

DARK POOLS, INTERNALIZATION, AND EQUITY MARKET QUALITY



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Executive Summary

Over the past decade, the U.S. equity market has been transformed by the forces of technology, regulation, and globalization. Today, the way in which investors, market participants, intermediaries, and trading venues interact is highly automated and critically dependent on speed. Significantly, the dominance of the incumbent exchanges has been eroded and liquidity has fragmented over numerous trading venues as competition has intensified.

Within this fragmented environment, off-exchange trading, including broker/dealer internalization and dark pools in which prices are not displayed prior to execution, has grown significantly. Undisplayed or “dark” trading away from public exchanges is estimated to account for approximately 31% of consolidated volume as of March 2012—a growth of around 48% since the start of 2009.¹

From a market integrity perspective, the growth in dark trading raises potential concerns, ranging from a perceived decline in the transparency of markets

to a reduced willingness of investors to display quotes if dark venues free ride off those quotes and privatize order flow. Indeed, CFA Institute members have raised concerns that the incentive to display orders in public markets is being undermined by certain off-exchange trading practices. In turn, these concerns have implications for public price discovery, liquidity, and the quality and integrity of markets.

Regulators around the world have also voiced concerns about dark trading, including the U.S. Securities and Exchange Commission (U.S. SEC) in its equity market structure concept release (2010), the European Commission in its review in 2011 of the Markets in Financial Instruments Directive,² the International Organization of Securities Commissions (IOSCO) in its report on dark liquidity (2011), as well as regulators in Canada and Australia in their reviews of their respective market integrity rules. Certain regulatory proposals, including those of the U.S. SEC, remain under consideration.

¹Figures based on data presented in Table 1 in Section 2 of this report for March 2012 and on data from Thomson Reuters Equity Market Share Reporter for January 2009.

²Visit http://ec.europa.eu/internal_market/securities/isd/mifid_en.htm for more information.

This report presents an examination of the relationship between dark trading and market quality in order to inform public policy issues related to undisplayed liquidity and to address the aforementioned market integrity concerns. Specifically, we examine the relationship between different types of undisplayed trading volumes and market quality measures, including bid–offer spreads and top-of-book market depth.

The results of our analysis show that increases in dark pool activity and internalization are associated with improvements in market quality, but these improvements persist only up to a certain threshold. When a majority of trading occurs in undisplayed venues, the benefits of competition are eroded and market quality will likely deteriorate.

To protect market integrity, we recommend that (1) internalization of retail orders be required to offer meaningful price improvement, (2) regulators monitor the growth in dark trading and take appropriate measures if it grows excessively, and (3) dark trading facilities improve reporting and disclosures around their operations to enable investors and regulators to make more informed decisions about their use.

Summary of Findings

Market structure

- The U.S. equity market structure is fragmented. Today, equity trading is dispersed across 13 exchanges, at least one electronic communications network (ECN), approximately 16 reporting dark pools, and more than 200 broker/dealers who internalize order flow. Exchanges collectively account for approximately two-thirds of consolidated volume, and off-exchange transactions account for approximately one-third of total volume.
- Most exchanges are structured as electronic limit order book markets. Exchanges are generally both pre-trade and post-trade transparent: Prices and trading interest are displayed prior to execution, and transaction details are publicly disseminated in real time.
- ECNs operate similarly to exchanges in terms of secondary market trading of equity securities, generally being both pre-trade and post-trade transparent. There is only one significant ECN—LavaFlow—which accounts for approximately 1% of consolidated volume.
- Dark pools are systematized execution facilities that operate with limited pre-trade transparency. The prices of orders entered into the dark pool are not displayed to other market participants and are matched anonymously against contra-side orders.

- Several different types of dark pools operate in the United States, ranging from continuous-crossing systems operated by the large broker/dealers to independently operated block-cross platforms.
- In aggregate, dark pools have accounted for between 8% and 13% of consolidated volume over the past three years.
- Internalization involves broker/dealers internally executing client order flow against their own accounts on a systematic basis. Broker/dealer internalization is not subject to pre-trade transparency.
- Internalization and other over-the-counter (OTC) transactions represent approximately 18% of consolidated volume. Internalization is also thought to account for almost 100% of all retail marketable order flow.
- Retail internalization is driven by the purchase of order flow by wholesale OTC market makers from retail brokerage firms. This practice enables broker/dealers to “preference” those orders that are profitable to arbitrage and route unwanted orders to other market centers.
- Broker/dealer internalizers must match or beat the national best bid and offer (NBBO). Broker/dealers can provide price improvement to their customers in the form of sub-penny executions. Although this approach can provide savings to retail customers, it carries an opportunity cost to liquidity providers that post orders on public exchanges.
- Other OTC transactions include ad hoc, large, or irregular transactions between broker/dealers and other counterparties seeking to execute client order flow in the most efficient manner possible.
- The process by which orders are handled, routed, and executed can be very complex because of the fragmented nature of the equity market and the reliance on advanced technology and speed. Firms use algorithms to route different portions of an order to different venues in various sequences, taking into account such factors as minimization of market impact, minimization of information leakage, immediacy of execution versus cost of execution in various pools, and other factors to provide the most efficient executions possible.
- Once trades are executed, they are immediately reported to the consolidated tape—the mechanism for the provision of public post-trade transparency.
- Off-exchange transactions are reported to one of two main trade reporting facilities (TRFs) that are registered and overseen by the Financial Industry Regulatory Authority (FINRA). The largest TRF is operated by NASDAQ (the FINRA/NASDAQ TRF), and the other TRF is operated by the NYSE (the FINRA/NYSE TRF). Trades reported through the TRF are then printed on the consolidated tape.

Regulatory framework

- The regulatory framework surrounding the operation of exchanges is the Regulation National Market System (Reg. NMS). The key aspects of Reg. NMS include the Access Rule, which ensures that market participants have fair and nondiscriminatory access to markets and prices; the order protection rule, which protects displayed quotations at the best bid or best offer from being traded through; the sub-penny rule, which prevents exchanges, broker/dealers, and other market centers from displaying, ranking, or accepting any orders that are priced in an increment of less than 1 cent for stocks priced above \$1 (although it allows broker/dealers to execute transactions in sub-penny increments); and market data rules, which govern the allocation of revenues to market centers that contribute data to the consolidated quote and tape.
- Non-exchange-trading modalities that include dark pools, ECNs, and certain other broker/dealer systems are captured under Regulation Alternative Trading System (Reg. ATS). Alternative trading systems (ATSs) are not required to publicly display price quotations and are able to restrict access to their crossing systems and internalization pools.
- The issues associated with dark liquidity are prevalent internationally. A number of regulatory bodies in other jurisdictions have developed frameworks governing how dark pools and undisplayed orders are allowed to operate within their markets. Additionally, IOSCO has established a broad set of international best practices for regulatory treatment of dark pools and dark orders.

Literature review

- Overall, the academic literature most relevant to this study is at best mixed. Out of the studies reviewed, the most applicable are Weaver (2010, updated 2011); Degryse, de Jong, and van Kervel (2011); Buti, Rindi, and Werner (2010a); and O'Hara and Ye (2011). The first two support the notion that undisplayed trading harms market quality, whereas the latter two suggest undisplayed trading is associated with improvements in market quality. This division indicates that the relationship between undisplayed liquidity and market quality is complex.

Empirical analysis

Data

- A sample of 450 stocks stratified across listing market and market capitalization was selected by CFA Institute. For each stock, data on bid-offer spreads, top-of-book depth, off-exchange volumes, and other variables were obtained for a selection of dates over the period from the first quarter of 2009 through the second quarter of 2011.

- Off-exchange trades reported to the NASDAQ TRF, which account for approximately 95% of all off-exchange trading in our sample, have been subcategorized by NASDAQ according to the type of trading modality used.

Descriptive statistics

- The data show that relative bid–offer spreads have declined by approximately 50% over the review period of January 2009–May 2011. The decline in spreads is evident among large-capitalization, medium-capitalization, and small-capitalization stocks. The median quoted spread for large-cap stocks in our sample over the review period is 1 cent, or in relative terms, 4 basis points (bps). For medium-cap stocks, the median spread is 2 cents or 9 bps, and for small-cap stocks, it is 9 cents or 83 bps.
- Top-of-book depth, measured by the average size (in shares and in dollars) at the best bid or best offer across all markets displaying at the NBBO, is relatively flat over the review period. Median depth for large-cap stocks is 1,663 shares or \$66,905, compared with 454 shares or \$5,964 for small-cap stocks.
- The market shares of internalization and dark pools have trended upward over the review period for the total sample and for each of the large-, medium-, and small-cap subsamples, reflecting growth in undisplayed trading for all stocks. Internalization is higher among small-cap stocks relative to large- and medium-cap stocks, whereas dark pools are more active in large- and medium-cap stocks relative to small-cap stocks.

Regression analysis

- To analyze the relationship between dark trading and market quality, internalization and dark pool volumes (the independent variables of interest) and other explanatory variables are regressed against bid–offer spreads and depth (the dependent variables of interest), respectively. We test the hypothesis that there is no relationship between the proportions of dark trading and market quality.
- The results for the total sample suggest that increases in dark trading are initially associated with improvements in market quality. Bid–offer spreads decrease and depth increases as internalization and dark pool activity increase. The regression results illustrate an association between dark trading and market quality, but they do not definitively prove the direction of the relationship.
- The relationship between dark trading and market quality is likely quadratic. That is, beyond a certain threshold, it reverses such that market quality initially improves but then declines as dark trading increases. Specifically, we estimate that when a majority of trading in a stock occurs in undisplayed venues, market quality will likely deteriorate.

