189,969	1,390,655
# of trades for Phase 3B		506,245	753,767	1,446,740	750,593	372,431	753,767
# of bond-days		2,320,998	3,421,074	6,804,827	3,386,963	3,310,621	2,317,302

Notes: This table reports estimates of Disseminate x Post for number of trades. Panel A reports estimates from Phases 2, 3A, and 3B pooled together, while panel B reports estimates for each Phase separately. Robust standard errors clustered by bond and Phase are in parenthesis immediately below the estimates. All models include bond fixed effects. Mean for Disseminated is the 90-day average for newly disseminated bonds immediately before the Phase start. The third entry in each row is the percentage effect as computed by dividing the estimate by the Mean for Disseminated. Phase effects equal reports p-values of tests that the three Phase estimates are equal. The 60-day regressions use trades from 60 calendar days before and after the Phase change. The 90- and 180-day regressions are defined analogously. There are 8,324 Phase 2, 2,235 Phase 3A, and 2,129 Phase 3B control bonds in columns (2)-(4). Standard errors in parentheses. The model with trends in column (5) has linear and quadratic functions of time for investment grade and high-yield bonds specific to each Phase. Column (6) excludes Phase 1 bonds as controls for Phase 2, 3A and 3B. The characteristics used to construct the matched sample in column (7) are issue size at Phase start, time to maturity at Phase start, and years since issue at Phase start. We divide the sample into four issue size quartiles, and two groups for the other two characteristics: above/below the median time to maturity and years since issue. We exclude bonds in cells with 5 or fewer treated bonds or 5 or fewer control bonds.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 5. Estimates for Alternate Measures of Trading Activity (90-day Window)

	Volume ($)		Volume/Issue size		Average trade size	
	Mean	Estimate	Mean	Estimate	Mean	Estimate
	(1)	(2)	(3)	(4)	(5)	(6)
			A. Pooled			
All three phases	462,897	-25,177	0.186	-0.012**	649,910	3,189
		(20,264)		(0.005)		(10,702)
		-5.4%		-6.5%		0.5%
			B. By phase			
Phase 2	952,667	-66,553**	0.297	-0.039***	709,546	-9,121
		(32,934)		(0.009)		(18,210)
		-7.0%		-13.1%		-1.3%
Phase 3A	377,875	-34,729	0.163	0.007	541,930	-968
		(34,815)		(0.007)		(14,768)
		-9.2%		4.3%		-0.2%
Phase 3B	387,815	55,890	0.187	0.003	1,178,134	50,101**
		(37,133)		(0.008)		(25,197)
		14.4%		1.6%		4.3%
H_0: Phase effects equal (p-val)		0.042		0.000		0.138
# of trades		4,533,784		4,579,932		4,556,139
# of bond-days		3,421,206		3,421,431		864,168

Notes. This table reports estimates of Disseminate x Post for alternative measures of trading activity following the 90-day estimates in column (3) of Table 4. The Average Trade Size measure requires that there be at least one trade for a bond in the before and the after period to be included in the sample. See Table 4 notes for additional details.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6. Estimates for 7-Day Trading Cost per Round-trip Trade

	90-day mean for disseminated before phase start	Alternative time windows: 60 days	90 days	180 days	Alternative specifications (90-day window): With linear and quadratic trends specific to investment grade for each Phase	Without Phase 1 bonds as controls	Sample matched on size, time to maturity, and years since issuance
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				A. Pooled			
All three phases	1,301	-230***	-241***	-192***	-141***	-244***	-228***
		(60)	(51)	(40)	(49)	(59)	(65)
		-17.7%	-18.5%	-14.8%	-10.8%	-18.8%	-17.5%
				B. By phase			
Phase 2	1,413	-282***	-250***	-60	-205**	-241**	-230**
		(104)	(87)	(72)	(86)	(96)	(106)
		-20.0%	-17.7%	-4.2%	-14.5%	-17.1%	-16.3%
Phase 3A	947	-19	-54	-73**	-20	-13	-46
		(56)	(46)	(33)	(44)	(52)	(65)
		-2.0%	-5.7%	-7.7%	-2.1%	-1.4%	-4.9%
Phase 3B	4,030	-813***	-924***	-1,224***	-694**	-969***	-858***
		(234)	(225)	(164)	(296)	(222)	(256)
		-20.2%	-22.9%	-30.4%	-17.2%	-24.0%	-21.3%
H_0: Phase effects equal (p-val)		0.001	0.000	0.000	0.017	0.000	0.005
# of Phase 2 bonds		1,841	1,966	2,123	1,965	1,967	1,966
# of Phase 3A bonds		5,225	6,151	7,623	6,140	6,150	2,787
# of Phase 3B bonds		959	1,106	1,281	1,089	1,106	1,106
# of round-trips for Phase 2		295,540	413,813	808,282	411,830	283,895	399,824
# of round-trips for Phase 3A		185,810	284,456	608,293	283,513	225,295	245,586
# of round-trips for Phase 3B		96,152	145,334	275,367	144,710	71,848	145,340
# of bond-days		279,678	416,004	839,624	414,203	347,644	371,344

Notes: This table reports estimates of Disseminate x Post for 7-day trading cost per round-trip trade. There are 8,324 Phase 2, 2,235 Phase 3A, and 2,129 Phase 3B control bonds in columns (2)-(4). See Table 4 notes for details.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 7. Estimates for Alternative Measures of Trading Cost (90-day window)

	Trading cost per round-trip trade				Trading cost per round-trip bond traded				Daily price standard deviation (all trades)	
	1-day		14-day		1-day		7-day			
	Mean	Estimate	Mean	Estimate	Mean	Estimate	Mean	Estimate	Mean	Estimate
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
A. Pooled										
All three phases	1,299	-267***	1,344	-273***	0.842	-0.033***	0.964	-0.047***	0.841	-0.021***
		(46)		(58)		(0.006)		(0.007)		(0.005)
		-20.6%		-20.3%		-3.9%		-4.9%		-2.5%
B. By phase										
Phase 2	1,318	-131	1,448	-387***	0.666	0.008	0.806	-0.027**	0.875	-0.003
		(84)		(99)		(0.010)		(0.011)		(0.009)
		-9.9%		-26.7%		1.2%		-3.3%		-0.3%
Phase 3A	965	-164***	996	52	0.970	-0.064***	1.087	-0.065***	0.862	-0.033***
		(36)		(59)		(0.009)		(0.010)		(0.007)
		-17.0%		5.2%		-6.6%		-6.0%		-3.8%
Phase 3B	4,017	-1,166***	4,070	-1,072***	0.532	-0.075***	0.561	-0.061***	0.554	-0.042***
		(186)		(237)		(0.016)		(0.018)		(0.012)
		-29.0%		-26.3%		-14.1%		-10.9%		-7.6%
H_0: Phase effects equal (p-val		0.000		0.000		0.000		0.000		0.011
# of round-trips/trades		715,950		891,664		715,978		843,609		4,271,416
# of bond-days		365,946		430,484		365,954		415,993		589,716

Notes. This table reports estimates of Disseminate x Post for alternative measures of trading cost following the 90-day estimates in column (3) of Table 6. 1-day and 14-day round-trips are constructed similar to the 7-day round-trips with the restriction that the two trades in the round-trip span at most 1 and 14 calendar day (including the day of the first trade) respectively. Trading cost per round-trip bond traded is the difference in price per bond between the second and the first trade in the round-trip at $100 par. The trading cost per round-trip trade measures the total cost (difference in price per bond times the number of bonds). The daily price standard deviation is the within-day price standard deviation.

Table 8. Estimates by Trade Size

	Number of trades						Trading cost per round-trip trade					
	Vol < $100k		$100k <= Vol < $1Mil		Vol >= $1Mil		Vol < $100k		$100k <= Vol < $1Mil		Vol >= $1Mil	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	A. Summary statistics											
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
# of trades/round-trips	1,440,045	1,568,370	359,352	368,930	328,473	337,924	274,710	315,429	59,562	63,405	53,780	56,685
Share of trades/round-trips	67.7%	68.9%	16.9%	16.2%	15.4%	14.9%	70.8%	72.4%	15.3%	14.6%	13.9%	13.0%
Volume ($M)	31,903	34,302	106,948	107,681	1,221,074	1,226,051	3,092	3,342	12,797	12,934	117,017	119,310
Share of volume	2.3%	2.5%	7.9%	7.9%	89.8%	89.6%	2.3%	2.5%	9.6%	9.5%	88.0%	88.0%
	B. Pooled											
	Mean	Estimate	Mean	Estimate	Mean	Estimate	Mean	Estimate	Mean	Estimate	Mean	Estimate
All three phases	0.539	-0.066***	0.139	-0.012***	0.204	-0.018***	209	-8***	950	-106***	6,276	-1,031***
		(0.023)		(0.004)		(0.005)		(2)		(24)		(322)
		-12.2%		-8.6%		-8.8%		-3.8%		-11.2%		-16.4%
	C. By phase											
Phase 2	1.126	0.020	0.331	-0.019**	0.212	-0.029***	187	-5	868	-82**	7,056	-1,191**
		(0.036)		(0.008)		(0.009)		(3)		(37)		(603)
		1.8%		-5.7%		-13.7%		-2.7%		-9.4%		-16.9%
Phase 3A	0.514	-0.032	0.106	-0.013**	0.223	-0.011	218	-8***	971	-59*	5,222	-498
		(0.031)		(0.006)		(0.009)		(3)		(35)		(412)
		-6.2%		-12.2%		-4.9%		-3.7%		-6.1%		-9.5%
Phase 3B	0.131	-0.251***	0.098	0.001	0.148	-0.011	218	-31***	1,215	-327***	8,439	-1,664***
		(0.056)		(0.010)		(0.010)		(11)		(75)		(615)
		-191.8%		1.0%		-7.4%		-14.2%		-26.9%		-19.7%
H_0: Phase effects equal (p-val)		0.000		0.274		0.294		0.081		0.005		0.258
# of trades/round-trips		3,008,415		728,282		666,397		590,139		122,967		110,465
# of bond-days		3,190,387		2,341,085		309,770		309,770		90,667		74,087

