Competition and Exchange Data Fees

Jonathan Brogaard, James Brugler and Dominik Rösch*

Abstract

We investigate how the introduction of market data fees impacts trading and market quality. We find that introducing data fees decreases an exchange's market volume, time with competitive quotes, and visible liquidity, as well as diminishing its role in price discovery. Brokers route their market and limit orders away from the impacted exchange. Market-wide, fee introduction decreases price discovery and liquidity for both small and large orders. The results indicate that data fees alter market participation and that changes to the fees on one exchange can reverberate throughout the stock market.

JEL Codes: G12, G14

Keywords: Data Fees, Exchange Competition, Market Quality

* Brogaard is at the David Eccles School of Business, University of Utah, Email: brogaardj@eccles.utah.edu. Brugler is at the University of Melbourne, Email: james.brugler@unimelb.edu.au. Rösch is at the State University of New York at Buffalo, Email: drosch@buffalo.edu. We are grateful for helpful comments from Jim Angel, Giovanni Cespa, Carole Comerton-Forde, Terry Hendershott, Thomas Marta, Andreas Park, Chester Spatt, Kumar Venkataraman, Sunil Wahal, Zhuo Zhong and seminar participants at the IEX ARC 2020 Conference, Plato Market Innovator (MI3) 2021 Conference, the Eighth Annual SEC Conference on Financial Market Regulation, the 48^{th} Annual European Finance Association Annual Meeting, 2022 WFA Meeting, the Australian National University, Macquarie Business School, the University of Melbourne, the University of New South Wales, the University of Technology Sydney and the University of Western Australia.

1 Introduction

The U.S. Security and Exchange Commission's Regulation National Market System (Reg NMS), and indeed the overall US equity trading environment, are built around two Security Information Processors (SIPs) that ensure transparency and equal access to core market data, i.e., round-lot quotes that determine the national best bid and offer (NBBO) and trade prices and sizes. In contrast, exchanges are monopolistic suppliers of non-core data, such as odd-lot quotes and quotes beyond the best prices, and they offer lower latency access to core data. The sale of this non-core data constitutes a major and growing source of exchange revenue. As a result, the current market structure creates unequal access to information, and, as a result, sophisticated investors willing to pay for non-core data enjoy an informational advantage over those who do not.

This tension has recently ignited debate among exchanges, investors, and regulators over whether current data fees are excessive — and whether the existing definition of core data is outdated. Market regulators now plan to expand the definition of core data, making free some information that is currently sold for a fee.[1] How such a change would affect market quality remains an open and policy-relevant question.

In this paper, we investigate the opposite scenario: how markets react when non-core data that was previously freely available becomes subject to a fee. By studying this mirror image, we can infer how market structure may respond to the proposed reforms. Specifically, we analyze three events in which three US equity exchanges, Arca, Direct Edge, and BATS, introduced fees for previously free non-core data. We employ a difference-in-differences

[1] See European Commission (2021) and SEC (2020).

(DiD) framework, comparing a stock's trading on the fee-introducing exchange (treated) with trading in the same stock across all other exchanges (control) one month prior to the fee announcement and three months following its implementation. As we argue in more detail later, these three events also allow us to empirically test models of how unequal access to price data affects markets (Cespa and Foucault, 2014; Easley, O'Hara, and Yang, 2016).

We begin by examining whether the impacted exchange's market share reacts to data fee changes. When a fee is introduced, traders must decide whether the expected benefit of having access to non-core data outweighs the explicit costs of purchasing it. If the data are sufficiently valuable to all participants, we expect no change in trading volume at the impacted exchange. If some participants choose not to subscribe to the data, we expect that, at the margin, they will be less active on the impacted exchange, resulting in that exchange's volume declining. Using a difference-in-differences design, we find that the fees decrease trading volume by 12–15%. Our results are consistent across each event, and when controlling for stock-venue invariant effects and market-wide trends, and when controlling for stock-day invariant effects. Our results are also robust to using an arguably more exogenous control group: comparing foreign stocks trading in the treated exchange to trading in the international, home-exchange.

Besides decreasing trading volume, the amount of time the fee-introducing exchange has quotes at the national best bid and offer (NBBO) decreases, as do the number of intermarket sweep orders (ISOs) it executes. Consistent with these results, we examine detailed FINRA Rule 606 data on how customer orders are routed, and find that brokers route fewer market and limit orders to the exchange introducing the fee and that the effect is larger in less-sophisticated broker categories.

We next ask whether the decline in market participant trading activity alters liquidity and price discovery on the impacted venue. We capture three types of liquidity: the treated venue's quoted spread, depth, and effective spread. After the data fee introduction, liquidity on the impacted venue deteriorates. The quoted spreads increase by 23–36 basis points (bps), or approximately 9–14% of the average quoted spread on the treated venue, while depth falls by 6–7%. We find the treated venue's effective spread is essentially unchanged. This is not surprising, given we can only measure effective spreads when investors decide to trade at the treated exchange, and traders will only do so when it offers competitive quotes. However, when we decompose the effective spread measure into its price impact component (a proxy for information) and realized spread component (a proxy for intermediary revenue), we observe that both are changing and offsetting each other, which results in the effective spread null effect. The price impact component decreases while the realized spread component weakly increases.[2]

Finding that fee introductions affect the impacted exchange, we next ask whether they have a market-wide effect. If the fee introduction does not translate to wider implications, the argument for regulatory oversight is less obvious. Unlike the analysis so far, our difference-in-differences framework using stock-day-venue observations will not work; the dependent variable is observed at the stock-day level, and all stocks are impacted on the same dates. We thus adjust the specification to analyze market-wide outcomes. Specifically, we divide the sample of stocks into terciles based on market shares on the treated exchange in the pre-announcement period. Arguably, access to exchange data should be more important for

[2]For trades on treated venues, averages of these components are roughly similar in magnitude and are between 20 and 30 bps both before and after treatment. Average price impact on untreated venues is also between 20 and 30 bps, whereas average realized spreads on untreated venues are around 50% larger.

stocks that trade more frequently on that exchange. Accordingly, stocks with market share on the treated exchange that are in the top tercile are "treated," and those in the bottom tercile market share are the "untreated" group. We continue with a difference-in-differences framework, but this alternative measure of treatment allows for a market-wide evaluation. Put another way, we focus again on liquidity and price discovery, but now at the market-wide level.

As a validity check on our treatment vs. untreated categorization, we first show that fee introductions have a greater impact on trading for stocks with higher pre-announcement market shares. In this case, market-wide spreads increase slightly, depth declines, fewer larger orders are submitted according to SEC Rule 605 data, and the overall price process is less efficient, as measured by high-frequency volatility and the Hasbrouck pricing error. These effects suggest that at least part of the information previously impounded into prices at the affected venue is lost and not simply transferred to other venues. Overall, we show that one exchange's data fees can erode market-wide market quality and reduce liquidity for large orders.

Although the fees we study are modest in absolute size, they represent an infinite percentage increase, from zero to a positive price. As Shampanier, Mazar, and Ariely (2007) noted, "zero pricing of a good not only decreases its cost, but also adds to its benefits." Thus, even small fees can substantially alter participation for smaller investors. Many such investors may also forgo access simply due to inertia: before the fee, non-core data was available by default, whereas afterwards it is not. Small investors are unlikely to subscribe to data services directly; instead, their access typically comes through brokers, which dis-

appears once the fee is introduced unless clients actively opt in to pay the fee.[3] Larger and more sophisticated market participants, however, are both aware of such changes and more willing to pay for continued access. Exchanges that introduce market fees, therefore, drive a wedge between sophisticated participants willing to pay the fee and others — and create unequal access to price data.

Our findings contribute new causal evidence to the growing literature on exchange data fees and market design. Theoretical models suggest that increasing data fees can reduce market quality by relaxing competition among liquidity providers and weakening price discovery. For example, Cespa and Foucault (2014) show that higher data fees reduce incentives for informed trading and, subsequently, worsen liquidity. Easley et al. (2016) predict that, when data access becomes costly, "price-informed" traders benefit at the expense of "price-uninformed" ones, which increases volatility and cost of capital and discourages fundamental research. Our evidence, showing that both liquidity and price efficiency deteriorate following the introduction of data fees, is consistent with these theoretical predictions.[4]

The importance of non-core data for price discovery, particularly odd-lot quotes (Bartlett, McCrary, and O'Hara, 2023), makes our events closely aligned with the theoretical setting of Easley et al. (2016), in which only "price-informed" traders observe the price. Yet, our empirical setting differs in an important way: we show that the theoretical insights for the one venue setting also hold for the multiple trading venue setting. This finding is not obvious; investors might just move from one exchange to another. Our market-wide findings indicate

[3]For instance, Interactive Brokers (an important retail broker) released a statement on Arca's market data fee noting that "fees will be charged pending SEC approval. Currently this service is free of charge." (Interactive Brokers, 2006).

[4]For related analyses of exchange competition and design, see Foucault and Menkveld (2008), Ramos and von Thadden (2008), Pagnotta and Philippon (2018), and Budish, Lee, and Shim (2024).

the opposite and addresses questions about the competitiveness of the US exchange market.

Empirical studies have reached mixed conclusions about how much comeptition there is in the market for market data. Hendershott and Jones (2005) find that removing market data for three ETFs trading on Island ECN sharply reduces volume, particularly among liquidity traders. Jones (2018) argues that market data costs are small industry-wide and that data markets are characterized by "robust competition." Conversely, Brannon and Jennings (2019) show that exchanges can raise data fees and increase revenues, and Glosten (2020) argue that data products are complements across venues, limiting competitive constraints. Spatt (2020) discusses how cross-subsidization and tiered pricing reduce exchange competitiveness. Finally, Hendershott, Rysman, and Schwabe (2025) show that the NYSE gained market share after launching its Integrated Feed, suggesting that enhanced data availability benefits all traders, not just subscribers.

Our events differ from general fee increases because we can clearly identify a discreet change in access to data. Our events are also different from the events examined in Hendershott, Rysman, and Schwabe (2025) and other previously studied events around access to market data. For example, Boehmer, Saar, and Yu (2005) investigate how markets react to the initial availability of non-core data for a fee. These events capture changes in pre-trade transparency rather than differential access to price information.

We add to the literature by providing a well-identified analysis of how data fees affect both exchange-level and market-wide outcomes. Our results show that traders are sensitive to data fees, as reflected in lower market share for fee-imposing venues and deterioration in liquidity and price discovery both locally and system-wide. These findings demonstrate that unequal data access, even when self-selected, has significant implications for market

performance. Taken together, our evidence suggests that expanding the definition of core data, and thereby restoring equal access, would likely improve overall market quality.

2 Data fee introductions, data, and methodology

This section describes our three data-fee-introduction events, the data and construction of variables, and the methodology we use.

2.1 Three data fee introductions

Exchange fees for non-core data are complex and change frequently.[5] As such, different market participants face different total costs for market data, and it is difficult to summarize the average cost of market data. Instead, we study three events in which exchanges introduce fees for the first time. These events are advantageous because we can clearly identify moments when the cost of market data unambiguously increases for all market participants without a change in pre-trade information (compared with the first time that "non-core" data become available for a fee, as studied in Boehmer et al., 2005). Our events also took place after the 2005 introduction of Reg NMS, which introduced the concept of core- and non-core data.[6]

Our first event is the introduction of fees for order book information by Arca ("Arca-book") on January 1, 2009 (SEC, 2015, p.6). As early as 2006, this exchange filed with the SEC to establish fees for ArcaBook (SEC, 2008b). The filing was subsequently approved in December 2008. These initial fees included a $750 per month access fee, a monthly fee of $15 per device for professional subscribers for ETFs and equities data governed by the CTA

[5]For example, see https://www.nasdaqtrader.com/Trader.aspx?id=Global_Market_Data or https://www.nyse.com/market-data for a list of the products offered by NASDAQ and NYSE, respectively.

[6]For an in-depth discussion of core and non-core data, see Sections 3 of Hendershott et al. (2025) and V.A of SEC (2008a).

Plan, and $15 per device and month for data covering other equities securities governed by the Nasdaq UTP plan. For non-professional subscribers, the monthly fees per device were $5 for both categories.[7]

The second event is the introduction of fees for order book data on the Direct Edge EDGX exchange ("EDGX Book Feed"). This product contains information on all displayed orders, executions, and order modifications, and Direct Edge initially provided free of charge to all member firms. On February 22, 2012, Direct Edge announced the introduction of monthly fees of $500 for internal use and $2,500 for users wishing to distribute the feed externally (DirectEdge, 2012a,b). Implementation of the fees took place on May 1, 2012 (SEC, 2012a, p. 3).

Our final event is the introduction of market data fees by BATS exchange on July 1, 2013 (SEC, 2013b,c, pp.1-2). The "BATS PITCH" fee structure initially comprised a total charge of $1,500 per month for depth of book data for internal use only, covering both the BZX and BYZ exchange (Reuters, 2013). It was announced on April 2, 2013 (BATS, 2013).[8] For top-of-book and last-sale data, these fees total $1,000 across both sub-exchanges. For firms wishing to distribute the data externally, the total monthly costs was set at $7,500 for depth-of-book data and $5,000 for top-of-book and last-sale data.[9]

[7]Though these fees might seem small, "The reasonably projected revenues from the proposed fees for NYSE Arca's non-core data are $8 million per year." (SEC, 2008b, p.5).

[8]EDGX and BATS merged in 2014, and CBOE acquired BATS in 2017. During our sample period, EDGX and BATS were not part of a larger exchange family. For the first event (Arca), we investigate the effect at the exchange-family level in subsequent robustness tests.

[9]Differences in available data across our three events are marginal. In all cases, exchanges provide data of their limit order book; the main difference is whether the data are aggregated (Arcabook, BATS PITCH) or at an order-by-order level (EDGX Book Feed). According to Arca, ArcaBook contains "a compilation of all limit orders resident in the NYSE Arca limit order book" (SEC, 2008a, p. 7) and BATS states that BATS PITCH contains "depth of book quotations" (SEC, 2013b, p. 3). On the other hand, EDGX states that "EDGX Book Feed ... includ[es] ... order executions, order cancellations, order modifications, order identification numbers and administrative messages" (SEC, 2012a, p. 2). Further, exchanges in all cases charge per user fees, and these fees, in general, are passed through to clients. See Interactive Brokers (2006).

To ensure our results are not contaminated by other rule changes, we looked through all SEC filings for relevant changes around our events. We do not find any such relevant changes.[10,11]

2.2 Data

Data for our analysis are obtained from the NYSE Trade and Quote (TAQ) database. The TAQ data contain trades and quotes for all securities listed on the NYSE, Nasdaq, and other US exchanges. Using the TAQ data, we calculate a set of liquidity and trading activity variables at the stock-day level separately for the exchange introducing the fee and for all other trading venues. The sample includes all common stocks (SHRCD = 10 or SHRCD = 11) that are listed on the NYSE or Nasdaq and that have a closing price of above USD 5 at least once.

Our sample period consists of three event windows. For ARCA, we consider the one month before and the three months after the implementation of the data-fees. For the other two events, we consider the one month preceding the announcement of the data-fee introduction and the three months following its implementation. In total we have 249 trading days. We choose to focus on the periods before announcement and after implementation

[10] Judging the potential impact of a filing is complicated. For example, Direct Edge, on the event date we study (May 1, 2012), also filed to change its fee structure. Direct Edge wrote, "The Exchange proposes to amend Flag N so that it only applies to orders that remove liquidity from the EDGX book in Tape C securities." Direct Edge also wrote that it "proposes to add Flag BB for orders that remove liquidity from the EDGX book in Tape B securities." Given that, "Currently, Flag N is yielded when an order removes liquidity from the EDGX book in Tapes B or C securities." There seems to be no change in the fee (the amount stayed the same) but rather just a change in the flags. See SEC (2012b), page 3.

[11] We also look carefully to determine whether there were any maker-taker fee changes around our events. To locate any potential confounding changes at the trading venues, we look at SEC filings from Arca, Direct Edge, and BATS during our event window that mention "maker," "taker," or "rebate." Of the 41 filings, only one is linked to a change in the maker-taker fees; on March 5, 2009, Arca increased both maker rebates and taker fees by 0.01 cents. Most other filings are relevant for options only, for example, introduction of a new investor tier and a restriction of rebates by the message-to-trade ratio.

to ensure that our analysis is not affected by changes in order-routing decisions by traders anticipating the introduction of fee introduction. We use a one-month pre-announcement window to exclude the most severe months of the Global Financial Crisis (surrounding the bankruptcy of Lehman Brothers in September 2008) while retaining roughly equal sample sizes for each event.[12] Our three-month post-implementation windows allow sufficient time for the effects of data fees to manifest in the market while avoiding subsequent confounding factors, such as changes in trading fees, technology or market structure, e.g., the merger between in BATS and Direct Edge. For the Arca fee introduction, we use the implementation date as the announcement date due to the substantial regulatory and legal processes occurring over the period from the initial filing in 2006 to the implementation date in 2009.

The set of variables we analyze include the log dollar volume traded, the log dollar volume traded via ISOs, the time at NBBO, the average percent effective spread, percent realized spread, and percent price impact across trades.[13] Appendix Table 1 contains detailed descriptions of all variables. For all variables, we estimate one value using trades and quotes on the venue introducing the market fee (the "treated" venue) and another using trades and quotes across all other trading venues. In other words, during the three specific event windows, Arca, Direct Edge, and BATS (exchange codes P, K, and Z), are the treated exchanges, separately, and all other exchanges serve as controls.

To estimate the time each venue quotes prices at the NBBO, we estimate the NBBO following Holden and Jacobsen (2014) and compare the NBBO each second to the quotes of the exchange. If the bid and the ask are equal to the national best bid and ask prices,

[12] We also find that our results are generally robust to using equally-sized windows prior to the announcement date and after the implementation date (see the Internet Appendix available for download here).

[13] ISO dollar volume is computed across all trades with a condition containing "F" in the TAQ database.

the time at NBBO for that second takes the value of one, and zero otherwise. We sum up the time at NBBO over the continuous trading session.[14] Note, that when using the time at NBBO we only have one observation per stock-day for the treated exchange. The time that the other exchanges quote at the NBBO (and the treated exchange is not) is then automatically given by 6.5 hours minus the seconds the treated exchange quotes at NBBO prices.

Trade-level effective spreads, realized spreads, and price impacts are computed at five minute horizons with trade directions assigned according to the Lee and Ready (1991) algorithm. For each variable defined at the trade-level, the stock-day value is the average across all trades in treated and untreated venues respectively.[15] To limit the effect of outliers on our results, we split our sample into categories based on whether or not the trade takes place in the pre or post-event window, and whether trades take place on treated or untreated venues. Then, for each of the four categories, we winsorize each variable at the 1% and 99% level. Stocks with insufficient trading data to calculate our activity and liquidity variables are excluded from the final sample. Our final sample consists of 3,061, 2,809, and 2,788 stocks for each event. In total, our sample includes 3,646 unique stocks that, during our

[14] Multiple exchanges can be at the NBBO at the same time, since different venues may simultaneously post identical best bid and offer prices. To account for this, we measure the time that the treated exchange is at the NBBO, whether exclusively or jointly with other exchanges. The total time across treated and non-treated venues can therefore exceed the 6.5-hour trading day by the duration in which they are both at the NBBO. Our definition of "time at NBBO for the treated exchange" thus includes both exclusive and joint participation. We focus on this aggregate measure to avoid mechanically inducing negative correlation in a difference-in-differences framework, which would otherwise exaggerate the estimated treatment effect. We also exclude stock-days where the continuous trading session is less than 6.5 hours.

[15] We gratefully use the code provided by Craig Holden and Stacey Jacobsen to calculate each of our variables, as described in Holden and Jacobsen (2014), with slight modifications to separate estimation into different venues.

sample period, trade on the treated as well as the untreated venues.[16]

2.3 Summary statistics

Table 1 presents stock-day summary statistics for our sample for trades on the exchange introducing the fee (treated) and all other venues (untreated). Panel A contains averages across stock-days for trading on the treated exchanges, and Panel B contains averages across stock-days on the untreated venues.[17]

Table 1 about here

Average log dollar volume traded is 12.4 on treated exchanges and 14.6 on untreated venues. Log volume declines by approximately 0.12 for treated venues from the pre-announcement to post-implementation periods and is unchanged for non-treated venues. Treated trading activity is approximately 11% of total volume, averaged across all stock-venue-days ($4.1m of trades on the treated exchange compared with $33.9m on other venues).[18]

Displayed liquidity is lower on treated exchanges compared with non-treated exchanges (average treated quoted spreads are 2.7% vs. 0.9% for non-treated exchanges), which is expected, as the latter category combines liquidity across multiple venues, while the former may not have active markets in all securities. In contrast, the average effective spread for

[16] To illustrate how we define our variables, BATS announced the introduction of data fees on April 2, 2013. The fee was implemented on July 1, 2013. For each stock and trading day in the month before the announcement date and for the three months after the implementation date, we compute each variable using only trades and quotes on BATS; we also use only trades and quotes on other trading venues excluding BATS. The stock-day trading activity or simple average of liquidity variables on BATS is our treated observation, and the same variables using trades and quotes from other venues is the untreated observation.