- One possible explanation is as follows: Initially, competition for order flow among on- and off-exchange venues causes more aggressive quoting in the limit order book to obtain incoming order flow. When lit markets dominate (i.e., dark market share <50%), this competition helps to reduce bid–offer spreads. However, when most orders are filled away from lit markets, investors could withdraw displayed quotes because of the reduced likelihood of those orders being filled. As investors become disincentivized from displaying orders, bid–offer spreads are likely to widen.
- Therefore, competition among various types of trading venues should be maintained and a predominance of dark trading should be avoided.

Summary policy considerations

Although a wholesale revision of the market structure regulatory framework is not necessary, we believe certain improvements are needed to ensure a level playing field and to support competition, particularly given the current trajectory of growth in dark trading. To that end, we recommend the following considerations.

1. Require internalization of retail orders to provide meaningful price improvement.

Meaningful price improvement could be defined as the minimum price variation (MPV) or half the MPV if the displayed spread between the best bid and the best offer equates to the MPV.³

This proposal would require broker/dealers to either internalize marketable retail order flow with significant price improvement, thereby generating economically meaningful savings for retail investors, or route the order flow to an exchange to execute against the displayed quotations in the order book. This approach would provide some protection to market participants posting limit orders by limiting the scope for OTC market makers to step in front of those orders by simply matching the best prices posted in displayed markets or by providing only nominal price improvement. It would thus minimize any disincentive to post displayed limit orders and would uphold market integrity.

This consideration is, in the context of retail orders, consistent with the proposals of the CSA (Canadian Securities Administrators)/IIROC (Investment Industry Regulatory Organization of Canada) and ASIC (Australian Securities & Investments Commission).

³The MPV in U.S. markets is 1 cent for stocks priced above \$1 and 0.01 cent for stocks priced below \$1.

2. Monitor growth in the proportion of dark trading volume, and take appropriate measures.

Regulators should monitor developments with respect to internalization and dark pool activity. Regulators should consider introducing measures to restrict the use of dark orders and dark trading facilities if such activity becomes excessive, such as if the share of dark trading exceeds 50%. One possible measure would be to lower the threshold at which ATSS must display orders and meet general access requirements from the current level of 5% of the trading volume in a given stock.

This proposal is consistent with the IOSCO principles and is analogous to the recommendations of CSA/IIROC and ASIC to monitor growth in dark liquidity.

3. Improve reporting and disclosure around the operations of dark trading facilities.

Insufficient information about the operations of dark pools, internalization pools, the types of orders that are accepted within those systems, and the process by which orders are matched makes it difficult for investors to make informed decisions about whether or how to utilize dark trading facilities. It also makes it harder for regulators to monitor their growth (the second consideration) and to evaluate how dark pools affect price discovery and liquidity. Dark trading facilities should, therefore, voluntarily reveal greater information about their operating mechanics and report more information on the volumes they execute. Such disclosures would improve transparency and enable all stakeholders to better understand their relative benefits and drawbacks.

Implementation of these considerations would help protect displayed orders while offering meaningful savings to retail investors executing away from public markets, maintain competition, and further transparency. More fundamentally, these measures would enhance market integrity and underpin investor confidence in the equity market structure.

1. Introduction

Since the establishment of formalized stock exchanges in the United States more than 200 years ago, equity markets have continuously evolved. But over the past decade, the pace of evolution has accelerated as a result of the combined forces of technology, regulation, globalization, and competition. Together, these forces have transformed the structure and functioning of equity markets. The way in which investors, market participants, intermediaries, and trading venues interact is now highly automated, extremely fast, intensely competitive, and dependent on scale more than ever before. In essence, the U.S. equity market today represents a vast, decentralized electronic network that is critically dependent on technology to generate and match order flow at great speed.

The main trends characterizing the evolution of the market over the past decade⁴ include a decrease in average trade sizes and a significant increase in overall quote traffic and transaction volumes (largely owing to the adoption of electronic systems that have improved operational efficiency and network capacity); a reduction in trading costs (both bid–ask spreads and commissions); some pronounced periods of volatility; and increasing fragmentation of liquidity.

Regarding fragmentation, one of the most conspicuous trends has been the shift in trading volume from the primary listing markets to new trading venues and, in particular, to off-exchange business as competition has intensified. The market share of NYSE Euronext⁵ in NYSE-listed stocks, for example, fell to 25.1% of the consolidated share volume in October 2009 from 79.1% in January 2005.⁶ More generally, market shares for almost all exchanges continue to trend downward while off-exchange volume increases.

Off-exchange business can be broadly categorized into transactions that occur in alternative trading systems (ATSs), such as electronic communications networks (ECNs) and dark pools (undisplayed liquidity pools that facilitate the execution of orders in a systematized way); broker/dealer internalization (internal execution of client orders against the broker/dealer’s own account on a systematic basis—internalization is the dominant trading modality for retail orders, in which brokerages route retail order flow to an off-exchange market maker that may or may not be affiliated with the brokerage); and other over-the-counter (OTC) transactions. A common denominator of dark pool transactions, broker/dealer internalization, and other OTC transactions is their absence of pre-trade transparency. That is, orders are not publicly displayed prior to execution. Consequently, these types of transactions can be considered to represent “dark” liquidity. In contrast, on-exchange business

⁴See, for example, Angel, Harris, and Spatt (2010).

⁵NYSE Euronext operates the NYSE (New York Stock Exchange) and NYSE Arca in the United States. It also operates the NYSE MKT, formerly the Amex (American Stock Exchange), which caters to small growth companies.

⁶See U.S. SEC (2010).

is largely (though not exclusively) pre-trade transparent.⁷ Dark liquidity is estimated to have grown by approximately 48% between January 2009 and March 2012, to account for around 31% of consolidated volume.⁸

A number of concerns about the current market structure have been raised by both investors and regulators. These concerns relate to a perceived degradation of transparency arising from the growth in dark trading and the corresponding fall in the market share of “lit” venues, an uneven playing field between different types of trading venues and different classes of investors that could potentially distort competition and fairness, and a greater potential for systemic risk propagation as a result of the dependence on automation and the interconnectedness of markets.

A more fundamental concern associated with the growth in dark liquidity is that the willingness of investors to post displayed limit orders—the building blocks of price discovery—could be potentially harmed if a significant proportion of orders are filled off-exchange at the expense of the limit order submitter. At its worst, this scenario could disincentivize investors from displaying orders altogether.

The question thus arises: What exactly do these market structure concerns mean for overall market integrity? More precisely, and more quantifiably, what is the relationship between dark liquidity and market quality? This issue is central to the debate on market structure and is the focus of this report.

Specifically, we examine the relationship between different types of undisplayed, off-exchange volumes and market quality measures, including bid–offer spreads and top-of-book market depth.

The objective of this report is to inform public policy issues related to undisplayed liquidity and to address the aforementioned market integrity concerns. The report contributes to the literature by attempting to separate off-exchange volume into its component parts, thereby enabling one to isolate the effects on market quality from dark pools and from internalization.

The rest of this report is structured as follows. Section 2 provides an overview of the U.S. equity market structure. Section 3 addresses the key aspects of the prevailing regulatory framework. Section 4 examines existing academic literature. Section 5 explains the data used for this study. Section 6 presents descriptive statistics. Section 7 presents the results of the analysis, and Section 8 concludes and offers policy considerations on the basis of the findings.

⁷Most exchanges operate electronic limit order books, in which the top-of-the-book trading interest is publicly displayed in the consolidated quote stream if it constitutes the national best bid and offer (NBBO) for a stock, whereas the depth of trading interest beneath is displayed to participants of the exchange. Note that exchanges do facilitate undisplayed liquidity as well—see Section 2 for details.

⁸Figures are based on data presented in Table 1 in Section 2 of this report for March 2012 and on data from Thomson Reuters Equity Market Share Reporter for January 2009.

2. Market Structure

Today, equity trading in the United States is dispersed over 13 exchanges, at least one ECN, approximately 16 reporting dark pools, and more than 200 broker/dealers who internalize order flow. Trading can be distilled into “exchange” transactions and “off-exchange” transactions, with the latter encompassing ECNs, dark pools, internalization, and any other OTC transactions.

The following sections present a review of each of these different types of trading venues and trading modalities.⁹ Later in this section, the processes by which orders are handled, executed, and reported are also set out.

2.1. Exchanges

Most registered exchanges are structured as electronic limit order book markets. Such markets are multilateral (meaning that multiple buyers and sellers can trade against each other within the system), offer nondiscriminatory access, and operate according to nondiscretionary rules and procedures.

Limit order book markets result in trades when an acceptable match between buy and sell orders occurs. This requires either a buy or a sell order to cross the spread between the highest bid and lowest offer submitted so that acceptable prices for both buyer and seller overlap. Typically, limit order books operate according to price and then time priority for the sequencing of order execution. Price–time priority ensures the fair treatment of orders.

The role of brokers in limit order book markets is limited to facilitating the execution of client orders. But many exchanges include market makers who provide liquidity and ensure smooth market functioning. The activities of liquidity providers supplement the interaction of customer orders and facilitate the operation of a continuous market.

