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journal homepage: www.elsevier.com/locate/finmarStock exchanges as platforms for data and trading[☆]Terrence Hendershott^a, Marc Rysman^b, Rainer Schwabe^{c,*}^a U.C. Berkeley, United States^b Boston University, United States^c Cornerstone Research, United States

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ABSTRACT

We study linkages between stock exchanges' proprietary data sales and trading activity by analyzing the introduction of a new data product, the New York Stock Exchange's Integrated Feed (NYSE IF). Consistent with trading and data being complements, firms that subscribed to the NYSE IF increased their share of trading on the NYSE. In principle, firms subscribing to the NYSE IF could impose a negative externality on non-subscribing firms due to increased information asymmetry. However, consistent with information purchases having a positive network externality due to increased liquidity, non-subscribing firms also increased their share of trading on the NYSE.

1. Introduction

Stock exchanges are textbook examples of multi-sided platforms (Evans and Schmalensee, 2011) bringing together buyers and sellers of stock, and providers and takers of liquidity. Less well recognized is that stock exchanges are also multi-sided platforms for users of trading and data. To facilitate trading, exchanges provide information on the trading process. Stock exchanges charge for both trading services and the data that trading-related activity generates. These trading and data services are used by overlapping sets of firms (some use both, some only one) and the value of these services is interconnected. Data from a stock exchange, for example, are more valuable when the exchange carries more trading activity.

Many firms that consume data do so in order to trade, so they are naturally on “both sides” of this platform. Platform economics applies to cases like this, just as platform economics helps us understand internet platforms like eBay where sellers also purchase from other vendors, or credit card networks where merchants are often also cardholders who regularly use corporate or small business cards. What is critical is that access to data affects trading volumes by attracting both traders that do and do not purchase data and, conversely, that trading activity by traders that do not purchase data affects the value of market data.

The effect of the provision of exchange data on trading is theoretically unclear. Purchasers of data may trade more on that

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* Corresponding author.

E-mail addresses: hender@haas.berkeley.edu (T. Hendershott), mrysmar@bu.edu (M. Rysman), rschwabe@cornerstone.com (R. Schwabe).

exchange, which creates liquidity on the exchange that can further attract traders that do not purchase data. By contrast, because not all traders purchase all data, the sale of market data has the potential to create information asymmetry among traders.¹ Such asymmetry can impose negative externalities on non-purchasers of market data, leading to less overall trading.

Understanding the interaction between market data and firms' trading decisions is fundamental to understanding competition among stock exchanges and, therefore, for effective regulation of stock exchanges. The 1975 Congressional mandate for a national market system for financial securities encourages competition among financial markets and stock exchanges. Financial market regulators must manage this competition, including the dissemination and pricing of stock exchanges' data. For example, the U.S. Securities and Exchange Commission (SEC) organized a roundtable discussion on these issues in the fall of 2018 (SEC, 2018) and issued a rule in December 2020 expanding the set of "core" data that is distributed by stock exchanges at regulated prices (SEC, 2020a).

How the pricing of exchanges' proprietary (non-core) data products affects exchange competition depends in part on whether externalities linking trading and data services exist. If such linkages are weak or non-existent, the pricing of data products can be understood independently of the competitive dynamics of the market for trading services. If these externalities are large, joint analysis of trading and market data competition is important, as the literature on platform economics prescribes (Rochet and Tirole, 2003; Rysman, 2009; Jullien et al., 2021).

This paper provides new empirical evidence of the linkages between trading services and market data products offered by exchanges. We analyze the impact of the introduction of NYSE IF, which provides order-by-order depth of book information, in April 2015 on trading activity on the NYSE. Our first main result is that, consistent with trading and data being complements, firms that subscribe to proprietary data from an exchange tend to trade more on that exchange. Our second main result is that the additional trading by the subscribers to the proprietary data also leads to more trading by non-subscribers. This shows that data and trading are linked via externalities between firms that subscribe to proprietary data and those that do not, and that these externalities are positive so that access to these proprietary data tends to generate more trading on the exchange by all firms. That is, these results show that stock exchanges are platforms for data and trading.

Traders' choices about where to trade affect the value of stock exchanges' data products. Trading activity and order book depth enhance the informational content of the data; the best quotes, often referred to as the best bid and offer (BBO) change more frequently and there are more orders beyond the top of the book. The effect of trading activity on the value of data is one set of linkages between "sides" of the market that make stock exchanges platforms for data and trading.

The main focus of this paper is on the externality that runs in the reverse direction, from data purchases to trading. As traders buy more market data from a particular exchange, the overall volume of trading on that exchange may increase or decrease. Trading activity may increase because traders use market data to make order routing decisions, among other uses. That is, the information in market data is an input to traders' decisions about where to send their orders. Market data can enter these decisions in a variety of ways, but a common theme is that market data reduces uncertainty about the price, likelihood, or timing of order execution. By reducing the uncertainties around order execution on an exchange (or across multiple exchanges), market data makes trading on that exchange more attractive to traders. In Appendix A, we discuss different ways that higher-quality market data reduces uncertainty and affects traders' decisions about where to route orders.

Data purchases also have externalities or indirect effects on traders that do not purchase data. Previous papers identify potential positive and negative externalities (Shkilko and Sokolov, 2020; Boehmer et al., 2005; Easley et al., 2016). Negative externalities arise when some traders purchase the data, acquiring an informational advantage over non-purchasing traders. This possibility has led some market participants to believe that not purchasing the available proprietary data from exchanges means "trading at a disadvantage" (SEC, 2018). Positive externalities can arise from increased trading by traders that purchase data from an exchange generating more liquidity on that exchange, creating value for traders that do not purchase data (Barclay and Hendershott, 2004). These externalities show that stock exchanges are platforms between consumers of market data and consumers of trading services.

We test for the existence and relevance of these linkages between market data and trading using the introduction of a new data product for the New York Stock Exchange (NYSE) in April 2015: the NYSE Integrated Feed (NYSE IF), a full order-by-order depth of book product. We find that this introduction led to a 1.0 percentage point increase in the proportion of total U.S. equities trading on the NYSE, an increase of 8.6 % over the NYSE's pre-NYSE IF proportion of total trading of 11.6 %.

Using new data on firm-level data purchases and trading obtained from the NYSE Group, we are further able to test for the direct and indirect effects of access to the NYSE IF that characterize platform markets. These firm-level data cover trading at the NYSE, NYSE Arca, NYSE National, and NYSE MKT/American (which we refer to as NYSE Group Exchanges). The data therefore cover all NYSE Group exchanges except NYSE Chicago, which became part of NYSE Group only in 2018. Because these data cover only trading on NYSE Group exchanges, we cannot study the shift of firms' overall (i.e., at all trading venues) trading toward the NYSE that followed the introduction of the NYSE IF as we do in the exchange-level analysis. Rather, we study the impact of the introduction of the NYSE IF on two outcomes. First, we look at the proportion of firms' trading on the NYSE Group Exchanges that took place on the NYSE; this measures shifts in the mix of trading within NYSE Group Exchanges. We test whether gaining access to NYSE IF makes trading on the NYSE more attractive relative to other NYSE Group Exchanges, such as NYSE Arca. Second, we look at firms' total trading volume (measured by the number of shares traded) on the NYSE.

We find that access to the NYSE IF led firms to increase the proportion of their trading on NYSE Group Exchanges that took place on

¹ Throughout this paper, when we refer to firms or traders, we mean firms or traders that place orders and trade directly on stock exchanges (or other trading venues). These traders that interact directly with exchanges are specialized proprietary trading or market making firms, investment banks, or brokers that trade on behalf of their clients.

the NYSE by between 6.8 and 7.7 percentage points. Estimates of the effect of subscribing to the NYSE IF on the total number of shares that firms traded on the NYSE are less precise and indicate an increase of 31.4 %–61.0 %. Firms that did not subscribe to the NYSE IF increased the proportion of their trading on NYSE Group Exchanges that took place on the NYSE by 2.7 percentage points. These results are consistent with access to the NYSE IF having both a direct (indirect) effect on subscribers (non-subscribers) through externalities. Thus, our results are consistent with a positive spillover from data purchases to trading at the NYSE.

We begin with an overview of related literature in Section 2. We then discuss the types of data products that stock exchanges provide in Section 3. We present our empirical analysis in Section 4. Section 5 concludes.

2. Related literature

This paper is closest to three studies of discrete changes in access to market data: [Hendershott and Jones \(2005\)](#), [Boehmer et al. \(2005\)](#), and [Brogaard et al. \(2024\)](#). Consistent with our findings, these papers find evidence of a positive relationship between the availability of market data for a given exchange and increased trading activity on that exchange. This paper differs from this previous work in that it documents the direct and indirect linkages between data and trading and we study the linkage of data and trading at the firm level, rather than only at the market level.

[Hendershott and Jones \(2005\)](#) study Island ECN's decision in September 2002 to "go dark" by ceasing to display its limit order book for three exchange-traded funds. Island went from publicly displaying its full order book in real-time on its website to not displaying any orders, even to its subscribers (i.e., firms authorized to trade on Island). Island opted to "go dark" to avoid complying with the obligations, imposed by Regulation ATS, to display its quotes on the national market system and route orders to other exchanges if better prices were available there (and receive orders from other exchanges).

[Hendershott and Jones \(2005\)](#) document that trading volume on the Island ECN dropped following its "going dark," although a considerable amount of trading activity continued to take place on Island. Specifically, Island's share of trading volume for the three affected ETFs dropped from 36 %, 36 %, and 21 % during the five-week period leading up to "going dark" to 16 %, 22 %, and 12 %, respectively, during the five-week period following that event. Consistent with less informed traders valuing information/transparency more, [Hendershott and Jones \(2005\)](#) also find that the mix of traders at Island changed after it went dark, with a greater proportion of liquidity traders, who they interpret as relatively uninformed, switching to other exchanges while a greater proportion of informed traders continued to trade on Island.

[Boehmer et al. \(2005\)](#) study the introduction of the NYSE's OpenBook product in January 2002. OpenBook allowed subscribers to see aggregate volume available at each level of the NYSE's order book, for a fee. [Boehmer et al. \(2005\)](#) find that, following the introduction of OpenBook, volume shifted from floor brokers to the NYSE's electronic limit order book as traders' "new ability to see depth in the book seems to make self-management of the trading process more attractive" relative to delegation to floor brokers. While the authors did not analyze the effect of trading volume on the NYSE relative to other exchanges, their findings suggest that access to OpenBook made trading on the NYSE's electronic limit order book more attractive as order book information reduced uncertainty about the likelihood, price, or timing of execution.

[Brogaard et al. \(2024\)](#) study three instances where stock exchanges increased data fees. They find that the fee increases led to decreases in these exchanges' shares of equity trading volumes. This result echoes our finding that the NYSE's market share increased following the introduction of the NYSE IF and is consistent with some traders reacting to data fee increases by cancelling their subscriptions and routing more of their trading to other venues.