[17] Summary statistics by event and with a three-month pre-event window are presented in Tables IA.1 to IA.4 in the Internet Appendix.

[18] Average dollar volumes traded are significantly larger than the respective exponentials of average log dollar volumes due to Jensen's Inequality.

trades executed on treated exchange is 49bps vs. 67bps on all other venues, which may reflect that these venues attract more orders when overall liquidity is good. Trades have similar average price impact across treated and untreated, though realized spreads are (necessarily) higher in non-treated venues.

Effective spreads, realized spreads, and price impact all decline after fee implementation on both venue categories. Quoted spreads rise on treated exchanges by approximately 15bps vs. a fall of 6bps on non-treated exchanges. Treated log dollar depth falls by 0.04 on treated exchanges vs. an increase of 0.01 on non-treated exchanges.

2.4 Methodology

We use a difference-in-differences approach to identify the effect of fees for order book information on trading volumes. Our strategy treats the introduction of fees as quasi-natural experiments that exogenously raise the price for order-book information on one exchange but not others. For each of our three events, we construct a sample of the following: a) stock-day observations of log dollar volume (total and split into ISO and non-ISO volume); b) time at NBBO (seconds with both the ask and the bid price at NBBO) for the venue introducing the fee; and c) a sample of stock-day observations for all other venues where the stock is traded. We assign stock-days on the venue introducing fees as the treated group and stock-days on all other venues as the untreated group.

We use two different key specifications. The first specification is:

$$y_{ijt} = \beta \, Treat_j \times Post_t + \psi \, Treat_j + \theta_{it} + \varepsilon_{ijt}, \tag{1}$$

where y_{ijt} is the trading activity or market quality variable for stock i on venue j (either the treated or untreated exchange) and date t. $Treat_j$ is an indicator variable taking the value one for trades taking place on the treated exchanges and zero otherwise.[19] $Post_t$ is an indicator variable taking the value one if the date is within three months after the fee introduction for venue j and zero otherwise. θ_{it} fixed effect for each stock-day. The parameter β identifies the effect of the fee introduction. In Equation (1), we control for unobserved stock-day effects and for time-invariant differences between the venues using stock-day (θ_{it}) and venue ($Treat_j$) fixed effects, respectively. Therefore, β captures time-varying venue-specific changes, while controlling for stock-day variation.

The second specification includes stock-venue and day fixed effects:

$$y_{ijt} = \beta\, Treat_j \times Post_t + \theta_{ij} + \gamma_t + \varepsilon_{ijt}, \tag{2}$$

where $Treat_j$ and $Post_t$ are defined as per Equation (1). θ_{ij} is a stock-venue fixed effect, γ_t is a daily fixed effect. The key parameter of interest is β, which again captures the effect of the fee introduction on the trading activity or market quality variable for trading on the treated exchange relative to the untreated venues. In Equation (2), our fixed effect approach captures the stock-venue invariant effect. That is, we control for the variation that exists across stock-venues. The day-fixed effects capture market-wide differences that affect all stock-venue pairs. Recall that the unit of observation is at the stock-day-venue level. Thus,

[19] In regressions in which we pool all three events together, a venue only takes the value $Treat_j = 1$ during the window around the announcement and implementation of its fee introduction. For example, Direct Edge will have $Treat_j = 1$ starting one month prior to the fee announcement date, February 22, 2012, until three months after its implementation on May 1, 2012. All other dates, the Direct Edge data would be part of the group making up $Treat_j = 0$.

this specification corresponds to the typical finance difference-in-differences regression, fixed effects structure, where our unit dimension is the stock-venue (instead of the more standard, firm) and our time dimension is the day.[20]

We estimate all regressions using standard errors, clustered at the stock-venue level, that are robust to any form of error dependence within stock-venue pairs or stock-event pairs.

3 Market participants' response to data fees

We test how traders respond to the fee introductions by examining log dollar value traded on treated exchanges vs. other exchanges using difference-in-differences regressions. We do so based on the methodology discussed in Section 2.4. Results from these differences-in-differences regressions, estimated separately for each event, are in Panel A of Table 2. Columns (1), (3) and (5) refer to the treatment effect estimated using stock-day fixed effects; Columns (2), (4) and (6) refer to the model estimated using stock-venue and date fixed effects.

Table 2 about here

The point estimates for the effect of fee introduction on log volume in Table 2 are highly consistent across events specifications. After introducing fees, venues lose 12–15% of their existing volume, averaged across stocks, relative to venues that do not introduce fees.[21] The effect is highly statistically significant. In terms of dollar value, a 12–15% fall corresponds to about \$500,000 to \$620,000 less daily volume for the average stock on the treated venues in the sample, or \$34,000 to \$42,000 for the median stock.[22] Compared to average

[20] Note that the $Treat_j$ indicator is excluded from Equation (2) as it is co-linear with the stock-venue fixed effects.

[21] Because the dependent variable is in logs, the treatment effect approximates percentage changes in volumes.

[22] As noted in Section 2.3, average dollar volume traded on treated (untreated) exchanges is \$4.15m (\$33.9m).

pre-announcement market shares of treated exchanges (11.6%, see Table 1), a 12–15% drop in relative volume on treated exchanges corresponds to a 1.4 to 1.7 percentage point fall in market share, which is similar to the change in average treated market share after implementation (-1.3 percentage points to 10.3%). Using three-month pre-event windows generates very similar estimates (see Table IA.5 in the Internet Appendix).

Taken at face value, our estimates demonstrate that some market participants shun the treated venue, either by routing their orders to other venues or by not trading at all. For example, small traders that lose access to non-core data suddenly lose access to odd lot quotes. The loss in the visibility of odd-lot quotes significantly worsens prices small traders see (Bartlett et al., 2023), and, given that traders trade more if prices are better, they will trade less after the fee introduction, especially at the fee introducing venue.

The magnitude of the effect may seem large relative to the magnitudes of the fees that are introduced. We believe the size of the effect reflects the presence of strong non-linear equilibrium effects, as per Foucault, Pagano, and Röell (2013) and Farboodi, Singal, Veldkamp, and Venkateswaran (2025). For example, the loss of small (likely uninformed) traders at the treated venue decreases liquidity, but liquidity exerts a "gravitational" effect (Foucault et al., 2013). The initial loss in market liquidity will cause other traders to also shun the treated venue.

Empirically, finding such large responses to relatively small changes is not uncommon. For example, Bessembinder, Hao, and Zheng (2020) find that increasing Designated Market Maker (DMM) incentives to provide liquidity by merely USD 1,000 per month leads to a decrease in quoted and effective spreads of almost 10% (0.81 and 0.74 bps, p.59 and p.62,

respectively).[23] The policy change studied in Bessembinder et al. (2020) directly affects only one market participant per stock, whereas the market data fees affect all participants. Furthermore, zero pricing can induce consumers to place higher value on a product than they would in the presence of small, non-zero costs (Shampanier et al., 2007; Iizuka and Shigeoka, 2022), potentially exacerbating the effects of data fee introductions.

To ensure the results are not contaminated by empirical concerns, we rule out a number of alternative explanations. Specifically, we consider the effects of reverse causality, spillover effects, and omitted confounders.

3.1 Reverse causality

In general, our estimates rely on the assumption that absent the treatment, trading volume on the treated exchange would have developed equally as on the non-treated exchanges, the so-called parallel trend assumption. While empirically untestable, a common way is to investigate differences in trends pre-treatment.

Data fees are set strategically by the exchange, and it is possible that fees are introduced in a way that invalidates this assumption. For example, exchanges may offer free data to build market share and then begin charging for data when market share begins to plateau or fall (with any eye toward offsetting the decline in its trading revenue).[24] In this case, the introduction of fees coincides with a reduction of trading volume on the treated exchange that are not driven by the fee itself. In other words, instead of fees reducing trading volumes,

[23] On p.46, Bessembinder et al. (2020) elaborate that DMMs receive rebates of "\$0.0035 per share when supplying liquidity to trades in less active securities [i.e., trading volume less than 1 million shares], whereas . . . the rebate for suppling [sic] liquidity in more active securities ranged from \$0.0025 to \$0.0030 per share." In other words, at the threshold, incentives increase by less than USD 1,000 ($= 1,000,000 \times (0.0035 - 0.0025)$ per month.

[24] We thank an anonymous referee for this description of the possible data fee–setting decision by an exchange.

lower trading volumes might increase fees, a case of reverse causality that would violate parallel trends.

We test for such an effect following the methodology of Rambachan and Roth (2023) and estimate a dynamic difference-in-difference regression. We estimate treatment effects of fee introduction on the log volume traded on the treated venues separately for each business day in the pre- and post-treatment periods. Figure 1 presents the results. The day-zero reference period corresponds to the business day prior to fee announcement. Before the treatment, most estimates are positive and/or are statistically not different from zero, with little evidence of a consistent trend in either direction. After the event, all treatment effects point estimates are negative, and the vast majority are statistically significantly different from zero, indicating that trading volume on the treated exchange dropped compared to the control. These results are highly consistent across events and support the parallel-trend assumption.

Figure 1 about here

Figure 1 further demonstrates that the size of the effect of fees on market share accumulates over time, especially during the first four weeks after introduction. This accumulation over time is consistent with the presence of gravitational or positive feedback effects, whereby market participants learn about the effect of fees on venue-level liquidity over time, and it further decreases the incentives to route orders to the venue. We further note that the effect of fees on volume is economically and statistically significant within one week following fee introduction (see Table IA.6 in the Internet Appendix for a formal test) and so is not affected by additional regulatory filings by Direct Edge approximately one month after fee

introduction.

Parallel trends could hold in the pre-announcement period but fail to hold in the post-implementation period. The fact that volume evolves in similar ways for each event is important because exchanges face uncertain waiting times between notifying their intention to introduce market data fees and receiving approval. The gaps between announcement and implementation therefore act as a quasi-random component — driven by the regulatory process — that is plausibly uncorrelated with expected future trading volume. For Arca, this gap is more than two years; for Direct Edge and BATS, the gaps are two-and-a-half and three months respectively. In each case, implementation follows very shortly after SEC approval is given (SEC, 2008b, 2012a, 2013a).

Because of the large gap for Arca, in our main analysis, we use an event window around the implementation date. To address pre-trend concerns, we can also investigate trading around the announcement date. We find a strong positive trend before announcement, which largely continues in the post-announcement period (see Figure IA.1). This is inconsistent with fees being introduced to deal with expected falling trading revenue.

3.2 Spillovers

The estimates presented so far capture both the average market share drop on the treated exchange by stock as well as any resultant increase in market share on the untreated exchanges (e.g., if traders migrate from the treated exchange to control exchanges due to the fee). This spillover effect will increase the magnitude of our coefficients; and the point estimates of Table 2 will be larger than the drop in the treated exchange market share by some amount since they capture the percentage drop on the treated venue and rise on other

venues.[25] In this case, spillovers are also caused by the treatment, and whether one should focus on estimating only direct or total (i.e., including spillovers) effects is largely a matter of research focus and the question of interest. Spillovers can also occur in less obvious ways, not caused by the treatment. If, as before, trading volume at the treated exchange exogenously declines because market share declines, trading volume in the control exchange increases by the same amount, which is also a spillover effect.

To estimate potential spillover effects, we examine trading volumes in American Depository Receipts and the underlying shares listed in the international market where the company is listed.[26] Trading is reasonably segmented across these markets, often leading to price pressure in one and deviations from the law of one price across both markets (Rösch, 2021). Because trading is reasonably segmented, spillovers should only marginally influence the results when we compare ADRs trading on the treated exchange and ADRs trading in the international market. Therefore, if spillovers were material, we should observe different estimates for the effects of fees on ADR trading volume when the control group is the same ADR traded on non-treated US exchanges compared to when the control group is the underlying stock traded in the international market. In general, stocks traded in international markets are likely much less affected by the treatment.

Table 3 re-estimates our main regressions described in Equations (1) and (2) for these

[25] For example, consider a stock of which the treated exchange trades 15 shares on average and all other venues trade 85 shares. Suppose also that the fall in shares traded on the treated exchange trades exactly equals the rise in shares traded on untreated exchanges. A difference-in-differences in log volume of 15% corresponds to approximately 1.8 fewer (more) shares traded on the treated (untreated) exchange, or a 12% drop in pre-event volume on the treated exchange.

[26] We obtain the ISINs of all American Depository Receipts (ADRs, share codes 12, 13, 15) and foreign shares (share codes 30, 31, 32) listed in the US from CRSP, and, for simplicity, refer to both as ADRs. Each ADR is then matched to its underlying share traded in international markets using the Deutsche Bank DR Directory (adr.db.com). For the international shares, we construct daily trading volume in USD from Datastream by multiplying the end-of-day USD closing price (`close_usd`) by the number of shares traded (`volume`).

samples. In Panel A, all details are the same as the main effects in Table 2, other than the sample, which focuses only on ADRs traded in the US (treated vs. non-treated exchanges). Despite the reduction in sample size, we still detect economically and statistically significant reductions in volume for the treated exchange vs. non-treated US exchanges in four of the six specifications at the 10% level or better. Moreover, the magnitudes of the effects are comparable to results using all listed US equities (Table 2).

In Panel B, we conduct the same tests, but now the control group is trading in the underlying stock of the ADR in the international market where it is listed. The point estimates for the change in volume are highly similar or even larger in magnitude in Panel B. This is the opposite of what we would find if spillovers are materially affecting our results.

Table 3 about here

3.3 Omitted confounders

The estimates being highly consistent when estimated independently for each of the three events (Table 2) helps alleviate concerns of an unobserved confounder.[27] Also, both the estimated R^2 and the point estimate are similar across different specifications, indicating that our results are likely not driven by omitted variables (Oster, 2019).

[27]For the first event, the exchange introducing the fee (Arca) is part of the NYSE exchange-family. Table IA.7 in the Internet Appendix presents estimates for the treatment effect for this event on log volume at the exchange-family level. These results, which correspond to the average fall in exchange-family log volume across all stocks traded on NYSE or Arca, are consistent with the effect using Arca volume only.

3.4 Types of trading volume

We next consider how fees affect different *types* of volume traded on the treated exchanges. The presence of Reg NMS means that market orders must be routed to the exchange with the best prices, i.e., the NBBO as established by core-data. However, traders have full discretion over where they submit limit orders and intermarket sweep orders. Market shares could fall because exchanges attract fewer limit orders after fees (and so spend less time at the NBBO and have fewer market orders routed to it) or because they attract fewer ISOs. As our main results across exchanges are highly consistent, we pool samples across the three events and report the pooled results for most of the remaining analysis. We include per-event estimates for all relevant specifications in the Internet Appendix.

In Table 4, we first estimate our pooled treatment effects using the entire sample of US equities. Columns (1) and (2) report a 13–15% fall in market share for treated exchanges, consistent with estimates before.

Table 4 about here

In columns (3), (4), and (5) of Table 4, we estimate potential components of trading volume that lead to the fee introduction's effect on trading activity. Columns (3) and (4) estimate the differences-in-differences regressions explaining log dollar value; this is similar to columns (1) and (2), but we now also distinguish between ISO and non-ISO trades using an indicator variable. In other words, instead of explaining the dollar value of the treated versus the untreated exchange, given by y_{ijt} in Equations (1) and (2), we explain $y_{ijt,ISO}$ with ISO equal to zero or one if $y_{ijt,ISO}$ refers to, respectively, the non-ISO or ISO dollar value of stock

i in exchange j on day t. To ensure that our estimates indicate changes in trading volume specific to ISO and non-ISO trades, in this case we create fixed effects at the stock-day-volume category (ISO vs. non-ISO) or the stock-venue-volume category level for Equations (1) and (2) respectively.

The interaction, $Treat \times Post$, indicates a drop in the dollar value of non-ISO trades of around 12.5% to 14.6%. The triple interaction term, $Treat \times Post \times ISO$, captures the incremental effect of the treatment on ISO trades. Both specifications indicate a further drop in the dollar value of ISO trades of around 2.2% to 2.4%, which is statistically significant at the 1% level. In other words, regressions in columns (3) and (4) indicate that fees affect the market share of ISO trades more than non-ISO trades.

Column (5) of Table 4 estimates the effect of the treatment on the time the treated exchange quotes prices at the NBBO. Because we only have one observation per stock-day, we cannot include day fixed effects. Results indicate that the treatment causes a drop in the time an exchange is at NBBO of around 17%.[28]

3.5 Broker routing decisions

We are interested in explaining why market share of the treated exchange drops after the event. One potential reason is that brokers avoid the treated exchange and instead route (when allowed) market orders or limit orders to competing exchanges.[29]

Rule 606 filings require brokers to report the fraction of their non-directed orders (i.e., the

[28] Results with a three-month pre-event window are presented in Table IA.8 in the Internet Appendix and are highly consistent with Table 4.

[29] A growing literature suggests that brokers may make routing decisions that are in their best interest, and not necessarily their clients'. (Battalio et al., 2016; Cimon, 2020; Anand et al., 2021) Some brokers may have been unwilling to pay the data fee (presumably those who decreased their volume at the impacted exchange, as they would bear the expense but the client would realize the benefit).

customer did not specify a trading venue) routed to different exchanges, and the percentage of these orders that are market orders, limit orders (with no distinction between marketable and nonmarketable), and other orders. We download filings for all 146 available brokers one quarter before the announcement and one quarter after the implementation of the market data fee from vrs.vista-one-solutions.com.[30]

We estimate the average percentage of market and limit orders before and after the event routed to any of the three treated venues and calculate the difference in both. Similar to when using the time at NBBO, Rule 606 data only report percentages of orders routed to specific venues and so the Rule 606 data aggregates to one when measured across all venues. Therefore, we cannot estimate panel regressions with day fixed effects.

Table 5 reports the results. Panel A of Table 5 estimates the average across all brokers that routed any orders to a treated venue before the event. On average, 7.8% of market orders and 9.2% of limit orders are routed to a treated venue before the event, i.e., in the last quarter of 2008 to Arca, in the last quarter of 2011 to Direct Edge, and in the first quarter of 2013 to BATS. This average drops to 5.5% and 7.5% after the event for market and limit orders, respectively. With a t-statistic of -2.07, the difference for market orders is statistically significant.

Table 5 about here

Panel B estimates the average across brokers that routed limit orders to a treated venue before the event, which limits the number of available brokers to 17. Using this subsample,

[30] We drop from our analysis brokers that did not route any orders to the treated exchange in the pre-event period.

we find that the drop in both market and limit orders is about 5% larger (from 16% to 11% for market orders and from 19% to 14% for limit orders) and statistically significant, with a t-statistic of -2.08 and -1.77, respectively.

The drop in market orders in Table 5 could be mechanically related to the fact that the treated exchange quotes less time at the NBBO (see Table 4), and, given brokers' obligations for best execution (Reg NMS), the percentage of orders routed to the treated exchange should fall. The drop in limit orders cannot be explained by any mechanical relation to previous results (though part of it could be due to marketable limit orders, which would be affected by Reg NMS).

We further investigate the effect of data fees on broker routing decisions by splitting the set of brokers into categories based on the types of businesses in which the firm engages, according to FINRA BrokerCheck documents.[31] We split firms into two categories based on whether or not the broker is a participant in the over-the-counter, inter-dealer market for corporate securities and whether or not the broker is an underwriter or selling group participant. Brokers that engage in the aforementioned activities and their customers are, on average, larger and more sophisticated, compared to those that do not.

Results split by broker categories are contained in the final four columns of Table 5. We find that the negative effect of fees on order routing decisions is concentrated among a) brokers who do not participate in the interdealer market ($IDM = 0$) and b) those who do not participate in underwriting groups ($UW = 0$). In contrast, there is no significant effect for brokers' sophisticated competitors. The evidence is stronger for market orders than limit

[31] Brokers are obliged to report to FINRA's Central Registration Depository certain information about the firm, including lists of controlling entities, firm history, and firm operations. These filings require each broker to specify all types of business that the firm expects to engage in that will account for 1% or more of annual revenue (FINRA, 2021).

orders, though the small sample size for limit order routing decisions affects our power in these tests.