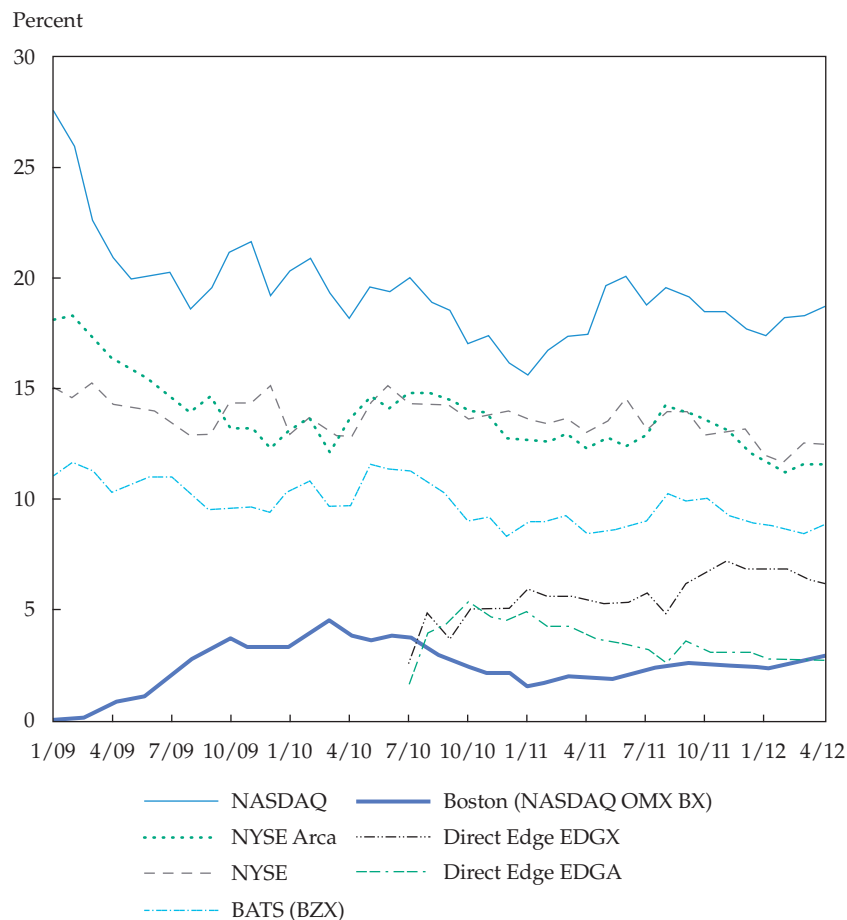
Exchanges are generally both pre-trade and post-trade transparent: Prices and trading interest are displayed prior to execution, and transaction details are publicly disseminated in real time. But exchanges do permit hidden order functionality, meaning that undisplayed or “dark” liquidity can reside in exchange systems. Such hidden liquidity on exchanges,

⁹See also U.S. SEC (2010) for a thorough account of U.S. equity market structure.

however, is reasonably small. For any given exchange, it typically accounts for less than 1% of the consolidated share volume. For all exchanges in aggregate, hidden liquidity accounts for approximately 3–4% of the consolidated volume.¹⁰

Figure 1 illustrates the market share trends for the seven largest exchanges over the period of January 2009–April 2012. As noted previously, nearly all exchanges lost market share over this period. The corollary is that off-exchange trading has grown. The only exchange

Figure 1. Exchanges' Market Share of Consolidated Volume, January 2009–April 2012



Source: Based on data from Thomson Reuters Equity Market Share Reporter.

¹⁰Figures obtained from Rosenblatt Securities.

that appears to have gained market share over this period is Direct Edge (EDGX and EDGA). Note, however, that prior to July 2010, Direct Edge was registered as an ECN, so it does not appear in the market share statistics prior to this month. Consequently, its series artificially starts from a base of zero and hence is not fully comparable.

A full list of exchanges and their approximate average market share is provided in [Table 1](#).

2.2. Electronic Communications Networks

ECNs operate similarly to exchanges in terms of secondary market trading of equity securities. They are multilateral electronic trading venues, typically structured as limit order book markets that are generally pre-trade and post-trade transparent. The primary difference from exchanges is that ECNs are typically regulated as alternative trading systems. As such, they do not provide the full range of functions that exchanges do (for example, they are not listing venues) and are not subject to the same regulatory responsibilities, including surveillance and oversight requirements, as registered exchanges.

Most of the ECNs that competed with the primary exchanges in the 1990s have since been acquired or merged with the large exchange operators. For example, Instinet, the largest ECN at one time, was partially spun off and merged with the Island ECN to create Inet, which was later acquired by NASDAQ. Similarly, Archipelago was acquired by NYSE Euronext and now operates as the exchange NYSE Arca. Consequently, today there is only one significant ECN—LavaFlow—which accounts for less than 2% of the consolidated share volume.

2.3. Dark Pools

Dark pools are systematized execution facilities that operate without full pre-trade transparency. That is, orders entered in the dark pool are not displayed to other market participants and are matched anonymously against contra-side orders. Many dark pools do, however, send out indications of interest (IOIs) to select market participants; such IOIs may indicate the security, number of shares, and side (buying or selling interest), but no price. In that regard, dark pools can be considered to operate with a limited degree of pre-trade transparency. Dark pools are registered as ATs for regulatory purposes.

The primary economic purposes of dark pools, and dark orders in otherwise transparent venues, are to reduce information leakage and minimize market impact costs. Dark pools also provide the possibility of price improvement and reduced transaction costs more

generally. Two ways in which dark pools realize these benefits are by crossing offsetting customer orders at the midpoint of the national best bid and offer, thereby saving on both exchange fees and the bid–offer spread, and by restricting access to undesired market participants (such as high-frequency trading firms from the perspective of the institutional buy side). For these reasons, such facilities have been historically popular for execution of large block orders, enabling investors to obtain efficient, low-cost executions for nonstandard types of business. However, today, order and transaction sizes in dark pools are, on average, broadly equivalent to those on transparent exchanges.

There are several different types of dark pools operating in the United States. Rosenblatt Securities—a well-established source of dark pool statistics—categorizes dark pools into four groups: pools operated by bulge-bracket brokerage firms, pools operated by market makers, independent or agency pools, and consortium-sponsored pools. An alternative classification is provided by TABB Group, which categorizes dark pools according to their function, namely: block-cross platforms, continuous-cross platforms, and liquidity-provider platforms. The last category corresponds to the dark pools run by the large market makers, such as Knight and Getco.¹¹

Based on the Rosenblatt Securities and TABB Group classifications, independent/agency and consortium-sponsored dark pools are mostly block-cross platforms, meaning that periodic auctions take place within the system in which the volumes crossed at each point are of a large size. Examples include Liquidnet (independent/agency) and Level ATS (consortium sponsored). In comparison, broker/dealer-operated dark pools are most commonly continuous-cross platforms, in which crossings are more frequent and are typically of smaller sizes. Examples of continuous-cross platforms include Credit Suisse Crossfinder and Goldman Sachs Sigma X, the two largest dark pools in operation.

Crossing systems are automated systems that match order flow in an orderly or systematized fashion between counterparties using the system or network. Orders are typically crossed at a point within the spread of the best bid and offer reference prices. Some dark pools facilitate only the matching of customer-to-customer order flow, whereas others (typically those operated by broker/dealers) allow customer order flow to also execute against the broker's own account.

Some dark pools facilitate the aggregation of liquidity from different sources to deepen the pool of available liquidity, which makes them attractive for executing large orders. Additionally, access to certain dark pools may be limited to only certain counterparties—for example, clients of the bank that sponsors the dark pool or buy-side-only institutions.

¹¹See also Zhu (2012) for a good overview of dark pools and their classifications.

In aggregate, dark pools have accounted for between 8% and 13% of the consolidated volume over the past three years.¹² A list of dark pools and their approximate market shares, along with other trading venues, is provided in Table 1.¹³

Table 1. U.S. Equity Trading Venues' Market Share of Consolidated Volume as of March 2012

Venue	Average Market Share of Consolidated Volume (%)
<i>Exchanges</i>	
NASDAQ Stock Market	18.1
New York Stock Exchange	12.3
NYSE Arca	11.7
BATS BZX Exchange	8.3
Direct Edge EDGX Exchange	6.3
NASDAQ OMX BX (formerly the Boston Stock Exchange)	2.8
Direct Edge EDGA Exchange	2.7
BATS Y-Exchange (BYX)	2.6
NASDAQ OMX PSX (formerly the Philadelphia Stock Exchange)	1.0
National Stock Exchange (NSX)	0.4
Chicago Stock Exchange (CHX)	0.4
NYSE MKT (formerly NYSE Amex/ American Stock Exchange)	0.2
CBOE Stock Exchange	0.2
Total exchanges	67.0
<i>ECNs</i>	
LavaFlow	1.8
Total ECNs	1.8
<i>Dark pools</i>	
Credit Suisse Crossfinder	1.9
Goldman Sachs Sigma X	1.5
Knight Link	1.4

¹²Figures are based on data primarily from TABB Group, Rosenblatt Securities, and NASDAQ.

¹³There are more dark pools in operation than those presented in Table 1, which only shows figures for those venues that report their volume to TABB LiquidityMatrix. Any volume from non-reporting dark pools is, therefore, accounted for in the residual OTC category.