Notes: This table reports estimates of Disseminate x Post for number of trades and 7-day trading cost per round-trip trade split by trade size. Numbers in Panel A exclude Phase 1. The specifications follow those for the 90-day estimate in column (3) of Tables 4 and 6.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 9. Estimates for 7-Day Trading Costs Per Round-trip Trade by Round-trip Type

	CDC		DDD		DDC/CDD	
	(1)	(2)	(3)	(4)	(5)	(6)
			A. Summary statistics			
	Before	After	Before	After	Before	After
# of round-trips	94,596	107,170	62,457	67,438	229,015	258,052
Share of round-trips	24.5%	24.8%	16.2%	15.6%	59.3%	59.6%
Volume ($M)	54,267	56,284	46,227	46,023	33,533	32,656
Share of volume	40.5%	41.7%	34.5%	34.1%	25.0%	24.2%
			B. Pooled			
	Mean	Estimate	Mean	Estimate	Mean	Estimate
All three phases	2,562	-454***	1,035	-225***	579	-71**
		(154)		(52)		(28)
		-17.7%		-21.7%		-12.3%
			C. By phase			
Phase 2	2,764	-366	904	-290***	708	-196***
		(240)		(74)		(48)
		-13.2%		-32.1%		-27.7%
Phase 3A	1,826	-55	1,059	-141*	472	66**
		(193)		(84)		(31)
		-3.0%		-13.3%		14.0%
Phase 3B	6,272	-1,589***	1,366	-308**	1,291	-259
		(440)		(153)		(189)
		-25.3%		-22.5%		-20.1%
H_0: Phase effects equal (p-val)		0.006		0.361		0.000
# of round-trips		201,766		129,895		487,067
# of bond-days		148,917		91,801		259,002

Notes. This table reports estimates of Disseminate x Post for trading cost per round-trip trade by round-trip type. There are three types of round-trip trades: CDC, DDD and CDD/DDC. Numbers in Panel A exclude Phase 1. The specification is the same as column (3) of Table 6.

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 10. Daily Dealer Revenue in 7-day Round-trips

	Revenue per round-trip trade		Revenue per round-trip bond traded	
	Mean	Estimate	Mean	Estimate
	(1)	(2)	(3)	(4)
		A. Pooled		
All three phases	1,749	-277***	7.490	-0.0617
		(93)		(0.0942)
		-15.8%		-0.8%
		B. By phase		
Phase 2	1,818	-146	5.442	0.115
		(145)		(0.132)
		-8.0%		2.1%
Phase 3A	1,171	20	8.902	0.112
		(107)		(0.155)
		1.7%		1.3%
Phase 3B	3,789	-1,246***	6.645	-0.845***
		(289)		(0.228)
		-32.9%		-12.7%
H_0: Phase effects equal (p-		0.000		0.001
# of round-trips		839,184		839,196
# of dealer-days		152,190		152,187

Notes. This table reports estimates of Disseminate x Post for dealer revenues from 7-day round-trips. We only include dealers that have at least 1,000 trades from July 2002 - December 2006 or are in the top 20% of the dealers (ranked by number of trades) trading in that phase. A dealer that meets the above criteria in a phase is also included in other phases conditional on them trading at least once in that phase. There are 590 dealers in Phase 2, 599 in Phase 3A, and 590 in Phase 3B. See Table 4 notes for details.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 11. Aggregate Reduction in Trading Cost and Dealer Revenue

	Number of trades (Jul 02-Dec 06)	Mean per round-trip (90-day pre-period)	Total cost/revenue (Jul 02-Dec 06)	Reduction per round-trip (90-day pre-period)	Total reduction in cost/revenue (Jul 02-Dec 06)	Reduction in cost/revenue per year
	(1)	(2)	(3)	(4)	(5)	(6)
			Panel A. Trading cost: cost per round-trip trade			
Phase+No phase	22,582,689	1,301	14,690,892,594	241	2,721,214,025	**604,714,228**
Phase 1	4,130,856	1,413	2,918,256,531	250	516,357,000	114,746,000
Phase 2	2,934,629	1,413	2,073,178,112	250	366,828,625	81,517,472
Phase 3A	7,742,494	947	3,665,481,341	54	209,047,338	46,454,964
Phase 3B	1,144,757	4,030	2,306,807,581	924	528,877,734	117,528,385
No Phase	6,629,953	1,301	4,313,034,972	241	798,909,337	177,535,408
Total	22,582,689		15,276,758,537		2,420,020,034	**537,782,230**
			Panel B. Dealer revenue: revenue per round-trip trade			
Phase+No phase	22,582,689	1,749	19,743,034,532	277	3,127,702,427	**695,044,984**
Phase 1	4,130,856	1,818	3,754,031,000	146	301,552,488	67,011,664
Phase 2	2,934,629	1,818	2,666,926,235	146	214,227,917	47,606,204
Phase 3A	7,742,494	1,171	4,531,725,154	-20	-77,424,940	-17,205,542
Phase 3B	1,144,757	3,789	2,168,533,063	1,246	713,183,611	158,485,247
No Phase	6,629,953	1,749	5,796,271,251	277	918,248,491	204,055,220
Total	22,582,689		18,917,486,705		2,069,787,567	**459,952,793**

This table estimates the aggregated reduction in trading cost and dealer revenue per year in the corporate bond market because of the transparency. Panel A measures the reduction in trading cost and Panel B measures the reduction in dealer revenue. In both the panels, Phase + No Phase uses the aggregate all phase estimates. For Phase 1, we use the estimates for Phase 2 (the means in table 2 for Phase 1 and 2 are similar) and for No Phase, we use the aggregate estimates. In Panel A, the estimates in column (2) and (4) for trading cost per round-trip trade measures are from Table 6. In Panel B, the estimates in column (2) and (4) for revenue per round-trip trade are from Table 10.

Appendix A: NAIC analysis and Phase 1

In this Appendix, we briefly review the National Association of Insurance Companies (NAIC) database and use it to study Phase 1. Although TRACE data did not exist before July 2, 2002, the NAIC maintains trading records for member insurance companies since 1994. Bessembinder, Maxwell, and Venkataraman (2006) use NAIC transaction data to estimate trade execution costs in Phase 1 and other Phases and argue that there are spillovers from Phase 1 to other Phases.

We use our methodology on the NAIC database to examine the effects of Phase 1 of TRACE. There are two important differences between our approach and Bessembinder, et al. First, we use a difference-in-differences research design. Second, we directly measure price standard deviation as a proxy for trading costs, rather than using a structural model of trading to impute trading costs.

We find that TRACE does not have a significant effect on price standard deviation using NAIC data. Further, our analysis of TRACE above shows significant negative effects on both trading costs and price standard deviation due to dissemination for Phase 3B bonds. It is therefore a surprise that we do not find similar results for Phase 1. If there are spillover effects from Phase 1, we would have expected smaller, rather than larger, results for subsequent Phases.

While using the NAIC database, we discovered a systematic error in how NAIC's trades are reported. Many NAIC trades are disaggregated and reported as multiple transactions in the NAIC database. For example, insurance companies must separately report bonds purchased and sold in the same calendar year from bonds purchased and held through the end of the year. This means if an insurance company purchases $1 million par of a bond on January 1, 2001 and sells $500,000 of this before December 31, 2001 and the remaining $500,000 in the following year, under NAIC reporting guidelines, this single purchase would be split into two separate purchases of $500,000 each. Total volume is unaffected by splitting the trade, but the number of trades is overstated and price standard deviation is understated. A more complete discussion of this misreporting of trades is explained in the NAIC Data Appendix C.[34]

Table A1 reports difference-in-differences estimates of trading activity and price standard deviation (both grouped and ungrouped) for 90 days before and after Phase 1 using the NAIC database. The estimating equation is the same as in column (4) of Table 4, but we use non-disseminated NAIC bonds from Phases 2, 3A, and 3B as control bonds. The mean number of trades for Phase 1 bonds in the NAIC is 0.301 (grouped) and 0.368 (ungrouped). This is substantially lower than the mean number of Phase 1 trades in TRACE of 15.527, shown in Table 3, and shows that the NAIC represents a small percentage of bond trading. Although not reported in the table, the mean number for Phases 2, 3A, and 3B are even smaller at between 0.021-0.058 per day. We cannot examine trading costs because we do not have matched trades. Price standard deviation for Phase 1 bonds is 0.560 (grouped) and 0.437 (ungrouped), which is lower than the mean of 0.988 for Phase 1 TRACE trades shown in Table 3.

[34] Previous research on the NAIC database does not mention this problem of disaggregation. We do not know if other research papers treat these multiple transactions as multiple trades.