Data fees can affect the routing decisions of brokers who do not subscribe both directly (because lack of data prohibits them from estimating expected execution quality) and indirectly (if, in equilibrium, market quality is worse after fees are introduced). For subscribing brokers, only the indirect effect of fees should affect their routing decisions. For brokers that do not subscribe, both the direct and indirect effects will impact their decisions, and so they should experience a larger shock. The results are consistent with less sophisticated brokers being less likely to subscribe to costly market data than other brokers. These results may also reflect that small traders tend to rely on less sophisticated brokers.

4 Data fee changes and venue market quality

Having shown that trader behavior is influenced by data fees, we turn to whether this impacts the fee-introducing venue's market quality.

Traders losing access to a venue's market data can affect that venue's market quality in complex ways. The order book information that we study covers non-core data, such as depth away from the best bid and ask and information regarding core data (e.g., the best bid and ask prices), at a lower latency than that available via the SIP. This kind of information is plausibly more relevant for sophisticated traders, such as high-frequency traders and institutional brokers, than for retail traders and their brokers, which is consistent with our results at the broker level using Rule 606 filings in Table 5. The initial direct effect of data fees would be fewer uninformed orders are routed to the venue, which should lead

to a decrease in liquidity, all else being equal. If some traders previously use the order book data to fill price gaps, quoted depths should fall (Cao, Hansch, and Wang, 2008). Consistent with findings by Boehmer, Saar, and Yu (2005), losing access to order book data should also decrease depth at best bid and ask prices.

In equilibrium, traders who subscribe to the data (and so have no change in their information set) still must condition their order submission strategies on the behavior of non-subscribing traders. Informed traders seeking to profit from better information about future price movements have a strong incentive not only to avoid venues with poor liquidity but also to route their orders where their trades reveal the least amount of information to the rest of the market. If depth declines and, given that depth is more important for large orders, we expect the number of large orders to drop. We have also already observed that treated venues execute fewer ISO trades (Table 4). These orders are more likely to come from informed traders than from liquidity traders (Chakravarty et al., 2012). A substantial literature also documents that large (institutional) orders tend to contain more information than other kinds of traders, such as retail (Nofsinger and Sias, 1999; Gompers and Metrick, 2001; Sias, Starks, and Titman, 2001; Yan and Zhang, 2009), and that depth is particularly important for price discovery (Chung, Lee, and Rösch, 2020). Thus, we hypothesize that the data fee introduction has a direct effect on liquidity, through reduced participation, and an indirect effect on price discovery as informed traders seek liquidity elsewhere.

We test the liquidity effect with regressions analogous to those in columns (1)–(4) of Table 4; now, however, the dependent variables are (time-weighted) average proportional quoted spread, and, when the treated venue quotes at NBBO for each stock-day on treated and untreated venues, (log of) quoted depth. Table 6 presents the results.

Table 6 about here

Consistent with the liquidity hypothesis, we find a significant increase in quoted spread and reduction in depth at the treated venue. The treatment effect on the quoted spread is around 23 bps (t-statistic of 7.75) in the specification with stock-day fixed effects and almost 36 bps (t-statistic of 12.1) in the specification with stock-venue and day fixed effects. These correspond to approximately 9 to 14% of the average quoted spread on the treated venue. For depth at NBBO, we find a decrease of around 7% (-22.8) and 6% (-8.88).[32]

We then test the price discovery hypothesis by examining — around fee introduction on treated and untreated venues — changes in average total trading costs for customer trades (effective spreads), informativeness of customer trades (price impact), and dealer revenue from market making (realized spreads). Parameter estimates for these regressions are presented in columns (5) to (10) of Table 6. Columns (5) and (6) present results for average effective spread with stock-day fixed effects and stock-venue and day fixed effects respectively. Columns (7) and (8) present these results for price impact. Columns (9) and (10) present the results for realized spreads.

Table 6 provides weak evidence that average trading costs diminish after the introduction of fees. Whether a drop in liquidity results in an increase in average transaction costs for trades that do execute is unclear, given that undirected trades are automatically sent to the exchange with the best prices. Even if overall liquidity falls at the venue introducing data fees, realized transaction costs might not change because a) fewer trades are executed at the

[32]Results by event and pooled results with a three-month pre-event window are presented in Tables IA.9 to IA.12 in the Internet Appendix. We find a negative and significant effect of fees on log depth in all specifications. For quoted spreads, we find positive and significant coefficients for the majority of specifications. For BATS, however, the sign of the effect changes. For the three-month pre-event window, estimates without stock-venue fixed effects are not statistically significant.

venue and b) the trades that are executed might be routed to the venue only when liquidity is comparable high. The estimated coefficient corresponding to the treatment effect is -0.6 bps in the specification with stock-day fixed effects (t-statistic of -3.32), but it is very close to zero in the specification with stock-venue and day fixed effects.

There is, however, substantial evidence that the components of effective spreads changed significantly after fees. In both econometric specifications, the effect of fees on average price impact is negative and highly significant (columns (7) and (8)). The size of the parameter estimate is around -1.4 to -1.5 bps across both specifications, which corresponds to approximately 5% of the average trade price impact across all stock-days on the treated exchange in our sample. The coefficient is statistically significant at the 1% threshold in both specifications.

Columns (7) and (8) of Table 6 demonstrate that trades on treated exchange become less informative of future price movements, on average, after the introduction of data fees, relative to trades on other venues with no change in data fees. With no effect on effective spreads, it must be that dealer revenue per trade (realized spreads) increases. Columns (9) and (10) of Table 6 confirm this point. The coefficients on average realized spread are 0.0059 when using stock-day fixed effects and 0.0098 when using stock-venue and day fixed effects, significant at the 5% and 10% level respectively. This shows that liquidity suppliers capture much of the reduced adverse selection risk, rather than passing this on via tighter spreads on orders that execute. Lower competition is consistent with predictions of Cespa and Foucault (2014) and Easley et al. (2016).

Together, our difference-in-difference regressions for transaction costs and transaction costs components demonstrate that trades executed on treated exchanges after fees are in-

troduced are less informative regarding future price movements, and that liquidity providers make greater per-trade revenue when quoting on these venues after fees. The improvement in per-trade revenue is counterbalanced by lower trading volume, implying an ambiguous effect on total market maker revenue.

Regarding overall price discovery, the fact that treated exchanges execute less volume after fee introduction relative to other exchanges, and that trades that do execute post-fees are less informative, implies that the contribution of treated exchanges to price discovery falls.[33]

Overall, our results are consistent with predictions by Cespa and Foucault (2014) and Easley et al. (2016). Importantly, however, our analysis focuses on the introduction of a data fee at a single venue, whereas both Cespa and Foucault (2014) and Easley et al. (2016) examine market-wide effects.

5 Data fee changes and market-wide market quality

We next investigate whether a venue-level data fee leads to discernible *market-wide* effects on overall market quality. A possible market-wide effect is important for at least two reasons. First, from a regulatory point of view, fees for market data may simply result in orders being transferred from the exchange introducing the fee to other trading venues (spillovers, as mentioned before) — but without any overall effect on the price formation process. In this case, the case for regulatory intervention in the market for market data is weaker. Second,

[33] We also directly estimate the contribution of the treated exchange to the information share, as defined by Hasbrouck (1995) and Lien and Shrestha (2009). However, because information shares aggregate to one when measured over all exchanges, we cannot estimate panel regressions with day fixed effects. These regressions estimate a drop in the information share of the treated exchange of between 1.7% and 7.6% depending on the definition of information share, with t-statistics between -3.14 and -10.7, respectively. See Table IA.13 in the Internet Appendix.

theoretical predictions regarding the effect of data fees relate to market-wide market quality, not venue-level market quality. There is limited empirical evidence regarding this theory.

Both Cespa and Foucault (2014) and Easley et al. (2016) show that data fees can harm market-wide market quality. In Cespa and Foucault (2014), reducing data fees leads to better price discovery and smaller pricing errors because market data helps reduce risk for speculators who bet against pricing errors (allowing them to trade more aggressively). This mechanism introduces a complex and non-linear relationship between fees and profits for the exchange: a reduction in data fees not only reduces the per-unit profit that the exchange earns on its data but also reduces the value of market data to traders, exactly because lower fees reduce pricing errors in equilibrium. The exchange optimally chooses a high fee, which ensures that not all traders subscribe to the data, thus reducing market quality compared with the case of no fees. High fees also reduce competition between liquidity providers, which leads to relatively illiquid markets. Similar mechanisms are relevant in Easley et al. (2016), where data fees induce information asymmetry between data purchasers and other traders. High fees affect not just market quality but also the production of fundamental information; the latter falls because fundamental data and market data are complements, which in turn increases volatility and the cost of capital.[34]

Each of our events can be thought of as increases in the market-wide cost of market data, and so theory predicts that the introduction of data fees will increase market-wide volatility and worsen price discovery and liquidity.

Market-wide consequences of venue-level effects require some form of spillovers. Previ-

[34]Cespa and Vives (2021) model trading venues as platforms that supply technology allowing traders more flexibility in submitting orders (including co-location facilities and data feeds). From a regulatory point of view, fee reductions improve liquidity for market participants, but this comes at the cost of lower industry profits.

ously we noted that, at the venue level, we do not detect significant spillovers in *trading volume* from the treated venue to others; see Section 3.2. However, the lack of venue level trading volume spillovers does not exclude the treatment causing market-wide consequences for market quality. (In fact, if changes in the treated venue do not cause an equal and opposite sign change in other venues, then there must be market-wide consequences.) For example, if the drop in liquidity at the treated exchange is not compensated by an increase in liquidity at other venues, there must be a drop in market-wide liquidity. Given that treated venues have a market-share of on average around 11% in the pre-event period, treated venues are large enough to have market-wide consequences.

5.1 Market-wide methodology

A complication with analyzing market-wide effects in our setting is that the fees affect all stocks simultaneously. There is no cross-sectional variation in market data fees that permits a traditional differences-in-differences approach like that we have been using so far. Instead, we split our sample of stocks for each event based on a plausible ex-ante measure of how important the introduction of data fees will be for each event: the stock's market share on the treated exchange. Specifically, we split our stocks into sub-samples for each event based on whether that stock's market share on the treated exchange is in the top or bottom tercile in the pre-announcement period. We classify stocks in the top tercile for market share as the "treated" group and those in the bottom tercile for market share as the "untreated." The intuition is relatively straightforward: market data fees on an exchange should be more important for stocks that trade relatively heavily on that exchange. This style of analysis is sometimes referred to as continuous difference-in-differences (e.g., Atanasov and Black,

2016), and it is used in a number of finance settings.[35]

Based on these sample splits, we estimate the market-wide effect of fees for market data on market quality via the following regressions:

$$y_{ijt} = \beta \, High_{ij} \times Post_t + \theta_{ij} + \gamma_t + \varepsilon_{ijt} \tag{3}$$

$$y_{ijt} = \beta \, High_{ij} \times Post_t + \psi \, High_{ij} + \theta_i + \gamma_t + \varepsilon_{ijt}. \tag{4}$$

In Equation (3), market quality is regressed onto stock × event fixed effects, time fixed effects, and an indicator (treatment) variable equal to one (zero) if stock i has a pre-announcement market share on the treated exchange in the top (bottom) tercile for event j, $High_{ij}$, multiplied by a post-event indicator, $Post_j$. That is, in these regressions, j indexes events and not exchanges, as it did for the difference-in-differences approach across markets.[36] Equation (4) is analogous, except that the stock–event fixed effect in Equation (3) is replaced by a stock fixed effect and an indicator distinguishing treated from untreated market-share stocks.[37, 38]

[35] See e.g., Chetty and Saez (2005), Faccio and Parsley (2009), and Atanasov, Black, Ciccotello, and Gyoshev (2010).

[36] The first fixed effect in Equation (3) and the dummy variable $High_{ij}$ is indexed by stock and event because stock i may be in the top or bottom tercile market share category for one event and not for another. The two specifications are equivalent when estimating the treatment effect on a event-by-event basis.

[37] Note that we cannot estimate the market-wide treatment effect with stock-day fixed effects, as we do in Equation (2), because these effects are co-linear with the treatment effect.

[38] A possible concern with our market-wide approach is that it is hard to make meaningful comparisons between stocks split based on relative trading activity on the treated exchange. For example, perhaps only the largest and most liquid stocks are actively traded on these exchanges, while small illiquid stocks are not. Though this would not necessarily invalidate our approach, as parallel trends may still hold across small vs. large stocks, we note that there are no large differences in size or trading volume across the high vs. low market share terciles. Stocks in the low tercile have an average (median) market capitalization of \$3.75b (\$415m). The average (median) market capitalization for stocks in the high tercile category is \$5.29b (\$483m). For daily dollar volume traded, the average (median) for the low group is \$30.2m (\$2.4m) and \$41.2m (\$3.0m) for the high. The small differences in fragmentation by stock size observed in our sample are consistent with findings from the existing fragmentation literature (e.g., O'Hara and Ye, 2011). Tables IA.14 to IA.18 present summary statistics for market-wide trading and liquidity variables across our main pooled regressions, by event and using symmetric pre- and post-event windows.

5.2 Fees and market share

We first estimate the effect of data fees on the treated exchange market share. The dependent variable in these regressions is the percentage volume that is executed on the treated exchange for stock i on date t. This relationship is particularly important because our identification strategy relies on the assumption that treated stocks are more exposed to the fee and should have a greater reduction in volume on the exchange introducing the fee. Table 7 presents these regressions. Because Table 7 shows results at the event level, estimates using stock-event fixed effects are equivalent to those using stock-only fixed effects, and the specifications in Equations 3 and 4 are equivalent.

Table 7 about here

Our market-wide difference-in-differences regressions provide evidence that market data fees have a greater impact on order routing decisions for stocks with higher pre-announcement market share. After market-data fees are introduced, stocks with greater pre-announcement market share on the treated exchanges have a larger reduction in market share on these exchanges, indicating that the direct and indirect impact of fees on order routing decisions are greater for these stocks. This demonstrates that stocks in the treated category are more exposed to the treatment than the untreated stocks.[39]

[39] Regressions using a three-month pre-event window are presented in Table IA.19 in the Internet Appendix and are consistent with results using the shorter window.

5.3 Price discovery

We next directly test the effect of data fees on market-wide displayed volatility, Hasbrouck (1993) pricing errors and liquidity. Midquote volatility is the square root of the sum of squared one-second NBBO midquote, as recorded in the WRDS Intraday Indicator database. The pricing errors are the average absolute difference between the midprice and the efficient price as per Hasbrouck (1993) by stock and day. Table 8 contains the results from these regressions. Volatility and pricing errors increase for the treated stocks, suggesting that price discovery and market efficiency are harmed by data fees and consistent with Cespa and Foucault (2014) and Easley et al. (2016).[40]

Table 8 about here

Chowdhry and Nanda (1991) show that informed traders trade more aggressively when the trades of small liquidity traders are spread across multiple markets, and that informativeness of prices therefore increases as the number of markets increases. This effect provides an additional potential explanation for why fees lead to less informative prices, assuming that lower market share on a single exchange leads to lower overall market fragmentation. We test this explanation by estimating the effect of trading fees on market fragmentation, as measured by Herfindahl-Hirschmann indices (HHI) of market shares across all venues. We find, consistent with this theory, a significant increase in HHIs (i.e., less fragmentation) equivalent to around 0.7 standard deviations for treated stocks.

[40]Results by event and with three-month pre-event windows are presented in Tables IA.20 to IA.23 in the Internet Appendix. Pooled results are similar regardless of pre-event windows, while point estimates for volatility and pricing errors are positive for all events but only statistically significant in the BATS event.

5.4 Market-wide liquidity

Cespa and Foucault (2014) and Easley et al. (2016) both predict that decreased price informativeness after increased data fees is driven in part by worse liquidity and less competition between liquidity suppliers. We test these predictions by examining how fee introductions affect the prices and quantities available at the NBBO. Columns (1) to (4) of Table 9 present analogous regressions to Table 8, where the dependent variables are the quoted spread and log of depth at the NBBO. The size of the bid-ask spread matters primarily for small orders, whereas depth at the best bid and ask is more relevant for large orders.

Table 9 about here

Data fees dampen market-wide displayed liquidity. Quoted spreads increase by around 3 basis points, (t-statistics of 2.1 and 2.3), and depth at the NBBO falls by around 6% after fees are introduced (t-statistics of -6.0).[41,42] Effective spreads and realized spreads also increase by around 2.5 to 3 basis points, while price impact is unchanged. Supportive of theory, higher realized spreads indicate that market makers earn higher average revenues on trades that actually execute, rather than just posting wider average spreads.

Given that traders split large orders into smaller trades, it is not straightforward to

[41] Changes in displayed market-wide depth could reflect a reduction in "duplicated" or "phantom" liquidity by algorithmic market makers posting quotes across exchanges and canceling the remaining limit orders when an order executes on a single exchange, rather than a genuine change in liquidity provision (as per Baldauf and Mollner, 2020 and van Kervel, 2015.) We follow Chung et al. (2020) and Hendershott et al. (2011) and estimate two proxies for algorithmic trading and liquidity provision: the negative of the ratio of the total dollar volume traded to the number of quote changes, expressed in $100s, and the log ratio of number of quote changes to the number of trades by stock-venue or stock-day. The effect of market data fees on these proxies is small and insignificant (see Table IA.24 in the Internet Appendix.)

[42] Liquidity results by event and using a three-month pre-event window are available in Tables IA.25 to IA.28 Internet Appendix. The effects are consistent across these specifications other than for Arca and for quoted spreads using the three-month event windows, where we do not detect statistically significant estimate.

empirically measure the frequency of large orders. However, market-wide, we can use Rule 605 data to measure the frequency of large orders. Rule 605 requires executing venues to disclose the number of shares they receive for execution and how many of these are executed separately across four different size categories and five different order types every month and for each stock (Battalio et al., 2016; Chung et al., 2020).

Similar to the Rule 606 data, we download filings for all available (59) venues one month before the announcement and up to three months after the implementation of the market data fee from vrs.vista-one-solutions.com.[43] The average stock-day dollar volume across all trades reported in our Rule 606 filings is more than USD 20 million per month — around 1 million per day, and around half the dollar volume across all venues (from Table 1).

We sum the number of shares submitted for trading and executed across all venues for which we have data separately for all market orders and outside-the-quote-limit orders by stock-month and within the four reported size categories. We then explain the (logarithm) of the number of shares submitted, as well as executed, by indicator variables. As before, we distinguish between small and large orders by an indicator variable, which is equal to one for orders in the top two size categories (above 2,000 shares) and zero otherwise.

Table 10 about here

Table 10 reports the results. For treated stocks, we find that, after the data fee introduction, the submissions of shares as part of large market orders decrease by around 14% relative to untreated stocks, and the number of shares executed drops by around 4% to 5%.

[43] We only have data for a subset of all venues and do not observe data at the exchange-level. In total, our Rule 606 data cover around half of all executed USD trading volume.

We find similar results for outside-the-quote-limit orders: submissions decrease by around 6% (but not statistically significant with a t-statistic of -1.47), and the number of shares traded as part of large outside-the-quote-limit orders decreases by 12% to 14% (depending on whether we use stock or stock times event fixed effects).[44]

The evidence presented in Tables 7 to 10 shows that fee introductions worse price efficiency and higher volatility, as predicted by theory. The main mechanism behind this result is the effect that market fees have on market depth and large order submissions. The average market-wide costs and informativeness of small trades are unaffected. Given that smaller, less sophisticated brokers (or their clients) are more sensitive to data fees (Section 3.5), these results must be interpreted as equilibrium outcomes that capture both direct and indirect effects of fees across market participants.

The combination of venue-level and market-wide effects indicates that data products are not perfect substitutes across exchanges. If traders could seamlessly migrate to other venues and rely only on alternative feeds, we would expect volume losses at the treated venues to be offset by gains elsewhere, with little impact on market-wide outcomes. Instead, our results suggest that data products exhibit partial complementarity; the loss of one feed reduces the value of others and undermines overall price discovery. In addition, migration is incomplete because venues differ in order flow composition, trading technology, and broker routing practices, which prevents other exchanges from fully replacing the lost liquidity. These factors explain why fee increases at individual venues generate measurable deterioration in

[44] As a robustness check, we sum shares across all order types and also find a drop in shares as part of large orders submitted and traded — around 5% (t-statistic of -1.45) and 8% (-3.50), respectively. We also present results by event and with a three-month pre-event window in Tables IA.29 to IA.32 in the Internet Appendix. All point estimates for the triple interaction term are negative and statistically significant in most specifications.

stock-level liquidity and efficiency.