Table 1. U.S. Equity Trading Venues' Market Share of Consolidated Volume as of March 2012 (continued)

Venue	Average Market Share of Consolidated Volume (%)
Getco GETMatched	1.2
Barclays LX	1.1
Deutsche Bank SuperX	0.8
UBS PIN	0.7
Knight Match	0.7
Morgan Stanley MS POOL	0.7
LeveL ATS	0.6
Liquidnet	0.6
BIDS Trading	0.5
Instinet Cross	0.5
Citi Match	0.5
ConvergEx Millennium	0.3
ConvergEx VortEx	0.2
Total dark pools	13.2
<i>Broker/dealer internalization/OTC</i>	
More than 200 firms	18.0
Total broker/dealer	18.0
Total	100.0

Note: LavaFlow ECN's executed volume includes FLOW matched shares and GOTO routed shares. Approximately half of LavaFlow volume relates to matched shares on its system (FLOW), and half relates to routed shares (GOTO). Therefore, FLOW matched shares are estimated to account for 0.9% of consolidated volume. Estimations are based on data from www.lavatrading.com.

Sources: Based on data from TABB LiquidityMatrix, Thomson Reuters Equity Market Share Reporter, www.lavatrading.com, and U.S. SEC.

2.4. Internalization/Retail Market Making

Internalization involves broker/dealers internally executing client order flow against their own accounts on a systematic basis. Internalization is a bilateral form of trade execution in which the broker/dealer (the OTC market maker) acts as the counterparty to all incoming orders, trading as principal and using its own risk capital. It is, therefore, classified as an off-exchange activity. Internalization represents a form of dark liquidity because OTC market

makers are not subject to any requirements to display quotes prior to execution. Furthermore, similar to dark pools, these market makers may discriminate among the counterparties that they will accept orders from.

The practice of internalization is not regulated as such. However, firms conducting internalization are required to register with the SEC and adhere to applicable conduct of business rules as established by the Financial Industry Regulatory Authority (FINRA), the industry's self-regulatory body.

Broker/dealer internalization represents a significant proportion of overall trading activity, as shown in Table 1. Internalization is also thought to account for almost 100% of all retail marketable order flow, whereby brokerages route marketable retail orders to a wholesale OTC market maker.

Broker/dealer internalization is typically driven by the purchase of order flow by wholesale OTC market makers from retail brokerage firms. Many wholesalers have standing payment for order flow agreements with retail brokerages, typically paying 0.1 cent per share or less to the retail brokerage for the order flow.¹⁴ Another variant of this model is one in which the market maker and brokerage are vertically integrated, affiliated entities under the same corporate group.

Upon receipt of the order flow, the wholesale market maker typically fills orders internally against its own account or, if an order is undesirable, routes it to other wholesalers, other internalization pools, other market centers, or exchanges for execution. The routing algorithm is determined by such factors as the depth of liquidity available in other pools, other payment for order flow arrangements, trading venue access fees, and so forth.¹⁵ In this manner, internalization is also referred to as “preferencing,” reflecting the fact that the retail market maker executes the orders it chooses under the terms of its pre-arranged agreement with the retail brokerage firm and routes any unwanted orders elsewhere. Because retail investors are typically less well-informed than professional or institutional investors, retail order flow is very desirable to wholesale market makers. Their information advantage means that they can preference those retail orders that are on the wrong side of the market (that is, against the direction of expected market movements in the short-term and hence profitable to the market maker) and route any other orders to other market centers. This practice has also been referred to as “cream skimming” in academic literature (see Section 4 for further discussion).

¹⁴See U.S. SEC (2010).

¹⁵The standard “take” fee—the fee charged when market orders execute against resting liquidity in exchange books—ranges between \$0.0018 and \$0.003 per share (ASIC 2011, p. 109; Rosenblatt Securities; U.S. SEC 2010).

Table 2 shows the proportion of market orders routed to wholesale OTC market makers for a selection of retail brokerages based on firms' SEC Rule 606 public disclosures on order routing practices. The table illustrates that nearly all retail market orders are internalized and that such internalization activity is dominated by a handful of wholesalers. Although market orders are almost exclusively internalized, some customer limit orders are routed to exchanges.¹⁶

Table 2. Proportion of Market Orders in NYSE Euronext-Listed Stocks Routed to Wholesale OTC Market Makers for a Selection of Brokerages, 1Q2012 (%)

OTC Market Maker	Brokerage						
	E*TRADE	TD Ameritrade	Scottrade	Vanguard Brokerage Services	Charles Schwab	Edward Jones	Raymond James & Associates
Citigroup Global Markets/ Automated Trading Desk	5.2	—	20.9	20.2	0.1	18.2	15.8
Knight Capital Americas	8.4	—	40.7	22.0		13.4	15.1
Citadel	17.1	76.0	18.6	35.7	0.2	30.0	16.1
UBS Securities	7.4	18.0	13.9	17.0	99.7	6.1	6.0
E*TRADE Capital Markets	61.9	—	—	—		32.2	35.2
Other wholesalers		—	—	—		—	11.8
Total	100.0	94.0	94.1	94.9	100.0	99.9	99.9

Source: Based on information in SEC Rule 606 reports for each company (— means not disclosed).

Broker/dealers have to provide best execution for their clients, so the prices at which they internalize order flow must match or beat the NBBO. Because there are no quoting obligations for internalization, broker/dealers can provide price improvement to their customers in the form of sub-penny executions, often to the magnitude of \$0.0001 per share.¹⁷ Therefore, although internalization can reduce trading costs, such savings are often only nominal. For example, on a 100-share marketable buy order (most orders are for a few hundred

¹⁶For example, the TD Ameritrade Rule 606 report for 1Q 2012 shows 52% of limit orders in NYSE Euronext-listed stocks routed to NYSE Arca. Similarly, the Scottrade Rule 606 report shows 44.7% of limit orders routed to LavaFlow ECN and 31.5% of limit orders routed to Direct Edge EDGX Exchange for NYSE Euronext-listed stocks. However, E*TRADE, Vanguard Brokerage Services, Edward Jones, and Raymond James & Associates routed all of their limit orders in NYSE Euronext-listed stocks to wholesalers. The relative proportions of market orders and limit orders handled by these brokerages vary. In some cases (e.g., Scottrade, Vanguard, Raymond James), the proportion of market orders is broadly equivalent to the proportion of limit orders for orders in NYSE Euronext-listed stocks.

¹⁷See Section 3 for details on the sub-penny rule. See also CFA Institute (2010b) comment letter to the U.S. SEC on sub-penny trading.

shares or less) for a stock trading at \$19.99 bid–\$20.01 offer, the OTC market maker might fill the order at \$20.0099, saving the investor \$0.0001 per share from the offer price for a total saving of 1 cent on the \$2,000 transaction.

One way in which broker/dealers may profit from retail transactions is by sweeping the market with immediate-or-cancel (IOC) contra-side orders to execute against hidden liquidity at exchanges residing between the NBBO. Continuing our example from the previous paragraph, suppose that there are hidden limit sell orders at \$20.00 resting at exchanges while the displayed NBBO remains \$19.99 bid–\$20.01 offer.¹⁸ Having sold at \$20.0099 to the retail investor, the OTC market maker may send out IOC orders to buy all the undisplayed liquidity offered at \$20.00, thereby replenishing its inventory (assuming the hidden size offered is sufficient to cover the market maker’s short position) and profiting by \$0.0099 per share on the round-trip transaction. Internalization can become very profitable when one considers the frequency with which the process occurs—a round-trip transaction takes a matter of milliseconds.

Other sources of potential profit are flickering quotes and latency arbitrage.¹⁹ The order protection rule of Regulation NMS (see Section 3) contains a provision exempting “flickering quotes”—defined as the least aggressive ask and bid quotes over the previous one second—from the evaluation of a trade through. Broker/dealers with faster data feeds than the public consolidated quote stream may be able to arbitrage between the “stale” NBBO seen by slow traders, such as retail customers, and the updated NBBO seen by fast traders with proprietary data feeds within the permitted one-second window before a trade through is enforced.

Using the previous example, suppose two exchanges are at the displayed NBBO of \$19.99 bid–\$20.01 offer. Suppose further that a broker/dealer has a resting limit order offering \$20.01 at Exchange A but the best offer quickly updates to \$20.00 at Exchange B. A retail investor with a slower data feed sees the best offer still at \$20.01 and submits a marketable buy order within the one-second window (making the least aggressive offer of \$20.01 flicker compliant). An OTC market maker can match the offer of \$20.01 at Exchange A to fill the incoming marketable buy order and then quickly lift the offer of \$20.00 at Exchange B, making a profit of \$0.01 per share without violating trade-through rules. This example suggests that regulators should consider the appropriateness of the one-second time window under the flicker quote exemption because of the ease it affords relatively more sophisticated market participants to profit from it.

¹⁸Numbers are for ease of illustration only.

¹⁹See, for example, McNish and Upson (2011).

Moreover, although internalization does provide price improvement, it carries an opportunity cost to liquidity providers that must be balanced against the aforementioned savings provided to retail investors. Wholesale broker/dealers are effectively provided with an option to trade against incoming marketable order flow. Only if they choose not to exercise that option does the order flow get routed elsewhere. Consequently, the order flow eventually reaching the exchanges is filtered, meaning that there are fewer opportunities for displayed liquidity providers—those posting limit orders on exchanges—to trade against retail order flow.²⁰ Investors who submit passive limit orders on exchanges take on risk by displaying their trading intentions; however, that risk may not be commensurately rewarded if the interception of marketable order flow by retail market makers leaves limit orders unfilled, or filled only because those limit orders are on the wrong side of the market. At its worst, this situation could disincentivize liquidity providers from displaying quotes altogether, which might have negative repercussions for price discovery and overall market integrity.