[Easley et al. \(2014\)](#) is similar in spirit. The authors study an event that reduced information asymmetry between traders on and off the trading floor: a technology upgrade to the NYSE specialist posts that reduced the latency in reporting trades and quotes. They find the change significantly raised stock prices and improved liquidity and trading volume.

This paper also contributes to the literature on competition between stock exchanges by documenting links between data and trading services. This implies that competition, demand, and pricing for proprietary data and for trading services are interconnected. [Cantillon and Yin \(2011\)](#) survey the research on exchange competition and emphasize the importance of taking the multi-sided nature of stock exchanges into account when analyzing competition between them. More recently, [Budish et al. \(2024\)](#) argue that competition between exchanges can lead to inefficient investment in "speed technology," which they define to include both proprietary data products and co-location services. [Pagnotta and Philippon \(2018\)](#) and [Cespa and Vives \(2022\)](#) model competition between exchanges via investments to provide faster trading. [Chao et al. \(2017, 2019\)](#) highlight the role of tick-size frictions and trading fee schemes in explaining competition and fragmentation among stock exchanges. [Foucault and Menkveld \(2008\)](#) and [Battalio et al. \(2008\)](#) examine brokers' and traders' order routing decisions.

3. Overview of market data products

As of late 2024, equity trading in the U.S. takes place on 16 stock exchanges, 30 alternative trading systems (ATS), as well as through broker-dealer internalizers and wholesalers. Stock exchanges account for nearly half of U.S. equity shares traded. The 16 stock exchanges can be classified into four groups according to their ownership: Intercontinental Exchange controls NYSE, NYSE American, NYSE Arca, NYSE Chicago, and NYSE National; NASDAQ controls NASDAQ, NASDAQ BX, and NASDAQ PSX; Cboe Global Markets controls BYX Equities, BZX Equities, EDGA Equities, and EDGX Equities; Investors Exchange (IEX), Members Exchange (MEMX), MIAX Pearl, and Long-Term Stock Exchange (LTSE) are independent. To facilitate trading, each stock exchange provides data on trades and orders, which are referred to as "market data." Market data are often divided into two categories: core (securities information processor ("SIP") or consolidated feed) data and non-core (or proprietary) data.

Consolidated feed data are assembled by the SIPs, which aggregate data from all exchanges to provide (1) last sale reports, including the price and amount of the latest sale of a security and the exchange where it took place; and (2) best bid and best offer (also known as *top of book*) price quote information across all exchanges (SEC, 2008, pp. 42–43). The BBO information reported by the SIPs is limited to “round lots,” which for most stocks means orders for blocks with multiples of 100 shares; the consolidated feeds do not report “odd lot” quotes of less than 100 shares (SEC, 2010). SIP data services collect the required data from each stock exchange and distribute it to subscribers for a fee. By regulation, exchanges must supply the necessary data to the SIP no later than they distribute the data to their proprietary data customers.² Among other uses, brokers access the consolidated feed to comply with Rule 603(c) of Regulation NMS, known as the Vendor Display Rule, which requires broker-dealers, in a context in which a trading or order-routing decision can be implemented, to provide a consolidated display of market data when they are providing equity quotation or trade information to customers (FINRA, 2015, p. 1).

Proprietary data products, in contrast, are offered by individual exchanges and contain data about only that exchange, not about the market as a whole. Exchanges offer a variety of proprietary data products, some of which provide only top of book data while others provide varying levels of depth-of-book information.

- a. Best bid or offer (“BBO”): Shows the best prices available at the exchange, and the quantities available at these prices. This provides the same data as the SIP, but only for the exchange in question.
- b. Order book: Shows quantities available at each price level at and beyond the top of the book. The NYSE Group offers this type of data through its OpenBook products for the NYSE and American exchanges and as ArcaBook for NYSE Arca. NYSE National and NYSE Chicago do not offer an order book only data product. They do, however, offer a full order-by-order depth of book product, Integrated Feed, which contains order book information. The NYSE’s order book products include information on odd lot orders.
- c. Full order-by-order depth of book: Shows order book information, along with detailed information about the nature of each adjustment to the order book. That is, it provides data on each trade, new order, order cancellation, or order modification, providing additional detail about movements in the order book. NYSE Group Exchanges offer these data through their Integrated Feed products. The NYSE was the last major exchange to introduce a full order-by-order depth of book product – NYSE Arca offered an Integrated Feed product since 2011 (SEC, 2011); NYSE MKT/American introduced an Integrated Feed product in late 2015 (SEC, 2015b) and NYSE National introduced its Integrated Feed product in 2020 (SEC, 2020b). As noted above, with this type of data, users can determine the number and type of orders that make up the order book and where their own limit orders would be in the electronic order book queue at a given level of the order book. Firms use this information to better predict the likelihood that their marketable orders will be executed on the exchange in question at their desired prices. Firms also use order-by-order depth of book data to make strategic order routing decisions for their liquidity-providing limit orders.
- d. Order imbalance: Information about aggregate quantities and prices submitted during auction periods.
- e. Trade data: Reports all transactions executed on the exchange. This information is also reported in the SIP.

Different market participants may use proprietary data for a number of purposes, including.

- a. To inform investment decisions by enhancing their understanding of liquidity and likely price movements.
- b. To inform order routing decisions by enabling them to assess the likelihood of execution at various venues.
- c. To enable the operation of trading platforms (dark pools or alternative trading systems (ATS)).

Some market participants argue that they must purchase the most sophisticated and complete data feeds from all exchanges in order to be competitive. For example, Doug Cifu, co-founder and chief executive officer of Virtu Financial, remarked that: “Without proprietary data feeds, there’s not a firm today, either as a market maker or an institutional agency broker or prop trading firm that can exist. It’s just that simple” (SEC, 2018, p. 58). Many market participants believe that not subscribing to the available proprietary data would mean they are, as described by IEX CEO Brad Katsuyama, “trading at a disadvantage” (SEC, 2008, p. 64).

However, other market participants believe that proprietary data feeds are not necessary for their business models. Jeff Brown, Senior Vice President and Head of the Office of Legislative and Regulatory Affairs at Charles Schwab asserted that “one of the questions we’ve looked at is, you know, if they use a SIP for pricing or do they use the direct feeds for pricing, does that impact our clients’ execution? And so we’ve studied that. And the result is that it’s an insignificant difference between the use of them, which is odd because we’ve heard so much about how, you know, the direct feeds are necessary for execution” SEC (2018, p. 170).

The NYSE’s data confirms that not all market participants purchase all data (we describe our data in Section 4.1). Table 1 shows the percentage of firms that purchased each combination of data products from the NYSE in December 2018. It also reports the proportion of trading volume on the NYSE that these firms account for. Notably, 20.4 % of firms that traded on NYSE during that month did not purchase data specific to the NYSE.³ The most common choice was for firms to purchase only OpenBook data (49.5 % of firms), but such firms account for only 9.4 % of trading volume. By contrast, the most active firms purchased all three types of data (BBO, OpenBook, and Integrated Feed) – just 8.7 % of firms that traded on NYSE purchased all three types of data, but those firms account for 34.4 % of trading volume. The patterns are also similar for NYSE Arca, NYSE National, and NYSE American, although National does not

² “Dissemination of Quotations in NMS Securities,” 17 CFR § 242.602 (2014).

³ Note that we cannot rule out that firms that traded on NYSE and did not purchase data were trading on behalf of a firm that did purchase data. However, some of the firms in question are proprietary trading firms and would not typically be routing other firms’ orders.

Table 1
Data purchases by firms trading on the NYSE in December 2018

Subscriptions	Proportion of Firms	Proportion of Volume
BBO Only	0.0 %	0.0 %
OpenBook Only	49.5 %	9.4 %
Integrated Feed Only	2.9 %	3.3 %
BBO and OpenBook	7.8 %	23.7 %
BBO and Integrated Feed	0.0 %	0.0 %
OpenBook and Integrated Feed	10.7 %	27.6 %
OpenBook, Integrated Feed, and BBO	8.7 %	34.4 %
None	20.4 %	1.6 %

BBO is the NYSE's best bid and offer (top of book) data; OpenBook is the NYSE's order book product, which reports all bid and offer prices quoted on the NYSE and corresponding aggregate limit order volumes at each price level; and Integrated Feed is the NYSE's full order-by-order depth of book. The proportion of firms subscribing to each combination of data products is calculated as the number of firms that traded on the NYSE and subscribed to that unique combination of data products in December 2018 divided by the total number of firms that traded on NYSE in December 2018 (103). Proportion of volume is calculated as the total combined number of shares traded by firms that subscribed to that unique combination of data products in December 2018 divided by the total number of shares traded on the NYSE in December 2018.

offer an order book only product.

But these are not the only buyers of NYSE data: there are hundreds of firms that do not trade directly on the NYSE but purchase its market data products. Those firms are not reflected in the figures reported in Table 1. These firms may use NYSE data for a variety of purposes, including to develop trading strategies or to operate a dark pool or ATS. These firms may also trade on the NYSE through brokers — it is theoretically possible that the firms that do not purchase the data are simply executing orders under the direction of clients who do purchase it. However, our empirical work identifies significant differences in behavior between these groups (see Section 4.3).

Firms obtain market data from the NYSE by subscribing for a monthly fee. Users pay an access fee, as well as several use-related fees; fee levels are publicly available (NYSE, 2018). Among firms that traded on the NYSE in December 2018, the median monthly bill for NYSE market data was \$1320. If we limit attention to firms that traded on the NYSE and paid for NYSE data, the median monthly data bill was \$5580. There is considerable variation in the data fees paid, with the firm at the 95th percentile among those both trading on the NYSE and purchasing NYSE data paying \$81,350 per month.

Stock exchanges make different choices regarding whether and how much to charge customers for market data. It is common for new stock exchanges or exchanges focused on increasing their share of trading to offer their data free of charge. Established stock exchanges typically charge for their data, as the NASDAQ exchanges (nasdaqtrader.com), the Cboe exchanges (Cboe Global Markets, 2018), and most NYSE Group Exchanges (NYSE, 2018) do. Stock exchanges may choose to transition from a no-fee model to one where they charge for their data as NYSE Arca did in 2009 (SEC, 2010) and the BATS exchanges (BZX and BYX) did in 2013 (SEC, 2013). Pricing strategies such as these are natural outcomes in platform markets where building a base of users on all “sides” of the market is crucial for a platform's viability. For example, Rysman (2009) reports that the independent Yellow Pages publisher “Yellow Book” had a policy of offering advertising for free in the first year it entered a new city. Yellow Book did this to increase the number of advertisers that appeared in their books, since having more advertisers would, in turn, drive more consumers to use its books.