6 Conclusion

This paper has examined the role of data fees in modern financial markets. Although exchanges are required to provide core data to the Security Information Processor (SIP) for public distribution, they may charge for non-core data.

We show that when a trading venue introduces a fee for non-core data previously available for free, it experiences declines in trading activity, liquidity, and price discovery. Importantly, these effects extend beyond the affected venue and lead to broader market-wide deterioration in market quality. Our findings suggest that data fees imposed by a single exchange can distort trading behavior in ways that harm overall market efficiency and liquidity.

Importantly, the introduction of data fees also influences brokers' routing decisions. Brokers have an incentive to route non-core orders to the venue with the largest share of traders having access to non-core data. In this venue, the quote will likely execute faster than in other venues, resulting in better execution quality. As liquidity tends to have a "gravitational" effect, whereby greater liquidity attracts more trading and, in turn, even greater liquidity (Foucault et al., 2013), even a modest decline in liquidity can trigger a feedback loop that further reduces liquidity. This effect may be particularly pronounced if non-subscribers are primarily noise or liquidity traders, whose orders, while uninformed about future prices, are essential for maintaining active markets. As Black (1986) famously noted, "noise makes trading in financial markets possible."

Although our three events occurred more than a decade ago, the broader implications are

highly relevant to today's environment. Since 2013, the cost of proprietary market data has continued to rise, and the number of exchange data products has expanded. These developments amplify the concerns revealed in our study. If modest fee introductions from 2009 to 2013 were sufficient to reduce venue competitiveness, impair liquidity, and weaken price discovery, then today's much larger costs are even more likely to shape market outcomes. In particular, rising fees risk excluding a broader set of investors, leaving a smaller group of sophisticated traders as the primary purchasers of data. This dynamic raises the possibility of a bifurcated market, with concentrated informed trading and weaker overall liquidity provision, as in the models by Cespa and Foucault (2014) and Easley et al. (2016). Our evidence thus contributes directly to the ongoing policy debate over the welfare implications of exchange data fees.

A Appendix

A.1 Pricing error

We estimate Hasbrouck (1993) pricing errors as in Rösch et al. (2017, Section 1.3). For every stock-day we decompose midpoint prices into an efficient price and a pricing error using a five-lag VAR model with the following endogenous variables: (1) the logarithmic NBBO midpoint price return estimated from quotes prevailing trades; (2) the sign of the trade; (3) the sign of the trade times the number of shares traded; and (4) the sign of the trade times the square root of the number of shares traded. We then calculate the average absolute pricing error per stock-day.

Appendix Table 1: Variable definitions

Variable	Formula	Definition
Dollar Volume	$\sum_{n}^{N_{it}} s_n \times P_n$	N_{it} is the number of trades during market hours as per TAQ data for stock i on day t (split by venue where appropriate). P_n is the trade price and s_n is the number of shares of the n^{th} trade.
Trade Size ($)	$\frac{1}{N_{it}} \sum_{n}^{N_{it}} s_n \times P_n$	N_{it}, P_n, and s_n are defined as before.
ISO Dollar Volume	$\sum_{n}^{N_{it}} s_n \times P_n \times ISO_n$	N_{it}, P_n, and s_n are defined as before. ISO_n is an indicator variable equal to 1 if trade n is an Intermarket Sweep Order and 0 otherwise.
Seconds at NBBO	$\lvert\{BBO_{isj} = NBBO_{is}\}\rvert$	BBO_{isj} is the best bid and offer of stock i at second s on exchange j (during the continuous trading session) and $NBBO_{is}$ is the national best bid and offer price. BBO is equal to $NBBO$ if both the bid and the ask are equal.
Effective Spread (%)	$\frac{100}{N_{it}} \sum_{n}^{N_{it}} \left(\frac{D_n(P_n - M_n)}{M_n} \right)$	N_{it} and P_n are defined as before, D_n is the Lee-Ready signed trade direction of trade n in stock i on day t, and M_n is the NBBO midquote immediately preceding the trade.
Realized Spread (%)	$\frac{100}{N_{it}} \sum_{n}^{N_{it}} \left(\frac{D_n(P_n - M_{n+5})}{M_n} \right)$	N_{it}, P_n, D_n and M_n are defined as before. M_{n+5} is the NBBO midquote five minutes after the trade.
Quoted Spread (%)	$\frac{100}{T_{it}} \sum_{s}^{T_{it}} \left(\frac{Ask_s - Bid_s}{M_s} \right)$	T_{it} is the number of seconds of continuous trading for stock i on day t, Ask_s, Bid_s, and M_s are, respectively, the best ask, bid, and midpoint price at second s.
Quoted Depth	$\frac{1}{T_{it}} \sum_{s}^{T_{it}} \left(\frac{AskSize_s + BidSize_s}{2} \right)$	T_{it} is the number of seconds of continuous trading for stock i on day t, $AskSize_s$ and $BidSize_s$ are the number of shares available at, respectively, the best ask and bid price at second s.
Price Impact (%)	$\frac{100}{N_{it}} \sum_{n}^{N_{it}} \left(\frac{D_n(M_{n+5} - M_n)}{M_n} \right)$	N_{it}, P_n, D_n and M_n and M_{n+5} are defined as before.
Midquote Volatility	$\frac{100}{T_{it}} \sum_{s}^{T_{it}} \sqrt{(r_s - \bar{r}_s)^2}$	T_{it} is the number of one second intervals in the trading day for stock i on day t, r_s is the one second log midquote return at the s^{th} one second interval and $\bar{r}_s$ is the average one second log midquote return in stock i and day t.
Rule 606 market orders	$mktorders_{btj}$	$mktorders_{btj}$ is the percentage of non-directed market orders received by broker b on day t for securities listed on exchange j that are routed towards the treated exchange, as reported in Rule 606 filings.
Rule 606 limit orders	$lmtorders_{btj}$	$lmtorders_{btj}$ is the percentage of non-directed limit orders received by broker b on day t for securities listed on exchange j that are routed towards the treated exchange, as reported in Rule 606 filings.

Appendix Table 1 (continued): Variable definitions

Variable	Formula	Definition
Upper/Lower Information Share	$\frac{(\psi F)^2}{\psi \Omega \psi^t}$	following Hasbrouck (1995, Eq 16). Ω is the co-variance matrix of the price innovations of the BBO price at the treated exchange and the $NBBO$ price at all the other exchanges. F is the Cholesky factorisation of Ω. We derive an upper and lower Information Share, depending on whether F contains the innovation in the price at the treated exchange first or last. For details see Appendix 1.
Information Share	$\frac{Upper_{it}+Lower_{it}}{2}$	$Upper_{it}$ and $Lower_{ijt}$ is, respectively, the upper and the lower Hasbrouck (1995) Information Share of stock i on day t on the treated exchange.
Modified Information Share		following Lien and Shrestha (2009).
Pricing error	$\frac{1}{N_{it}} \sum_n^{N_{it}} \lvert M_{i,n} - \mu_{i,n} \rvert$	N_{it} is as before. $M_{i,n}$ is the log of the NBBO midpoint price prevailing trade n of stock i on day t. $\mu_{i,n}$ is the efficient price as in Hasbrouck (1993). For details see Appendix A.1.
Market Share	$\frac{DollarVolume_{ijt}}{DollarVolume_{it}}$	$DollarVolume_{ijt}$ is Dollar Volume (see above) of stock i on day t at exchange j and $DollarVolume_{it}$ is market-wide Dollar Volume.

References

Anand, A., M. Samadi, J. S. Sokobin, and K. Venkataraman (2021). Institutional order handling and broker-affiliated trading venues. *Review of Financial Studies 34*, 3364–3402.

Atanasov, V., B. Black, C. Ciccotello, and S. Gyoshev (2010). How does law affect finance? An examination of equity tunneling in Bulgaria. *Journal of Financial Economics 96*, 155–173.

Atanasov, V. A. and B. S. Black (2016). Shock-based causal inference in corporate finance and accounting research. *Critical Finance Review 5*, 207–304.

Baldauf, M. and J. Mollner (2020). High-frequency trading and market performance. *Journal of Finance 75*, 1495–1526.

Bartlett, R., J. McCrary, and M. O'Hara (2023). The market inside the market: Odd-lot quotes. *Review of Financial Studies 38*, 661–711.

BATS (2013). BATS Global Markets U.S. Market Data Fees Effective July 1, 2013. https://markets.cboe.com/us/equities/notices/fee_schedule/2013/. Accessed: 2020-09-22.

Battalio, R., S. A. Corwin, and R. Jennings (2016). Can brokers have it all? On the relation between make-take fees and limit order execution quality. *Journal of Finance 71*, 2193–2238.

Bessembinder, H., J. Hao, and K. Zheng (2020). Liquidity Provision Contracts and Market Quality: Evidence from the New York Stock Exchange. *Review of Financial Studies 33*, 44–74.

Black, F. (1986). Noise. *Journal of Finance 41*(3), 528–543.

Boehmer, E., G. Saar, and L. Yu (2005). Lifting the veil: An analysis of pre-trade transparency at the NYSE. *Journal of Finance 60*, 783–815.

Brannon, I. and R. H. Jennings (2019). Equity exchange fees and revenues. *Working Paper*.

Budish, E., R. S. Lee, and J. J. Shim (2024). A Theory of Stock Exchange Competition and Innovation: Will the Market Fix the Market? *Journal of Political Economy 132*(4), 1209–1246.

Cao, C., O. Hansch, and X. Wang (2008). Order placement strategies in a pure limit order book market. *Journal of Financial Research 31*, 113–140.

Cespa, G. and T. Foucault (2014). Sale of price information by exchanges: Does it promote price discovery? *Management Science 60*, 148–165.

Cespa, G. and X. Vives (2021). Exchange competition, entry, and welfare. *Review of Financial Studies*, forthcoming.

Chakravarty, S., P. Jain, J. Upson, and R. Wood (2012). Clean sweep: Informed trading through intermarket sweep orders. *Journal of Financial and Quantitative Analysis 47*, 415–435.

Chetty, R. and E. Saez (2005). Dividend taxes and corporate behavior: Evidence from the 2003 dividend tax cut. *Quarterly Journal of Economics 120*, 791–833.

Chowdhry, B. and V. Nanda (1991). Multimarket trading and market liquidity. *Review of Financial Studies 4*, 483–511.

Chung, K. H., A. J. Lee, and D. Rösch (2020). Tick size, liquidity for small and large orders, and price informativeness: Evidence from the tick size pilot program. *Journal of Financial Economics 136*, 879–899.

Cimon, D. A. (2020). Broker routing decisions in limit order markets. *Journal of Financial Markets*, forthcoming.

DirectEdge (2012a). Direct Edge Market Data Notice 12-02: Market Data Fees. https://web.archive.org/web/20120329183740/http:/www.directedge.com/About/Announcements/ViewNewsletterDetail.aspx?NewsletterID=619. Accessed: 2021-07-21.

DirectEdge (2012b). Notice of Filing and Immediate Effectiveness of Proposed Rule Change Relating to Fees Associated with Receipt of the EDGX Book Feed. https://cdn.cboe.com/resources/regulation/rule_filings/approved/2012/SR-EDGX-2012-14-Revised.pdf. Accessed: 2020-09-22.

Easley, D., M. O'Hara, and L. Yang (2016). Differential access to price information in financial markets. *Journal of Financial and Quantitative Analysis 51*, 1071–1110.

European Commission (2021). Capital Markets Union: Commission proposes new measures to boost Europe's capital markets. https://ec.europa.eu/commission/presscorner/detail/en/ip_21_6251. Accessed: 2021-12-08.

Faccio, M. and D. C. Parsley (2009). Sudden deaths: Taking stock of geographic ties. *Journal of Financial and Quantitative Analysis 44*, 683–718.

Farboodi, M., D. Singal, L. Veldkamp, and V. Venkateswaran (2025). Valuing financial data. *Review of Financial Studies 38*(3), 938–980.

FINRA (2021). About BrokerCheck. https://www.finra.org/investors/learn-to-invest/choosing-investment-professional/about-brokercheck. Accessed: 2021-02-19.

Foucault, T. and A. J. Menkveld (2008). Competition for order flow and smart order routing systems. *Journal of Finance 63*, 119–158.

Foucault, T., M. Pagano, and A. Röell (2013). *Market liquidity: Theory, evidence, and policy*. Oxford University Press.

Glosten, L. R. (2020). Economics of the stock exchange business: Proprietary market data. *Working Paper*.

Gompers, P. A. and A. Metrick (2001). Institutional investors and equity prices. *Quarterly Journal of Economics 116*, 229–259.

Hasbrouck, J. (1993). Assessing the quality of a security market: A new approach to transaction-cost measurement. *Review of Financial Studies 6*, 191–212.

Hasbrouck, J. (1995). One security, many markets: Determining the contributions to price discovery. *Journal of Finance 50*, 1175–1199.

Hendershott, T. and C. M. Jones (2005). Island goes dark: Transparency, fragmentation, and regulation. *Review of Financial Studies 18*, 743–793.

Hendershott, T., C. M. Jones, and A. J. Menkveld (2011). Does algorithmic trading improve liquidity? *Journal of Finance 66*, 1–33.

Hendershott, T., M. Rysman, and R. Schwabe (2025). Stock exchanges as platforms for data and trading. *Journal of Financial Markets*, 100986.

Holden, C. W. and S. Jacobsen (2014). Liquidity measurement problems in fast, competitive markets: Expensive and cheap solutions. *Journal of Finance 69*, 1747–1785.

Iizuka, T. and H. Shigeoka (2022). Is zero a special price? Evidence from child health care. *American Economic Journal: Applied Economics 14*(4), 381–410.

Interactive Brokers (2006). Data fee website from 2006-10-16, accessed via the WayBack-Machine. https://web.archive.org/web/20061016015415/http://www.interactivebrokers.com/en/accounts/fees/marketData.php?ib_entity=llc. Accessed: 2025-10-10.

Jones, C. M. (2018). Understanding the market for U.S. equity market data. *Working Paper*.

Lee, C. M. and M. J. Ready (1991). Inferring trade direction from intraday data. *Journal of Finance 46*, 733–746.

Lien, D. and K. Shrestha (2009). A new information share measure. *Journal of Futures Markets 29*, 377–395.

Nofsinger, J. R. and R. W. Sias (1999). Herding and feedback trading by institutional and individual investors. *Journal of Finance 54*, 2263–2295.

O'Hara, M. and M. Ye (2011). Is market fragmentation harming market quality? *Journal of Financial Economics 100*, 459–474.

Oster, E. (2019). Unobservable selection and coefficient stability: Theory and evidence. *Journal of Business & Economic Statistics 37*, 187–204.

Pagnotta, E. S. and T. Philippon (2018). Competing on speed. *Econometrica 86*, 1067–1115.

Rambachan, A. and J. Roth (2023). A more credible approach to parallel trends. *Review of Economic Studies 90*(5), 2555–2591.

Ramos, S. B. and E.-L. von Thadden (2008). Stock exchange competition in a simple model of capital market equilibrium. *Journal of Financial Markets 11*, 284–307.

Reuters (2013). BATS exchanges to start charging for market data. https://www.reuters.com/article/batsglobalmarkets-marketdata-fees-idUSL2N0D52AC20130418. Accessed: 2020-09-22.

Rösch, D. (2021). The impact of arbitrage on market liquidity. *Journal of Financial Economics 142*(1), 195–213.

Rösch, D. M., A. Subrahmanyam, and M. A. van Dijk (2017). The dynamics of market efficiency. *Review of Financial Studies 30*, 1151–1187.

SEC (2008a). Release No. 34-59039. https://www.sec.gov/rules/sro/nysearca/2008/34-59039.pdf. Accessed: 2021-07-29.

SEC (2008b). Self-Regulatory Organizations; NYSE Arca, Inc.; Order Setting Aside Action by Delegated Authority and Approving Proposed Rule Change Relating to NYSE Arca Data. https://www.sec.gov/rules/sro/nysearca/2008/34-59039.pdf. Accessed: 2020-09-22.

SEC (2012a). Self-Regulatory Organizations; EDGX Exchange, Inc.; Notice of Filing and Immediate Effectiveness of Proposed Rule Change Relating to Fees Associated with Receipt of the EDGX Book Feed. https://www.sec.gov/rules/sro/edgx/2012/34-66864.pdf. Accessed: 2020-09-22.

SEC (2012b). SR-EDGX-2012-17. https://cdn.cboe.com/resources/regulation/rule_filings/approved/2012/SR-EDGX-2012-17.pdf. Accessed: 2024-08-26.

SEC (2013a). Release No. 34-69936; File No. SR-BATS-2013-39. https://www.sec.gov/files/rules/sro/bats/2013/34-69936.pdf. Accessed: 2021-07-21.

SEC (2013b). Self-Regulatory Organizations; BATS Exchange, Inc.; Notice of Filing and Immediate Effectiveness of a Proposed Rule Change to Impose Fees for Market Data. https://www.sec.gov/rules/sro/bats/2013/34-69936.pdf. Accessed: 2020-09-22.

SEC (2013c). Self-Regulatory Organizations; BATS Exchange, Inc.; Notice of Filing and Immediate Effectiveness of Proposed Rule Change Related to Fees for Use of BATS Exchange, Inc. https://www.sec.gov/rules/sro/bats/2013/34-69933.pdf. Accessed: 2020-09-22.

SEC (2015). Post-Hearing Briefing of NYSE ARCA. https://www.sec.gov/litigation/apdocuments/3-15350-post-hearing-brief-nyse-arca.pdf. Accessed: 2021-01-06.

SEC (2020). SEC Proposes to Modernize Key Market Infrastructure Responsible for Collecting, Consolidating, and Disseminating Securities Market Data. https://www.sec.gov/news/press-release/2020-34. Accessed: 2021-12-08.

Shampanier, K., N. Mazar, and D. Ariely (2007). Zero as a special price: The true value of free products. *Marketing Science 26*(6), 742–757.

Sias, R. W., L. T. Starks, and S. Titman (2001). The price impact of institutional trading. *Working Paper*.

Spatt, C. S. (2020). Is equity market exchange structure anti-competitive? *Working Paper*.

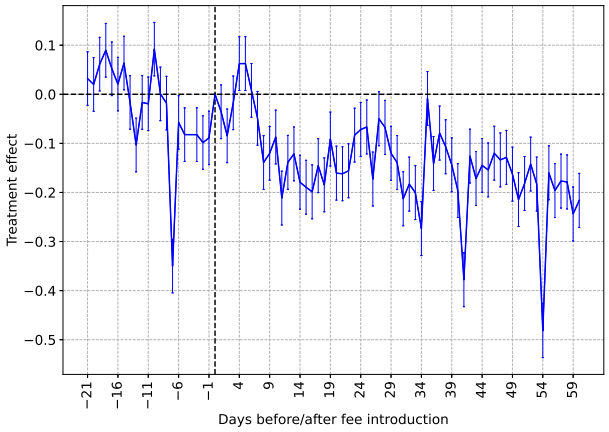
van Kervel, V. (2015, 03). Competition for order flow with fast and slow traders. *Review of Financial Studies 28*(7), 2094–2127.

Yan, X. and Z. Zhang (2009). Institutional investors and equity returns: Are short-term institutions better informed? *Review of Financial Studies 22*, 893–924.

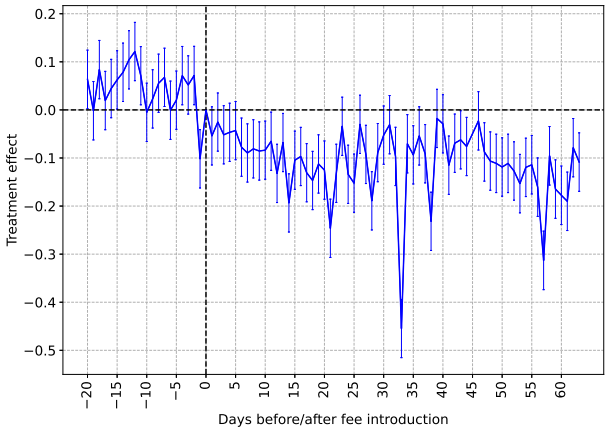
Figure 1: Trading Activity Around Fee Introduction: Treatment effect by trading day

This figure plots dynamic treatment effects of fee introduction on total log dollar volume traded on the treated exchange, estimated separately for each event. The treated sample includes daily trading in all stocks in our sample on the exchange introducing order book fees. The untreated sample includes daily trading in the same stocks on all other exchanges not introducing fees. The regression model is $y_{ijt} = \beta_r \sum_{r \neq 0} \mathbb{1}[R_{it} = r] \times Treat_j + FE_{ijt} + \varepsilon_{ijt}$ where y_{ijt} is the log of total dollar volume executed in stock i on date t on venue type j (treated and untreated respectively), R_{it} is time relative to treatment (i.e. $R_{it} = 1$ is the first trading day after fee introduction, $R_{it} = 0$ is the trading day prior to fee announcement), $Treat_j$ is an indicator variable for treatment status and FE_{ijt} are various fixed effects (see Section 2.4 for details). Standard errors are clustered at the stock-venue level and confidence intervals are computed at the 95% significance level.