The process of internalization for marketable retail orders is summarized in **Figure 2**. Solid arrows represent the routing of order flow, and dashed arrows represent possible payments.

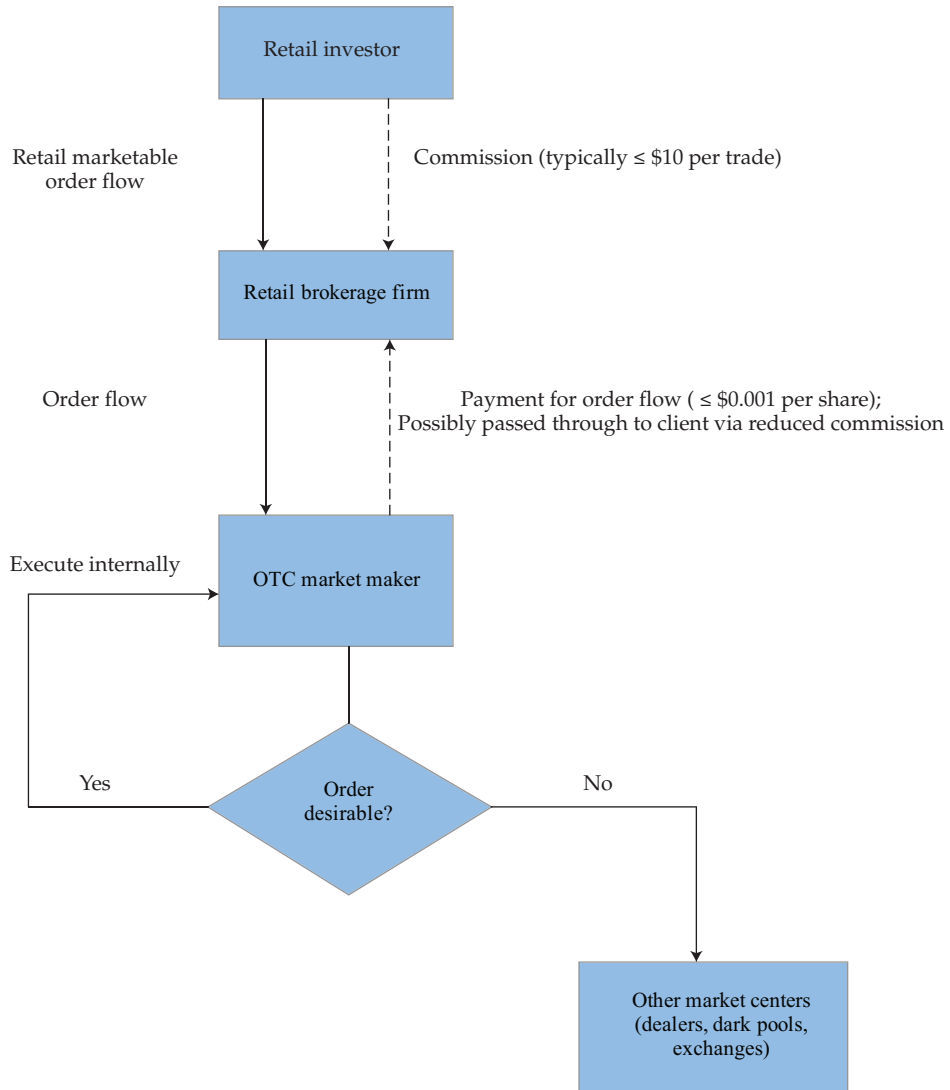
2.5. Other OTC

Any other off-exchange transactions between broker/dealers and their counterparties that do not belong to the aforementioned activities can be simply classified as OTC. Such transactions include ad hoc, large, or irregular transactions between broker/dealers and other counterparties seeking to execute client order flow in the most efficient manner possible. Broker/dealers conducting such OTC transactions may use their own inventory to meet their clients' specific needs and then lay off their risk exposure in subsequent trades with other counterparties.

Many OTC transactions represent technical trades that are non-price-forming. Such trades do not represent real or addressable liquidity and thus are reported with a special identifier that excludes them from official volume figures. An example is a guaranteed volume-weighted average price (VWAP) trade in which the executing broker undertakes a series of transactions on the open market and then flips the shares back to the customer at the guaranteed price. Only the original open market transactions are included in the public consolidated tape information.

²⁰In July 2012, the SEC approved the NYSE's Retail Liquidity Program, in which retail orders sent to the exchange will execute against undisplayed retail price improvement orders residing within the exchange system. The Retail Liquidity Program is akin to internalization in that retail orders will largely not interact with displayed orders within the limit order book of the exchange.

Figure 2. Retail Market Making



2.6. Institutional Order Processing

As the preceding discussion suggests, the process by which orders are handled, routed, and executed can be very complex, such is the fragmented nature of the equity market and the reliance on advanced technology and speed.

At the institutional level, the chain of events from order origination to execution is partly dependent on the scale and resources of the buy-side institution originating the order. It is common for buy-side firms to send their orders to their broker/dealer to handle the routing and execution, although many large buy-side institutions operate their own systems to handle this process as well.

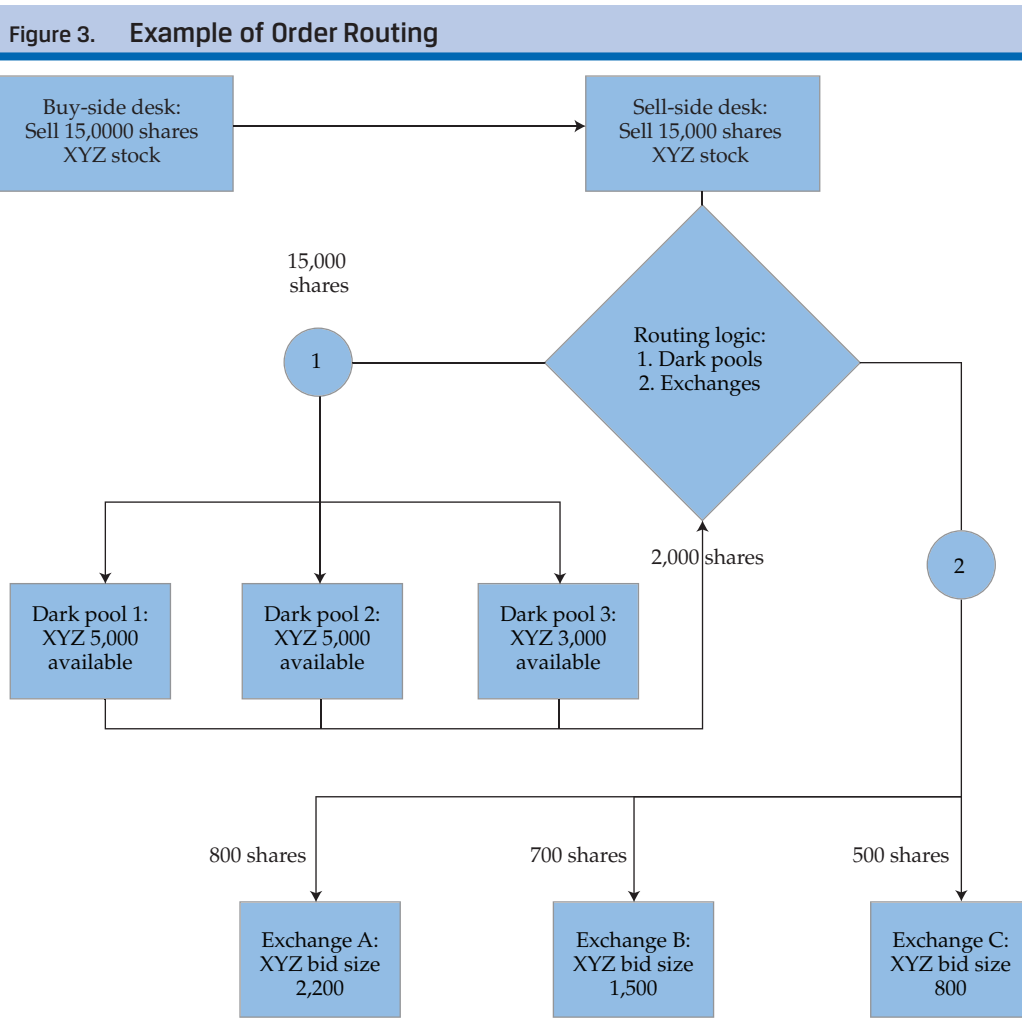
The vast majority of institutional orders are processed using computerized algorithms (algos). These algos take the institutional order (the “parent” order) and spray pieces of it (“child” orders) into the market to minimize the price impact that would otherwise occur if the full order were dropped into the marketplace too quickly.

Algos determine the parameters of the order (what, when, where, how much, etc.), taking into account such factors as minimization of market impact, minimization of information leakage, immediacy of execution versus cost of execution in various pools, and other market-specific circumstances to provide the most efficient executions possible. In this respect, algos perform the role formerly fulfilled by floor brokers or the “upstairs” trading desks of sell-side firms.