4. The effect of the introduction of the NYSE IF on trading activity

We next turn to our empirical analysis of the link between market data and trading activity following the launch of a new market data product for the NYSE. As discussed above, the NYSE Group introduced a full order-by-order depth of book data product for the NYSE (NYSE Integrated Feed or NYSE IF) in early 2015. The NYSE registered the NYSE IF with the SEC in January 2015 (SEC, 2015a) and the first subscriptions went live in April 2015; in our analyses, we use April 2015 as the date of the NYSE IF's introduction. The NYSE IF offers an order-by-order view of the evolution of the NYSE's order book. With the NYSE IF, users can determine the number and type of orders that make up the order book and where their own limit orders would be in the electronic order book queue at a given level of the order book. Firms use this information to better predict the likelihood that their marketable orders will be executed on the NYSE at their desired prices. Firms also use the NYSE IF to make strategic order routing decisions for their liquidity-providing limit orders.

The NYSE IF's launch gave firms access to new data about activity on the NYSE that, in principle, would lead them to increase their trading on the NYSE. For reasons discussed above, this could either attract or deter volume from other market participants without access to the NYSE IF. After analyzing the effect of the NYSE IF on the NYSE's market share, we will analyze trading by subscribing and non-subscribing firms (that we also refer to as adopters and non-adopters).

4.1. Data sources and description of the uptake of the NYSE IF

We use three data sources to study the impact of the NYSE IF's launch. The first is data on the monthly total number of shares traded, by trading venue. These data were provided by the NYSE, but are essentially identical to publicly available data published by Cboe Global Markets. The data report trading volume for each public exchange, as well as aggregated volumes for ATS and dark pools

reported by the NYSE and NASDAQ trade reporting facilities (TRFs). We use these data to examine the impact of the introduction of the NYSE IF on the NYSE's share of overall trading.

The other two data sources are proprietary: NYSE data on monthly trading volumes and data purchases by NYSE-member firms. Our firm-level data present trading volumes in terms of the number of shares traded, not dollar volume. Because trading fees are charged on a per-share basis, this is a better measure of revenue-generating trading activity for stock exchanges than dollar volume. Unlike our data on total volume by exchange, which cover all equities trading in the U.S., the firm-level data on data purchases and trading volumes are limited to activity on NYSE Group Exchanges (NYSE, NYSE Arca, NYSE National, and NYSE MKT/American⁴). They cover the period from January 2013 to May 2019. The data are comprehensive in that they cover all 167 firms that traded on the NYSE during this period. However, the data identify only the firm placing orders on NYSE Group Exchanges, not their clients who they may be trading on behalf of.

Analyzing the nexus between data purchases and trading activity required matching records of data purchases with trading volume statistics. We grouped firm names that, in some cases, were recorded differently in each dataset. We did this using a fuzzy matching algorithm followed by manual review. We also grouped together accounts for subsidiaries of the same parent company.⁵

Table 2 presents descriptive statistics for our firm-level dataset. Of the 167 firms that traded on the NYSE during our sample period, 31 subscribed to the NYSE IF at some point in time. Firms that subscribed to the NYSE IF (which we refer to as adopters) were more active; their average monthly trading volume on NYSE Group Exchanges was ten times higher than that of firms that did not subscribe to the NYSE IF (non-adopters). The standard deviations on monthly trading volumes indicate significant heterogeneity across firms. Adopters were also more consistently active, on average trading during 71 of the 77 months covered by our data, compared to an average of 55 months for non-adopters. Perhaps counterintuitively, adopters relied less on the NYSE than non-adopters; they did 48 % of their trading on the NYSE, on average, compared to 72 % for non-adopters.⁶ Adopters were more likely to be users of other NYSE proprietary data products (BBO and OpenBook) and were more likely to have traded on other NYSE Group Exchanges. It is notable that most firms, both adopters and non-adopters, traded on NYSE Arca and NYSE MKT/American, as well as on the NYSE.

The first firms to subscribe to the NYSE IF started doing so in April 2015.⁷ As shown in Fig. 1, take-up of the NYSE IF was gradual. Four firms started subscribing to the NYSE IF in April 2015. That rose gradually to 22 firms in December 2015 and stabilized between 24 and 27 firms thereafter. The proportion of trading volume on the NYSE by firms subscribing to the NYSE IF increased in tandem with the number of firms subscribing, starting at 4.4 % in April 2015 and rising to 45.9 % in December 2015. The proportion of trading volume at the NYSE accounted for by NYSE IF subscribers continued to grow until stabilizing at levels between 62 % and 66 % in mid-2017.

We learned through conversations with NYSE Group staff that both the timing of the launch of the NYSE IF and the differences in adoption dates across firms were idiosyncratic and not driven by other factors related to trading activity on the NYSE. The NYSE was the last major exchange to introduce a full order-by-order depth of book product. NYSE Arca offered such a product since 2011 (SEC (2011)). The gradual uptake of the NYSE IF was related in part to logistical issues related to setting up access.

A variety of firms subscribed to the NYSE IF, including⁸

- a. Proprietary trading firms and market makers trading for their own accounts. According to the NYSE's data use client classifications, 29 of 31 adopters were in this category (18 of these are also listed under other categories). These firms include NYSE Designated Market Makers and Supplemental Liquidity Providers. The prominent participation of these firms suggests that the introduction of the NYSE IF would have enhanced liquidity on the NYSE.
- b. Brokers that act as agents, executing trades on behalf of their clients (16 adopters, all of whom are also listed under other categories).
- c. Firms that use market data to run dark pools or ATS (16 adopters, all but one of whom are also listed under other categories).

4.2. Effect on NYSE's share of U.S. Equities trading

The launch of the NYSE IF in April 2015 had a substantial impact on the NYSE's share of total U.S. equities trading. Trading on the NYSE accounted for 11.6 % of total U.S. equities trading, on average, during the 24 months leading up to the launch of the NYSE IF. As shown in Fig. 2, the NYSE's share of overall U.S. equities trading increased gradually following the introduction of the NYSE IF in April

⁴ NYSE MKT became NYSE American in July 2017.

⁵ Both the matching of firm names and the grouping of firms and subsidiaries was independently reviewed by two research assistants. We then worked with them to resolve all discrepancies.

⁶ When calculating the proportion of firms' trading on NYSE Group Exchanges that took place on the NYSE, we conservatively calculate trading volume on the NYSE (the numerator) using only trading in Tape A shares (and excluding trading in Tape B and C shares) to avoid accounting for changes due to the introduction of Tape B and C trading to the NYSE in April 2018, toward the end of the sample period. In general, Tape A is NYSE-listed stocks; Tape C represents NASDAQ-listed stocks; Tape B is the regional stock exchanges with most being NYSE Arca.

⁷ We classify a firm as subscribing to NYSE IF in a given month if the NYSE reports any fees relating to NYSE IF during the month in question. Reported fees may be \$0 during trial periods; firms charged \$0 fees for NYSE IF are also considered to be subscribed to NYSE IF.

⁸ While we had access to firm names that enabled us to make these classifications, we do not mention any NYSE client by name or provide more detailed breakdowns of subscribers due to confidentiality restrictions. Five firms that traded on a NYSE Group Exchange but not on the NYSE also subscribed to NYSE IF, as did 39 firms that did not trade directly on any NYSE Group exchange. These firms may have traded on the NYSE through intermediaries, but this is not observable in our data.

Table 2

Summary statistics on firm-level data on data subscriptions and trading on NYSE Group Exchanges

	NYSE IF Adopters	NYSE IF Non-Adopters	All Firms
Number of Firms	31	136	167
Monthly trading volume on NYSE Group Exchanges (millions of shares)			
Mean	1588.20	145.35	413.19
Standard deviation	1675.09	464.45	999.57
Number of months with trading activity on NYSE Group Exchanges			
Mean	71.03	54.91	57.90
Standard deviation	13.80	25.93	24.91
Proportion of trading on NYSE Group Exchanges that took place on NYSE			
Mean	0.48	0.72	0.67
Standard deviation	0.19	0.30	0.29
Subscribed to NYSE BBO (at least one month)	0.77	0.09	0.22
Subscribed to NYSE OpenBook (at least one month)	0.97	0.82	0.85
Traded on NYSE Arca (at least one month)	1.00	0.69	0.75
Traded on NYSE National (at least one month)	0.68	0.09	0.20
Traded on NYSE MKT/American (at least one month)	0.97	0.96	0.96

This table presents summary statistics on firms' monthly trading volumes on NYSE Group Exchanges and their purchases of proprietary data products from these exchanges between January 2013 and May 2019. Adopters are firms that subscribed to the NYSE IF during any month in our data; non-adopters are firms that never subscribed to the NYSE IF. All means and standard deviations are across firms; that is, they are calculated in two stages: first the mean value for each firm and then the mean and standard deviation across firms. The number of months with trading activity on NYSE Group Exchanges is out of a maximum of 77 months. BBO is the NYSE's best bid and offer (top of book) data. OpenBook is the NYSE's order book product. Traded on NYSE Arca (at least one month) reports the proportion of firms that traded on NYSE Arca during at least one month of our sample period. Traded on NYSE National (at least one month) and Traded on NYSE MKT/American (at least one month) report the analogous proportions for those exchanges.

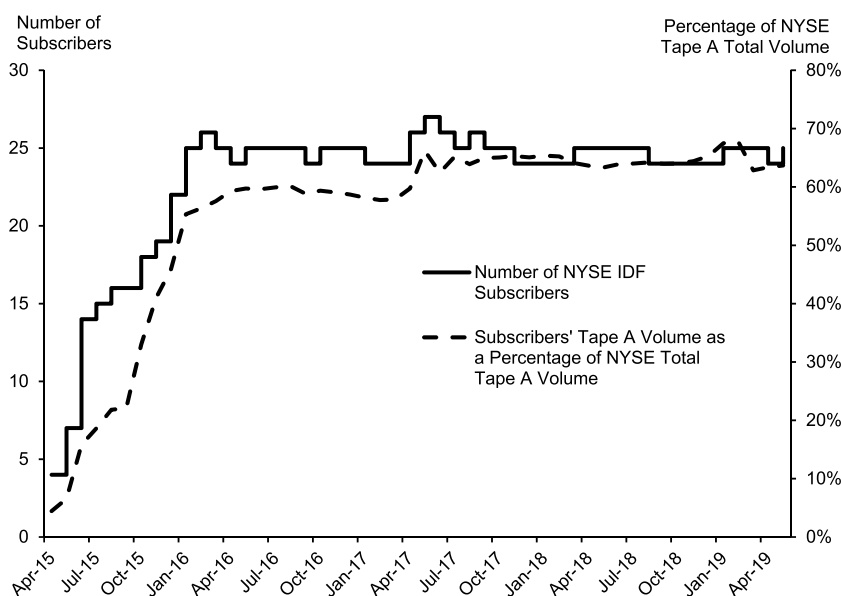


Fig. 1. Number of subscribers to the NYSE IF and proportion of total trading on the NYSE accounted for by NYSE IF subscribers: April 2015 to May 2019

We plot the number of firms subscribing to the NYSE IF (solid line) alongside the proportion of NYSE's Tape A volume (i.e., volume in NYSE-listed stocks) that subscribers account for (dashed line). The first firms to subscribe to the NYSE IF and trade on the NYSE started doing so in April 2015. Trading on the NYSE was limited to Tape A stocks until April 2018.