(a) Arca



(b) Direct Edge



(c) BATS

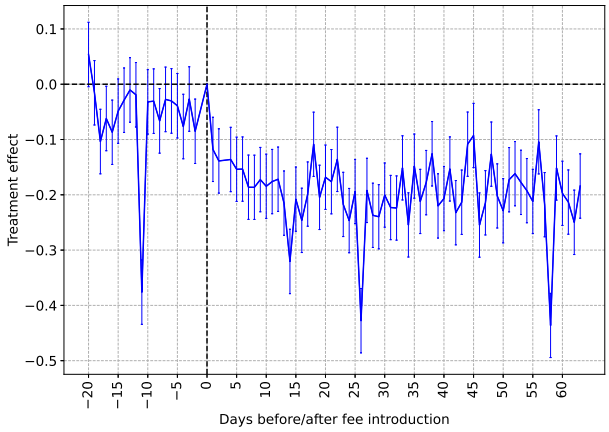


Table 1: Summary statistics

This table reports means, standard deviations, minimums, maximums and quantiles at the 25th, 50th and 75th levels for trading activity and liquidity variables for treated (Panel A) and untreated venues (Panel B). The sample includes stock-days in the one month prior to the fee announcement ("Pre-Fee") and three months after the fee implementation ("Post-Fee"), pooled across all three events. Dollar volume, market share, effective spread, realized spread, price impact, seconds at NBBO (when both bid and ask prices at the treated exchange are equal to the NBBO), and information share (Hasbrouck, 1995) are defined as per Section 2.2 and Appendix Table 1. All variables are Winsorized at the 1% level separately for treated venues and untreated venues in each of the pre-announcement and post-implementation periods.

	Mean	SD	Min	25%	50%	75%	Max	Mean Pre-Fee	Mean Post-Fee
Panel A: Trading on Treated Exchanges									
Log Dollar Volume	12.391	2.7276	4.9767	10.559	12.499	14.389	18.350	12.490	12.357
Log ISO Dollar Volume	11.726	2.6754	4.8283	9.8810	11.743	13.701	17.687	11.808	11.698
Market Share (%)	10.629	8.6610	0.0086	4.8993	8.3043	14.307	100.00	11.557	10.314
Effective Spread (%)	0.4908	1.1028	0.0128	0.0621	0.1455	0.3956	10.258	0.5459	0.4721
Realized Spread (%)	0.2612	0.9993	-2.6144	-0.0013	0.0374	0.1611	9.4762	0.2923	0.2506
Price Impact (%)	0.2271	0.6687	-1.9997	0.0134	0.0677	0.2167	6.1170	0.2537	0.2180
Quoted Spread (%)	2.6601	6.4885	0.0282	0.2680	0.7115	1.9072	56.851	2.5475	2.6976
Log Dollar Depth	1.1452	0.9705	0.0000	0.4567	0.8750	1.5383	5.1814	1.1772	1.1351
Seconds at NBBO	6,224.0	6,374.9	7.0000	1,118.0	3,844.0	9,472.0	22,964	6,441.1	6,154.9
Information Share	0.2710	0.1909	0.0023	0.1003	0.2426	0.4324	0.7038	0.2757	0.2690
Panel B: Trading on Non-treated Venues									
Log Dollar Volume	14.576	2.7324	6.9854	12.705	14.740	16.616	20.382	14.568	14.579
Log ISO Dollar Volume	13.536	2.8168	6.0684	11.583	13.664	15.660	19.699	13.505	13.546
Effective Spread (%)	0.6700	1.4619	0.0153	0.0725	0.1736	0.5333	11.926	0.7100	0.6563
Realized Spread (%)	0.4102	1.2035	-0.8920	0.0154	0.0534	0.2299	10.335	0.4403	0.3999
Price Impact (%)	0.2558	0.6264	-1.3303	0.0305	0.0815	0.2258	5.3693	0.2678	0.2517
Quoted Spread (%)	0.8846	1.7488	0.0182	0.1127	0.2712	0.7683	13.752	0.9277	0.8703
Log Dollar Depth	2.1704	1.1834	0.5319	1.3319	1.8202	2.7064	6.9697	2.1699	2.1705

Table 2: Trading activity by event

This table reports coefficients (t-statistics) for the effect of fee introduction on total log dollar volume traded on the treated exchange, estimated separately for each event. The treated sample includes daily trading in all stocks in our sample on the exchange introducing order book fees. The untreated sample includes daily trading in the same stocks on all other exchanges not introducing fees. The regression model is $y_{ijt} = \beta\, Treat_j \times Post_t + FE_{ijt} + \varepsilon_{ijt}$, where y_{ijt} is the log of total dollar volume executed in stock i on date t on venue type j (treated and untreated respectively), $Treat_j$ is an indicator variable for treatment status, $Post_t$ is an indicator variable for observations in the post-implementation period and FE_{ijt} are various fixed effects (see Section 2.4 for details). Standard errors are clustered at the stock-venue level.

	ARCA		DEDGE		BATS	
	(1)	(2)	(3)	(4)	(5)	(6)
Treat × Post	-0.1226***	-0.1181***	-0.1375***	-0.1526***	-0.1278***	-0.1404***
	(-19.5)	(-8.83)	(-18.6)	(-8.51)	(-17.9)	(-7.36)
Treat	-1.7700***		-2.4607***		-2.8041***	
	(-217)		(-311)		(-272)	
# Stocks	3,061	3,061	2,809	2,809	2,788	2,788
# Days	81	81	83	83	82	82
# Obs.	474,858	474,858	442,811	442,811	428,497	428,497
Adj. R^2	0.96	0.94	0.96	0.92	0.96	0.93
Stock × Day FE	X		X		X	
Stock × Treat FE		X		X		X
Day FE		X		X		X

Table 3: ADR trading activity by event

This table reports coefficients (t-statistics) for the effect of fee introduction on total log dollar volume traded in ADRs, estimated separately for each event. In both Panels A and B, the treated sample includes daily trading in all ADRs in our sample on the exchange introducing order book fees (treated). In Panel A, the untreated sample is trading in the same ADRs in other US exchanges. In Panel B the untreated sample is trading in underlying stock of the ADR in its home market. The regression model is $y_{ijt} = \beta\ Treat_j \times Post_t + FE_{ijt} + \varepsilon_{ijt}$, where y_{ijt} is the log of total dollar volume executed in stock i on date t on venue type j (treated and untreated respectively), $Treat_j$ is an indicator variable for treatment status, $Post_t$ is an indicator variable for observations in the post-implementation period and FE_{ijt} are various fixed effects (see Section 2.4 for details). Standard errors are clustered at the stock-venue level.

Panel A: ADRs vs. US Exchanges						
	ARCA		DEDGE		BATS	
	(1)	(2)	(3)	(4)	(5)	(6)
Treat × Post	-0.1312***	-0.1319***	-0.1280***	-0.1306*	-0.0390	-0.0389
	(-5.93)	(-2.77)	(-5.33)	(-1.91)	(-1.32)	(-0.61)
Treat	-1.3845***		-2.7959***		-2.7110***	
	(-49.4)		(-64.8)		(-62.8)	
# Stocks	128	128	117	117	122	122
# Days	82	82	84	84	83	83
# Obs.	20,650	20,650	19,554	19,554	20,054	20,054
Adj. R^2	0.97	0.94	0.95	0.93	0.96	0.93
Stock × Day FE	X		X		X	
Stock × Treat FE		X		X		X
Day FE		X		X		X
Panel B: ADRs vs. Foreign Exchanges						
	ARCA		DEDGE		BATS	
	(1)	(2)	(3)	(4)	(5)	(6)
Treat × Post	-0.1858***	-0.1595***	-0.1668***	-0.2137***	-0.0908*	-0.1049*
	(-5.21)	(-3.48)	(-4.05)	(-3.52)	(-1.76)	(-1.72)
Treat	-2.6021***		-3.5132***		-3.7323***	
	(-16.4)		(-18.3)		(-23.3)	
# Stocks	128	128	117	117	122	122
# Days	83	83	85	85	84	84
# Obs.	20,402	20,402	19,264	19,264	19,785	19,785
Adj. R^2	0.74	0.96	0.71	0.95	0.77	0.96
Stock × Day FE	X		X		X	
Stock × Treat FE		X		X		X
Day FE		X		X		X

Table 4: Pooled trading activity

This table reports coefficients (t-statistics) for the effect of fee introduction on total log dollar volume traded on the treated exchange, log dollar volume executed via intermarket sweep orders (ISOs), and seconds spent at NBBO for the treated exchange, pooled across all three events. The treated sample includes daily trading in all stocks in our sample on the exchange introducing order book fees. The untreated sample includes daily trading in the same stocks on all other exchanges not introducing fees. In Columns (1) and (2), the regression model is $y_{ijt} = \beta Treat_j \times Post_t + FE_{ijt} + \varepsilon_{ijt}$, where y_{ijt} is the log of total dollar volume executed in stock i on date t on venue type j (treated and untreated respectively), $Treat_j$ is an indicator variable for treatment status, $Post_t$ is an indicator variable for observations in the post-implementation period and FE_{ijt} are various fixed effects (see Section 2.4 for details). Columns (3) and (4) split observations into ISO and non-ISO volume and include the interaction terms of ISO-status with $Treat_j$, $Post_t$ and the triple-interaction. In column (5), the dependent variable is the time an exchange spends with quotes equal to the NBBO (measured in log seconds). This variable has only one observation per stock-day. Standard errors are clustered at the stock-venue level.

	Log Volume		Log Volume		Log Seconds at NBBO
	(1)	(2)	(3)	(4)	(5)
Treat × Post	-0.1525***	-0.1302***	-0.1458***	-0.1250***	
	(-36.8)	(-13.7)	(-33.8)	(-13.1)	
Treat × Post × ISO			-0.0223***	-0.0239***	
			(-4.05)	(-4.93)	
Post					-0.1667***
					(-22.89)
Treat	-2.3083***		-2.4757***		
	(-376)		(-379)		
Post × ISO			0.0426***	0.0425***	
			(12.74)	(14.3)	
Treat × ISO			0.4598***	0.4525***	
			(60.3)	(68.8)	
ISO			-0.6427***	-0.6318***	
			(-119)	(-135)	
# Obs.	1,346,166	1,346,166	2,647,002	2,647,002	553,734
Adj. R^2	0.90	0.97	0.96	0.89	0.45
Stock × Treat FE		X			X
Stock × Treat × ISO FE				X	
Day FE		X		X	
Stock × Day FE	X				
Stock × Day × ISO FE			X		

Table 5: Broker routing decisions

This table reports the average percent of market and limit orders that brokers route to exchanges one-quarter before announcement (Pre), one-quarter after implementation ($Post$), and the change from before announcement to after implementation of market data fees ($\Delta = Post - Pre$). Each quarterly broker-market pair is a separate observation, where the market is either NYSE, Nasdaq, or Amex referring to the exchange where the stock is listed. In Panel A we use all brokers that routed orders to the treated exchange before the event. In Panel B we use all brokers that routed limit orders to the treated exchange before the event. The difference in order routing percentages is estimated for all brokers (Δ_{All}), brokers split by whether they participate in the inter-dealer over-the-counter market for corporate securities according to FINRA BrokerCheck filings ($\Delta_{IDM=1}$ vs. $\Delta_{IDM=0}$) and brokers split by whether they participate in underwriting selling groups according to FINRA BrokerCheck filings ($\Delta_{UW=1}$ vs. $\Delta_{UW=0}$). Standard errors are clustered by market when estimating the statistical significance of the Δ terms. The data is from Rule 606 filings, available at vrs.vista-one-solutions.com.

Panel A: All brokers which routed orders to the treated exchange pre-event

	Pre	Post	Δ_{All}	$\Delta_{IDM=1}$	$\Delta_{IDM=0}$	$\Delta_{UW=1}$	$\Delta_{UW=0}$
Rule 606 market orders	7.8417	5.4736	-2.3682**	-1.4087	-3.4149**	-2.1757	-2.9956***
			(-2.07)	(-0.91)	(-2.01)	(-1.47)	(-3.57)
Rule 606 limit orders	9.1737	7.4710	-1.7027	-1.9690	-1.4122	-2.2303	-0.0170
			(-1.32)	(-0.89)	(-1.14)	(-1.39)	(0.01)
# Obs.	115	115	115	60	55	88	27
# Brokers	27	27	27	11	16	21	6

Panel B: All brokers which routed limit orders to the treated exchange pre-event

	Pre	Post	Δ_{All}	$\Delta_{IDM=1}$	$\Delta_{IDM=0}$	$\Delta_{UW=1}$	$\Delta_{UW=0}$
Rule 606 market orders	15.787	11.043	-4.7442**	-2.424	-8.1661**	-4.7865	-4.6447***
			(-2.08)	(-0.88)	(-2.11)	(-1.48)	(-4.01)
Rule 606 limit orders	18.508	14.103	-4.4053*	-4.5747	-4.1548	-4.9067	-3.2253*
			(-1.77)	(-1.22)	(-1.46)	(-1.40)	(-1.95)
# Obs.	57	57	57	34	23	40	17
# Brokers	17	17	17	9	8	13	4

Table 6: Quotes and transaction cost components

This table reports coefficients (t-statistics) for the effect of fee introduction on proportional quoted spreads, log of quoted depth (the average of the dollar value available when the exchange is at the best bid and ask), proportional price impact, proportional effective spreads and proportional realized spreads, pooled across all three events. The treated sample includes daily trading in all stocks in our sample on the exchange introducing order book fees. The untreated sample includes daily trading in the same stocks on all other exchanges not introducing fees. The regression model is $y_{ijt} = \beta\, Treat_j \times Post_t + FE_{ijt} + \varepsilon_{ijt}$, where y_{ijt} is the relevant dependent variable for stock i on date t and venue type j (treated and untreated respectively), $Treat_j$ is an indicator variable for treatment status, $Post_t$ is an indicator variable for observations in the post-implementation period and FE_{ijt} are various fixed effects (see Section 2.4 for details). Standard errors are clustered at the stock-venue level.

	Quoted Spread		Log Depth		Effective Spread		Price Impact		Realized Spread	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Treat × Post	0.2268***	0.3626***	-0.0678***	-0.0568***	-0.0062***	-0.0028	-0.0139***	-0.0146***	0.0059**	0.0098*
	(7.75)	(12.1)	(-22.8)	(-8.88)	(-3.32)	(-0.44)	(-6.90)	(-4.81)	(2.29)	(1.74)
Treat	1.7503***		-1.3439***		-0.0374***		0.0092***		-0.0449***	
	(37.7)		(-208)		(-17.9)		(4.84)		(-18.2)	
# Stocks	3,646	3,646	3,646	3,646	3,646	3,646	3,646	3,646	3,646	3,646
# Days	249	249	249	249	249	249	249	249	249	249
# Obs.	1,329,868	1,329,868	1,073,633	1,073,633	1,361,257	1,361,257	1,361,305	1,361,305	1,361,328	1,361,328
Adj. R^2	0.33	0.69	0.88	0.84	0.92	0.66	0.55	0.27	0.75	0.45
Stock × Day FE	X		X		X		X		X	
Stock × Treat FE		X		X		X		X		X
Day FE		X		X		X		X		X

Table 7: Changes in treated exchange market shares

This table reports coefficients (t-statistics) for the effect of fee introduction on treated exchange market shares, estimated separately for each event. The treated sample includes daily trading in all stocks that have top tercile pre-announcement market shares on the exchange introducing order book fees. The untreated sample includes daily trading in all stocks with bottom tercile market shares on the exchange introducing fees. The regression model is $y_{ijt} = \beta\ High_{ij} \times Post_t + FE_{ijt} + \varepsilon_{ijt}$ where y_{ijt} is the percentage volume that is executed on the treated exchange for stock i on date t, $High_{ij}$ is an indicator variable for whether the stock is in the top tercile group, $Post_t$ is an indicator for observations in the post-implementation period and FE_{ijt} are various fixed effects (see Section 5.1 for details). Standard errors are clustered at the stock level.

	ARCA	DEDGE	BATS
	(1)	(2)	(3)
Treat × Post	-0.0358***	-0.0315***	-0.0203***
	(-20.0)	(-21.6)	(-21.7)
# Stocks	1,945	1,805	1,790
# Days	82	84	83
# Obs.	145,083	138,045	133,706
Adj. R^2	0.25	0.27	0.44
Stock FE	X	X	X
Day FE	X	X	X

Table 8: Market-wide changes in price efficiency

This table reports coefficients (t-statistics) for the effect of fee introduction on market-wide volatility, price efficiency and trading concentration across venues (Herfindahl-Hirschmann indices), pooled across all three events. The treated sample includes daily trading in all stocks that have top tercile pre-announcement market shares on the exchange introducing order book fees. The untreated sample includes daily trading in all stocks with bottom tercile market shares on the exchange introducing fees. The regression model is $y_{ijt} = \beta High_{ij} \times Post_t + FE_{ijt} + \varepsilon_{ijt}$ where y_{ijt} is the relevant dependent variable defined above measured for stock i on date t and event j (ARCA, Direct Edge or BATS), $High_{ij}$ is an indicator variable for whether the stock is in the top tercile group for event j, $Post_t$ is an indicator for observations in the post-implementation period and FE_{ijt} are various fixed effects (see Section 5.1 for details). Standard errors are clustered at the stock-event level.

	Volatility		Pricing Error		Herfindahl-Hirschmann	
	(1)	(2)	(3)	(4)	(5)	(6)
Treat × Post	0.0068***	0.0069***	0.0049**	0.0045**	0.0064***	0.0065***
	(2.59)	(2.85)	(2.10)	(1.97)	(6.69)	(6.79)
Treat	-0.0012		-0.0070**		-0.0135***	
	(-0.30)		(-2.17)		(-12.4)	
# Stocks	3,064	3,064	3,064	3,064	3,064	3,064
# Days	249	249	249	249	249	249
# Obs.	416,880	416,880	408,191	408,191	410,368	410,368
Adj. R^2	0.61	0.74	0.39	0.46	0.52	0.56
Stock FE	X		X		X	
Stock × Treat FE		X		X		X
Day FE		X		X		X

Table 9: Market-wide changes in quotes

This table reports coefficients (t-statistics) for the effect of fee introduction on market-wide proportional quoted spreads, log of quoted depth at the NBBO, proportional price impact, proportional effective spreads and proportional realized spreads, pooled across all three events. The treated sample includes daily trading in all stocks that have top tercile pre-announcement market shares on the exchange introducing order book fees. The untreated sample includes daily trading in all stocks with bottom tercile market shares on the exchange introducing fees. The regression model is $y_{ijt} = \beta\, High_{ij} \times Post_t + FE_{ijt} + \varepsilon_{ijt}$ where y_{ijt} is the relevant dependent variable defined above measured for stock i on date t and event j (ARCA, Direct Edge or BATS), $High_{ij}$ is an indicator variable for whether the stock is in the top tercile group for event j, $Post_t$ is an indicator for observations in the post-implementation period and FE_{ijt} are various fixed effects (see Section 5.1 for details). Standard errors are clustered at the stock-event level.