Dissemination of bonds results in a slight increase in trading activity in Phase 1, using NAIC data. The point estimate is 0.020, with standard error 0.011. These results are unchanged with other specifications shown in columns (3)-(5), and are also present for the sample of ungrouped trades shown in Panel B. Dissemination also causes no detectable effect on price standard deviation in Phase 1, either for grouped or ungrouped trades.[35]

There are several possible reasons for why NAIC results on price standard deviation from Phase 1 differ from our TRACE results for Phase 2, 3A, and 3B. First, it may be that TRACE has no effect on Phase 1 bonds because those bonds were already actively traded, with widespread knowledge about pricing. Second, the insurance segment of the corporate bond market, which NAIC covers, may behave very differently than the remainder of the market. Finally, it may be difficult to detect changes since the amount of trading captured by NAIC is so much smaller than the entire corporate bond market covered by TRACE. According to the Federal Reserve's Flow of Funds statement, insurance companies own 24.6% of outstanding corporate bonds in 2002Q3-2006Q4.[36] However, insurance company trading, reported by the NAIC, is not representative of the rest of the corporate bond market.

Table A2 compares the cleaned NAIC and TRACE datasets by Phase and shows that insurance company trades are very different from the rest of the corporate bond market for our time period and the universe of bonds.[37] First, a high percentage of Phase 1, Phase 2, and Phase 3B TRACE bonds are contained in NAIC (94.3%, 86.6%, and 72.8% respectively). However, NAIC only contains 42.7% of Phase 3A TRACE bonds. Second, even though coverage is comparable, NAIC volume and number of trades are a small percentage of total volume and number of trades. Even though, as noted above, insurance companies may own 25% of outstanding bonds, for Phase 1 the share of NAIC trades is 1.37% of all trades in the 90-day period following dissemination (using grouped trades). For Phases 2, 3A, and 3B, NAIC trades represent 2.79%, 1.85%, and 3.16% of grouped trades during the 90-day window around dissemination.

Table A2 also compares price standard deviation between NAIC and TRACE. The standard deviation for NAIC trades is typically much smaller than for TRACE. It's worth noting that the NAIC price standard deviation is measured using far fewer CUSIPS and bond-days. In Phase 2, for example, we measure TRACE price standard deviation for 2,099 CUSIPs and 78,386 bond-days, while we only measure it for 902 CUSIPs and 1,866 bond-days in NAIC using grouped trades. This restricts our ability to draw strong inferences about price standard deviation using the NAIC sample.

We conclude that the NAIC database represents a small fraction of the trading in the corporate bond market covered by TRACE. Summing volume across all four Phases in the 90 days after Phase start, NAIC volume is only 6.9% of total TRACE volume. NAIC trades are also typically larger than those

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[35] Although not reported, we also looked at the effect of dissemination on NAIC bonds in Phases 2, 3A, and 3B. These results are very sensitive to the sample of control bonds used and we cannot draw any firm conclusions.
[36] Campbell and Taksler (2003) estimate that insurance companies hold between one-third and 40% of corporate bonds.
[37] In order to examine trading in Phase 1 bonds before the start of Phase 1, we use NAIC data from the period January 1, 2000 until July 1, 2002. We only compare trading activity between the NAIC and TRACE databases during the TRACE period, which starts July 2, 2002.

in the TRACE database consistent with buy-and-hold trading strategies of insurance companies. Given this difference, conclusions drawn about TRACE from the NAIC dataset may not be representative of the overall corporate bond market.

Appendix B: TRACE Data

Our data source for corporate bond trading is the Academic Corporate Bond TRACE data, i.e. Academic TRACE, purchased from FINRA. Beginning in July 2002, TRACE publicly provided price and volume for large, highly rated bonds in disseminated trades. FINRA classified these first bonds as Phase 1 bonds and over the course of the next three years, FINRA released trading data for all corporate bonds in a total of four phases. Throughout, exact volumes were reported for trades less than 1MM for high-yield bonds and trades less than 5MM for investment grade bonds. Amounts over that were only reported as greater than 1MM and/or 5MM, respectively.

In March 2010, FINRA released a "Historical" TRACE dataset, which includes both disseminated and non-disseminated trade reports, starting from TRACE's initiation in July 2002, and also includes the exact volume for all trades. That is, it released trade reports for bonds that had not yet been "phased in" and which were not publicly disseminated at the time of the trade. In February 2017, FINRA appended anonymized dealer identifiers to this Historical TRACE dataset to form the Academic Corporate Bond TRACE dataset.

During our time period, July 1, 2002 until December 31, 2006, there are 37,934,432 unique trade reports on 41,676 different CUSIPs in the Academic TRACE dataset. FINRA requires that all FINRA registered dealers self-report trade reports. This means that an interdealer trade should be reported twice, by both the buying dealer and the selling dealer. A trade between a dealer and customer is only reported once, by the dealer.

There are a number of reporting errors in this self-reported data. This appendix and the corresponding Tables B1 and B2 describe the steps we take to convert the raw Academic TRACE dataset to our analysis sample. That is, we list the steps we took to eliminate duplicate trade reports for the same trade and to correct errors in reporting.

We use the following fields, defined below, in the data set to construct our cleaned sample:

- **First Trade Control Number** is the unique (within the reporting day) number assigned by TRACE to a trade report
- **CUSIP** is a universal security identifier
- **Execution Date** is the date the trade was reported executed
- **Execution Time** is the time the trade was reported executed
- **Reporting Date** is the date the trade was actually reported to TRACE
- **Reporting Time** is the time the trade was actually reported to TRACE
- **Price** is the reported bond price and excludes any commission reported by the firm in the transaction[38]

[38] We received one of the earliest releases of the Academic Corporate Bond database. The version of the data that FINRA originally provided to us includes a field, CMSN_TRD, which purports to indicate whether a commission is assessed on the trade. The subsequent version of the dataset that we use does not include this information. In the TRACE User guide (2008 and 2017 versions), it states that "The reported price for a reported transaction must

- **Quantity** is the reported volume as a number of bonds
- **Reporter ID** is the anonymized hash code for the dealer who reports the trade
- **Give-up Reporter ID** is the hash code for the dealer in Give-up trades
- **Contraparty ID** is the hash code reported for the party on the other side of the trade
- **Give-up Contraparty ID** is the hash code for the party on the other side of the trade in Give-up trades
- **Reporter Capacity** indicates whether the reporter is acting as an agent or principal
- **Contraparty Capacity** indicates whether the contraparty is acting as an agent or principal
- **Buy/Sell Indicator** reports whether the reporting party is buying or selling
- **Dissemination** reports whether a trade was disseminated or not
- **Locked-in Flag** indicates that the reporting party submits the trade report on its own behalf as well as on behalf of the contraparty
- **Trade Status** corresponds to the type of report (trade, cancellation, modify)
- **As Of Indicator** represents if a trade is reported for a prior business day as in the case of a reversal or when the execution and reporting date differ

Most of these fields are self-reported. More detailed definitions for some of the variables will appear below as we discuss their use. There are additional fields associated with each trade report, which we do not use as part of our analysis.

Eliminate bonds based on characteristics

Before eliminating and correcting trade reports, we match the Academic TRACE dataset to the universe of corporate bonds in the Mergent FISD database. FISD is our source for bond characteristics such as issue size, ratings, maturity, etc. which we add to the Academic TRACE dataset. We drop all TRACE bonds that do not match to FISD by CUSIP. We also drop all bonds with equity-like characteristics (convertibles, exchangeables, etc.) since their equity component may be included in the bond price. We next drop all Rule 144a bonds because TRACE did not disseminate trading information on these bonds during 2002-2006. Finally, FISD does not report a correct issue size in some cases. For example, there are some bonds in FISD with reported issue size of $0. After hand checking a number of cases with small issue size, we decided to drop all bonds with reported FISD issue size of less than $100,000. The number of trades eliminated and their corresponding CUSIPs affected by these steps are shown in the first section of Table B1. In total, we drop 10,018 CUSIPs which correspond to 4,652,061 trade reports.

Eliminate trade reports because of self-reported errors

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be inclusive of a mark-up or markdown, but is exclusive of a commission, since a commission is reported in a separate field. TRACE will, however, incorporate the commission into the disseminated price." In the TRACE data code book (before 2012 and the Academic Corporate Bond database from 2017), it says: "This field [price] represents the reported bond price and is inclusive of any commission, mark-ups, and/or mark-downs reported by the firm in the trade transaction." Based on our analysis, we believe that reported price in our dataset does not include commissions.

Next, we eliminate trade reports which do not take place as reported since they are later modified, cancelled, or reversed. These are catalogued in the second section of Table B1. These are trade reports where FINRA dealers have themselves identified errors. That is, FINRA dealers insert a second trade report to correct a previous report. When identifying trades reports that are subsequently modified, cancelled or reversed, we rely on two data fields: Trade Status and First Trade Control Number.

The field Trade Status can take on values of "T" (new trade report), "X" (trade cancel), "C" (correction cancel), "R" (new correction), and "Y" (reversal). When a trade is first reported, it has a trade status of "T." If a member firm wishes to cancel a trade they reported earlier in the day, it must submit a new report containing the same CUSIP, Date, Price, Quantity, Reporter ID, and Contraparty ID of the original trade and mark Trade Status with an "X", indicating that this trade is cancelling the original trade. If a member firm wishes to correct a trade reported earlier in the day, it must submit two reports. One report, containing the details in the original report, must be marked "C" to indicate that the original report is cancelled as part of a correction. The other report, containing the correct trade information, must be marked "R" to indicate that it is a newly reported, correct trade. Cancellations that are reported on a different day than the original report are categorized as reversals and marked "Y".