2015, approaching 14.0 % in September 2015 and stabilizing at levels between 12.7 % and 14.1 % thereafter. The NYSE accounted for 13.1 % of total U.S. equities volume during the 24 months following the launch of the NYSE IF, an increase of 1.5 percentage points over the pre-NYSE IF period. Analyzing trading on the NYSE as a proportion of trading on public exchanges in the U.S. (excluding trading on ATS and dark pools) yields very similar results for both the qualitative analysis results shown in Fig. 2 and the regression analysis discussed below.

In order to verify that the introduction of the NYSE IF led to an increase in the proportion of trades executed on the NYSE, we estimate the following:

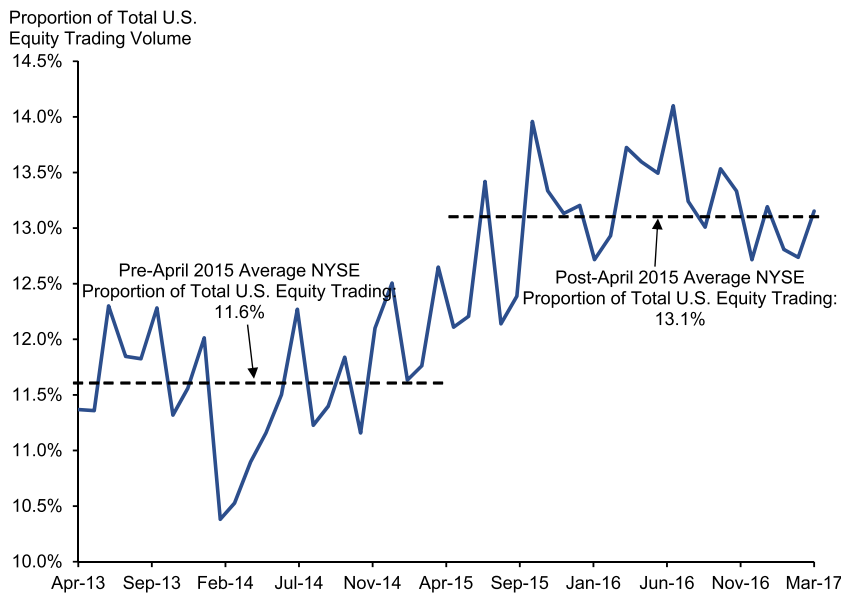


Fig. 2. Proportion of U.S. equities trading volume on the NYSE before and after the launch of the NYSE IF: April 2013 to March 2017
We plot the NYSE's share of total U.S. equity trading volume from April 2013, two years before the NYSE IF became available, through March 2017, two years after the NYSE IF became available. The NYSE's average share of trading increased from 11.6 % over the two years before the NYSE IF's launch to 13.1 % during the two years following the NYSE IF's launch.

$$NYSE\ Shr_t = \alpha + \beta X_t + \gamma NYSE\ IF_t + \varepsilon_t \quad (1)$$

$NYSE\ Shr_t$ denotes the share of U.S. equities, scaled to be between 0 and 1, trading in month t that took place on the NYSE; α is a constant term, X_t is a vector of covariates, which we describe below; $NYSE\ IF_t$ is a dummy variable that takes a value of 1 after the NYSE IF launched in April 2015 and 0 otherwise; and ε_t is an error term that we assume is mean independent of the explanatory variables.

Table 3 presents results from four regression specifications, variants of equation (1) with different covariates X . The coefficient of interest, γ , which measures the impact of the introduction of the NYSE IF, is labeled *Introduction of NYSE Integrated Feed (April 2015)*. In all four specifications, this coefficient is positive and statistically significant at the 95 % confidence level (indicated by two or three asterisks).⁹

The first specification does not control for any potentially confounding factors. The coefficient of interest in specification 1 is 0.015, indicating an increase of 1.5 percentage points in the proportion of NYSE trading. This corresponds to the increase in averages shown in Fig. 2.

In specifications 2–4 in Table 3, we control for other potentially confounding factors.

- Time trends:** Time trends unrelated to the introduction of the NYSE IF could affect the proportion of trading accounted for by the NYSE. For example, the proliferation of dark pools and ATS could generate a downward trend in the proportion of trading at the NYSE. In the specifications shown, the time trend is allowed to be a quadratic curve, not just a straight line.
- Market structure:** Changes in the competitive landscape could affect the proportion of trading at the NYSE. We identify four relevant events during our sample period: The NYSE started trading stocks whose primary listing was not on the NYSE (referred to as Tape B and C stocks, as opposed to Tape A stocks, which are listed on the NYSE) in April 2018; IEX became a public exchange in August 2016; Cboe Stock Exchange went offline in May 2014; and NSX/NYSE National went offline during two windows: between June 2014 and November 2015 and between February 2017 and April 2018.
- Trading volumes:** Total trading volumes may be a proxy for market conditions that may favor (or hinder) trading on the NYSE. In specification 2, we control for total U.S. equities trading (in logarithms); in specification 3, we control for trading on public exchanges and on ATSs or dark pools separately (also in logarithms); and in specification 4, we control for the proportion of trading that goes through public exchanges as opposed to dark pools or ATSs.

Controlling for these factors reduces the estimated effect of introducing the NYSE IF to 1.0 percentage point (specifications 2–4).¹⁰

⁹ We use Newey-West standard errors with lag 3. Using conventional and heteroscedasticity-robust (White) standard errors does not alter these conclusions.

¹⁰ Inclusion of a lagged dependent variable (here, the percentage of U.S. equities trading that took place on the NYSE the previous month) as a regressor does not qualitatively alter the results. Coefficients on the lagged dependent variable term are not statistically significant in any of the specifications shown in Table 3.

Table 3

Regression estimates of impact of the NYSE IF on trading on the NYSE

Independent Variable	Dependent Variable			
	Proportion of NYSE Trading Volume			
	(1)	(2)	(3)	(4)
Introduction of NYSE Integrated Feed (April 2015)	0.015*** (0.002)	0.010** (0.004)	0.010** (0.004)	0.010** (0.004)
Introduction of NYSE Tape B-C (April 2018)	0.001 (0.002)	−0.006 (0.004)	−0.008 (0.005)	−0.006 (0.005)
Time Trend		−0.000 (0.000)	0.000 (0.000)	−0.000 (0.000)
Time Trend Squared		0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
NSX/National Active		0.004** (0.002)	0.005*** (0.002)	0.004** (0.002)
IEX Active		−0.005* (0.002)	−0.004* (0.002)	−0.003 (0.002)
CBOE Active		−0.007 (0.005)	−0.006 (0.004)	−0.007 (0.005)
Total U.S. Equity Volume Traded (log)		−0.008 (0.007)		
U.S. Equity Volume Traded on Public Exchanges (log)			0.022 (0.014)	
U.S. Equity Volume Traded on ATS or Dark Pools (log)			−0.040** (0.019)	
Proportion of Total U.S. Equity Volume Traded on Public Exchanges				0.043 (0.058)
Constant	0.116*** (0.001)	0.321* (0.170)	0.541** (0.209)	0.090** (0.037)
Observations	78	78	78	78
R-squared	0.600	0.650	0.667	0.645

We regress the NYSE's share of U.S. equities trading on several covariates, including a dummy variable for the introduction of the NYSE IF in April 2015. Significance levels are *** 1 %, ** 5 %, * 10 %. Newey-West standard errors (lag = 3) are in parentheses. The regressions are estimated using data from January 2013 through June 2019.

All of the measures of the impact of introducing the NYSE IF are economically significant. An increase of 1.5 percentage points in the NYSE's share of trading amounts to 12.9 % of the NYSE's pre-launch mean of 11.6 %. The lowest estimate shown, 1.0 percentage point, is 8.6 % higher than the pre-launch mean. A very rough calculation of the impact of such a change on the NYSE Group's revenues confirms that it is economically significant: an 8.6 % increase in trading on the NYSE would have translated to roughly \$11.5 million in additional revenue from net transactions fees in 2016.¹¹

When interpreting these results, it is helpful to consider the extent to which different exchanges compete directly or have carved out more specific niches. For example, the NYSE and NASDAQ are the primary venues for listings of large firms; NYSE Arca is known as a prominent venue for ETFs; and NYSE MKT/American is known to specialize in small-capitalization companies. Nevertheless, as of 2015, NYSE-listed stocks accounted for a considerable amount of trading volume (ranging from 37 % at NYSE Arca to 51 % at BATS BYX) on all exchanges except NYSE MKT/American, which did not offer trading for NYSE-listed stocks. It appears that the bulk of the NYSE's gains came at the expense of NASDAQ. In March 2015, on the eve of the introduction of the NYSE IF, the NYSE's share of U.S. equity trading volume was 12.6 %, compared to 16.3 % for NASDAQ; a year later in March 2016, the NYSE's share had grown by 1.1 percentage points to 13.7 % while NASDAQ's had fallen by 2.3 percentage points to 14.0 %.

We test the robustness of these results by using an intercept-only structural break test to select a date after which the NYSE's share changed. We find that June 2015, two months after the introduction of the NYSE IF, is the most likely break date, and we reject the null hypothesis that the intercept does not change. The results are shown in [Appendix B](#). The proximity of the most likely break date to the introduction of the NYSE IF further supports the conclusion that the data platform led to an increase in the share of equities traded on the NYSE.

4.3. Firm-level effects on the proportion of trading on the NYSE

We next use firm-level data to analyze the effects of the introduction of the NYSE IF on firms' order routing decisions at a more granular level. As described above, the firm-level dataset contains monthly data on purchases of data products and on trading on NYSE

¹¹ Absent the increase due to the launch of NYSE IF, trading volume on the NYSE would have been 246.2 billion shares (the actual volume traded on the NYSE in 2016) divided by 1.086, or approximately 226.7 billion shares in 2016. The difference between actual trading volume in 2016 and our estimate of what trading volume would have been absent the launch of NYSE IF is 19.5 billion shares. The average net transaction fee per share traded on the NYSE in 2016 was \$0.000592. Multiplying this net transaction fee by the 19.5 billion affected shares yields \$11.5 million.

Group Exchanges (NYSE, NYSE Arca, NYSE National, and NYSE MKT/American) from January 2013 to May 2019 for all 167 member firms that traded on the NYSE during this period.

Because this firm-level dataset is limited to trading on NYSE Group Exchanges, we cannot study the shift of firms' overall (i.e., on all trading venues) trading toward the NYSE that followed the introduction of the NYSE IF, as we do in the exchange-level analysis presented in Subsection 4.2. Rather, we study the impact of the introduction of the NYSE IF on two outcomes. First, we look at the proportion of firms' trading on NYSE Group Exchanges that took place on the NYSE. This measures shifts in the mix of trading at NYSE Group Exchanges. We hypothesize that gaining access to the NYSE IF made trading on the NYSE more attractive relative to other NYSE Group Exchanges, such as NYSE Arca. Second, we look at firms' total trading volume on the NYSE (measured by the number of shares traded).