	Quoted Spread		Log depth		Effective Spread		Price Impact		Realized Spread	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Treat × Post	0.0318**	0.0327**	-0.0629***	-0.0603***	0.0292***	0.0285***	0.0024	0.0022	0.0276***	0.0269***
	(2.06)	(2.26)	(-6.04)	(-6.02)	(2.59)	(2.76)	(0.56)	(0.53)	(2.82)	(2.93)
Treat	0.0081		0.0307**		-0.0115		0.0008		-0.0142	
	(0.30)		(2.34)		(-0.58)		(0.14)		(-0.89)	
# Stocks	3,064	3,064	3,064	3,064	3,064	3,064	3,064	3,064	3,064	3,064
# Days	249	249	249	249	249	249	249	249	249	249
# Obs.	416,880	416,880	416,880	416,880	416,836	416,836	416,835	416,835	416,835	416,835
Adj. R^2	0.66	0.81	0.82	0.87	0.66	0.80	0.23	0.28	0.52	0.64
Stock FE	X		X		X		X		X	
Stock × Treat FE		X		X		X		X		X
Day FE		X		X		X		X		X

Table 10: Market-wide changes in trading volume from large trades

This table reports coefficients (t-statistics) for the effect of fee introduction on (logarithm of) market-wide trade volumes split by trade size, pooled across all three events. The treated sample includes daily trading in all stocks that have top tercile pre-announcement market shares on the exchange introducing order book fees. The untreated sample includes daily trading in all stocks with bottom tercile market shares on the exchange introducing fees. The regression model is $y_{imj} = \beta\, High_i \times Post_m \times Large_j + FE_{imj} + \varepsilon_{imj}$ where y_{imj} is the number of submissions or trades for stock i in month m in one of the four size categories as defined for Rule 605 (j), $High_i$ is an indicator variable for whether the stock is in the upper tercile (treated) group, $Post_m$ is an indicator for months in the post-implementation period, $Large_j$ is an indicator variable equal to one for the top two size categories and zero otherwise, and FE_{imj} are various fixed effects (see Section 5.1 for details). Panels A and B aggregate the cumulative number of order submissions and shares traded reported in Rule 605 filings across all brokers for, respectively, all market orders and outside-the-quote limit orders separately by stock-month and within the four reported size categories. Standard errors are clustered at the stock-event level.

	Panel A: Market-orders				Panel B: Limit-orders			
	Submissions		Trades		Submissions		Trades	
$High \times Post \times Large$	-0.1378***	-0.1352***	-0.0459**	-0.0434**	-0.0567	-0.0569	-0.1174**	-0.1370***
	(-4.14)	(-4.17)	(-2.04)	(-1.98)	(-1.44)	(-1.47)	(-2.48)	(-2.97)
$High \times Post$	0.0200	0.0230	0.0686***	0.0648***	0.1129***	0.1143***	0.0797***	0.0866***
	(0.86)	(1.01)	(3.75)	(3.65)	(4.29)	(4.45)	(3.01)	(3.36)
$High \times Large$	0.0221	-0.0004	-0.0755***	-0.0878***	-0.4070***	-0.4240***	-0.2574***	-0.2573***
	(0.69)	(-0.01)	(-2.75)	(-3.26)	(-6.58)	(-6.90)	(-4.93)	(-4.97)
$Post \times Large$	0.0875***	0.0815***	0.0605***	0.0515***	-0.1855***	-0.1863***	-0.0501	-0.0535*
	(3.70)	(3.53)	(3.90)	(3.42)	(-7.17)	(-7.36)	(-1.58)	(-1.74)
$Large$	0.1606***	0.1393***	-0.0279	-0.0501***	-0.7146***	-0.7369***	0.2842***	0.2359***
	(7.22)	(6.43)	(-1.47)	(-2.71)	(-17.91)	(-18.72)	(7.74)	(6.54)
$High$	-0.2597***	0.0085	-0.0783***	0.0177	0.0306	0.0950***	0.0688**	-0.0218
	(-9.51)	(0.60)	(-3.30)	(1.22)	(0.83)	(2.99)	(2.11)	(-1.43)
# Stocks	3,041	3,041	3,041	3,041	3,041	3,041	3,041	3,041
# Months	4	4	4	4	4	4	4	4
# Obs.	78,175	78,175	76,047	76,047	74,676	74,676	53,411	53,411
Adj. R^2	0.65	0.71	0.72	0.78	0.59	0.63	0.59	0.65
Stock FE	X		X		X		X	
Stock × Event FE		X		X		X		X
Month FE	X	X	X	X	X	X	X	X

Internet Appendix

Competition and Exchange Data Fees

1 Information share

For each stock and each day, we construct two series of 1-second midpoint quote prices from 10:00 to 15:30, one based on best bid offer prices at the treated exchange (BBO) and one estimated from national best bid offer prices excluding the treated exchange, constructed following Holden and Jacobsen (2014) ($NBBO^{-}$).We then estimate an error-correction vector autoregression (VAR) model with 60 lags using the log prices of BBO and $NBBO^{-}$ as the co-integrated VAR process and the difference in both log prices as the co-integrated process. Given that we assume that both prices are co-integrated, both contain a single random-walk component, which is identified as the efficient price. Information share (of the BBO price) measures the proportion of the variance at the treated exchange to total variance of the efficient price. The information share can be interpreted as the fraction at which the price at the treated exchange moves first, before the $NBBO^{-}$ price.

As explained by Hasbrouck (1993, p. 1183), because price innovations across both markets are correlated, we derive an upper and a lower Information Share by either permutating the price at the treated exchange first or last.

We also estimate the information share of the treated exchange from midpoint prices prevailing trades. We estimate the information share of the treated exchange as the contribution of that exchange to the total variance of the common (random-walk) component, following Hasbrouck (1995). As in Hasbrouck (1995) we derive a lower and an upper bound of the information share because when prices at different venues move at the same time the

movement cannot be uniquely attributed to any venue. In the regression, we use the upper and lower bounds, the average of the lower and upper bounds, and also estimate a modified information share following Lien and Shrestha (2009).

Figure IA.1: Trading activity around Arca fee announcement — Treatment effect by week

This figure plots dynamic treatment effects of data fee filing on log dollar volume traded on Arca in three-month pre- and post-treatment periods where treatment is defined as the date of Arca's first filing to introduce data fees (May 23, 2006). The estimation specification is analogous to those in Table 2 except separate treatment effects are estimated for each week of the sample, with the reference period corresponding to the week up to and including fee announcement. Confidence intervals are computed at the 95% significance level.

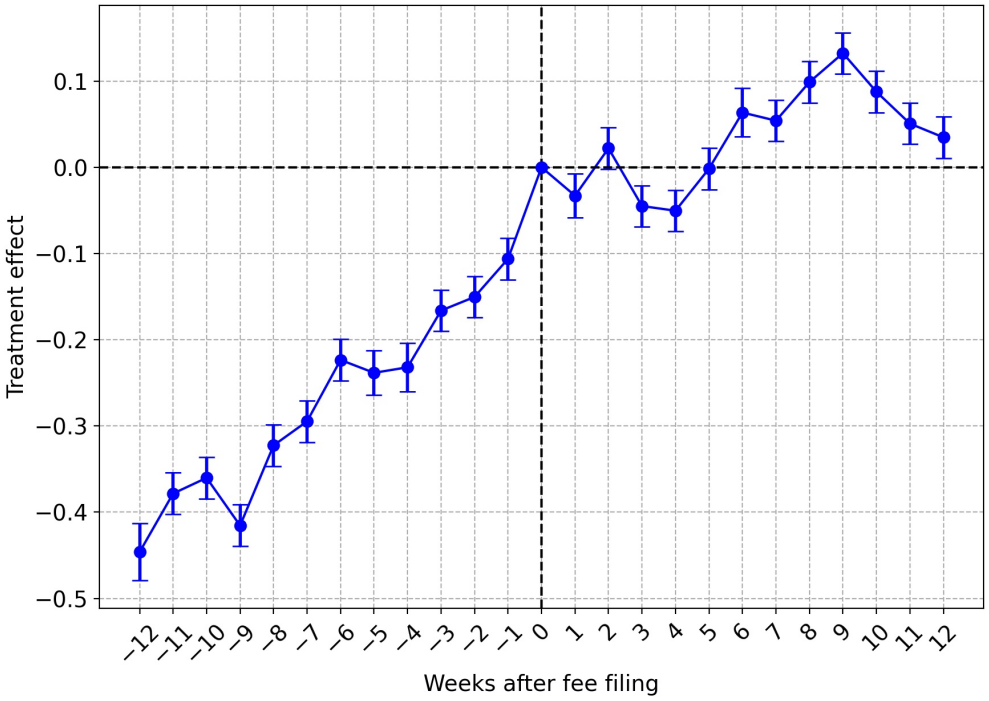


Table IA.1: Summary statistics — Arca

This table reports means, standard deviations, minimums, maximums and 25th, 50th and 75th quantiles for trading activity and liquidity variables for trading on treated exchanges and untreated venues. All details are as per Table 1 except that the treated sample includes daily trading in all stocks in our sample on Arca during the first event window. The untreated sample includes trading in the same stock-days on all other exchanges not introducing fees.

	Mean	SD	Min	25%	50%	75%	Max	Mean Pre-Fee	Mean Post-Fee
Panel A: Trading on Treated Exchanges									
Log Dollar Volume	12.405	3.0457	4.9767	10.361	12.641	14.664	18.350	12.498	12.371
Log ISO Dollar Volume	11.669	3.0049	4.8283	9.5519	11.781	13.962	17.687	11.749	11.640
Market Share (%)	15.952	9.7679	0.0087	10.431	14.907	19.463	100.00	16.963	15.587
Effective Spread (%)	0.8820	1.5998	0.0128	0.1108	0.2621	0.8317	10.258	0.9800	0.8450
Realized Spread (%)	0.4708	1.4112	-2.6144	-0.0057	0.0576	0.3209	9.4762	0.5305	0.4483
Price Impact (%)	0.4000	0.9013	-1.9997	0.0458	0.1425	0.3950	6.1170	0.4408	0.3846
Quoted Spread (%)	4.1726	9.3867	0.0282	0.2561	0.6690	3.0782	56.851	4.1879	4.1673
Log Dollar Depth	1.3359	0.9330	0.0000	0.6950	1.0117	1.6818	5.1814	1.2608	1.3601
Seconds at NBBO	8,604.1	5,638.4	7.0000	4,271.0	7,293.0	12,129.0	22,964	8138.8	8751.0
Information Share	0.3553	0.1879	0.0023	0.2115	0.3820	0.5000	0.6981	0.3499	0.3572
Panel B: Trading on Non-treated Venues									
Log Dollar Volume	14.025	2.9251	6.9854	11.863	14.190	16.256	20.382	14.095	14.000
Log ISO Dollar Volume	13.087	3.0159	6.0684	10.854	13.214	15.427	19.699	13.139	13.069
Effective Spread (%)	1.1114	2.0234	0.0153	0.1149	0.2860	1.0636	11.926	1.1732	1.0884
Realized Spread (%)	0.6565	1.6358	-0.8920	0.0128	0.0675	0.4524	10.335	0.7065	0.6379
Price Impact (%)	0.4442	0.8425	-1.3303	0.0671	0.1618	0.4385	5.3693	0.4582	0.4390
Quoted Spread (%)	1.4145	2.3742	0.0182	0.1793	0.4337	1.4560	13.752	1.5634	1.3640
Log Dollar Depth	2.1458	1.1658	0.5319	1.3112	1.7885	2.6982	6.9697	1.9986	2.1928

Table IA.2: Summary statistics — Direct Edge

This table reports means, standard deviations, minimums, maximums and 25th, 50th and 75th quantiles for trading activity and liquidity variables for trading on treated exchanges and untreated venues. All details are as per Table 1 except that the treated sample includes daily trading in all stocks in our sample on Direct Edge during the second event window. The untreated sample includes the trading in the same stock-days on all other exchanges not introducing fees.

	Mean	SD	Min	25%	50%	75%	Max	Mean Pre-Fee	Mean Post-Fee
Panel A: Trading on Treated Exchanges									
Log Dollar Volume	12.384	2.4873	4.9767	10.643	12.387	14.246	18.350	12.541	12.331
Log ISO Dollar Volume	11.758	2.4702	4.8283	10.002	11.693	13.614	17.687	11.921	11.704
Market Share (%)	8.9783	7.5209	0.0157	4.6652	7.0436	10.772	100.00	9.6681	8.7459
Effective Spread (%)	0.3315	0.7164	0.0128	0.0527	0.1204	0.3011	10.258	0.3203	0.3352
Realized Spread (%)	0.1832	0.7526	-2.6144	0.0022	0.0388	0.1339	9.4762	0.1676	0.1884
Price Impact (%)	0.1493	0.5185	-1.9997	0.0031	0.0441	0.1574	6.1170	0.1533	0.1480
Quoted Spread (%)	2.6486	5.0784	0.0282	0.3616	1.0501	2.3232	56.851	2.1178	2.8264
Log Dollar Depth	1.4370	0.9563	0.0000	0.7826	1.1994	1.8657	5.1814	1.4985	1.4173
Seconds at NBBO	5,214.1	5,904.1	7.0000	985.0	2,792.0	7,251.0	22,964	5767.4	5039.7
Information Share	0.2634	0.1693	0.0023	0.1256	0.2316	0.3867	0.6981	0.2699	0.2613
Panel B: Trading on Non-treated Venues									
Log Dollar Volume	14.740	2.6753	6.9854	12.899	14.844	16.756	20.382	14.777	14.728
Log ISO Dollar Volume	13.700	2.7851	6.0684	11.789	13.786	15.814	19.699	13.711	13.697
Effective Spread (%)	0.5048	1.1197	0.0153	0.0607	0.1424	0.3995	11.926	0.4683	0.5170
Realized Spread (%)	0.3269	1.0081	-0.8920	0.0153	0.0472	0.1761	10.335	0.2933	0.3381
Price Impact (%)	0.1784	0.5067	-1.3303	0.0243	0.0618	0.1626	5.3693	0.1744	0.1797
Quoted Spread (%)	0.6818	1.4021	0.0182	0.0916	0.2133	0.5583	13.752	0.6098	0.7059
Log Dollar Depth	2.2436	1.2191	0.5319	1.3734	1.8938	2.7828	6.9697	2.3006	2.2249

Table IA.3: Summary statistics — BATS

This table reports means, standard deviations, minimums, maximums and 25th, 50th and 75th quantiles for trading activity and liquidity variables for trading on treated exchanges and untreated exchanges. All details are as per Table 1 except that the treated sample includes daily trading in all stocks in our sample on BATS during the third event window. The untreated sample includes trading in the same stock-days on all other exchanges not introducing fees.

	Mean	SD	Min	25%	50%	75%	Max	Mean Pre-Fee	Mean Post-Fee
Panel A: Trading on Treated Exchanges									
Log Dollar Volume	12.382	2.5880	4.9767	10.651	12.480	14.245	18.350	12.423	12.369
Log ISO Dollar Volume	11.754	2.4855	4.8283	10.054	11.758	13.523	17.687	11.757	11.753
Market Share (%)	6.4160	4.3963	0.0086	3.6424	5.6211	8.1913	100.00	6.9689	6.2411
Effective Spread (%)	0.2232	0.4378	0.0128	0.0439	0.0924	0.2314	10.258	0.2362	0.2192
Realized Spread (%)	0.1101	0.5195	-2.6144	-0.0018	0.0242	0.1008	9.4762	0.1234	0.1059
Price Impact (%)	0.1163	0.4198	-1.9997	0.0087	0.0419	0.1262	6.1170	0.1233	0.1141
Quoted Spread (%)	1.0100	1.8060	0.0282	0.2179	0.5538	1.1126	36.918	1.0945	0.9833
Log Dollar Depth	0.7023	0.8467	0.0000	0.2032	0.3994	0.8126	5.1814	0.7764	0.6798
Seconds at NBBO	5,231.8	6,861.1	7.0000	564.0	1,767.0	7,312.0	22,964	5700.8	5080.1
Information Share	0.1764	0.1679	0.0023	0.0465	0.1168	0.2568	0.6981	0.1885	0.1726
Panel B: Trading on Non-treated Venues									
Log Dollar Volume	15.015	2.4547	6.9854	13.334	15.117	16.823	20.382	14.908	15.050
Log ISO Dollar Volume	13.862	2.5459	6.0684	12.107	13.932	15.739	19.699	13.721	13.906
Effective Spread (%)	0.3556	0.7476	0.0153	0.0552	0.1255	0.3459	11.926	0.3939	0.3435
Realized Spread (%)	0.2257	0.6629	-0.8920	0.0173	0.0500	0.1701	10.335	0.2672	0.2126
Price Impact (%)	0.1286	0.3501	-1.3303	0.0197	0.0506	0.1288	5.3693	0.1314	0.1278
Quoted Spread (%)	0.5180	0.9495	0.0182	0.0891	0.2119	0.5400	13.752	0.5434	0.5098
Log Dollar Depth	2.1176	1.1576	0.5319	1.3118	1.7725	2.6312	6.9697	2.1731	2.1005

Table IA.4: Summary statistics — 3 month pre-announcement window

This table reports means, standard deviations, minimums, maximums and 25th, 50th and 75th quantiles for trading activity and liquidity variables for trading on treated exchanges and untreated exchanges. All details are as per Table 1 other than the pre- and post-announcement windows are both three months.

	Mean	SD	Min	25%	50%	75%	Max	Mean Pre-Fee	Mean Post-Fee
Panel A: Trading on Treated Exchanges									
Log Dollar Volume	12.445	2.7363	4.9767	10.600	12.560	14.443	18.561	12.533	12.357
Log ISO Dollar Volume	11.726	2.6754	4.8283	9.8810	11.743	13.701	17.687	11.808	11.698
Effective Spread (%)	0.5064	1.1368	0.0131	0.0639	0.1515	0.4064	10.088	0.5409	0.4721
Realized Spread (%)	0.2621	1.0260	-2.7813	-0.0027	0.0370	0.1630	9.1605	0.2736	0.2506
Price Impact (%)	0.2418	0.7084	-2.0612	0.0143	0.0713	0.2301	6.3498	0.2656	0.2180
Quoted Spread (%)	2.7352	6.5993	0.0285	0.2650	0.6997	1.9666	56.851	2.7737	2.6976
Log Dollar Depth	1.1437	0.9706	0.0000	0.4547	0.8731	1.5367	5.1834	1.1704	1.1351
Seconds at NBBO	6,224.0	6,374.9	7.0000	1,118.0	3,844.0	9,472.0	22,964	6,441.1	6,154.9
Information Share	0.2710	0.1909	0.0023	0.1003	0.2426	0.4324	0.7038	0.2757	0.2691
Panel B: Trading on Non-treated Venues									
Log Dollar Volume	14.593	2.7228	6.9854	12.719	14.750	16.621	20.429	14.607	14.579
Log ISO Dollar Volume	13.536	2.8168	6.0684	11.583	13.664	15.660	19.699	13.505	13.546
Effective Spread (%)	0.6784	1.4717	0.0157	0.0746	0.1795	0.5420	11.743	0.7008	0.6563
Realized Spread (%)	0.4100	1.2055	-1.0408	0.0154	0.0545	0.2313	10.122	0.4203	0.3999
Price Impact (%)	0.2645	0.6456	-1.2789	0.0308	0.0840	0.2346	5.5439	0.2774	0.2517
Quoted Spread (%)	0.9025	1.8058	0.0188	0.1150	0.2790	0.7747	14.428	0.9356	0.8703
Log Dollar Depth	2.1703	1.1835	0.5319	1.3318	1.8202	2.7064	6.9703	2.1696	2.1705

Table IA.5: Trading activity by event — 3 month pre-announcement window

This table reports coefficients (t-statistics) for the effect of fee introduction on total log dollar volume traded, estimated separately for each fee introduction event. All details are as per Table 2 other than the pre- and post-announcement windows are both three months.

	ARCA		DEDGE		BATS	
	(1)	(2)	(3)	(4)	(5)	(6)
Treat × Post	-0.1516***	-0.1472***	-0.1129***	-0.1255***	-0.1603***	-0.1654***
	(-27.1)	(-10.3)	(-17.2)	(-7.38)	(-24.6)	(-8.81)
Treat	-1.7410***		-2.4853***		-2.7715***	
	(-250)		(-379)		(-286)	
# Stocks	3,106	3,106	2,840	2,840	2,808	2,808
# Days	122	122	123	123	122	122
# Obs.	721,577	721,577	655,942	655,942	636,658	636,658
Adj. R^2	0.96	0.94	0.96	0.92	0.96	0.93
Stock × Day FE	X		X		X	
Stock × Treat FE		X		X		X
Day FE		X		X		X

Table IA.6: Trading activity — 1 week post-event window

This table reports coefficients (t-statistics) for the effect of fee introduction on log dollar volume traded using one month pre- and one week post-event windows, pooled across all three events. The treated sample includes daily trading in all stocks in our sample on the exchange introducing order book fees. The untreated sample includes daily trading in the same stocks on all other exchanges not introducing fees. Each stock-day-venue combination contributes one observation to the regression. Standard errors are clustered at the stock-venue level.