The field, First Trade Control Number, facilitates tracking corrections and cancellations. This field contains a unique number for each new trade report. Any report that is cancelling or correcting an earlier report will contain the First Trade Control Number of the original report so that it can be linked back to the proper report. We group together reports with the same First Trade Control Number and order reports by reporting time within each group to determine which trades have been cancelled or corrected and thus need to be eliminated. The last report within a group indicates which reports to eliminate. For example, if the last report is "R" (new correction), then the last report will be kept, and all earlier reports will be eliminated. If the last report is "X", then all reports in the group will be eliminated as this trade has been cancelled. In our dataset, all modification and cancellation reports can be matched to an original trade report as Table B1 shows. We eliminate 1,250,351 reports due to modifications and 1,013,223 reports due to cancelations, including both the original trade reports and the modify/cancel reports.

The last Trade Status is reversals, which are cancellations that are reported on a different day from the original trade report. Trade reversals are identified by a "Y" in the Trade Status field and also by the As Of Indicator field by "R". Since the original trade and its reversal are reported to TRACE on different days, the First Trade Control Number of reversal trades do not necessarily match the First Trade Control Number of the original trade. Therefore, to link a reversal to its original trade, we match the reports using nine identifying characteristics: CUSIP, Execution Date, Execution Time, Price, Quantity, Reporter ID, Contraparty ID, Buy/Sell indicator, and Reporter Capacity. We called matches with these criteria a "nine-way" match.

Using these nine characteristics sometimes leads to many-to-many matches; that is, there is often more than one possible pairing. (In fact, it appears that many reversals are the result of a trade being entered twice and the second report being reversed). After matching reversal and non-reversal reports using these nine trade characteristics, we eliminate exact matches as follows. If there is only one exact match, both the reversal and its matched trade are eliminated. If there is more than one exact match, we eliminate the reversal trade and one of the matching trades. Since, by definition, the trades occur at the same time, date, price, and volume, the cleaned dataset is unaffected by the choice of which matching trade reports we eliminate. For example, if there are four reversals and five non-reversals, we drop the four reversals and drop the first four non-reversals. We drop a total of 841,108 trade reports due to exact matches of reversal reports, most of which are not part of many-to-many matches.

Unfortunately, unlike all modifications and cancellations, not all reversals have an exact nine-way match. A large number of the unmatched reversals have an eight-way match to another trade if we drop the same execution time requirement. Since execution time is self-reported, we assume these eight-way matches were the original trades that were meant to be reversed, and we eliminate the reversal and the matched trade from the sample following the steps above. We drop an additional 87,250 reports. Next, we relax the requirement that the price must be exact in an eight-way reversal and look for matches when prices are rounded to 0.01.[39] This relaxation allows us to eliminate 5,694 additional trade reports. Even after eight-way matches, there are 30,724 reports labeled as reversals that we were unable to match to an original trade. We dropped these reversal reports from the dataset.

Table B1 shows that 3,228,350 trade reports are eliminated from the sample because of self-reported errors.

Modifying trade reports based on TRACE submission rules

There are multiple conventions or paths by which the transacting parties can be reported to TRACE. In addition to self-reporting, TRACE also allows another party (such as a clearing firm) to fulfill the reporting obligation of transacting party. There are three fields that are used when trade reports do not report the transacting dealers in the trade. They are Reporter Give-up ID, Contraparty Give-up ID, and Locked-in Flag. In a Give-up trade, a clearing firm can submit a report on behalf of the either of the transacting dealers. When this is the case, either the Reporter Give-up ID or Contraparty Give-up ID is populated by the ID of the transacting dealer. To correctly identify the transacting parties in these trades, we replace the Reporter ID (Contraparty ID) with the Reporter Give-up ID (Contraparty Give-up ID).

The other case where TRACE allows a variance on its reporting requirements is a locked-in trade report. In a locked-in trade report, the reporting party submits the trade report on its own behalf as well as on behalf of the contraparty. That is, there is only one trade report, rather than a separate report from the buying dealer and selling dealer. When the Locked-in Flag is checked, the reporter ID and the contraparty ID are the same, but one give-up field is populated. For each trade report where the Locked-in Flag is marked, we follow the convention in the paragraph above for the give-up fields and modify the Reporter or Contraparty ID fields in the existing trade report. In addition, we create a new

[39] Prices are only rounded in this step to identify reversals. In subsequent steps, we return to the original price.

buy or sell trade report corresponding to the missing report. For this missing report, we treat the contraparty of the locked-in report as the reporting party and use the Contraparty Capacity field of the locked-in report for the Reporting Capacity field. It is important to create these extra reports for the matching process described below. Since these newly created reports correspond to the same trade as an existing report, they will be eliminated following the steps to identify duplicate trade reports. Table B1 shows that 523,125 extra trade reports are created.

Eliminate trade reports with timing issues

We next drop trade reports from our sample because of issues with their execution date. We eliminate a small number of trade reports reported to be executed before July 1, 2002, which is the beginning of TRACE. Then, we drop any trade report that occurs before the traded bond's offering date or after its maturity date. Many trades that occur before the offering date correspond to the when-issued market. Trades that occur after maturity date often occur on bonds that are bankrupt. Finally, we drop all reports that are reported to have occurred on SIFMA holidays. Even though bond trades occur on these holidays, we drop these days because trading activity is limited to a subset of dealers. After these eliminations, we are left with 29,387,759 reports.

Eliminate redundant trade reports

A bond trade may generate multiple trade reports. To identify redundant trade reports, we define a bond trade as an exchange of bonds between two principals. We define principals as parties (dealers or customers) that hold a bond for some time period and in so doing assume the risk that the bond price may change. A significant part of our data cleaning process involves identifying and keeping bond trades while eliminating extraneous trade reports.

FINRA requires that every dealer in a trade report a separate trade report. (As mentioned above, customer do not report trade reports.) This means for example, if two dealers trade a bond between them, both dealers will file a trade report. Dealer A will report they sold a bond to Dealer B, while Dealer B will report they purchased a bond from Dealer A. Since these two reports only represent one trade, it is important to identify that fact and consolidate the two trade reports into one.

In some trades, another dealer (or more) may act as an agent. In an agency transaction, a dealer intermediates between two principals by transferring the bond from one principal to the other while not assuming any price risk. We will refer to the trade reports that involve agency transactions as an agency chain. In a common case, Dealer C will purchase a bond from Dealer A and transfer it to Dealer B at the same price plus a commission. (Commissions are reported in a separate field and are not used to eliminate redundant reports.) In this case, TRACE requires four trade reports to be generated: Dealer C reports she bought the bond from Dealer A as an agent and sold the bond to Dealer B as an agent. Dealer A reports she sold the bond to Dealer C as a principal and Dealer B reports she bought the bond from Dealer C as a principal. Thus, this one bond trade will generate four trade reports, which must be identified and culled to one report in order to properly measure trading activity.

For all trades, our aim is to keep only one trade report that reflects the transfer of bond ownership and price risk. We next present some more formal examples of the discussion above. An agency chain involving three dealers generates four trade reports in the following way:

Reporter	**Contraparty**	**Buy/Sell Indicator**	**Reporter Capacity**
Dealer A	Dealer C	Sell	Principal
Dealer C	Dealer A	Buy	Agent
Dealer C	Dealer B	Sell	Agent
Dealer B	Dealer C	Buy	Principal

In this example, Dealer C acts in an agency capacity to intermediate between two principals: Dealer A and B. Therefore, we consolidate these four trade reports into a single trade record as follows.

Reporter	**Contraparty**	**Buy/Sell Indicator**
Dealer A	Dealer B	Sell

This consolidated record never shows up as a report; we construct it from the four trade reports. We mark this consolidated trade record as an agency chain with Dealer C as agent and adopt the convention of preserving the sell-side report.

The most common type of agency chain occurs when a customer is involved as a principal (either as the final Buyer or initial Seller) as illustrated below:

Reporter	**Contraparty**	**Buy/Sell Indicator**	**Reporter Capacity**
Dealer A	Customer	Buy	Agency
Dealer A	Dealer B	Sell	Agency
Dealer B	Dealer A	Buy	Principal

In this example, Dealer A acts in an agency capacity to intermediate between a customer and Dealer B. We consolidate these three trade reports into a single agency trade record as follows.

Reporter	**Contraparty**	**Buy/Sell Indicator**
Dealer B	Customer	Buy

Agency chains can be far more complicated than these examples and involve longer sequences of trade reports where the reporter capacity is Agency. We discuss this below.

Turning now to principal-to-principal trades, the simplest example of a principal-to-principal trade with redundant reports is the following:

Reporter	**Contraparty**	**Buy/Sell Indicator**	**Reporter Capacity**
Dealer A	Dealer B	Buy	Principal

Dealer B	Dealer A	Sell	Principal

We consolidate these trade reports into a single record as follows:

Reporter	Contraparty	Buy/Sell Indicator
Dealer B	Dealer A	Sell

To identify candidate redundant reports, for both agency and principal trade reports, we match trade reports on the following fields: CUSIP, Execution Date, Execution Time, Price, Quantity, Reporter ID, Contraparty ID, Buy/Sell Indicator, and Reporter Capacity. Execution Time is used to break ties when there are many-to-many matches. Every interdealer trade should have two paired reports and every agency buy trade should be matched with an agency sell trade.

There are many instances in which a trade report cannot be matched with another one, despite that fact that a match should exist by TRACE convention. In many of these instances, potential matches differ by one field.

After working with the data, we have identified four common difficulties with matching trade reports.