Our analysis of firms' proportion of trading on the NYSE addresses firms' split of trading among exchanges directly. We therefore focus mainly on these results. The analysis of firms' trading volumes on the NYSE offers an alternative, but more indirect, perspective on this question. Furthermore, as documented below, firms' trading volumes fluctuate considerably month-to-month, making inference more challenging.

Firms that adopted the NYSE IF were more likely than those that did not to increase the proportion of their trading (among NYSE Group Exchanges) on the NYSE. Fig. 3 shows the distribution of changes in NYSE IF-adopting firms' proportion of trading on the NYSE from the 24 months before adopting the NYSE IF to the 24 months after adopting it (dark gray bars). It also shows the distribution of changes in the proportion of trading on NYSE from the 24 months before the NYSE IF's launch (in April 2015) to the 24 months after among firms that did not subscribe to the NYSE IF (non-adopting firms; light gray bars). Areas where light and dark bars overlap are shown in a medium tone of gray.

While reactions by specific firms to the availability of the NYSE IF vary widely, it is evident that the distribution of dark bars is to the right of the distribution of light bars, meaning that NYSE IF adopters increased their proportion of trading more than non-adopters. Indeed, 22 of 28 adopters that traded on the NYSE in both the 24 months before and the 24 months after adoption increased their proportion of trading on the NYSE following their adoption of the NYSE IF; most (16) of these firms increased their proportion of their trading on the NYSE by between 5 and 20 percentage points.¹² More than half (56 out of 99) of non-adopters that traded on the NYSE during both the 24 months before and the 24 months after the launch of the NYSE IF increased their proportion of trading on the NYSE after April 2015.¹³

While the distribution of light bars is to the left of the dark bars, it is centered to the right of 0 %, indicating that most non-adopters also increased their proportion of trading on the NYSE following the launch of the NYSE IF. This is consistent with the launch of the NYSE IF having positive externalities on firms that did not subscribe to it, as one might expect in a platform.

The distribution of changes in the total number of shares traded on the NYSE shows a similar, if more varied, pattern of volume increases and decreases (Fig. 4). The distribution of dark bars (adopters) is to the right of the distribution of light bars (non-adopters). NYSE IF adopters were more likely to increase their total volume of trading on the NYSE (18 of 28 adopter firms) than non-adopters (35 of 99 non-adopter firms). Among the adopters that increased their total trading on the NYSE, 13 did so by more than 20 %. The bars at the right edge of chart (100 %+) indicate that trading volume on NYSE increased by 100 % or more for five NYSE IF adopters and nine firms that did not adopt the NYSE IF.

Specific examples illustrate how access to the NYSE IF increased firms' trading on the NYSE. A large proprietary trading firm that began subscribing to the NYSE IF in June 2015 markedly increased the proportion of its trading on the NYSE (as a percentage of its total trading on NYSE Group Exchanges for which we have this information) from 49.3 % during the two years leading up to its adoption of the NYSE IF to 54.8 % during the 24 months following its adoption. The number of shares it traded on the NYSE increased by 30.1 % between those same time periods.

Similarly, an order routing firm related to a large stock exchange provides an example of a very different type of firm that nonetheless reacted similarly to access to the NYSE IF. The firm began subscribing to the NYSE IF in August 2015. The NYSE accounted for 71.6 % of its trades on NYSE Group Exchanges during the two years leading up to its adoption of the NYSE IF. In the 24 months following this event, the share of its trading volume on NYSE Group Exchanges that went to the NYSE increased to 83.1 %.

We estimate regression models of the two outcomes discussed above, the proportion of trading on the NYSE and firms' volume of trading on the NYSE, to test whether the introduction of the NYSE IF led both adopters and non-adopters to trade more on the NYSE. When analyzing the responses of firms to subscribing to the NYSE IF, we estimate within-firm comparisons of pre- and post-adoption outcomes. Our dataset enables us to account for the considerable heterogeneity among the firms in our data (see Table 2) by incorporating firm fixed effects. Our regression models are of the following form:

$$Y_{i,t} = \alpha_i + \beta X_{i,t} + \gamma NYSE\ IF_{i,t} + \varepsilon_{i,t}. \quad (2)$$

Subscripts i and t index firms and time periods (months), respectively. The dependent variable $Y_{i,t}$ denotes the outcome of interest (proportion of trading or trading volume on the NYSE) for firm i in month t . The indicator $NYSE\ IF_{i,t}$ takes a value of 1 if firm i subscribed to the NYSE IF in month t and is 0 otherwise. We classify a firm as subscribing to the NYSE IF in a given month if the NYSE

¹² Three adopters did not trade on the NYSE before they adopted NYSE IF. A comparison of pre- and post-adoption trading is therefore not possible for these firms.

¹³ These statistics cover 127 firms. A total of 167 firms traded on the NYSE during our sample period; 37 non-adopters did not trade during either the 24 months leading to the launch of NYSE IF, the 24 months following the launch of NYSE IF, or both. Three adopters did not trade on the NYSE in the 24 months before their adoption.

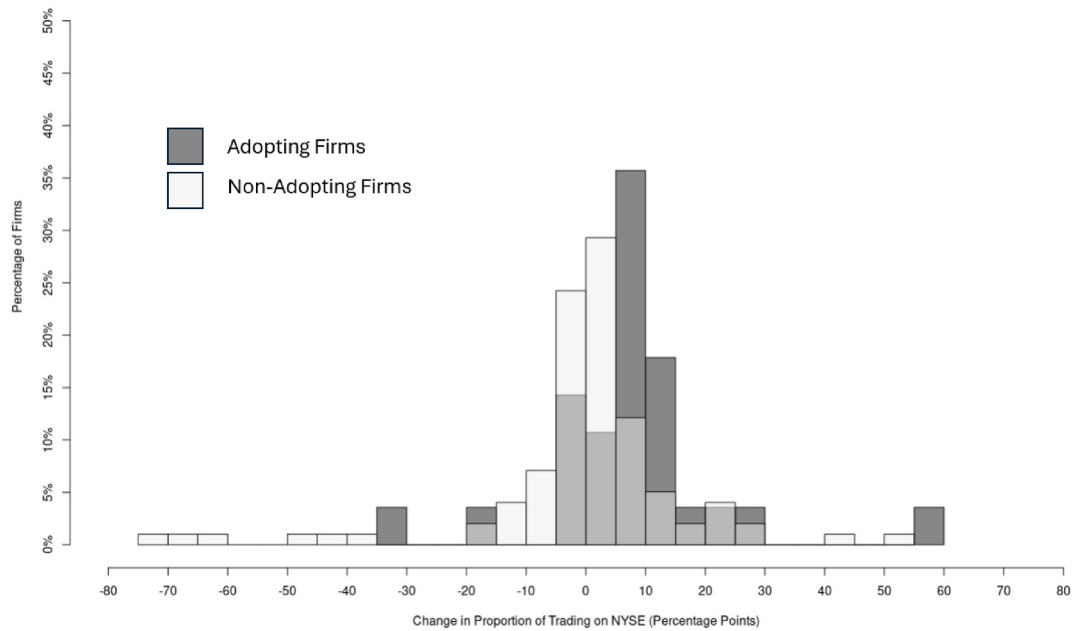


Fig. 3. Distribution of changes in the proportion of trading on the NYSE following adoption (adopting firms) or launch (non-adopting firms) of the NYSE IF

Proportions are calculated as the volume of shares traded on NYSE relative to all four NYSE Group Exchanges over 24 months before or after the adoption or launch of the NYSE IF. Only firms reporting trading in both periods are shown.

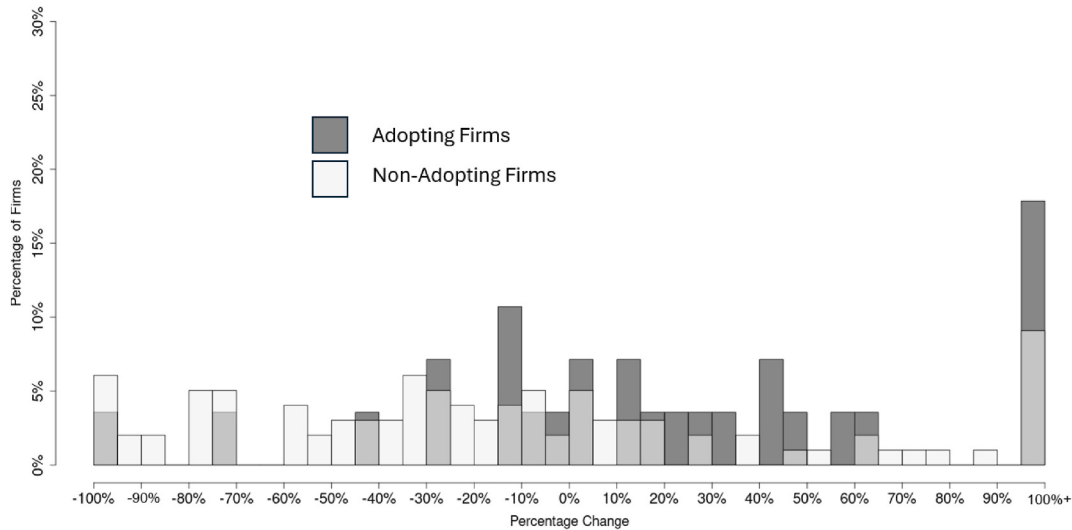


Fig. 4. Distribution of percentage changes in the number of shares traded on the NYSE following adoption (adopting firms) or launch (non-adopting firms) of the NYSE IF

We compare the volume of shares traded on NYSE over 24 months before or after the adoption or launch of the NYSE IF. Only firms reporting trading in both comparison periods are shown.

reports any fees relating to the NYSE IF during the month in question. The coefficient of interest is γ , which captures the average effect of subscribing to the NYSE IF.

In order to isolate the effect of subscribing to the NYSE IF (γ), we control for a series of factors that could also influence firms' trading on the NYSE. The terms α_i are firm fixed effects, which capture the effect of all (observable and unobservable) time-invariant firm characteristics on the variable of interest (here, trading on the NYSE). The vector of covariates $X_{i,t}$ includes changes in equity trading market structure, as well as linear and quadratic time trends in some specifications. We include linear and quadratic time trends in some specifications to ensure that the estimated effect of adoption of the NYSE IF is not contaminated with pre-existing trends

in adopting firms' trading patterns. All control variables vary over time and one factor, the volume that a firm trades on other NYSE Group Exchanges (used only in the volume regressions for Table 5), varies both over time and across firms.

The regression coefficients in Table 4 are estimates of the relationship between the proportion of firms' trading (on NYSE Group Exchanges) that goes to the NYSE and various regressors, including *Subscribed to NYSE IF*. The estimated coefficients for the variable of interest, *Subscribed to NYSE IF*, are all positive and statistically significant at the 95 % confidence level, indicating that subscribing to the NYSE IF is associated with an increase in the proportion of firms' trading on the NYSE.