Sell-side firms provide a sophisticated range of order management and execution services to their clients. In addition to various algos, these services include smart order routing systems (SORs) that seek out liquidity across multiple venues and help optimize execution as well as direct electronic access to exchanges, dark pools, and other market centers. Downstream, exchanges have also developed their own SORs and other technological innovations, both to sell to market participants and to handle the order flow routed to the exchange in question when it is not immediately or fully executable within the exchange’s own pool of liquidity.

The use of sophisticated algos to slice orders into small sizes and spread them across multiple venues to effect transactions partly reflects the need to compete with other sophisticated algorithmic traders, including high-frequency trading (HFT) firms that dominate trading activity in the equity market. An increasingly common feature of the algos developed by the sell-side for their clients is the inclusion of anti-gaming logic and allocation optimization. Such features are designed to minimize the risk of predatory algorithms sniffing out larger blocks of liquidity that typically reside behind child orders and almost instantaneously adjusting public quotes to profit against the incoming order flow.

A simplified example of the process by which orders are routed is illustrated in **Figure 3**. The exact routing process is dependent on such factors as the type of order, price, timing (such details are omitted here for simplicity), and minimization of information leakage along each step of the process. The chain of events depicted in the figure begins with the buy-side institution sending the order to its broker; as noted earlier, however, large buy-side institutions that employ their own algos may skip this step of the process and route directly to the various market centers, often using broker-sponsored platforms that provide direct electronic access to different trading venues.



This simplified description highlights the efficiencies to be gained from the use of algos and the critical importance of technology in navigating across the fragmented marketplace.

2.7. Trade Reporting and Public Price Transparency

Once trades are executed, they are immediately reported to the consolidated tape—the mechanism for the provision of public post-trade transparency.

There are three networks under the consolidated tape system: Networks A and B for the reporting of trades in NYSE-listed and NYSE MKT-listed securities, respectively, and Network C for the reporting of trades in NASDAQ-listed securities. Networks A and B are governed by the Consolidated Tape Plan and are operated by NYSE Technologies, whereas Network C is overseen by NASDAQ's UTP (Unlisted Trading Privileges) Plan.

Exchanges and other market centers send details of executed trades in real time to the relevant central data consolidator of the respective network, which then publishes the trades on the consolidated tape.

Off-exchange transactions are reported to one of two main Trade Reporting Facilities (TRFs) that are registered and overseen by FINRA. The largest TRF is operated by NASDAQ (the FINRA/NASDAQ TRF), through which approximately 93%²¹ of all off-exchange transactions are reported. The other TRF is operated by NYSE (the FINRA/NYSE TRF). FINRA also maintains the Alternative Display Facility (ADF) and the OTC Reporting Facility (ORF) for OTC trades, but these facilities are largely unused.

Importantly, all transactions reported through a TRF are sent to the central data consolidator for inclusion in the consolidated tape. This means that all transactions, whether executed on- or off-exchange, are reported via the same public mechanism.²² In this respect, the consolidated tape has a linking effect on the equity market, acting as a repository for all transaction information across the trading network.

²¹Based on data from www.nasdaqtrader.com.

²²It should be noted that all on-exchange transactions are required to be reported in real time, whereas off-exchange transactions must be reported (through FINRA) within 30 seconds. A second point of note is that an exchange is required to send trade information to the central consolidator at the same time it disseminates information on its proprietary data feed. But because of aggregation, information published on the consolidated quote and tape is visible approximately 5–10 milliseconds later than proprietary exchange feeds. Proprietary trading firms further minimize latencies by utilizing co-location facilities provided by exchanges. See U.S. SEC (2010) for further discussion.

Similarly, public pre-trade transparency is realized via the consolidated quote system. Exchanges send quotation information to the central data consolidators (as previously described) that assimilate bids and offers from across the displayed market centers and produce the NBBO for dissemination through the consolidated quote stream. But as noted elsewhere in this report, ATSs, such as dark pools, do not publish quotes in the public consolidated quotation feed.²³

²³Alternative trading systems (including dark pools) are exempt from having to display quotation information unless the trading volume for a stock on their system exceeds 5% of consolidated volume for that stock. See Section 3 for more details.

3. Regulatory Framework

The key regulatory development shaping the foundation of the current U.S. equity market structure was the establishment of the National Market System (NMS) following the Securities Acts Amendments in 1975. The aim of the amendments was to create a market system that provided for greater competition between market operators and participants, that promoted transparency in terms of the visibility and accessibility of prices, and that made markets interconnected.

In 2005, the rules governing the National Market System were consolidated and updated by the SEC under Regulation NMS (Reg. NMS). The rules require the protection of displayed quotations, fair and nondiscriminatory access to market prices, and improvements to the consolidation of data.

3.1. Regulation NMS

Following are summaries of the key features of Reg. NMS.

1. *Rule 610—Access Rule*

Rule 610 establishes standards for access to quotations in NMS stocks. It is designed to ensure that market participants have fair and nondiscriminatory access to markets and prices, thereby facilitating competition. As noted in Section 3.2, the provisions for fair and open access under Rule 610 only apply to exchanges; they do not generally apply to ATSS unless an ATS executes more than 5% of the volume in a given stock. ATSS are thus able to operate as dark venues.

A key feature of Rule 610 is that it enables market participants to access different market centers via private linkages, replacing the previous linkage system, ITS (Intermarket Trading System). Such private linkages include, for example, the type of SOR functionality provided by broker/dealers and exchanges outlined in Section 2. Importantly, to enable this type of access, Rule 610 prohibits trading venues from imposing unfairly discriminatory terms that would prevent or inhibit efficient access by any market participant.

The other pertinent element of Rule 610 is that it caps the fees that trading venues can charge for accessing protected quotations (i.e., the take fees for hitting resting liquidity) at \$0.003 per share. The fee limit is designed to ensure that market participants are not unduly restricted from accessing displayed quotations.

2. Rule 611—Order Protection Rule

Rule 611, also known as the “trade-through rule,” protects displayed quotations at the top of the order book. Specifically, incoming orders cannot execute against resting liquidity at prices inferior to the NBBO before first exhausting the trading interest at the best bid or offer. In other words, marketable orders cannot trade through the best prices. By extension, undisplayed trading venues do not benefit from trade-through protection because they do not display quotes in the public consolidated quotation system.

Rule 611 provides protection to market participants that post displayed limit orders, thereby upholding inter-market price priority for displayed and accessible quotations. Significantly, Rule 611 effectively removed the protections afforded to the manual quotation systems of incumbent floor-based exchanges, thereby accelerating the shift toward fully electronic markets.

It is worth emphasizing, however, that orders below the top of the order book are not covered under Rule 611. Accordingly, once a market center has satisfied its requirements under Rule 611, it can execute the remainder of the order within its system even though its remaining order book quotations (below its best-priced orders) may be inferior to other market centers. That is, a customer may receive an inferior average price for his or her order than would otherwise be the case with through-the-book trade-through protection.²⁴

3. Rule 612—Sub-Penny Rule

Rule 612 prevents exchanges, broker/dealers, and other market centers from displaying, ranking, or accepting any orders that are priced in an increment of less than \$0.01 or, for stocks that trade at less than \$1, in an increment of less than \$0.0001. The purpose of the sub-penny rule is to prevent liquidity from fragmenting over excessively diffuse pricing points and to protect limit orders from yielding execution priority to other limit orders that provide incremental but economically insignificant price improvement.

²⁴The U.S. SEC raised the issue of extending trade-through protection below the top of the order book in its 2010 concept release. No rules have been passed at the time of this writing.

It is notable, however, that although Rule 612 prevents sub-penny quoting, it does not prohibit sub-penny executions by broker/dealers. As the explanatory text to Rule 612 notes, “In addition, a broker/dealer could, consistent with the proposed rule, provide price improvement to a customer order that resulted in a sub-penny execution as long as the broker/dealer did not accept an order priced above \$1.00 per share in a sub-penny increment.” This rule has resulted in a significant proportion of retail marketable orders being executed in sub-penny increments. Indeed, because broker/dealers are not required to publish quotations, they are not constrained in their ability to execute in sub-penny increments to the same extent as exchanges. As noted in Section 2.4, sub-penny transactions could generate adverse consequences for market integrity relative to the economically small benefits accruing to the investor receiving price improvement from the sub-penny transaction.

4. Rules 601 and 603—Market Data Rules

Rules 601 and 603 reflect refinements to the plans governing the consolidation of market data. In particular, they revise the formulas for the allocation of revenue to the market centers that contribute data to the consolidated quote and consolidated tape. The rules also strengthen plan governance arrangements and authorize market centers to distribute their own data independently (in addition to their submissions to the consolidated quote and tape).

Finally, Reg. NMS aims to improve the transparency of order routing and execution practices by requiring market centers to publish monthly execution quality statistics (Rule 605). It also requires broker/dealers to publish quarterly reports on their order routing practices, including details of the venues to which they route orders (Rule 606). Collectively, the transparency provided under Rules 605 and 606 is designed to strengthen competition among market centers and broker/dealers.

3.2. Regulation ATS

Regulation ATS (Reg. ATS) was introduced in 1998. It was established to capture multi-participant non-exchange-trading modalities, including dark pools, ECNs, and broker/dealer systems.²⁵ Because these entities are not considered to meet the specifications of an exchange, they are not bound by the same requirements as exchanges, such as market surveillance obligations and other self-regulatory responsibilities.