	Log Volume	
	(1)	(2)
Treat × Post	-0.0282***	-0.0390***
	(-4.85)	(-3.59)
Treat	-2.3083***	
	(-377)	
# Obs.	406,717	406,717
Adj. R^2	0.98	0.91
Stock × Day FE	X	
Stock × Treat FE		X
Day FE		X

Table IA.7: Trading activity — NYSE exchange-family

This table reports coefficients (t-statistics) for the effect of fee introduction on total log dollar volume traded, estimated for the Arca event where treated volume is computed at the exchange-family (NYSE) level, rather than volume traded on Arca only. The treated sample includes daily trading in all stocks in our sample on the exchange family introducing order book fees. The untreated sample includes daily trading in the same stocks on all other exchanges not introducing fees. Standard errors are clustered at the stock-venue level.

	NYSE Family	
	(1)	(2)
Treat × Post	-0.1298***	-0.1341***
	(-20.3)	(-10.1)
Treat	-1.2065***	
		(-70.7)
# Obs.	474,998	474,998
Adj. R^2	0.94	92
Stock × Day FE	X	
Stock × Treat FE		X
Day FE		X

Table IA.8: Pooled trading activity — 3 month pre-announcement window

This table reports coefficients (t-statistics) for the effect of fee introduction on log dollar volume traded, volume executed via intermarket sweep orders (ISOs) and otherwise, and seconds spent at NBBO. All details are as per Table 4 other than the pre- and post-announcement windows are both three months.

	Log Volume		Log Volume		Log Seconds at NBBO
	(1)	(2)	(3)	(4)	(5)
Treat × Post	-0.1642***	-0.1390***	-0.1508***	-0.1263***	
	(-44.0)	(-14.7)	(-39.0)	(-13.3)	
Treat × Post × ISO			-0.0264***	-0.0300***	
			(-5.35)	(-6.99)	
Post					-0.1432***
					(-20.02)
Treat	-2.2966***		-2.4757***		
	(-399)		(-379)		
Post × ISO			0.0146***	0.0160***	
			(4.78)	(5.95)	
Treat × ISO			0.4639***	0.4585***	
			(66.5)	(76.6)	
ISO			-0.6148***	-0.6052***	
			(123)	(-141)	
# Obs.	2,014,177	2,014,177	3,962,408	3,962,408	817,347
Adj. R^2	0.90	0.97	0.96	0.89	0.44
Stock × Treat FE		X			X
Stock × Treat × ISO FE				X	
Day FE		X		X	
Stock × Day FE	X				
Stock × Day × ISO FE			X		

Table IA.9: Quotes and transaction cost components — Arca

This table reports coefficients (t-statistics) for the effect of fee introduction on proportional quoted spreads, log of quoted depth (the average of the dollar value available when the exchange is at the best ask and bid), proportional price impact, proportional effective spreads and proportional realized spreads. The treated sample includes daily trading in all stocks in our sample on Arca during the first event window. The untreated sample includes daily trading in the same stocks on all other exchanges not introducing fees. All other details are as per Table 6 in the main paper.

	Quoted Spread		Log Depth		Effective Spread		Price Impact		Realized Spread	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Treat × Post	0.4040***	0.8660***	-0.0647***	-0.0672***	0.0080*	0.0091	-0.0178***	-0.0183**	0.0272***	0.0274**
	(4.47)	(9.13)	(-20.7)	(-6.97)	(1.66)	(0.60)	(-3.61)	(-2.53)	(4.12)	(1.98)
Treat	2.9869***		-1.0432***		-0.0120***		0.0172***		-0.0345***	
	(25.5)		(-186)		(-2.61)		(3.82)		(-5.92)	
# Stocks	3,067	3,067	3,067	3,067	3,067	3,067	3,067	3,067	3,067	3,067
# Days	82	82	82	82	82	82	82	82	82	82
# Obs.	464,732	464,732	320,200	320,200	478,542	478,542	478,621	478,621	478,626	478,626
Adj. R^2	0.25	0.63	0.94	0.88	0.91	0.73	0.56	0.30	0.76	0.51
Stock × Day FE	X		X		X		X		X	
Stock × Treat FE		X		X		X		X		X
Day FE		X		X		X		X		X

Table IA.10: Quotes and transaction cost components — Direct Edge

This table reports coefficients (t-statistics) for the effect of fee introduction on proportional quoted spreads, log of quoted depth (the average of the dollar value available when the exchange is at the best ask and bid), proportional price impact, proportional effective spreads and proportional realized spreads. The treated sample includes daily trading in all stocks in our sample on Direct Edge during the second event window. The untreated sample includes daily trading in the same stocks on all other exchanges not introducing fees. All other details are as per Table 6 in the main paper.

	Quoted Spread		Log Depth		Effective Spread		Price Impact		Realized Spread	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Treat × Post	0.6742***	0.5862***	-0.0962***	-0.1130***	-0.0198***	-0.0326***	-0.0099***	-0.0066*	-0.0098***	-0.0263***
	(15.6)	(13.2)	(-17.0)	(-10.3)	(-7.66)	(-3.63)	(-4.30)	(-1.77)	(-3.08)	(-3.24)
Treat	1.5456***		-1.3361***		-0.0577***		-0.0020		-0.0533***	
	(31.6)		(-118)		(-19.0)		(-0.93)		(-17.3)	
# Stocks	2,831	2,831	2,831	2,831	2,831	2,831	2,831	2,831	2,831	2,831
# Days	84	84	84	84	84	84	84	84	84	84
# Obs.	438,916	438,916	376,548	376,548	447,956	447,956	447,931	447,931	447,939	447,939
Adj. R^2	0.34	0.65	0.86	0.85	0.89	0.77	0.46	0.18	0.72	0.49
Stock × Day FE	X		X		X		X		X	
Stock × Treat FE		X		X		X		X		X
Day FE		X		X		X		X		X

Table IA.11: Quotes and transaction cost components — BATS

This table reports coefficients (t-statistics) for the effect of fee introduction on proportional quoted spreads, log of quoted depth (the average of the dollar value available when the exchange is at the best ask and bid), proportional price impact, proportional effective spreads and proportional realized spreads. The treated sample includes daily trading in all stocks in our sample on BATS during the third event window. The untreated sample includes daily trading in the same stocks on all other exchanges not introducing fees. All other details are as per Table 6 in the main paper.

	Quoted Spread		Log Depth		Effective Spread		Price Impact		Realized Spread	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Treat × Post	-0.1082***	-0.1134***	-0.0307***	-0.0338***	-0.0002	0.0268***	-0.0079***	-0.0106***	0.0048*	0.0333***
	(-5.02)	(-5.07)	(-5.64)	(-3.01)	(-0.14)	(4.10)	(-3.58)	(-3.41)	(1.88)	(5.40)
Treat	0.6702***		-1.6158***		-0.0431***		0.0097***		-0.0486***	
	(25.0)		(-189)		(-22.1)		(4.69)		(-18.7)	
# Stocks	2,811	2,811	2,811	2,811	2,811	2,811	2,811	2,811	2,811	2,811
# Days	83	83	83	83	83	83	83	83	83	83
# Obs.	426,220	426,220	376,885	376,885	434,759	434,759	434,753	434,753	434,763	434,763
Adj. R^2	0.59	0.80	0.90	0.90	0.90	0.75	0.45	0.19	0.70	0.45
Stock × Day FE	X		X		X		X		X	
Stock × Treat FE		X		X		X		X		X
Day FE		X		X		X		X		X

Table IA.12: Quotes and transaction cost components — 3 month pre-announcement window

This table reports coefficients (t-statistics) for the effect of fee introduction on proportional quoted spreads, log of quoted depth (the average of the dollar value available when the exchange is at the best ask and bid), proportional price impact, proportional effective spreads and proportional realized spreads. All details are as per Table 6 other than the pre- and post-announcement windows are both three months.

	Quoted Spread		Log Depth		Effective Spread		Price Impact		Realized Spread	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Treat × Post	0.0094	0.1269***	-0.0646***	-0.0579***	-0.0071***	-0.0060	-0.0175***	-0.0157***	0.0091***	0.0080
	(0.33)	(4.40)	(-21.8)	(-9.05)	(-4.80)	(-1.00)	(-12.0)	(-6.14)	(4.69)	(1.58)
Treat	1.9676***		-1.3471***		-0.0365***		0.0128***		-0.0481***	
	(41.4)		(-209)		(-21.3)		(10.3)		(-26.9)	
# Stocks	3,695	3,695	3,695	3,695	3,695	3,695	3,695	3,695	3,695	3,695
# Days	370	370	370	370	370	370	370	370	370	370
# Obs.	1,972,450	1,972,450	1,078,373	1,078,373	2,024,396	2,024,396	2,024,427	2,024,427	2,024,464	2,024,464
Adj. R^2	0.33	0.66	0.88	0.84	0.92	0.65	0.55	0.27	0.74	0.43
Stock × Day FE	X		X		X		X		X	
Stock × Treat FE		X		X		X		X		X
Day FE		X		X		X		X		X

Table IA.13: Information shares

This table reports changes in Hasbrouck (1995) and Modified (Lien and Shrestha, 2009) Information Share after fee introduction. We report the upper and the lower Information Share measures and the average of both, pooled across all three events. The sample includes all stocks on the venue introducing order book fees in three month windows around fee introduction. *Post* is an indicator variable equal to one after the fee introduction and zero before. Each stock-day contributes one observation to the regression. We drop one half-trading day from the analysis (24 December 2008). Standard errors are clustered at the stock-venue level.

	Information Shares	Modified Information Shares	Upper Information Shares	Lower Information Shares
Post	-0.0257***	-0.0304***	-0.0170***	-0.0758***
	(-4.84)	(-5.00)	(-3.14)	(-10.7)
# Stocks	3,478	3,478	3,478	3,478
# Days	242	242	242	242
# Obs.	542,188	542,188	542,188	542,188
Adj. R^2	0.21	0.18	0.27	0.08
Stock FE	X	X	X	X

Table IA.14: Pooled market-wide summary statistics

This table reports means, standard deviations, minimums, maximums and 25th, 50th and 75th quantiles for trading activity and liquidity variables for market-wide trading in high and low terciles groups as explained in Section 5. The treated sample includes daily trading in all stocks that have a pre-announcement market share on the treated exchange in the top tercile and the non-treated sample includes daily trading in all stocks that are in the bottom market share tercile. Trading is pooled across all three events using one month pre-announcement and three-month post-implementation windows.

	Mean	SD	Min	25%	50%	75%	Max	Mean Pre-Fee	Mean Post-Fee
Panel A: High Market Share Stocks									
Market share	0.1318	0.1013	0.0001	0.0658	0.1055	0.1718	0.9934	0.1551	0.1237
Log volume	14.897	2.7198	8.1674	12.910	14.969	17.000	20.662	14.849	14.913
Effective spread (%)	0.6483	1.2383	0.0162	0.0747	0.1943	0.6043	10.176	0.6990	0.6307
Price impact (%)	0.1892	0.5137	-1.4175	0.0064	0.0479	0.1932	4.1816	0.1974	0.1864
Realized spread (%)	0.4584	1.0731	-0.8400	0.0357	0.1007	0.3560	8.9295	0.4999	0.4440
Quoted spread (%)	0.9167	1.7145	0.0164	0.0996	0.2858	0.8681	13.633	0.9860	0.8927
Log depth	8.8165	1.1867	5.9101	8.0035	8.7390	9.5491	12.565	8.8225	8.8145
Volatility	0.1218	0.2380	0.0041	0.0194	0.0451	0.1158	2.2684	0.1347	0.1173
Pricing error	0.1169	0.2412	0.0000	0.0099	0.0381	0.1155	2.3607	0.1257	0.1139
Herfindahl-Hirschmann	0.2935	0.1072	0.1503	0.2181	0.2696	0.3357	0.8041	0.2939	0.2934
Panel B: Low Market Share Stocks									
Market share	0.0763	0.0659	0.0001	0.0337	0.0573	0.1021	0.9594	0.0763	0.0763
Log volume	14.652	2.4744	8.4996	12.877	14.674	16.448	20.364	14.621	14.663
Effective spread (%)	0.6458	1.1462	0.0181	0.0924	0.2268	0.6552	9.5832	0.7228	0.6192
Price impact (%)	0.1851	0.4636	-1.2380	0.0106	0.0605	0.2117	3.6178	0.1947	0.1818
Realized spread (%)	0.4607	0.9766	-0.7345	0.0419	0.1193	0.4228	8.0248	0.5271	0.4378
Quoted spread (%)	0.8692	1.5205	0.0181	0.1299	0.3228	0.8857	12.390	0.9611	0.8374
Log depth	8.7177	1.2175	5.7202	7.9993	8.6500	9.3420	12.853	8.6925	8.7265
Volatility	0.1279	0.2369	0.0032	0.0209	0.0479	0.1266	2.1799	0.1483	0.1208
Pricing error	0.1214	0.2380	0.0000	0.0160	0.0457	0.1161	2.2960	0.1340	0.1171
Herfindahl-Hirschmann	0.3004	0.1109	0.1487	0.2209	0.2740	0.3515	0.7817	0.3044	0.2991

Table IA.15: Market-wide summary statistics — Arca

This table reports means, standard deviations, minimums, maximums and 25th, 50th and 75th quantiles for trading activity and liquidity variables for market-wide trading in high and low terciles groups as explained in Section 5. The treated sample includes daily trading in all stocks that have a pre-announcement market share on the treated exchange in the top tercile during the Arca event and the non-treated sample includes daily trading in all stocks that are in the bottom market share tercile during the Arca event, using one month pre-announcement and three-month post-implementation windows.

	Mean	SD	Min	25%	50%	75%	Max	Mean Pre-Fee	Mean Post-Fee
Panel A: High Market Share Stocks									
Market share	0.1932	0.1141	0.0001	0.1285	0.1770	0.2311	0.9934	0.2187	0.1835
Log volume	14.363	2.7284	8.1674	12.417	14.338	16.321	20.662	14.357	14.365
Effective spread (%)	0.9451	1.6226	0.0163	0.1233	0.2925	0.9549	10.176	1.0521	0.9045
Price impact (%)	0.3045	0.6531	-1.4175	0.0268	0.0989	0.3147	4.1816	0.3264	0.2962
Realized spread (%)	0.6333	1.3868	-0.8400	0.0466	0.1290	0.5007	8.9295	0.7138	0.6027
Quoted spread (%)	1.4040	2.2825	0.0168	0.1787	0.4775	1.5194	13.633	1.5671	1.3421
Log depth	8.3334	1.0288	5.9101	7.6461	8.3027	8.9901	12.565	8.3234	8.3372
Volatility	0.1585	0.2716	0.0041	0.0374	0.0707	0.1572	2.2684	0.1828	0.1493
Pricing error	0.1824	0.3102	0.0000	0.0263	0.0790	0.1917	2.3607	0.2064	0.1742
Herfindahl-Hirschmann	0.3443	0.1134	0.1574	0.2747	0.3193	0.3838	0.8041	0.3457	0.3438
Panel B: Low Market Share Stocks									
Market share	0.1200	0.0802	0.0001	0.0697	0.1130	0.1539	0.9594	0.1185	0.1206
Log volume	13.717	2.5800	8.4996	11.633	13.696	15.822	20.364	13.737	13.710
Effective spread (%)	1.2223	1.6609	0.0181	0.1704	0.5662	1.5467	9.5832	1.3451	1.1753
Price impact (%)	0.3482	0.6303	-1.2380	0.0437	0.1440	0.4336	3.6178	0.3692	0.3401
Realized spread (%)	0.8644	1.4159	-0.7345	0.0713	0.2513	1.0483	8.0248	0.9623	0.8268
Quoted spread (%)	1.6297	2.2023	0.0181	0.2399	0.7464	2.0956	12.390	1.7947	1.5664
Log depth	8.0411	1.1376	5.7202	7.1965	8.0605	8.8003	12.853	8.0138	8.0515
Volatility	0.2381	0.3360	0.0032	0.0453	0.1110	0.2794	2.1799	0.2722	0.2251
Pricing error	0.2242	0.3444	0.0000	0.0361	0.0903	0.2573	2.2960	0.2566	0.2129
Herfindahl-Hirschmann	0.3528	0.1161	0.1664	0.2663	0.3278	0.4103	0.7817	0.3505	0.3536

Table IA.16: Market-wide summary statistics — Direct Edge

This table reports means, standard deviations, minimums, maximums and 25th, 50th and 75th quantiles for trading activity and liquidity variables for market-wide trading in high and low terciles groups as explained in Section 5. The treated sample includes daily trading in all stocks that have a pre-announcement market share on the treated exchange in the top tercile during the Direct Edge event and the non-treated sample includes daily trading in all stocks that are in the bottom market share tercile during the Direct Edge event, using one month pre-announcement and three-month post-implementation windows.

	Mean	SD	Min	25%	50%	75%	Max	Mean Pre-Fee	Mean Post-Fee
Panel A: High Market Share Stocks									
Market share	0.1932	0.1141	0.0001	0.1285	0.1770	0.2311	0.9934	0.2187	0.1835
Log volume	14.363	2.7284	8.1674	12.417	14.338	16.321	20.662	14.357	14.365
Effective spread (%)	0.9451	1.6226	0.0163	0.1233	0.2925	0.9549	10.176	1.0521	0.9045
Price impact (%)	0.3045	0.6531	-1.4175	0.0268	0.0989	0.3147	4.1816	0.3264	0.2962
Realized spread (%)	0.6333	1.3868	-0.8400	0.0466	0.1290	0.5007	8.9295	0.7138	0.6027
Quoted spread (%)	1.4040	2.2825	0.0168	0.1787	0.4775	1.5194	13.633	1.5671	1.3421
Log depth	8.3334	1.0288	5.9101	7.6461	8.3027	8.9901	12.565	8.3234	8.3372
Volatility	0.1585	0.2716	0.0041	0.0374	0.0707	0.1572	2.2684	0.1828	0.1493
Pricing error	0.1824	0.3102	0.0000	0.0263	0.0790	0.1917	2.3607	0.2064	0.1742
Herfindahl-Hirschmann	0.3443	0.1134	0.1574	0.2747	0.3193	0.3838	0.8041	0.3457	0.3438
Panel B: Low Market Share Stocks									
Market share	0.1200	0.0802	0.0001	0.0697	0.1130	0.1539	0.9594	0.1185	0.1206
Log volume	13.717	2.5800	8.4996	11.633	13.696	15.822	20.364	13.737	13.710
Effective spread (%)	1.2223	1.6609	0.0181	0.1704	0.5662	1.5467	9.5832	1.3451	1.1753
Price impact (%)	0.3482	0.6303	-1.2380	0.0437	0.1440	0.4336	3.6178	0.3692	0.3401
Realized spread (%)	0.8644	1.4159	-0.7345	0.0713	0.2513	1.0483	8.0248	0.9623	0.8268
Quoted spread (%)	1.6297	2.2023	0.0181	0.2399	0.7464	2.0956	12.390	1.7947	1.5664
Log depth	8.0411	1.1376	5.7202	7.1965	8.0605	8.8003	12.853	8.0138	8.0515
Volatility	0.2381	0.3360	0.0032	0.0453	0.1110	0.2794	2.1799	0.2722	0.2251
Pricing error	0.2242	0.3444	0.0000	0.0361	0.0903	0.2573	2.2960	0.2566	0.2129
Herfindahl-Hirschmann	0.3528	0.1161	0.1664	0.2663	0.3278	0.4103	0.7817	0.3505	0.3536

Table IA.17: Market-wide summary statistics — BATS

This table reports means, standard deviations, minimums, maximums and 25th, 50th and 75th quantiles for trading activity and liquidity variables for market-wide trading in high and low terciles groups as explained in Section 5. The treated sample includes daily trading in all stocks that have a pre-announcement market share on the treated exchange in the top tercile during the BATS event and the non-treated sample includes daily trading in all stocks that are in the bottom market share tercile during the BATS event, using one month pre-announcement and three-month post-implementation windows.