Table 4 presents the results of five specifications that differ in both the observations analyzed and the independent variables included in the regression. All five specifications in Table 4 are estimated on a dataset of firms that traded on NYSE and subscribed to the NYSE IF during January 2013 to May 2019 (the period that our dataset covers). In specifications 1–4, we exclude the six firms that subscribed to the NYSE IF at some point in the sample and then unsubscribed later on. Excluding these six firms eliminates the possibility that our estimates mix the effects of the transition from not subscribing to the NYSE IF to subscribing with the effects of going from subscribing to not subscribing, which could differ. Specification 5 includes all 31 adopter firms and shows that results are qualitatively similar. Specification 4 excludes observations during the period between the introduction of the NYSE IF and the month when an individual firm started its subscription. This avoids contamination of our estimates of firms' pre-adoption NYSE trading proportion due to spillovers from other firms' earlier adoption of the NYSE IF.

In specification 1, we control only for time-invariant firm characteristics using firm fixed effects. This most parsimonious specification estimates that subscribing to the NYSE IF increases a firm's proportion of trading on the NYSE by 7.7 percentage points. In specification 2, we control for changes in market structure due to the entry and exit of various public exchanges during our sample period. Controlling for these factors marginally changes the estimated effect of subscribing to the NYSE IF to 7.4 percentage points. Adding linear and quadratic time trends to control for pre-existing trends in adopting firms' trading behavior again only marginally reduces the estimated effect of subscribing to the NYSE IF to 6.8 percentage points, as shown in specification 3.

In specification 4, we use the same control variables as in specification 2 but use a more stringent sample definition where the period between the launch of the NYSE IF and when a firm subscribes is excluded. We do not include time trends in specification 4 due to the inconsistent sample definition across time. Since we drop observations for some firms after April 2015, a time trend may capture changes in sample composition rather than overall trends in trading behavior. The results remain largely unchanged, and the estimated coefficient implies that subscribing to the NYSE IF increases a firm's proportion of trading on the NYSE by 7 percentage points.

In specification 5, we use the same control variables as for specifications 2 and 5 but include all adopters. Again, the results are qualitatively unchanged, and the estimated coefficient implies that subscribing to the NYSE IF increases a firm's proportion of trading on the NYSE by 5.6 percentage points.

We do not pursue a difference-in-differences estimator using non-adopters as a control group because we expect the adoption of the NYSE IF by some firms to affect trading activity by non-adopters through externalities; that is, spillover effects from the adoption of the NYSE IF could be significant.

The regressions for Table 5 estimate the relationship between the number of shares each firm traded on the NYSE and various regressors, including *Subscribed to NYSE IF*. We use the logarithm of the number of shares traded, which makes the interpretation of coefficients and comparisons across traders of different sizes easier than if we used the level of those variables. The specifications mirror those for Table 4. In addition to the regressors used for Table 4 and in specifications 2–5, we use a variable that controls for firms' trading volume on other NYSE Group Exchanges (i.e., on NYSE Arca, NYSE National, and NYSE MKT/American). Adding the

Table 4
Regression estimates of the impact of NYSE IF subscription on the proportion of firms' trading on the NYSE

Independent Variable	(1)	(2)	(3)	(4)	(5)
Subscribed to NYSE IF	0.077** (0.029)	0.074*** (0.026)	0.068** (0.031)	0.070** (0.029)	0.056** (0.023)
NSX/National Active		−0.021** (0.008)	−0.006 (0.010)	−0.022** (0.009)	−0.021*** (0.007)
IEX Active		−0.011 (0.015)	0.029* (0.016)	−0.010 (0.019)	0.013 (0.014)
CBOE Active		−0.024 (0.021)	0.000 (0.015)	−0.025 (0.018)	−0.017 (0.017)
Time Trend			0.004* (0.002)		
Time Trend Squared			−0.000** (0.000)		
Constant	0.452*** (0.016)	0.475*** (0.012)	0.408*** (0.037)	0.474*** (0.014)	0.453*** (0.010)
Firm Fixed Effects	Y	Y	Y	Y	Y
Observations	1784	1784	1784	1593	2202
Number of Firms	25	25	25	25	31
R-squared	0.710	0.717	0.728	0.686	0.768

We evaluate firms' responses to subscribing to the NYSE IF by regressing firms' monthly proportion of trading on NYSE Group Exchanges that took place on NYSE on a dummy variable indicating whether the firm subscribed to the NYSE IF in that month (*Subscribed to NYSE IF*) and other covariates. Significance levels are *** 1 %, ** 5 %, * 10 %. Standard errors clustered at the firm level are shown in parentheses.

control variable *Volume on Other NYSE Exchanges* helps us distinguish between overall increases in trading volume and increases in trading volume specifically on the NYSE. All five estimates of the effect of subscribing to the NYSE IF on firms' volume of trading on the NYSE are positive, with estimates ranging from 31.4 % (specification 1) to 61.0 % (specification 2). Shifts in overall trading volume on the NYSE are more dispersed than changes in the proportion of trading on the NYSE (see Figs. 3 and 4). This is reflected in the fact that only three of the five coefficients (specifications 2, 4, and 5) are statistically significant at the 95 % confidence level.

A possible concern is that firms may subscribe to the NYSE IF in response to short-run trading demands, biasing our estimates due to reverse causality. For example, it is possible that some firms subscribed to the NYSE IF because they anticipated trading large volumes of NYSE-listed securities that were most liquid on the NYSE exchange. However, two pieces of evidence cut against the reverse causality story. First, most firms that subscribed to the NYSE IF remained subscribed for the remainder of our sample period. This suggests that firms were not simply responding to short-term shocks to their trading demands. Second, we estimate "event-study" versions of specification 4 in Tables 4 and 5 where quarterly indicators are interacted with the NYSE IF adoption dummy. Results are shown in Fig. 5. The point estimates indicate a positive (though imprecisely estimated) effect of subscription to the NYSE IF, which remains positive two years after subscription. This suggests that the effect of subscription is long-lived, and not simply a response to short-term trading demands.

As mentioned above, a key characteristic of platform markets is that increased participation on one side (market data) generates benefits or costs for the other side (trading). In particular, the launch of the NYSE IF may lead to more or less trading on NYSE by firms that did not subscribe to the NYSE IF depending on whether the associated benefits in terms of liquidity outweigh the costs in terms of increased informational asymmetries. To test these duelling hypotheses, we estimate fixed effects regressions of the proportion of trading on the NYSE (among NYSE Group Exchanges) and of total trading volume on the NYSE by each firm on a dataset restricted to firms that did not subscribe to the NYSE IF.

$$Y_{i,t} = \alpha_i + \beta X_{i,t} + \gamma \text{NYSE IF}_t + \varepsilon_{i,t}. \quad (3)$$

As before, $Y_{i,t}$ denotes the outcome of interest (proportion of trading or trading volume on the NYSE) for firm i in month t and α_i are firm fixed effects. The only difference between the previous specifications is the regressor of interest, NYSE IF_t , a variable denoting the time period following the launch of the NYSE IF (the same variable of interest used in the exchange-level regressions for Table 3). This means that there is no "in-between" period for these regressions as dropped in the fourth specifications for Tables 4 and 5. Therefore, we estimate versions of specifications 1–3 in Tables 4 and 5 for non-adopters.

The regression results in Table 6 confirm that firms that did not subscribe to the NYSE IF nonetheless increased their trading on the NYSE following the launch of the NYSE IF. The coefficient of interest in specification 3 in Table 6 is 0.027 (statistically significant at the 95 % confidence level), indicating that the launch of the NYSE IF led firms that did not adopt the NYSE IF to do 2.7 percentage points more of their trading on NYSE Group Exchanges on the NYSE.

The results of analysis of trading volume (Table 6, Panel B) are less precise but consistent with our main results in Panel A. The coefficient in specification 4 is negative and significant, indicating a large decrease in trading volume on the NYSE by non-adopting firms. However, this appears to reflect factors unrelated to the launch of the NYSE IF, notably a pre-existing downward trend in trading

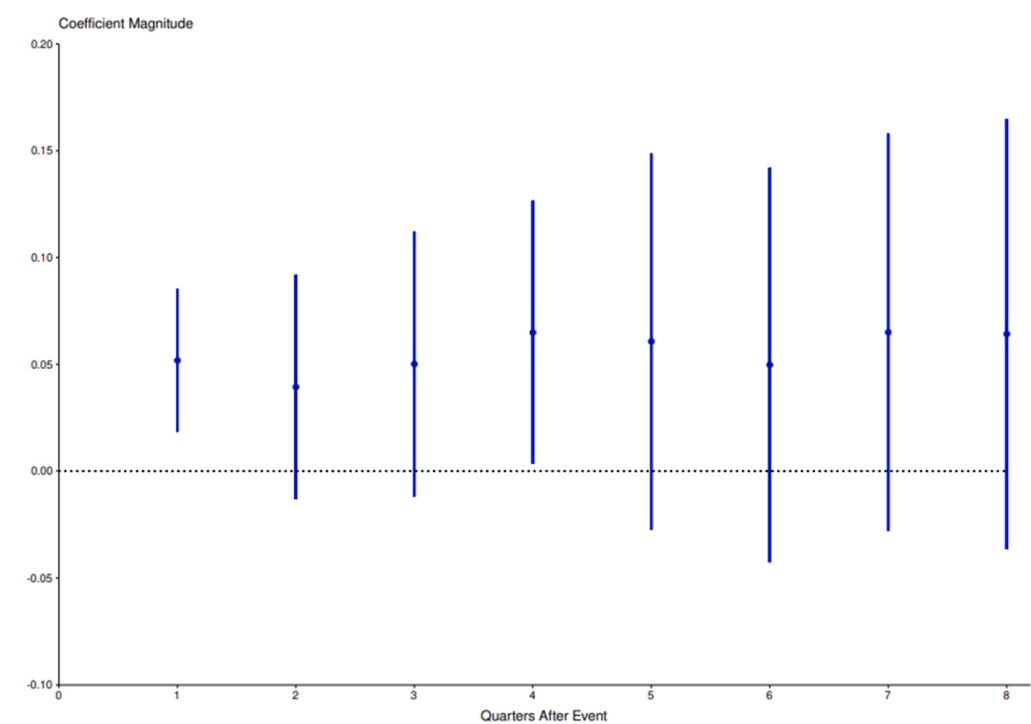
Table 5

Regression estimates of the impact of NYSE IF subscription on the volume of firms' trading on the NYSE