Fundamentally, U.S. securities market regulation is premised on a distinction between exchanges and broker/dealers. Because ATSs are not considered to be exchanges, they must register with the SEC as broker/dealers and adhere to the business conduct rules applicable to broker/dealers established by FINRA.

The pertinent aspects of Reg. ATS relate to two types of access requirements: order display and execution access, and fair access to ATS services.

Generally, ATSs, including dark pools and other broker/dealer systems, are not required to publicly display price quotations and are able to restrict access to their crossing systems and internalization pools to their clients or to only certain types of investors. In other words, ATSs can be discriminating about who has access to their systems and to their prices, in contrast to the fair access principles required of exchanges.

The ATS access requirements, however, change once a 5% trading volume threshold is exceeded. Specifically, if an ATS executes more than 5% of the trading volume in a given stock and displays orders to more than one person, then it must adhere to the general order display and execution access requirements applicable to exchanges. According to U.S. SEC (2010), there are no ATSs that currently exceed this 5% threshold. The SEC has proposed lowering the threshold at which these order display and access requirements would apply from the current level of 5% to 0.25%. The SEC has also proposed amending the definition of “bid” and “offer” to include actionable IOIs. This would require IOIs, which are currently

²⁵Although Reg. ATS was introduced in 1998, volume transacted on undisplayed ATSs, such as dark pools, did not begin to grow significantly until the middle of the next decade. One factor that may have contributed to the growth of ATSs was an amendment to federal legislation on pensions. The Employee Retirement Income Security Act (ERISA) of 1974, under Section 408 (b) (29 U.S.C.1106), prohibits a fiduciary from, among other things, dealing with the assets of a pension plan “in his own interest or for his own account.” But the Pension Protection Act (PPA) of 2006, Section 611, includes an amendment to the prohibitions under ERISA. Specifically, the PPA exempts transactions “. . . executed through an electronic communications network, alternative trading system, or similar execution system. . .” from the prohibited transactions under ERISA.

only transmitted by ATSS to select customers, to be subject to the public quoting requirements of exchanges. As noted in Section 3.3, these proposals remain under consideration as of this report's publication date.

Looking ahead, as the equity market evolves and trading venues and trading modalities continue to innovate, the historical regulatory distinction between exchanges and broker/dealers will increasingly blur. This transition suggests that a functional approach to regulation would be most appropriate to maintain a level playing field, in which all functionally similar trading venues are treated in the same way.

3.3. International Regulatory Developments regarding Dark Liquidity

The issues associated with dark liquidity are prevalent internationally. A number of regulatory bodies in other jurisdictions have developed frameworks governing how dark pools and undisplayed orders are allowed to operate within their markets. These initiatives provide useful context when considering the U.S. regulatory framework and possible improvements to that framework.

In 2011, the International Organization of Securities Commissions (IOSCO) published a report on principles for dark liquidity, which establishes a broad set of international best practices for regulatory treatment of dark pools and dark orders in otherwise transparent markets. According to IOSCO (2011), the issues surrounding dark liquidity include

- the potential impact on the price discovery process when there is a substantial number of dark orders (in dark pools or otherwise) that may not be published,
- the potential impact of fragmentation on information and liquidity searches, and
- the potential impact on market integrity arising from differences in access to markets and information.

IOSCO sets forth five broad principles designed to mitigate these issues. These include the following:

1. Regulators should generally require and promote public pre-trade and post-trade transparency. When allowing exemptions from pre-trade transparency, regulators should consider the potential impact on price discovery, fragmentation, fairness, and overall market quality.

2. Market rules and regulations should provide for priority of transparent orders over dark orders at the same price.
3. Reporting regimes should enable regulators to access information on dark orders and transactions.
4. Information should be made available to market participants about dark pools and dark orders so that they are able to understand the manner in which their orders are handled and executed.
5. Regulators should periodically monitor the development of dark pools and dark orders in their jurisdictions and take appropriate action as needed.

A number of national regulators have adopted standards to regulate dark liquidity within their respective markets that are broadly consistent with these principles.

In the European Union (EU), revisions to the Markets in Financial Instruments Directive (MiFID) and Regulation (MiFIR) propose handing responsibility for and oversight of the pre-trade transparency “waiver” process to the European Securities and Markets Authority.²⁶ This move is designed to ensure that exemptions from pre-trade transparency are applied consistently throughout the different EU member states.

In Canada, the Canadian Securities Administrators (CSA), in conjunction with the Investment Industry Regulatory Organization of Canada (IIROC), announced a revised framework for dark liquidity that will become effective in October 2012. The framework is based on three elements. First, visible orders will have execution priority over same-priced dark orders on the same marketplace. Second, to trade with a dark order, smaller orders must receive a minimum level of price improvement, defined as one trading increment (generally 1 cent) or half a trading increment for securities with a bid–ask spread of one trading increment. And third, IIROC will be permitted to introduce a minimum size threshold for the use of dark orders at a later date. CSA and IIROC will monitor market developments to consider whether and when IIROC should implement a minimum size.

In 2011, the Australian Securities & Investments Commission (ASIC) undertook a series of consultations on Australia’s equity market structure. In April 2012, ASIC provided an update on the direction of its market structure reforms on the basis of the consultation process. In the area of pre-trade transparency, ASIC has proposed, first, replacing the existing

²⁶MiFID permits waiving the obligation to publicly display orders for orders and trading systems satisfying one of the following criteria: (1) orders that are “large in scale”; (2) “reference price” systems, which passively match orders at a reference price from the lit market; (3) systems that formalize “negotiated transactions”, such as VWAP trades; and (4) orders held in an order management facility, such as “iceberg” orders.

AU\$1 million threshold for block trades (which are exempt from pre-trade transparency) with a tiered model to more closely link large trades with liquidity factors. Second, the proposals would require dark orders to provide “meaningful” price improvement of at least one tick size or the midpoint of the quoted best bid and offer prices. And third, although ASIC has not proposed introducing a minimum size threshold for dark orders at this stage, it will consider potential triggers for possible future application of a minimum size. The latter two measures are consistent with those announced in Canada by CSA/IIROC.

In the United States, in addition to considering lowering the volume threshold at which ATs would be required to display orders and in addition to considering including actionable IOIs in the consolidated quote data (as noted in Section 3.2), the SEC has considered introducing a “trade-at” rule. This rule would prevent a market center or broker/dealer from trading at the NBBO unless it had been displaying at that price at the time it received an order. The rule would require a market center or broker/dealer not displaying at the NBBO to either execute the order with significant price improvement or route the order to a venue displaying at the NBBO. Separately, the Joint CFTC–SEC²⁷ Advisory Committee on Emerging Regulatory Issues, in a report published in 2011, has also suggested that the SEC analyze further the impact of broker/dealer internalization, with the idea of considering whether to adopt a rule requiring that internalized or preferenced order flow be executed at a price materially superior to the best bid or offer.

As of this report’s writing, no rulemaking decisions have been made in the United States on any of the proposals.

²⁷CFTC is the Commodity Futures Trading Commission.

4. Literature Review

This section presents a summary of the academic literature most relevant to this study. In total, four studies suggest an adverse relationship between dark trading and market quality (meaning that undisplayed trading is associated with a reduction in market quality) and eight suggest a neutral or positive relationship.

Of the most recent literature directly related to this study, two studies suggest that dark trading is associated with a deterioration in market quality (Weaver 2010, updated 2011; and Degryse, de Jong, and van Kervel 2011) and two studies indicate that dark trading is associated with improved market quality (Buti, Rindi, and Werner 2010a; and O'Hara and Ye 2011). Overall, the results from the academic literature can be viewed as mixed.

4.1. Studies Suggesting an Adverse Relationship between Dark Trading and Market Quality

Weaver (2010, updated 2011). In this study, Weaver examines off-exchange trading and market quality in the U.S. equity market. He examines the market share of trading volume reported through a TRF and finds evidence that off-exchange reporting is associated with a reduction in market quality. In particular, Weaver finds that stocks with higher levels of off-exchange reporting have wider bid–offer spreads (quoted, effective, and realized). Weaver also finds that increased off-exchange reporting is associated with greater price impact per trade and higher volatility.

The study is based on cross-sectional regressions of various market quality measures against the proportion of volume reported through a TRF, based on data from October 2009. Weaver updated the study in 2011 using data from October 2010, after Direct Edge's conversion to an exchange in July 2010, in order to more cleanly capture undisplayed trading volume. The findings are the same as those in the 2010 version.

There are some limitations to this study. First, trades reported through a TRF are treated in aggregate and are collectively considered as internalization. Therefore, Weaver does not explicitly distinguish between different types of off-exchange trading. Second, the 2010 version revealed some exceptions to the overall conclusion that off-exchange reporting has a harmful effect on market quality. Specifically, for NASDAQ stocks, dollar-quoted spreads and TRF volume are negatively related (higher TRF volume is associated with

lower spreads). The same is true for NYSE stocks with regard to percentage quoted spreads and TRF volume. In the 2011 version, however, the relationship between the proportion of TRF volume and spreads is uniformly positive for NASDAQ and NYSE stocks (more TRF volume increases spreads), although there are some exceptions for Amex-listed stocks. Weaver infers that the removal of displayed ECN volume from the sample in the updated study could explain these differences. In other words, the results are stronger in the absence of displayed volume in the TRF data.

Overall, Weaver concludes that increased off-exchange trading is associated with a degradation of market quality.