	Mean	SD	Min	25%	50%	75%	Max	Mean Pre-Fee	Mean Post-Fee
Panel A: High Market Share Stocks									
Market share	0.0840	0.0428	0.0002	0.0570	0.0781	0.1039	0.9906	0.0969	0.0798
Log volume	16.584	2.1100	8.1674	15.171	16.753	18.215	20.662	16.536	16.599
Effective spread (%)	0.1744	0.3938	0.0162	0.0366	0.0746	0.1605	10.176	0.1876	0.1702
Price impact (%)	0.0443	0.2238	-1.4175	-0.0003	0.0129	0.0491	4.1816	0.0441	0.0444
Realized spread (%)	0.1320	0.3741	-0.8400	0.0229	0.0485	0.1178	8.9295	0.1458	0.1275
Quoted spread (%)	0.2347	0.5302	0.0164	0.0422	0.0965	0.2171	13.633	0.2396	0.2331
Log depth	9.7282	1.0441	5.9101	8.9898	9.6488	10.368	12.565	9.7430	9.7234
Volatility	0.0371	0.0885	0.0041	0.0094	0.0166	0.0337	2.2684	0.0407	0.0359
Pricing error	0.0280	0.0826	0.0000	0.0036	0.0089	0.0243	2.3607	0.0273	0.0282
Herfindahl-Hirschmann	0.2448	0.0747	0.1503	0.1972	0.2270	0.2685	0.8041	0.2368	0.2475
Panel B: Low Market Share Stocks									
Market share	0.0432	0.0373	0.0001	0.0215	0.0362	0.0541	0.9473	0.0398	0.0443
Log volume	14.010	1.8122	8.4996	12.722	13.865	15.301	20.364	13.904	14.043
Effective spread (%)	0.5005	0.5977	0.0192	0.1398	0.3199	0.6294	9.5832	0.5513	0.4846
Price impact (%)	0.1346	0.3935	-1.2380	0.0039	0.0691	0.2095	3.6178	0.1321	0.1353
Realized spread (%)	0.3763	0.6224	-0.7345	0.0633	0.1917	0.4727	8.0248	0.4313	0.3591
Quoted spread (%)	0.6844	0.7725	0.0181	0.2214	0.4677	0.8577	12.390	0.7195	0.6734
Log depth	8.6022	0.7244	5.7202	8.1581	8.5885	9.0405	12.853	8.4759	8.6418
Volatility	0.1042	0.1537	0.0032	0.0290	0.0603	0.1233	2.1799	0.1194	0.0995
Pricing error	0.0962	0.1472	0.0000	0.0273	0.0554	0.1098	2.2960	0.1029	0.0941
Herfindahl-Hirschmann	0.3110	0.1028	0.1487	0.2400	0.2896	0.3570	0.7817	0.3135	0.3101

Table IA.18: Pooled market-wide summary statistics — 3 month pre-announcement windows

This table reports means, standard deviations, minimums, maximums and 25th, 50th and 75th quantiles for trading activity and liquidity variables for market-wide trading in high and low terciles groups as explained in Section 5. The treated sample includes daily trading in all stocks that have a pre-announcement market share on the treated exchange in the top tercile and the non-treated sample includes daily trading in all stocks that are in the bottom market share tercile. Trading is pooled across all three events using three-month pre-announcement and three-month post-implementation windows.

	Mean	SD	Min	25%	50%	75%	Max	Mean Pre-Fee	Mean Post-Fee
Panel A: High Market Share Stocks									
Market share	0.1342	0.1008	0.0001	0.0686	0.1087	0.1744	0.9934	0.1446	0.1237
Log volume	14.920	2.7259	8.1674	12.930	14.997	17.012	20.751	14.927	14.913
Quoted spread	0.9393	1.7536	0.0168	0.1024	0.2961	0.8887	13.431	0.9858	0.8927
Log depth	8.8222	1.1915	5.9101	8.0094	8.7304	9.5419	12.555	8.8300	8.8145
Effective spread	0.6674	1.2711	0.0163	0.0777	0.2022	0.6236	10.028	0.7041	0.6307
Price impact	0.1989	0.5304	-1.2964	0.0067	0.0515	0.2069	4.1965	0.2115	0.1864
Realized spread	0.4675	1.0963	-0.9017	0.0356	0.1024	0.3656	8.8147	0.4911	0.4440
Volatility	0.1250	0.2413	0.0041	0.0199	0.0477	0.1202	2.1448	0.1327	0.1173
Pricing error	0.1176	0.2406	0.0000	0.0102	0.0391	0.1172	2.3038	0.1266	0.1139
Herfindahl-Hirschmann	0.2951	0.1071	0.1512	0.2188	0.2709	0.3415	0.7975	0.2967	0.2934
Panel B: Low Market Share Stocks									
Market share	0.0807	0.0694	0.0000	0.0356	0.0602	0.1085	0.9816	0.0851	0.0763
Log volume	14.655	2.4597	8.4996	12.874	14.666	16.450	20.364	14.648	14.663
Quoted spread	0.8886	1.5598	0.0191	0.1343	0.3344	0.9022	12.302	0.9396	0.8374
Log depth	8.6911	1.2028	5.7202	7.9702	8.6180	9.3083	12.643	8.6560	8.7265
Effective spread	0.6640	1.1861	0.0191	0.0959	0.2361	0.6737	9.6245	0.7087	0.6192
Price impact	0.1984	0.4929	-1.2050	0.0113	0.0648	0.2256	3.9371	0.2148	0.1818
Realized spread	0.4652	0.9983	-0.8996	0.0412	0.1207	0.4286	7.9613	0.4925	0.4378
Volatility	0.1317	0.2374	0.0038	0.0219	0.0515	0.1341	1.9863	0.1425	0.1208
Pricing error	0.1171	0.2308	0.0000	0.0148	0.0438	0.1117	2.0660	0.1172	0.1171
Herfindahl-Hirschmann	0.3010	0.1090	0.1487	0.2228	0.2756	0.3524	0.7733	0.3030	0.2991

Table IA.19: Market-wide changes in treated exchange market shares — 3 month pre-announcement windows

This table reports coefficients (t-statistics) for the effect of fee introduction on treated exchange market share, estimated separately for each event. All details are as per Table 7 other than the pre- and post-announcement windows are both three months.

	ARCA	DEDGE	BATS
	(1)	(2)	(3)
Treat × Post	-0.0181***	-0.0177***	-0.0161***
	(-11.2)	(-13.7)	(-18.8)
# Stocks	1,967	1,823	1,808
# Days	122	123	124
# Obs.	216,862	201,218	201,293
Adj. R^2	0.23	0.24	0.44
Stock & Day FE	X	X	X

Table IA.20: Market-wide changes in price efficiency- Arca

This table reports coefficients (t-statistics) for the effect of fee introduction on market-wide volatility, price efficiency and trading concentration across venues (Herfindahl-Hirschmann indices) for the Arca event. All other details are as per Table 8 in the main paper.

	Volatility	Pricing Error	Herfindahl-Hirschmann
	(1)	(2)	(3)
Treat × Post	0.0022	0.0016	-0.0057***
	(0.42)	(0.26)	(-3.55)
# Stocks	1,945	1,945	1,945
# Days	82	82	82
# Obs.	145,091	141,091	143,221
Adj. R^2	0.75	0.37	0.54
Stock & Day FE	X	X	X

Table IA.21: Market-wide changes in price efficiency — Direct Edge

This table reports coefficients (t-statistics) for the effect of fee introduction on market-wide volatility, price efficiency and trading concentration across venues (Herfindahl-Hirschmann indices) for the Direct Edge event. All other details are as per Table 8 in the main paper.

	Volatility	Pricing Error	Herfindahl-Hirschmann
	(1)	(2)	(3)
Treat × Post	0.0049	0.0020	0.0110***
	(1.06)	(0.60)	(6.85)
# Stocks	1,805	1,805	1,805
# Days	84	84	84
# Obs.	138,069	135,875	135,922
Adj. R^2	0.70	0.37	0.48
Stock & Day FE	X	X	X

Table IA.22: Market-wide changes in price efficiency — BATS

This table reports coefficients (t-statistics) for the effect of fee introduction on market-wide volatility, price efficiency and trading concentration across venues (Herfindahl-Hirschmann indices) for the BATS event. All other details are as per Table 8 in the main paper.

	Volatility	Pricing Error	Herfindahl-Hirschmann
	(1)	(2)	(3)
Treat × Post	0.0165***	0.0109***	0.0159***
	(6.74)	(5.47)	(9.45)
# Stocks	1,790	1,790	1,790
# Days	83	83	83
# Obs.	133,720	131,225	131,225
Adj. R^2	0.62	0.54	0.46
Stock & Day FE	X	X	X

Table IA.23: Market-wide changes in price efficiency — 3 month pre-announcement windows

This table reports coefficients (t-statistics) for the effect of fee introduction on market-wide volatility, price efficiency and trading concentration across venues (Herfindahl-Hirschmann indices). All details are as per Table 8 in the main paper other than the pre- and post-announcement windows are both three months.

	Volatility		Pricing Error		Herfindahl-Hirschmann	
	(1)	(2)	(3)	(4)	(5)	(6)
High × Post	0.0053**	0.0059**	0.0040*	0.0042*	0.0075***	0.0076***
	(2.02)	(2.43)	(1.71)	(1.87)	(7.93)	(8.14)
High	0.0016		-0.0035		-0.0140***	
	(0.40)		(-1.12)		(-12.9)	
# Stocks	3,156	3,156	3,156	3,156	3,156	3,156
# Days	245	245	245	245	245	245
# Obs.	425,844	425,844	425,844	425,844	425,844	425,844
Adj. R^2	0.61	0.74	0.39	0.45	0.53	0.56
Stock FE	X		X		X	
Stock × Event FE		X		X		X
Day FE	X	X	X	X	X	X

Table IA.24: Algorithmic trading activity

This table reports coefficients (t-statistics) for the effect of fee introduction on proxies for algorithmic trading activity, pooled across all three events in our sample. Columns (1) through (4) present across-venue regressions analogous to Columns (1) and (2) of Table 4. Columns (5) through (8) present market-wide regressions, analogous to Table 8. HJM is the negative of the ratio of the total dollar volume traded to the number of quote changes, expressed in $100s (similar to Hendershott, Jones, and Menkveld, 2011). Log Quote to Trade is the log of the ratio of the number of quote changes to the number of trades by stock-venue or stock-day. Standard errors are clustered at the stock level.

	Within-venue				Market-wide			
	HJM		Log Quote to Trade		HJM		Log Quote to Trade	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treat × Post	0.1505***	0.1074***	3.7577***	3.7880***	0.0345	0.0371	0.0172	0.0178
	(9.24)	(4.86)	(7.55)	(5.03)	(1.20)	(1.21)	(1.43)	(1.47)
Treat	0.0758***		12.04***		-0.2003***		-0.0030	
	(3.46)		(16.8)		(-5.32)		(-0.17)	
# Obs.	1,331,040	1,330,892	1,330,892	1,331,040	416,954	405,812	405,812	405,812
Adj. R^2	0.57	0.56	0.49	053	0.61	0.69	0.48	0.57
Stock × Treat FE		X		X		X		X
Day FE		X		X		X		X
Stock × Day FE	X		X		X		X	

Table IA.25: Market-wide changes in quotes — Arca

This table reports coefficients (t-statistics) for the effect of fee introduction on market-wide proportional quoted spreads and log of quoted depth (average dollar value available at NBBO) for the Arca event. All other details are as per Table 9 in the main paper.

	Quoted Spread	Log depth	Effective Spread	Price Impact	Realized Spread
	(1)	(2)	(3)	(4)	(5)
Treat × Post	-0.0463	0.0054	-0.0374	-0.0088	-0.0254
	(-1.38)	(0.38)	(-1.57)	(-0.88)	(-1.21)
# Stocks	1,945	1,945	1,945	1,945	1,945
# Days	82	82	82	82	82
# Obs.	145,091	145,091	145,049	145,048	145,048
Adj. R^2	0.78	0.82	0.77	0.27	0.63
Stock & Day FE	X	X	X	X	X

Table IA.26: Market-wide changes in quotes — Direct Edge

This table reports coefficients (t-statistics) for the effect of fee introduction on market-wide proportional quoted spreads and log of quoted depth (average dollar value available at NBBO) for the Direct Edge event. All other details are as per Table 9.

	Quoted Spread	Log depth	Effective Spread	Price Impact	Realized Spread
	(1)	(2)	(3)	(4)	(5)
Treat × Post	0.0914***	-0.0330*	0.0607***	0.0176***	0.0428***
	(3.88)	(-1.76)	(3.56)	(2.87)	(2.81)
# Stocks	1,805	1,805	1,805	1,805	1,805
# Days	84	84	84	84	84
# Obs.	138,069	138,069	138,067	138,067	138,067
Adj. R^2	0.80	0.88	0.78	0.22	0.61
Stock & Day FE	X	X	X	X	X

Table IA.27: Market-wide changes in quotes — BATS

This table reports coefficients (t-statistics) for the effect of fee introduction on market-wide proportional quoted spreads and log of quoted depth (average dollar value available at NBBO) for the BATS event. All other details are as per Table 9 in the main paper.

	Quoted Spread	Log depth	Effective Spread	Price Impact	Realized Spread
	(1)	(2)	(3)	(4)	(5)
Treat × Post	0.0547***	-0.1675***	0.0590***	0.0002	0.0593***
	(4.22)	(-9.09)	(6.17)	(0.04)	(6.40)
# Stocks	1,790	1,790	1,790	1,790	1,790
# Days	83	83	83	83	83
# Obs.	133,720	133,720	133,720	133,720	133,720
Adj. R^2	0.80	0.86	0.78	0.14	0.47
Stock & Day FE	X	X	X	X	X

Table IA.28: Market-wide changes in quotes — 3 month pre-announcement windows

This table reports coefficients (t-statistics) for the effect of fee introduction on market-wide proportional quoted spreads and log of quoted depth (average dollar value available at NBBO). All details are as per Table 9 other than the pre- and post-announcement windows are both three months.

	Quoted Spread		Log depth		Effective Spread		Price Impact		Realized Spread	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Treat × Post	-0.0213	-0.0202	-0.0637***	-0.0629***	-0.0142	-0.0138	0.0050	0.0041	-0.0181**	-0.0167*
	(-1.44)	(-1.45)	(-6.16)	(-6.25)	(-1.32)	(-1.37)	(1.42)	(1.20)	(-1.99)	(-1.93)
Treat	0.0715***		0.0385***		0.0376*		-0.0046		0.0419***	
	(2.79)		(3.34)		(1.96)		(-1.02)		(2.75)	
# Stocks	3,069	3,069	3,069	3,069	3,069	3,069	3,069	3,069	3,069	3,069
# Days	369	369	369	369	369	369	369	369	369	369
# Obs.	619,448	619,448	619,448	619,448	619,400	619,400	619,399	619,399	619,399	619,399
Adj. R^2	0.65	0.79	0.82	0.87	0.64	0.78	0.24	0.28	0.51	0.62
Stock FE	X		X		X		X		X	
Stock × Treat FE		X		X		X		X		X
Day FE		X		X		X		X		X

Table IA.29: Market-wide changes in trading volume from large trades — Arca

This table reports coefficients (t-statistics) for the effect of fee introduction on (logarithm of) market-wide trade volumes split by trade size for the Arca event. All other details are as per Table 10 in the main paper.

	Panel A: Market-orders		Panel B: Limit-orders	
	Submissions	Trades	Submissions	Trades
$High \times Post \times Large$	-0.0691**	-0.0037	-0.0851	-0.0186
	(-2.06)	(-0.11)	(-1.56)	(-0.29)
$High \times Post$	0.1245***	0.1248***	0.1093***	0.1200***
	(4.65)	(4.87)	(2.89)	(3.10)
$High \times Large$	-0.3307***	-0.3516***	-0.4595***	-0.6281***
	(-7.95)	(-8.15)	(-7.08)	(-8.61)
$Post \times Large$	0.1546***	0.1560***	-0.0487	0.0181
	(7.15)	(6.96)	(-1.49)	(0.46)
$Large$	0.1115***	0.0802***	0.8362***	0.8449***
	(3.96)	(2.72)	(19.63)	(18.79)
$High$	0.0824***	0.0793***	0.1435***	-0.0092
	(4.30)	(4.11)	(4.52)	(-0.35)
R^2 [%]	76.80	76.63	63.39	66.24
#Stocks	3,041	3,041	3,041	3,041
#Months	4	4	4	4
#Obs	27,480	27,338	26,461	20,196
Stock FE	Yes	Yes	Yes	Yes
Day FE	Yes	Yes	Yes	Yes

Table IA.30: Market-wide changes in trading volume from large trades — Direct Edge

This table reports coefficients (t-statistics) for the effect of fee introduction on (logarithm of) market-wide trade volumes split by trade size for the Direct Edge event. All other details are as per Table 10 in the main paper.

	Panel A: Market-orders		Panel B: Limit-orders	
	Submissions	Trades	Submissions	Trades
$High \times Post \times Large$	-0.0924	-0.0368	-0.1159	-0.1482
	(-1.53)	(-0.92)	(-1.63)	(-1.43)
$High \times Post$	-0.0042	0.0949***	0.2397***	0.0918*
	(-0.09)	(2.88)	(4.63)	(1.90)
$High \times Large$	0.3124***	0.5109***	0.7886***	1.3774***
	(5.27)	(10.47)	(9.92)	(12.73)
$Post \times Large$	0.1185***	-0.0386*	-0.4458***	-0.0661
	(3.13)	(-1.65)	(-9.92)	(-1.20)
$Large$	0.0003	-0.3014***	-1.0412***	-0.7125***
	(0.01)	(-10.43)	(-21.81)	(-12.21)
$High$	-0.1339***	-0.2190***	-0.0000	-0.0000
	(-4.30)	(-6.07)	(-0.00)	(-0.00)
R^2 [%]	68.30	80.32	56.28	67.25
#Stocks	3,041	3,041	3,041	3,041
#Months	4	4	4	4
#Obs	25,145	24,228	23,763	15,695
Stock FE	Yes	Yes	Yes	Yes
Day FE	Yes	Yes	Yes	Yes

Table IA.31: Market-wide changes in trading volume from large trades — BATS

This table reports coefficients (t-statistics) for the effect of fee introduction on (logarithm of) market-wide trade volumes split by trade size for the BATS event. All other details are as per Table 10 in the main paper.

	Panel A: Market-orders		Panel B: Limit-orders	
	Submissions	Trades	Submissions	Trades
$High \times Post \times Large$	-0.2098***	-0.0828**	0.0371	-0.3511***
	(-3.00)	(-2.07)	(0.53)	(-3.99)
$High \times Post$	-0.0716	-0.0372	-0.0113	0.0556
	(-1.60)	(-1.09)	(-0.26)	(1.18)
$High \times Large$	-0.0042	-0.3620***	-0.9527***	-0.9309***
	(-0.07)	(-7.78)	(-11.10)	(-10.93)
$Post \times Large$	-0.0388	0.0378	-0.1417***	-0.0403
	(-0.67)	(1.16)	(-2.74)	(-0.55)
$Large$	0.3176***	0.0537	-2.3121***	0.3851***
	(6.59)	(1.48)	(-36.11)	(5.56)
$High$	-0.0042	-0.3620***	-0.9527***	-0.9309***
	(-0.07)	(-7.78)	(-11.10)	(-10.93)
R^2 [%]	52.65	78.12	72.68	68.47
#Stocks	3,041	3,041	3,041	3,041
#Months	4	4	4	4
#Obs	25,550	24,481	24,452	17,520
Stock FE	Yes	Yes	Yes	Yes
Day FE	Yes	Yes	Yes	Yes

Table IA.32: Market-wide changes in trading volume from large trades — 3 month pre-announcement windows

This table reports coefficients (t-statistics) for the effect of fee introduction on (logarithm of) market-wide trade volumes split by trade size, pooled across all three events. All details are as per Table 10 other than the pre- and post-announcement windows are both three months in the main paper.

	Panel A: Market-orders		Panel B: Limit-orders	
	Submissions	Trades	Submissions	Trades
$High \times Post \times Large$	-0.1958***	-0.0444**	-0.0981***	-0.0870**
	(-7.66)	(-2.49)	(-2.92)	(-2.37)
$High \times Post$	0.0111	0.0001	0.1083***	0.0486**
	(0.57)	(0.01)	(4.54)	(2.24)
$High \times Large$	0.0814***	-0.0789***	-0.3668***	-0.2961***
	(3.53)	(-3.61)	(-7.16)	(-8.06)
$Post \times Large$	0.1418***	0.0373***	-0.2201***	-0.0151
	(7.76)	(3.05)	(-9.94)	(-0.62)
$Large$	0.1111***	0.0002	-0.6861***	0.2631***
	(6.12)	(0.01)	(-19.77)	(8.39)
$High$	-0.2497***	-0.0131	0.0317	0.0942***
	(-9.09)	(-0.55)	(0.93)	(3.19)
R^2 [%]	65.95	71.88	60.43	57.91
#Stocks	3,041	3,041	3,041	3,041
#Months	6	6	6	6
#Obs	118,446	115,500	112,889	81,454
Stock FE	Yes	Yes	Yes	Yes
Day FE	Yes	Yes	Yes	Yes