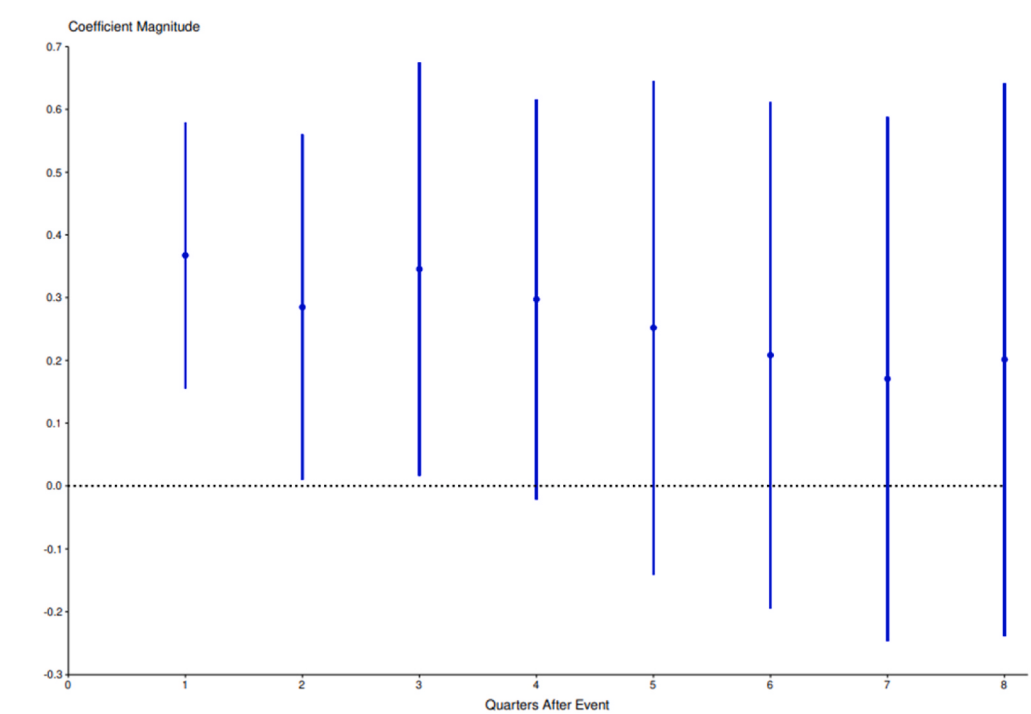
Independent Variable	(1)	(2)	(3)	(4)	(5)
Subscribed to NYSE IF	0.273 (0.166)	0.476** (0.206)	0.473* (0.255)	0.340** (0.139)	0.335* (0.196)
NSX/National Active		−0.008 (0.039)	0.032 (0.054)	−0.003 (0.036)	−0.016 (0.061)
IEX Active		−0.248* (0.130)	−0.120 (0.125)	−0.155 (0.095)	−0.069 (0.114)
CBOE Active		−0.011 (0.125)	0.008 (0.141)	−0.038 (0.102)	−0.019 (0.123)
Volume on Other NYSE Exchanges (log)		0.493** (0.197)	0.518** (0.191)	0.435** (0.189)	0.433*** (0.172)
Time Trend			0.007 (0.017)		
Time Trend Squared			−0.000 (0.000)		
Constant	19.766*** (0.094)	9.970** (3.951)	9.362** (3.896)	11.166*** (3.792)	11.133*** (3.452)
Firm Fixed Effects	Y	Y	Y	Y	Y
Firm-Specific Time Trends	N	N	N	N	N
Month-Year Fixed Effects	N	N	N	N	N
Observations	1721	1721	1721	1547	2067
Number of Firms	25	25	25	25	31
R-squared	0.776	0.808	0.809	0.806	0.845

We evaluate firms' responses to subscribing to the NYSE IF by regressing the natural logarithm of firms' monthly number of shares traded on NYSE on a dummy variable indicating whether the firm subscribed to the NYSE IF in that month (Subscribed to NYSE IF) and other covariates. Significance levels are *** 1 %, ** 5 %, * 10 %. Standard errors clustered at the firm level are shown in parentheses.

Panel A: Proportion of Firms' Trading on the NYSE



Panel B: Volume of Firms' Trading on the NYSE



(caption on next page)

Fig. 5. Event study plots for the dynamic impact of NYSE IF subscription

We plot the event-study versions of our regressions for [Tables 4 and 5](#) that measure the dynamic treatment effect of subscribing over a two-year event horizon. Plots show the resulting coefficients from interacting the treatment dummy with quarter-year dummies with clustered standard errors. Point estimates are shown as dots and 95 % confidence intervals as vertical bars.

Table 6

Regression estimates of impact of the launch of the NYSE IF on firms' trading on the NYSE and not subscribing to the NYSE IF

Independent Variable	Dependent Variable					
	Panel A: Proportion of NYSE Trading Volume			Panel B: NYSE Trading Volume (log)		
	(1)	(2)	(3)	(4)	(5)	(6)
Introduction of NYSE Integrated Feed (April 2015)	0.045** (0.020)	0.035*** (0.013)	0.027** (0.013)	−0.302*** (0.089)	−0.023 (0.066)	0.124 (0.081)
NSX/National Active		0.001 (0.007)	0.003 (0.008)		−0.005 (0.040)	0.042 (0.036)
IEX Active		0.036*** (0.013)	0.037*** (0.012)		−0.004 (0.080)	0.217*** (0.082)
CBOE Active		0.021 (0.013)	0.032** (0.013)		0.159** (0.061)	−0.079 (0.064)
Time Trend			0.001 (0.001)			−0.017** (0.007)
Time Trend Squared			−0.000 (0.000)			0.000 (0.000)
Volume on Other NYSE Exchanges (log)					0.146*** (0.032)	0.143*** (0.032)
Constant	0.684*** (0.012)	0.670*** (0.011)	0.647*** (0.026)	16.267*** (0.053)	14.258*** (0.476)	14.634*** (0.510)
Firm Fixed Effects	Y	Y	Y	Y	Y	Y
Observations	7468	7468	7468	7062	6184	6184
Number of Firms	136	136	136	136	134	134
R-squared	0.0196	0.030	0.030	0.022	0.073	0.080

We evaluate the reactions of firms that did not subscribe to the NYSE IF to the launch of the NYSE IF by regressing these firms' proportion of trading on NYSE (among NYSE Group Exchanges) in a given month (Panel A) and the natural logarithm of their total number of shares traded on NYSE in that month (Panel B) on a dummy variable marking the introduction of the NYSE IF in April 2015 and other covariates. Significance levels are *** 1 %, ** 5 %, * 10 %. Standard errors clustered at the firm level are shown in parentheses.

volumes by non-adopters. The coefficients of specification 6 indicate that the launch of the NYSE IF led firms to increase their total trading volume on the NYSE by 13.2 %, although the coefficient is imprecisely estimated and is not statistically significant at conventional levels. The comparison of this estimate with that in specification 5, which includes all the other controls besides the time trends and still returns a negative estimate, strongly suggests that the pre-existing downward trend is a source of downward bias in the estimates of specifications 4 and 5.

Overall, our empirical evidence consistently documents linkages between data subscriptions and trading, confirming that the NYSE acts as a platform for data and trading. The introduction of the NYSE IF led to increased trading activity by the firms adopting it ([Tables 4 and 5](#)). As discussed above, [Table 6](#) provides evidence on whether adopters' data purchases imposed positive or negative externalities on non-adopters. Consistent with the benefits of positive liquidity externalities outweighing any negative externalities arising from information asymmetry, the NYSE IF introduction attracted additional trading by firms that did not subscribe to the NYSE IF. This result is consistent with, but does not establish, that overall externalities were positive on net. For example, in principle, it is possible that the introduction of the NYSE IF drove adopters to the NYSE and thereby reduced liquidity on other exchanges so that non-adopters chose to trade more on the NYSE despite increased informational asymmetries. These firm-level results are mirrored in our exchange-level analysis of trading volumes on the NYSE, which increased as a proportion of total U.S. equities trading following the launch of the NYSE IF ([Table 3](#)).

5. Conclusion

To understand better how stock exchanges compete, we present qualitative and empirical evidence about the importance of linkages between stock exchanges' proprietary data sales and trading activity. Empirically, we focus on the introduction of a new data product at the NYSE and how that led to higher trading volumes on the exchange. We present a new customer-level data set drawn from the NYSE Group that matches data subscribers with traders. We show that, within NYSE Group exchanges, customers who purchased the new data product increased their trading at the NYSE and, furthermore, this led non-purchasers to trade at more on the exchange. This is consistent with positive externalities arising from the sale of proprietary market data. Overall, the results suggest that stock exchanges are platforms for trading and data.

These results are important because the effect of data sales on trading is theoretically unclear. Data sales can lead data purchasers to trade more on an exchange. That can lead to more liquidity on the exchange, which even traders that do not purchase data may find

attractive. However, the data sales may increase the presence of well-informed traders that leads to an information asymmetry for traders that do not purchase data. We find that traders that do not purchase data are attracted to exchanges that sell data, suggesting that the liquidity effect is more important.

These results have implications for exchange regulation.¹⁴ To the extent that the platform nature of stock exchanges is economically important, exchange competition in data fees cannot be analyzed in isolation, without accounting for the competitive dynamics in trading services. Competition is then properly understood as being between platforms (i.e., stock exchanges and other trading venues) that balance the needs of data consumers and traders.

CRediT authorship contribution statement

Terrence Hendershott: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Marc Rysman:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Rainer Schwabe:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Appendix A

In this Appendix, we describe how data are used by traders to make order routing decisions and, specifically, why market data for a particular exchange would make trading on that exchange more attractive. We begin by presenting three simple examples that illustrate how investors use data and why they would be willing to pay for it. As these examples show, market data from an exchange can reduce uncertainty about the likelihood, price, or timing of execution for an order on that exchange. Such reductions in uncertainty can encourage traders to route their orders to that exchange. After going through these examples, we explain two additional ways in which access to market data reduces uncertainty and may thereby drive order flow to an exchange.

Our objectives in presenting these qualitative descriptions are twofold. First, they provide a more detailed framework for understanding our empirical results in Section 3. Second, they provide a conceptual underpinning to the notion that the types of externalities that require the application of platform economics link the sale of exchanges' data and trading services. One set of linkages are self-evident: Trading and limit orders provide the information in which purchasers of data are interested, such as transaction volume, price movements, and the set of limit orders below the top of the book that allow traders to make better predictions about how new trades will cause the market to shift. Limit orders simultaneously generate both market liquidity and market data. Naturally, this value spills across firms. That is, firms that place orders on a stock exchange create value for other firms that purchase data. The linkages whereby data affects the value of trading are less obvious, and thus require more explanation.

Example 1. Uncertainty regarding execution of large orders on a single exchange

This simple example illustrates how seeing the limit order book can reduce uncertainty regarding likely execution prices for market orders.

An investor wishes to purchase 200 shares of a particular stock immediately. The consolidated feed is showing 100 shares available on exchange A at \$20.00. No other exchange is quoting an offer. Also, there is a limit sell order for 100 shares at \$20.10 on exchange A.

If the investor sees only the consolidated feed, the investor would not see the limit order at \$20.10 and would face uncertainty regarding the ultimate purchase price that would result from submitting a market order for 200 shares. If the entire order book were visible, the investor would be able to see that its second 100 shares would be executed at \$20.10, for a total weighted average price of \$20.05.

Example 2. Uncertainty regarding execution of large orders with two exchanges

For the second example, suppose that there are two exchanges, A and B, and their sell limit orders are as follows: A1 100 shares for \$20.00; A2 100 shares for \$20.02; B1 100 shares for \$20.04; B2 100 shares for \$20.10.