1. **Trade splitting**: We find many instances in which trade reports can be matched if we sum the volume across multiple reports on either the buy or sell side of the trade. In these cases, we believe the two dealers see the trading activity differently. For example, one dealer executes a sale of volume 5,000,000 and reports it as such. Meanwhile, the other dealer reports five buy transactions of 1,000,000.
2. **Reporting capacity mismatches**: There are many trades where the Reporter Capacity code appears to be inconsistent. That is, a dealer reports she is acting as an agent on one side of a transaction and a principal on the other.
3. **Dealer identification**: Many unmatched trade reports can be matched if we allow for multiple dealer IDs. This can occur, for example, if one dealer has merged with another dealer and now has two dealer IDs.
4. **Price corrections**: Many unmatched trade reports can be matched using different rounding or truncations for the per-bond price.

Addressing these difficulties by modifying the four fields: Quantity, Reporter Capacity, Contraparty ID, and Price, allows us to match many, although not all, of the unmatched reports. Modifying more fields or even multiple fields would increase our number of matches, but many of those modifications would also result in false matches. As a result, we try to minimize the number of fields we change to identify matches and only modify in a trade report one of the four fields we list above. In the following section, we describe our procedure for eliminating redundant reports in more detail.

Eliminating redundant trade reports

First, we match trade reports in agency chains without making any modifications. As shown in the examples above, one trade generates multiple trade reports which must be consolidated into one. If there is a sequence of trade reports that can be explained as an agency chain in different ways, we chose the way that corresponds to the most frequently observed type of agency chain. If there are multiple possible trade records that can rationalize a group of trade reports, we match trades chronologically by execution time. We eliminate 1,290,607 trade reports through the exact matching of agency chains.

After removing these trade reports, we next address trade splitting, wherein the dealers report one trade in multiple pieces. To deal with trade splitting, we aggregate all of the reports with the same CUSIP, Execution Date, Price, Reporter ID, and Contraparty ID. With these aggregated trade reports, we then match any additional agency chains, and we eliminate an additional 57,314 reports.

Next, we address the mismatches of reporting capacity codes. In each trade report, the reporting party classifies herself as either a principal or an agent. Every trade or agency chain must have a principal on both ends. Likewise, an intermediate dealer in an agency chain should report both an agency buy and an agency sell. We find many "broken chains" where the two trade reports from the same dealer for the same price and quantity on the same day are inconsistent. In one trade report, the dealer reports she is acting as an agent, and in the matched trade report, she reports she is acting as a principal. In these cases, we convert one of the reporting capacity codes to fix the broken agency chain. Table B1 shows that we eliminate 176,744 trade reports as a result of the new matches from modifying the capacity code. We eliminate an additional 3,736 trade reports when we aggregate volume, as above.

Then we address misreported dealer IDs. Ideally, matched buy and sell reports will have the reporter's ID of the buy report be the contraparty's ID in the sell report, and vice versa. However, a given dealer may be associated with more than one ID because of mergers, reorganizations, or because two dealers are subsidiaries of the same firm. If the reporting dealer populates the Contraparty ID field with an alternative dealer ID, we do not have an exact match. The example below illustrates this case:

Reporter	**Contraparty**	**Buy/Sell Indicator**
Dealer A	Dealer B	Buy
Dealer B	Dealer C	Sell

Suppose that dealer IDs A and C both represent the same dealer. By substituting A for C in the sell report, we can identify the match and eliminate one trade report. When we consolidate a match with a misreported contraparty ID, of the two possible dealer IDs, we always keep the ID that appears on the in the Reporter ID field. This is because we assume that the reporting side dealer's information about its ID is more likely to be accurate than the contraparty. The consolidated record is:

Reporter	**Contraparty**	**Buy/Sell Indicator**
Dealer B	Dealer A	Sell

As with Reporter Capacity mismatches, we look for misreported dealer ID matches with both exact and aggregated trade volumes. In total, modified dealer ID matches allow us to eliminate an additional 105,828 trade reports.

After eliminating redundant trade reports that are part of agency chains, we next match duplicate reports from interdealer principal-to-principal trades. Table B1 shows that 3,713,491 trade reports are dropped without any modifications to trade reports. As above, if there are multiple possible trade records that can rationalize a group of trade reports, we match trades chronologically by execution time. Then, we correct the same errors– reporting capacity mismatches and misreported dealer IDs, both with exact and aggregate volume – for these trade reports. An additional 934,536 trade reports are dropped using these modifications.

Because of the multiple dealer IDs discussed above, it is also possible that in some trades both dealers will be identified with two separate dealer IDs. For example, suppose that IDs A and C are identified with one dealer, and IDs B and D are identified with another dealer. The following two trade reports

Reporter	**Contraparty**	**Buy/Sell Indicator**
Dealer A	Dealer B	Buy
Dealer D	Dealer C	Sell

are redundant reports of a single principal-to-principal trade but will not be identified as such.

In keeping with our principle of making minimal corrections, we do not want to match these reports unless we have strong evidence that either IDs A and C or B and D belong to the same dealer. For example, if A and C represent the same dealer, then Dealer D was not really making an error when she filled in C for the contraparty.

To determine whether two IDs possibly represent the same dealer, we count how many times one ID is substituted for another in contraparty mismatches from the first pass, i.e., all the previous matching steps described above. If an ID (C, in our example) is modified at least 100 times in the first pass and the same substituting ID (A) is used in at least 95% of these instances, then we call this substitution (C -> A) a “common substitution,” and we infer that the two IDs belong to the same dealer. We identify 76 common substitutions.

We make all common substitutions throughout the dataset. In our example, we replace every instance of C with A. Then we make a second pass through the remaining trade reports to identify agency chains and principal-to-principal trades following the steps we used with the original IDs. We eliminate 21,188 additional trade reports.

Next, we consider possible corrections to the price field for the remaining unmatched trade reports. First, we round the prices of these trade reports to two significant digits and make a third pass to match trade reports in agency chains and principal-to-principal trades. This results in an additional

460,405 trade reports being eliminated. We make a fourth pass with truncated prices (e.g., we truncate 100.116 to 100.11, as opposed to rounding to 100.12). We eliminate additional 26,269 trade reports.

Modify or eliminate trade reports with price or volume issues

Some trade prices are vastly out of line with other prices for the bond during the same period. To identify these prices, we first define two reference prices, before and after the trade report. The reference prices are the median prices, weighted by volume, of the 10 trades immediately before and 10 trades immediately after the trade. If there are fewer than 10 trades in the 30 days before or after, we use all the trades in the 30 days. A trade price is vastly out of line if the bond price differs by more than $20 per bond in the same direction from both the before and after reference prices. When a trade is vastly out of line, we replace it with the volume-weighted median prices for the entire 20 trades or 60-day window. A total of 6,850 prices were replaced with the reference price.

These modifications do not necessarily correct all the prices that may be erroneous. For example, the procedure above does not correct the price if there is not another trade report in the 60-day window. We, therefore, drop trade reports less than the 0.01 percentile and 99.99 percentile of all trade prices in the sample. Table B1 shows we drop 4,848 trade reports.

Next, we eliminate trades from the dataset when volume information appears erroneous. Since, as mentioned above, all trades are self-reported, data entry errors are possible even though TRACE monitors reported trades. We, therefore, drop trade reports less than the 0.01 percentile and 99.99 percentile of all trade volumes in the sample. Table B1 shows we drop 3,283 trade report. We also eliminate 4,396 trade reports in which the volume of a single trade is higher than 50% of the issue amount. Then, we eliminate 2,425 trade reports in which the volume was reported as less than $1,000.

Remaining unmatched trade reports

After the steps to assemble the data set, there are still unmatched trade reports. Recall that every agency chain should generate at least two agency trade reports and every principal-to-principal should generate two dealer trade reports or a single dealer-customer trade report. This implies that if we have cleaned our dataset perfectly, there should be no unmatched agency or interdealer principal-to-principal trade reports. In fact, we are left with 835,426 unmatched agency trade reports, of which 429,578 are sells and 405,848 are buys, and 1,360,771 unmatched interdealer principal-to-principal trades reports, of which 585,407 are sells and 775,364 are buys. (These numbers are not shown in Table B1).

In addition, when we examine when these unmatched trade reports occurred, we find that they occur more frequently at the beginning of the sample period. For example, in August 2002, unmatched agency trade reports are 47% of all agency trade reports, while by August 2006 (near the end of our sample), it is 13%. Likewise, in August 2002, unmatched dealer trades are 27% of all trades, while by August 2006, it is close to 3%.

There are several possible reasons why unmatched reports remain in our data.

1. An unmatched report may represent a trade that occurred, but the other dealer failed to submit her own report.
2. An unmatched report may represent a trade that was modified, cancelled, or reversed, but we cannot identify it as such. For example, Table B1 shows there are 30,724 trade reports marked as reversals that were never matched to an earlier trade.
3. There may be two unmatched reports that describe the same trade. However, because of differences in reporting conventions or mistakes in data entry, the reports do not match.

If we knew why each an unmatched trade report exists, then we could process it appropriately. For example, if a trade report were of type 1, we would like to keep it in our sample. If a trade report were of type 2, we would like to eliminate it from our sample. If there is a group of trade reports of type 3, then one solution would keep all the buy trade reports or keep all the sell trade reports. Unfortunately, we do not know how to distinguish among different types of unmatched trade reports.