A buyer is looking to buy 200 shares immediately. Assuming it subscribed to a consolidated feed, the buyer would see the top of the book at each exchange: 100 shares for \$20.00 on Exchange A and 100 shares for \$20.04 on Exchange B.

The buyer could consider the following three options: (1) route a market order for 200 shares to Exchange A; (2) route simultaneous orders for 100 shares to Exchange A and 100 shares to Exchange B; (3) route an order for 100 shares to Exchange A and wait to see how prices reported in the consolidated feed evolve before submitting its order for the second 100 shares.

Abstracting from the time required to process and route orders and from high-frequency changes in quoted prices, all three options would result in execution at a volume-weighted average price of \$20.01. The “order protection rule” (also known as the “no trade-through” rule) stipulated by Regulation NMS prevents an exchange from executing an order at a price less favorable to the trader than

¹⁴ While we find the platform nature of exchanges to be natural, the SEC approved NYSE National Integrated Feed fees without agreeing with the proposition that “exchanges function as platforms between consumers of market data and consumers of trading services” (SEC, 2020b).

what is available at the top of the book at other exchanges.¹⁵ Under option 1, Exchange A will execute the trader's order for 200 shares immediately, as both \$20.00 and \$20.02 are better prices than what is available at Exchange B. Under option 2, Exchange A will execute the trader's order for 100 shares immediately and Exchange B will try to access Exchange A's top of book as observed at the time of order receipt. This will result in Exchange B sending an order to Exchange A priced at either \$20.00 or \$20.02, depending on whether Exchange A has already executed the trader's first order and updated its quote. If the Exchange B order is priced at \$20.00 and goes unexecuted Exchange B will likely wait to observe Exchange A's refreshed quote, resulting in Exchange B routing to Exchange A again, this time at \$20.02, and receiving a fill at that price. Under option 3, Exchange A would execute the first order for 100 shares at \$20.00 and then the trader would send a second order to Exchange A to be executed at \$20.02 after seeing Exchange A's quote updated to \$20.02. Under any of these scenarios, the trader faces the same sort of ex-ante uncertainty as it did in [example 1](#) above: at the moment it submits its first order, it would not be sure what price it will receive for its second 100 shares.

The equivalence between the three options above falls apart when we acknowledge that processing and routing an order takes some (very small) amount of time (routing delay) and that available quoted prices could change during that span. Option 1, where the trader sends a market order for 200 shares to Exchange A, has the best chance of being executed at the best prices currently available. Options 2 and 3, however, require additional time before the order for the second 100 shares reaches Exchange A as either Exchange B checks for prices available on other exchanges and routes the order to Exchange A (under option 2) or the trader observes the evolution of quotes at the top of the book and sends a second marketable order to Exchange A (under option 3). In either case, order A2 may be re-priced or canceled during the routing delay and lead the trader to miss out on the possibility of trading its second 100 shares at \$20.02.

The prevalence of non-routable order types offered by exchanges confirms that some market participants are concerned about both reducing execution uncertainty and minimizing the impact of routing delay. For example, an ISO limit order may be used to ensure immediate execution of the specified amount at its limit price or better as long as there are resting limit orders that it can be matched to, regardless of whether a more favorable price is advertised at another exchange.¹⁶ A primary reason a trader would use an ISO limit order (and assume responsibility for compliance with Regulation NMS's order protection rule) is to get immediate execution rather than endure the delay and uncertainty associated with having the exchange survey other exchanges for better prices. In total, non-routable order types accounted for 68.3 % of matched non-auction volume on NYSE in October 2019.¹⁷

Example 3. Uncertainty regarding execution of "odd lot" orders

The third example highlights uncertainty around the execution of small orders (i.e., odd lot orders, typically those less than 100 shares). One limitation of the SIP is that it reports the best bids and offers available at each exchange for "round lots" – that is, quotes to buy or sell blocks with multiples of 100 shares of a given security.¹⁸ According to the SEC's MIDAS tool, odd lot trades accounted for over 46 % of trades and 14 % of exchange trading volume in NMS stocks in Q3 2019.¹⁹

Suppose the orders reported by the SIP are as in [example 2](#), except that Exchange B also has an odd lot offer for 50 shares at \$19.99. Consider a situation where the trader wishes to buy 45 shares immediately. With only the SIP data, the trader would likely send a market order to Exchange A to be executed at the best offer price available of \$20.00. If the trader subscribed to an order book or full order-by-order depth of book data for Exchange B (or both exchanges), it would send his order to Exchange B to be executed at the more favorable price of \$19.99.

Uncertainty regarding the timeliness of market information

Our examples so far assume that a trader can perfectly observe the state of the market at the top of the order book, and thus our examples highlight the value to some traders of subscribing to order book data. Why might a trader subscribe to a BBO service, when the SIP provides the same information? In practice, there is always some amount of time that passes between activity on a stock exchange and when investors can observe that activity in their data feeds (i.e., after the market update has been received, processed,

¹⁵ SEC (2010), pp. 26–27) ("Another important type of linkage in the current market structure is the protection against trade-throughs provided by Rule 611 of Regulation NMS. A trade-through is the execution of a trade at a price inferior to a protected quotation for an NMS stock. A protected quotation ... must be an automated quotation that is the best bid or best offer of an exchange or FINRA. Importantly, Rule 611 applies to all trading centers, not just those that display protected quotations. Trading center is defined broadly in Rule 600(b)(78) to include, among others, all exchanges, all ATSS (including ECNs and dark pools), all OTC market makers, and any other broker-dealer that executes orders internally, whether as agent or principal Rule 611 also helps promote linkages among trading centers by encouraging them, when they do not have available trading interest at the best price, to route marketable orders to a trading center that is displaying the best price. Although Rule 611 does not directly require such routing services (a trading center can, for example, cancel and return an order when it does not have the best price), competitive factors have led many trading centers to offer routing services to their customers.").

¹⁶ "NYSE Arca Pillar Order Types and Modifiers," NYSE, https://www.nyse.com/publicdocs/nyse/markets/nyse-arca/NYSE_Arca_Order_Suite.xlsx. The term ISO limit order encompasses IOC ISO and Day ISO order types.

¹⁷ "NYSE Tape A - Order Type Usage (Percentage of Matched Volume)," NYSE, 2019, <https://www.nyse.com/publicdocs/nyse/markets/nyse/NYSE-Order-Type-Usage.pdf>.

¹⁸ SEC (2010), p. 63. In some cases, exchanges apply alternative definitions of round lots. See, e.g., "Rule 55. Unit of Trading—Stocks and Bonds," NYSE, https://nyseguide.srorules.com/rules/document?treeNodeId=csh-da-filter!WKUS-TAL-DOCS-PHC-%7B4A07B716-0F73-46CC-BAC2-43EB20902159%7D-WKUS_TAL_5665%23teid-134.

¹⁹ "Market Information Data and Analytics System (MIDAS); Market Structure; Market Activity Overview," U.S. Securities and Exchange Commission https://www.sec.gov/marketstructure/datavis/ma_overview.html#.XdxfbekIUK.

and redistributed by the SIP or after an individual firm has received and processed the update via exchange proprietary feeds), and between when a trader places an order and when an order reaches an exchange. In that amount of time, the state of the market can change, which can change the economics of some orders. Thus, obtaining data more quickly can be valuable for some trading strategies as it can reduce uncertainty regarding the “current” state of the market. While exchanges provide data to the SIP no later than they do to their BBO subscribers, the time involved in processing and redistributing the data to generate the SIP data feed means that unconsolidated data from a single exchange may reach subscribers more quickly. That is a primary reason why some traders subscribe to BBO feeds (Jones, 2018).²⁰

Uncertainty regarding the likelihood of execution of non-marketable orders

For an actively traded stock, there are typically several orders at each price in an order book. On most U.S. exchanges, orders at the same displayed price on the same exchange are executed in the order that they arrive.²¹ Information about the amount offered and the relative sequence of orders at each level of an order book, provided by full order-by-order depth of book data products, can help a trader who seeks to optimize or understand its order queue placement (see Moallemi and Yuan, 2017).

The detailed information provided by full order-by-order depth of book data enables traders to infer where their orders would be in the queues. Furthermore, traders can analyze the behavior of orders with different characteristics to better predict how long other participants' orders might be available. Thus, the detailed order book data reduces uncertainty regarding the likelihood of execution and makes it more likely that the trader would submit non-marketable orders at the exchange(s) for which it has visibility.

Appendix B

Table B1

Structural break tests for regression estimates of impact of launch of the NYSE IF on trading on the NYSE

Independent Variables	(1)	(2)	(3)
Time Trend	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)
Time Trend Squared	−0.000*** (0.000)	−0.000*** (0.000)	−0.000*** (0.000)
Total U.S. Equity Volume Traded (log)	0.001 (0.007)		
U.S. Equity Volume Traded on Public Exchanges (log)		0.013 (0.018)	
U.S. Equity Volume Traded on ATS or Dark Pools (log)		−0.016 (0.022)	
Proportion of Total U.S. Equity Volume Traded on Public Exchanges			0.051 (0.074)
Structural Break Date	2015m6	2015m6	2015m6
Structural Break Wald Test Statistic	20.199	23.706	21.696
Structural Break P Value	0.000	0.000	0.000
Observations	78	78	78
R-squared	0.536	0.541	0.540

We evaluate three versions of an intercept-only structural break test in the time series analysis for Table 3. The tests use a supremum Wald test methodology. Time Trend and Time Trend Squared are linear and quadratic time trend terms, respectively. We control for overall trading activity with the natural logarithm of the number of shares traded on all U.S. venues (Total U.S. Equity Volume Traded (log)) or separately for the number of shares traded on public exchanges (Total U.S. Equity Volume Traded on Public Exchanges (log)) and ATS and dark pools (Total U.S. Equity Volume Traded on ATS and Dark Pools (log)). Proportion of Total U.S. Equity Trading Volume Traded on Public Exchanges is the number of shares traded on public exchanges in the month in question divided by the total number of shares traded on all U.S. venues in that month. Significance levels are *** 1 %, ** 5 %, * 10 %. Standard errors clustered at the firm level are shown in parentheses. All specifications indicate that the most likely structural break date is June 2015, which is two months after the launch of the NYSE IF.

²⁰ Jones (2018) explains that: “Shortly after Reg NMS was adopted, there was an increase in the use of proprietary data feeds by market participants to get access to trades and top-of-book quote information faster than they could get it through SIPs.” Similarly, the U.S. Department of the Treasury (2017) notes that: “Many HFT firms rely on these proprietary data feeds to inform their trading, in part by consolidating information from exchanges’ proprietary feeds faster than it can be delivered by the SIP.”

²¹ While most markets execute non-marketable limit orders with the same limit price in the order they arrive, NYSE enforces a different priority rule whereby multiple orders at the same price point may share executions. An order’s place on the electronic order book queue is nonetheless relevant for the likelihood and timing of execution. See, “Parity & Priority,” NYSE, https://www.nyse.com/publicdocs/nyse/markets/nyse/Parity_and_Priority_Fact_Sheet.pdf.

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