Therefore, to check that our results are robust to the various types of possible errors, we construct three different final trade sets: 1) keeping all unmatched agency and interdealer principal-to-principal trades (both buy and sell), 2) dropping all unmatched agency and interdealer principal-to-principal trades (both buy and sell), and 3) we drop all unmatched buy reports in interdealer principal-to-principal trades, drop trade reports that are replicates of agency chains and principal-to-principal trades, and unmatched dealer sells where the difference between execution date and reporting date is greater than 1 day (more than 50% of these trades where 1 day). Table B1 shows that we have dropped 2,196,197 unmatched trade reports between the first sample and third sample.

In the paper, we report estimates using the conservative sample, but we have re-run all estimates in Table 3-11 using the moderate and aggressive samples as well. The results are similar across these three samples and are available upon request.

Constructing the Cleaned Phases Sample

The entire dataset of cleaned bonds is not necessarily useful when evaluating the effect of TRACE. Our empirical strategy is based on comparing a bond's trading behavior when it changes from non-disseminated to disseminated. If a bond does not have both disseminated and non-disseminated trades, it will not be useful for many of our statistical tests. Many bonds are disseminated for their entire trading history. These include bonds that belong to a FINRA Phase that are issued after the beginning of the Phase date, and bonds that may be issued before a Phase begins but only trade after the dissemination change date for that Phase. There are also bonds that are always non-disseminated. These are bonds that may mature before the beginning of their Phase date as well as bonds that belong to a Phase but never trade after the Phase begins.

Table B2 outlines the steps from Academic Cleaned Sample in Table B1 to the Cleaned Phase Sample, the sample of bonds which exist and have zero or non-disseminated trading before the start of a Phase and zero or disseminated trading after the start of a Phase. We begin with a list of all Phase 1, 2, 3A, and 3B bonds. There are 20,713 bonds in this list, of which 20,337 exist in the Cleaned Academic

TRACE Sample. They have 18,390,345 trades during our sample period. Thus, about two-thirds of the bonds in our Cleaned Academic TRACE Sample are in our Phase list and this represents 82.4% of the trades.

For Phases 2, 3A, and 3B, FINRA provided us with a list of bonds that began being disseminated at the start of each of the three Phases. This list was provided in a non-electronic format where bonds were identified with ticker symbols. Unfortunately, many ticker symbols longer than six characters were truncated. This was a problem for firms with a four-character company ticker symbol which also issued bonds with three-character security tickers. In particular, many GMAC bonds were truncated. Since FINRA also provided us with coupon and maturity dates for each bond, we were able to hand-match many of the truncated ticker symbols, but not all. The list of Phase 1 bonds was not provided by FINRA, and we generated it ourselves. If a bond has disseminated trades before the start of Phase 2, and is not part of the Phase 2, 3A, 3B samples or the FINRA50/120 samples, we classify it as a Phase 1 bond.

In addition to the four Phases that correspond to the FINRA dissemination dates, FINRA also maintained two other lists of bonds, which we call the FINRA50 and the FINRA120.[40] The FINRA50 represent 50 Non-Investment Grade (High-Yield) securities disseminated under Fixed Income Pricing System (FIPS2). This list of 50 bonds changes over time with bonds both entering and exiting. FINRA lists all of these bonds on their website and there are a total of 149 bonds that were in the FINRA50 at some point during its existence from July 1, 2002 until July 14, 2004. The FINRA120 list is a special set of 120 investment grade rated Baa/BBB that FINRA delayed Phase 2 dissemination for. Phase 2 dissemination started on March 3, 2003 for Phase 2 bonds but started on April 14, 2003 for the FINRA120. This special sample was created so that FINRA could conduct a controlled experiment to study the effects of dissemination in Phase 2, contained in Goldstein, Hotchkiss, and Sirri (2007).

Table B2 explains how we went from FINRA's list of Phase 2, 3A, and 3B bonds, and our list of Phase 1 bonds, to our Cleaned Phase Sample. For each Phase list, we only use bonds that exist in our Cleaned Academic TRACE Sample. Some bonds on the FINRA lists did not trade during our sample period and thus are not in the Cleaned Academic TRACE Sample. This is shown between lines 1 and 2 under Phases 2, 3A, and 3B.

We next eliminate any bonds that also exist in the FINRA50 or FINRA120 list. Following this, we eliminate bonds that do not exist (i.e., were not issued or matured) during the period 90 days before until 90 days after the start of the Phase. Finally, we dropped some bonds with data problems. There are a few bonds where FINRA report disseminated trades before the start of the Phase, or non-disseminated trades after start of Phase. After applying these steps for each Phase list, what remains is our cleaned sample by Phases. There is a total of 16,854 bonds in our Cleaned Phase Sample representing 15,952,736 trades during our time period.

[40] The list is available at http://www.finra.org/Industry/Compliance/MarketTransparency/TRACE/Announcements/P117685, last accessed March 7, 2019.

Appendix C: NAIC Data

The National Association of Insurance Companies (NAIC) dataset we use is from Mergent FISD available on WRDS. The NAIC requires insurance companies to self-report all securities transactions in their financial statements. There are 63,859 bonds with 1,933,095 reported transactions in the NAIC file over the period January 1, 2000 until December 31, 2006. Schedule D of the annual NAIC filings require insurers to report all bond transactions in one of three categories: bonds added to the portfolio during the calendar year and held through the end of the year, bonds deleted from the portfolio during the calendar year that were not added in the same year, and bonds added and deleted in the same calendar year. For each transaction, the database records the CUSIP, date, par value of the transaction, the actual value of the transaction, if it was an addition or deletion, and a field for the counterparty involved in the transaction. Prices are not reported but can be computed from the ratio of the value received in the transaction to the par value of the bonds in the transaction. Importantly, the names of the insurance companies involved in the transactions are excluded from the data.

To make the NAIC analysis comparable to the TRACE analysis, we first match our sample of NAIC bonds with the Academic TRACE sample by CUSIP. The universe of bonds which insurance companies trade is much larger than that reported by TRACE. 53,030 NAIC bonds representing 1,150,611 reported transactions are not included in our Academic TRACE sample and are eliminated. Table B1 reports the number of transactions and CUSIPs eliminated by this step.

Next, we eliminate reported transactions that are not connected to trades. The NAIC database contains all transactions involving insurance companies' bond portfolios, not only buy and sell transactions, but also other transactions such as bond calls and maturities. The type of transaction is coded in the counterparty field. We eliminate all transactions that change bond portfolio holdings that are not buys or sells. These include the following codes: CALL, CANCEL, CONVERT, EXCHANGE, ISSUE, MATURE, PUT, REDEEM, SINKING FUND, TAX-FREE EXCHANGE, TENDER, TRANSFER, PAYDOWN, and REPLACE.

There are two prevalent entries in the counterparty field comprising almost 15% of the cleaned database that required additional attention: DIRECT and VARIOUS. DIRECT may indicate a direct placement, similar to an underwriting, or it may indicate the name of a counterparty in an actual trade. VARIOUS is simply an ambiguous catch-all, where some records may be actual trades and some are not. To check whether DIRECT and VARIOUS represent actual trades, we matched these NAIC records to TRACE using the CUSIP, price, volume, and date of the transaction. For DIRECT, only about 3% of transactions match into the TRACE dataset, while for VARIOUS only about 1% of transactions match. Because of the problems identifying which of the DIRECT or VARIOUS transactions are actual trades, we eliminate them along with the other codes listed above that are not buys and sells. As shown in Table C1, all such filters eliminate 200,639 reported transactions on 8,588 different bonds.

We eliminate a small number of trades with data issues, i.e. missing prices, negative prices, etc. We next eliminate trades with timing issues, i.e., trades that are executed before or on the bonds' offering or after or on the bonds' maturity date. Finally, a large fraction of NAIC transactions take place on the offering and maturity dates. We believe that this is because insurance companies are large customers of bond offerings and hold many bonds until maturity. The NAIC rules require its members to list purchases as a transaction since the bonds are added to their portfolio. Since these transactions are probably part of the underwriting, we do not include them as trades. If an insurance company holds the bond until its maturity, that transaction will also be recorded by NAIC but we eliminate it. Finally, we also exclude transactions listed on bond holidays. These screens shown in Table C1 are similar to those applied to the TRACE dataset in Table B1.

After the screens and matching, there are 9,997 bonds and 505,753 reported transactions (which we believe to be buys and sells) in our "clean" NAIC sample. Importantly, the NAIC time period in Table C1 is thirty months longer than the TRACE time period in Table B1. When we restrict to the time period July 1, 2002 until December 31, 2006, there are 9,379 bonds and 332,224 transactions, as shown in the last three columns of Table C1.

As mentioned in Appendix A, we believe that many trades in TRACE are disaggregated by the NAIC reporting process. When comparing the NAIC and TRACE databases, there are multiple NAIC transactions that match to a single TRACE trade using CUSIP, date, price and counterparty, but not volume. However, if we group NAIC transactions by CUSIP, date, price and counterparty into a single record with a combined volume, many of these grouped NAIC trades match to a corresponding single trade in TRACE.

There are two reasons that trades are disaggregated in NAIC. The first reason is how NAIC requires transactions to be reported on Schedule D of the annual NAIC filing. Insurers must separately report bonds purchased and sold in the same year from bonds purchased and held through the end of the year. This means if an insurance company purchases $1 million par of a bond on January 1, 2001 and sells $500,000 of this before December 31, 2001 and the remaining $500,000 sometime in the following year, under NAIC reporting instructions, this single purchase would be split into two separate purchases of $500,000 each, reported in two different sections of Schedule D. One $500,000 purchase would be reported in the long-term purchase reporting section, and one $500,000 purchase would be reported in the short-term holding section.

When the NAIC database is compiled, the above trade would appear as two purchases of the same bond occurring on the same day at the same price. In TRACE, however, the dealer who sold the bond would report this as one $1 million trade. If we aggregate the volume of the NAIC trades that occur in the same bond, on the same day, at the same price, the NAIC transaction would match to the TRACE trade, as a single trade. It's worth noting that since the insurance company sold the bond holdings as two separate pieces of $500,000 each on two separate days, two distinct sales of $500,000 would be reported as two sales in both NAIC and TRACE.

A second reason for why a single trade may be reported as multiple trades is that distinct subsidiaries of an insurance company may book portions of a trade to their respective division, and each division makes its own statutory filings to the NAIC. This can occur, for instance, if part of a trade is allocated to the property and casualty group and another portion allocated to the life insurance group. In the NAIC database, this appears as two trades, while in TRACE, it appears as one trade.

We attempt to correct for these two reporting problems by grouping transactions that we believe correspond to the same trade. Any records that share the same date, CUSIP, counterparty, transaction type (buy or sell), and have prices within 1 cent of another are grouped and considered a single trade. We show this grouping in Table C1. In the cleaned NAIC file, from January 1, 2000 to December 31, 2006, the number of trades reduces from 505,753 to 412,758.

Table C1 reports the steps we took to process the raw NAIC file into our cleaned NAIC database. We only use those bonds from the NAIC database that are also in the Cleaned Academic TRACE database for our analysis.[41] Because of the misreporting issue discussed above, Table C1 reports the total number of transactions from the NAIC database in the column labeled "Ungrouped Trades." It also reports an estimate of the true number of trades by grouping transactions with identical CUSIP, date, price, and counterparty into a single record with volume summed for the grouping. These are labeled "Grouped Trades" in a separate column in Table C1. From July 1, 2002 to December 31, 2006, the clean NAIC database contains 9,379 bonds. There are 332,224 ungrouped trades, which correspond to 272,133 grouped trades. This compares to 22,582,689 trades on 30,814 bonds in the Cleaned Academic TRACE database over the same period.

To assign the bonds in NAIC to a TRACE Phase, we simply match the cleaned Phase list from TRACE used in Table B2 to the sample of cleaned NAIC bonds. Table A2 reports the number of NAIC CUSIPs, and both grouped and ungrouped trades in each Phase. Importantly, in Phase 1, we match 366 CUSIPs out of 388 TRACE Phase 1 CUSIPs.

As discussed in Appendix A, grouping trades does not affect our NAIC volume analysis. However, the price standard deviation increases when we group trades. We, therefore, report the analysis of NAIC trades both with and without grouping.

[41] 45,902 bonds in the NAIC database are not in the Cleaned Academic TRACE database. A large fraction of these bonds are SEC Rule 144a bonds. SEC Rule 144A bonds are not covered by TRACE during our sample period.

Table A1. NAIC Results for Trading Activity and Price Standard Deviation

	Number of trades					Price standard deviation				
	90-day mean for disseminated before start of the phase	Table 4 estimate (90-days)	With linear and quadratic trends specific to investment grade for each Phase	Without Phase 1 bonds as controls (in phases 2, 3A and 3B)	Sample matched on size, time to maturity, and years since issuance	90-day mean for disseminated before start of the phase	Table 7 estimate (90-days)	With linear and quadratic trends specific to investment grade for each Phase	Without Phase 1 bonds as controls (in phases 2, 3A and 3B)	Sample matched on size, time to maturity, and years since issuance
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
A. Grouped										
Phase 1	0.301	0.020*	0.018*	0.020*	0.027**	0.560	-0.139	0.035	0.054	0.597
		(0.011)	(0.011)	(0.011)	(0.012)		(0.150)	(0.153)	(0.158)	(0.363)
		6.7%	6.0%	6.7%	9.0%		-24.8%	6.2%	9.6%	106.5%
# of Phase 1 bonds		353	345	353	348		221	221	221	215
# of trades for treated Phase 1		10,618	10,585	10,618	10,599		5,450	5,450	5,450	5,385
# of bond-days for treated Phase 1		43,709	42,717	43,709	43,089		2,002	2,002	2,002	1,976
B. Ungrouped										
Phase 1	0.368	0.024*	0.022	0.024*	0.033**	0.437	-0.085	0.035	0.046	0.391
		(0.014)	(0.014)	(0.014)	(0.016)		(0.111)	(0.109)	(0.114)	(0.257)
		5.5%	5.0%	5.5%	7.6%		-19.5%	8.0%	10.5%	89.5%
# of Phase 1 bonds		353	345	353	348		262	262	262	258
# of trades for treated Phase 1		13,028	12,992	13,028	13,006		9,075	9,075	9,075	9,040
# of bond-days for treated Phase 1		43,705	42,713	43,705	43,085		2,736	2,736	2,736	2,724

Notes: This table reports estimates of Disseminate x Post for number of trades and daily price standard deviation for both grouped and ungrouped trades..
* significant at 10%; ** significant at 5%; *** significant at 1%

Table A2. Comparison of NAIC and TRACE Trading Activity After Phase Start (180 day window)

	Phase 1		Phase 2	Phase 3A	Phase 3B
	90-day after	180-day (only NAIC)	180-day	180-day	180-day
	(1)	(2)	(3)	(4)	(5)
			A. CUSIPs		
CUSIPs					
Phase CUSIPs in Cleaned NAIC Dataset	366	366	2,188	4,729	2,081
Phase CUSIPs in Cleaned TRACE Dataset	388		2,526	11,081	2,859
NAIC CUSIPs / TRACE CUSIPs	94.3%		86.6%	42.7%	72.8%
			B. Trading activity		
Volume					
NAIC volume	15,721,369,392	15,721,369,392	32,369,436,664	32,648,184,927	4,087,866,879
TRACE volume	275,211,550,501		253,914,752,867	485,050,421,819	125,532,896,675
NAIC volume/TRACE volume	5.7%		12.7%	6.7%	3.3%
Trades					
Ungrouped NAIC trades	6,970	6,970	15,239	16,895	3,968
Grouped NAIC trades	5,553	5,553	12,382	13,591	3,213
TRACE trades	404,481		443,402	736,470	101,692
Ungrouped NAIC trades/TRACE trades	1.72%		3.44%	2.29%	3.90%
Grouped NAIC trades/TRACE trades	1.37%		2.79%	1.85%	3.16%
Trade Size					
NAIC Ungrouped Average Trade Size	2,255,577	2,255,577	2,124,118	1,932,417	1,030,208
NAIC Grouped Average Trade Size	2,831,149	2,831,149	2,614,233	2,402,192	1,272,290
TRACE Average Trade Size	680,407		572,651	658,615	1,234,442
NAIC Ungrouped Average/TRACE Average	3.32		3.71	2.93	0.83
NAIC Grouped Average/TRACE Average	4.16		4.57	3.65	1.03
			C. Price standard deviation		
CUSIPs / Bond-Days used					
Ungrouped NAIC	278 / 1,416	278 / 1,416	1,084 / 2,756	1,396 / 3,300	507 / 826
Grouped NAIC	250 / 1,063	250 / 1,063	902 / 1,866	1,061 / 2,085	405 / 577
TRACE	342 / 17,784		2099 / 78,386	3,979 / 106,802	1,373 / 20,631
Price Standard Deviation					
Ungrouped NAIC	0.33	0.33	0.21	0.29	0.17
Grouped NAIC	0.47	0.47	0.33	0.48	0.26
TRACE	0.99		0.87	0.80	0.50
Ungrouped NAIC Std. Dev./TRACE Std. Dev.	0.34		0.25	0.37	0.33
Grouped NAIC Std. Dev./TRACE Std. Dev.	0.48		0.38	0.60	0.51

Notes. This table reports on comparisons between the cleaned NAIC file and the Academic TRACE file for 180 day window for the Phase Start.

Table B1. Steps from Academic TRACE File to Cleaned Academic TRACE Sample

	Affected CUSIPs (1)	Affected trade reports (2)	Remaining trade reports (3)
Source: Academic TRACE File	41,676	37,934,432	
Eliminate bonds based on characteristics			
Bonds unmatched to FISD by CUSIP	2,178	365,504	37,568,928
Convertible bonds	2,154	2,655,202	34,913,726
Exchangeable bonds	129	43,688	34,870,038
Other equity-linked bonds	625	210,005	34,660,033
SEC Rule 144a bonds	4,587	1,287,935	33,372,098
Bonds with missing issue size or issue size < 100,000	345	89,727	33,282,371
Eliminate trades because of self-reported errors			
Modifies: Trade reports matched to earlier report using sequence number	20,732	1,250,351	32,032,020
Modifies: Trade reports not matched to earlier report	0	0	32,032,020
Cancels: Trade reports matched to earlier report using sequence number	22,353	1,013,223	31,018,797
Cancels: Trade reports not matched to earlier report	0	0	31,018,797
Reversals: Trade reports matched to earlier report using nine-way match	21,278	841,108	30,177,689
Reversals: Trade reports matched to earlier report using eight-way match	8,725	87,250	30,090,439
Reversals: Trade reports matched to earlier report using eight-way match (with price rounding to two decimals)	1,137	5,694	30,084,745
Reversals: Trade reports not matched to earlier report	7,440	30,724	30,054,021
Modifying trade reports based on TRACE submission rules			
Add in extra trade reports for Locked-in trades	18,446	523,125	30,577,146
Eliminate trade reports with timing issues			
Trade reports executed earlier than July 1, 2002	956	2,195	30,574,951
Trade reports executed before bond's offering date (i.e., when-issued market)	6,770	291,840	30,283,111
Trade reports executed after bond's maturity date (i.e., bankrupt bonds)	347	93,287	30,189,824
Trade reports that occur on SIFMA holidays	20,775	802,065	29,387,759
Eliminate redundant trade reports			
First pass: Using Original IDs			
Agency chains, exact volume, original buyer-seller IDs	20,486	1,290,607	28,097,152
Agency chains, aggregate volume, original buyer-seller IDs	4,131	57,314	28,039,838
Agency chains, exact volume, original buyer-seller IDs, misreported agency/principal	13,139	176,744	27,863,094
Agency chains, aggregate volume, original buyer-seller IDs, misreported agency/principal	1,008	3,736	27,859,358
Agency chains, exact volume, misreported original contraparty ID	7,725	94,587	27,764,771
Agency chains, aggregate volume, misreported original contraparty ID	1,398	11,241	27,753,530
Interdealer principal-to-principal trade, exact volume, original buyer-seller IDs	26,350	3,713,491	24,040,039
Interdealer principal-to-principal trade, aggregate volume, original buyer-seller IDs	4,509	56,605	23,983,434
Interdealer principal-to-principal trade, exact volume, original buyer-seller IDs, misreported agency trade report	17,430	508,709	23,474,725
Interdealer principal-to-principal trade, aggregate volume, original buyer-seller IDs, misreported agency trade report	1,142	4,867	23,469,858
Interdealer principal-to-principal trade, exact volume, misreported original contraparty ID	17,002	353,622	23,116,236
Interdealer principal-to-principal trade, aggreage volume, misreported original contraparty ID	1,734	10,733	23,105,503

Second pass: Substitute in common dealer ID pairs from misreported original counterparty IDs			
Agency chains with all modifications using substitute IDs	965	2,963	23,102,540
Interdealer principal-to-principal trade with all modifications using substitute IDs	4,146	18,225	23,084,315
Third pass: rounding prices			
Agency chains with all modifications using rounded prices	6,079	246,541	22,837,774
Interdealer principal-to-principal trade with all modifications using rounded prices	15,306	213,864	22,623,910
Fourth pass: truncated prices			
Agency chains with all modifications using truncated prices	1,360	10,117	22,613,793
Interdealer principal-to-principal trade with all modifications using truncated prices	5,108	16,152	22,597,641
Modify or eliminate trade reports with price or volume issues			
Modify prices in trade reports that are vastly out of line	2,569	6,850	22,597,641
Eliminate trade reports with price less than 0.01 percentile and greater than 99.99 percen	284	4,848	22,592,793
Eliminate trade reports with volume less than 0.01 percentile and greater than 99.99 perc	1,564	3,283	22,589,510
Eliminate trade reports with volume/issue amount ≥ 50%	1,868	4,396	22,585,114
Eliminate trade reports with volume less than 1000	693	2,425	22,582,689
Cleaned Academic TRACE Sample keeping all unmatched trade reports	**30,814**	**22,582,689**	
Unmatched dealer buy trade reports	24,916	968,799	21,613,890
Unmatched dealer sell trade reports	21,904	783,012	20,830,878
Unmatched agency trade reports	15,451	444,386	20,386,492
Cleaned Academic TRACE Sample keeping unmatched dealer sell trade reports	**30,728**	**21,613,890**	
			2,196,197
Cleaned Academic TRACE Sample dropping all unmatched trade reports	**30,676**	**20,386,492**	

Notes. Filters are applied sequentially. This table reports the steps from the historical TRACE file to the Clean Historical TRACE file. Other equity-linked bonds have "KNOCK", "REVERSE", "EQUITY", "LINKED", and "TBD" in the bond's FISD issue name. A seven-way match is based on CUSIP, execution date, execution time, price, quantity, buy-sell indicator, and dealer-customer indicator. A six-way match drops the execution time requirement. SIFMA holidays correspond to "Recommended Early Close" and "Recommended Full Close" dates listed at http://www.sifma.org/uploadedfiles/research/statistics/statisticsfiles/misc-us-historical-holiday-market-recommendations-sifma.pdf. In the third pass, prices are rouned to two decimal places. In the fourth pass, prices are truncated to two decimal places. We use the rounded price for all subsequent steps after the fourth pass. We define a price of a trade record to be vastly out of line if the magnitude of difference between the price of that trade record and the volume weighted median of 10 records before and 10 records after is greater than 20 per $100 par and sign of difference before and after are opossite. We require that all the 10 trades to be within the 30 days before and 30 days after. If there are fewer than 10 trades in the 30-day window,

Table B2. Steps from FINRA's Phase Listings to Cleaned Phase Sample

	CUSIPs (1)	Trade records (2)
Cleaned Academic TRACE Sample (after Table B1) keeping all unmatched trade reports	30,814	22,582,689
Source: FINRA list of Phase 1-3B bonds	20,713	-
Bonds on both FINRA Phase list and Cleaned Academic TRACE Sample	20,337	18,390,345
Phase 1		
list of Phase 1 bonds*	464	4,910,313
bonds in FINRA50 at start of phase	3	33,172
bonds do not exist as of start of phase	65	745,749
bonds do not exist for the entire period 90 days before until 90 days after start of phase	8	536
Cleaned Phase 1 Sample	388	4,130,856
Phase 2		
FINRA's list of Phase 2 bonds	3,203	-
Phase 2 bonds in Cleaned Academic TRACE Sample	3,016	3,111,987
bonds in FINRA50 before or at start of phase	0	0
bonds do not exist as of start of phase	265	22,283
bonds do not exist for the entire period 90 days before until 90 days after start of phase	225	155,075
Cleaned Phase 2 Sample	2,526	2,934,629
Phase 3A		
FINRA's list of Phase 3A bonds	13,364	-
Phase 3A bonds in Cleaned Academic TRACE Sample	13,197	8,855,575
bonds in FINRA50 or FINRA120 before or at start of phase	78	651,859
bonds do not exist as of start of phase	969	181,008
bonds do not exist for the entire period 90 days before until 90 days after start of phase	1,069	280,214
Cleaned Phase 3A Sample	11,081	7,742,494
Phase 3B		
FINRA's list of Phase 3B bonds	3,682	-
Phase 3B bonds in Cleaned Academic TRACE Sample	3,660	1,512,470
bonds in FINRA50 or FINRA120 before or at start of phase	26	58,881
bonds do not exist as of start of phase	643	257,195
bonds do not exist during the period 90 days before until 90 days after start of phase	132	51,637
Cleaned Phase 3B Sample	2,859	1,144,757
Total Cleaned Phase 1-3B Sample	**16,854**	**15,952,736**

Notes. This table reports the match between the Cleaned Academic TRACE file and FINRA's Phase Listings. Not all bonds in the TRACE Academic Sample are classified in a FINRA Phase. Excluded bonds are those issued after 7/1/02 that are always disseminated and those that mature before 2/7/05 that are never disseminated. We construct the Phase 1 list by including all bonds with disseminated trades before Phase 2 that are not on the FINRA Phase 2, 3A, or 3B lists. The Phase 2, 3A, and 3B lists were obtained directly from FINRA. The FINRA50 and FINRA120 lists are from www.finra.org. Bonds in FINRA's Phase lists that are not in the Cleaned Academic TRACE Sample have either never traded during the sample period or have been eliminated due to cleaning process in Table A1.

Table C1. Steps from Historical NAIC File to Cleaned Academic Sample

	January 1, 2000 - December 31, 2006			July 1, 2002 - December 31, 2006		
	CUSIPs	Ungrouped trades	Grouped trades	CUSIPs	Ungrouped trades	Grouped trades
Original Source: NAIC Transactions File	63,859	1,933,095	1,490,831	50,968	1,341,769	1,032,125
Match NAIC Bonds with Cleaned Academic TRACE Sample keeping all unmatched trade records						
CUSIP not found in Cleaned Academic TRACE Sample keeping all unmatched trade records	53,030	1,150,611	884,359	40,454	819,448	629,630
Eliminate transactions which are not trades						
Non-trade indicated by counterparty field entry (calls, converts, etc.)	8,588	200,639	145,052	8,124	155,205	106,278
Eliminated trades with timing issues						
Trades executed on or before bond's offering date	3,813	53,580	29,053	2,000	20,474	11,856
Trades executed on or after bond's maturity date	556	1,026	944	556	1,026	944
Trades executed on weekend or SIFMA Holiday	5,086	20,131	17,661	3,789	11,963	10,449
Post July 2002 trades executed on days with no TRACE trades**	4	8	7	4	8	7
Eliminate trades with price and volume issues						
Trades with price less than 0.01 percentile and greater than 99.99 percentile	276	564	376	271	559	371
Trades with volume/issue amount >= 50%	202	472	318	126	294	191
Trades with volume less than 1000	176	311	303	158	270	265
Cleaned NAIC Sample	9,997	505,753	412,758	9,379	332,224	272,133

Notes: Filters are applied sequentially. The CUSIPs column gives total number of CUSIPs eliminated from the database by adding that row's filter. The trades column gives total
number of observations eliminated by adding that row's filter.**On June 11, 2004, the SEC declared a holiday when President Reagan died.
Grouping is done if the difference in Price is <= |0.01| and the day, counterparty, insurer type, and buy or sell are equal.

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