Degryse, de Jong, and van Kervel (2011). The authors study the impact of dark trading and visible fragmentation on market quality. They find that fragmentation in visible order books (in other words, competition among displayed venues) improves “global” liquidity—that is, liquidity consolidated across limit order books. But dark trading has a detrimental effect on liquidity measures, resulting in higher spreads and lower depth. The authors posit that the negative impact of dark trading is consistent with a “cream-skimming” effect between dark and visible markets because the informativeness of trades strongly increases with dark activity. That is, the degree of well-informed order flow (from professional traders) on exchanges is positively related to the level of less well-informed order flow preferred in dark markets.

There is much literature on order preferencing and adverse selection. In theory, high levels of internalized (particularly retail) order flow may cause the adverse selection component of the bid–offer spread on exchanges to increase, reflecting the greater risk of market participants trading against informed order flow. In other words, more internalization of retail orders results in a greater proportion of informed order flow routed to exchanges. Market participants, therefore, widen the quoted spread to compensate for the increased risk of adversely selecting informed or “toxic” order flow to trade against.

Easley, Kiefer, and O’Hara (1996). The authors examine the concept that purchased order flow (whereby brokers pay to acquire and internalize retail order flow) is used to cream skim uninformed liquidity trades, leaving the information-based trades to established exchanges. In their study, they focus on trades executed on the NYSE versus purchased order flow on the Cincinnati Stock Exchange. They find a significant difference in the information content of the different types of stock trades and conclude that this difference is consistent with cream skimming. The authors note that this practice—that is, fragmentation of orders by type—can impose wider costs on the market. The more successful the practice of preferencing is, the more profitable the strategy is for its pursuers. As more uninformed orders are preferred

(or internalized), prices become worse on the remaining orders. Wider prices on-exchange give greater scope for off-exchange order matching to be more profitable; it enables brokers to extract higher rents from customers because they can deal within a wider spread.

Zhu (2012). In this study, Zhu examines the impact of dark pools on price discovery in a theoretical setting and finds that execution risk is a key factor. Specifically, because order matching in a dark pool depends on the availability of other counterparties, some orders on the “heavier” side of the market—that is, the side with more orders—will fail to be executed. Well-informed professional traders are more likely to cluster on the heavier side of the market and hence suffer lower execution probabilities in a dark pool. In contrast, liquidity-seeking traders (those demanding immediacy) are less likely to cluster on the heavy side of the market and hence enjoy higher execution probabilities in dark pools. This difference in execution risk pushes relatively better-informed traders onto exchange order books—which contain the presence of market makers that can absorb excess order flow—and relatively uninformed liquidity-seeking traders into dark pools. Consequently, although the presence of better-informed order flow on exchanges improves price discovery (in an efficiency sense), it can also lead to wider spreads because market makers widen their quotes to compensate themselves for the increased adverse selection risk associated with the higher proportion of informed order flow on exchanges.

Taken together, these studies suggest that internalization and dark pool activity can lead to wider quoted spreads and generally poorer market quality. However, this conclusion is not uniform across the internalization literature; several studies suggest a benign effect on market quality from order preferencing.

4.2. Studies Suggesting a Neutral or Positive Relationship between Dark Trading and Market Quality

Larrymore and Murphy (2009). The authors explore the link between internalization and market quality by conducting an event study around the implementation of the Toronto Stock Exchange’s Price Improvement Rule in 1998. The rule required orders of 5,000 or fewer shares to receive price improvement or be routed to the limit order book for execution. The authors again note that in markets with high levels of internalized retail order flow, the adverse selection component of the bid–offer spread increases to reflect the greater risk of market makers trading against informed order flow. Larrymore and Murphy find that in the post-implementation period of the Price Improvement Rule, market quality

improved as reflected by declining spreads, reduced variance of pricing error, and greater depth, among other things. The outcome of improved market quality implies that market makers could compete more aggressively for order flow following the rule change because more limit orders came back on to the order book, thereby reducing adverse selection risk as reflected in the narrowing of spreads. In other words, brokers who previously internalized order flow could no longer earn abnormal profits and so either improved on the prices quoted in the displayed market or routed orders for execution on the exchange.

It is notable, however, that internalization rates (measured by the same counterparty executing both sides of a trade) increased for small transactions following the rule change. Specifically, as internalization rates increased for trade sizes between 1,200 shares and 5,000 shares, quoted spreads and volatilities declined and market depth increased. Consequently, Larrymore and Murphy conclude that “together, these findings suggest that increases in internalization rates are not necessarily associated with deteriorating market quality but may, in some instances, be associated with superior market quality” (p. 358). In other words, judiciously regulated internalization practiced under favorable market conditions—in this case, under the terms of the Toronto Stock Exchange’s Price Improvement Rule—can increase market quality.

Chung, Chuwongnant, and McCormick (2006). The authors examine order preferencing and adverse selection costs. Their findings are consistent with the hypothesis that brokers selectively internalize orders based on the information content of orders. But Chung et al. find that order preferencing is not necessarily harmful. They note that brokers are likely to charge uninformed traders lower commissions as compensation for the high spreads that they pay. To the extent that execution costs of uninformed traders are reduced by lower commissions, the net effect of order preferencing on overall execution quality can be positive, although accurate quantification of these benefits is difficult.

Other studies suggesting a neutral relationship. Two other notable studies that suggest a benign effect on market quality from order preferencing are Hansch, Naik, and Viswanathan (1999) and Peterson and Sirri (2003).

Hansch, Naik, and Viswanathan study execution quality, preferencing, and internalization for a sample of stocks on the London Stock Exchange and do not find any relationship between the extent of preferencing or internalization and spreads across stocks. Peterson and Sirri examine execution quality of retail order flow on primary and regional U.S. equity exchanges. They examine preferencing on regional exchanges, where dealers either are allowed to direct orders to themselves or pay to obtain order flow. Although execution quality is generally

found to be superior on the NYSE, the authors find that market quality is superior on the preferencing regional exchanges compared with the nonpreferencing regional exchanges. In sum, they do not find evidence that preferencing harms market quality.

The next four studies all indicate that dark trading is associated with improved market quality.

Buti, Rindi, and Werner (2010a). The authors analyze the relationship between dark pool activity and market quality based on a sample of 11 dark pools that voluntarily report their activity to SIFMA (Securities Industry and Financial Markets Association). Their sample captures approximately 50–60% of all dark pool activity reported by Rosenblatt Securities.

Looking first at the determinants of dark pool activity, Buti et al. find that more-liquid stocks with high volume and low volatility are generally associated with relatively high levels of dark pool activity. They also find that dark pool activity is higher for stocks with narrow quoted and effective spreads and high inside bid depth, suggesting that dark pools are more active when the degree of competition in the limit order book is higher.

Buti et al. also examine the relationship between dark pool activity and market quality across stocks and over time. For the cross-sectional analysis, the authors use a regression specification analogous to Weaver (2010, 2011), with market quality measures on the left-hand side and the proportion of dark pool volume on the right-hand side, alongside a quadratic term of the proportion of dark pool volume (to account for nonlinear effects) and other explanatory variables. Their results show that a higher amount of dark pool activity is associated with lower quoted and effective spreads, lower price impact, and lower volatility. That is, more dark pool activity is generally associated with higher market quality. Note that in the quadratic term, however, spreads decline initially but increase beyond a dark pool market share of approximately 8%, which may suggest a curvilinear relationship.

In the time-series analysis of dark pool activity and market quality, the authors find that higher dark pool activity is associated with lower spreads, greater depth, and lower volatility as measured by the standard deviation of returns. In sum, Buti et al. find no evidence that high levels of dark pool activity are associated with a worsening of market quality.

Buti, Rindi, and Werner (2010b). In this paper, the authors model the competition between a dark pool and a visible limit order book. They demonstrate that dark pool market share is higher when limit order book depth is high, when spreads are narrow, and when the tick size is larger. They also show that the initial level of liquidity determines the effect of the dark pool on spreads. For liquid stocks, the quoted spread remains very tight as dark pools

compete for, and attract, order flow from the displayed limit order book. But for illiquid stocks, the competition induced by the dark pool reduces the execution probability of limit orders, causing the spread to increase.

O'Hara and Ye (2011). The authors examine TRF volumes to measure fragmentation levels in individual stocks and use a variety of empirical approaches to compare execution quality and efficiency of stocks with different levels of fragmentation. O'Hara and Ye find that more-fragmented stocks have lower transaction costs. In particular, they find a negative relationship between effective bid-offer spreads and the proportion of TRF volume, implying that higher proportions of TRF volume are associated with narrower spreads and hence better market quality.

Gresse (2006). The author investigates the relationship between the trading activity of a dark pool crossing network and the liquidity of a traditional dealer market—in this case, the quote-driven segment of the London Stock Exchange. A cross-sectional analysis of bid-offer spreads shows that dealer market spreads are negatively related to crossing-network executions, which supports the notion that dark trading improves market quality. The author finds that risk-sharing benefits from crossing-network trading dominate fragmentation and cream-skimming costs.

4.3. Summary

Out of the studies reviewed here, the most applicable to the following analysis are Weaver (2010, 2011); Degryse, de Jong, and van Kervel (2011); Buti, Rindi, and Werner (2010a); and O'Hara and Ye (2011). The first two support the notion that undisplayed trading harms market quality, whereas the second two suggest undisplayed trading is associated with improvements in market quality.

Out of these studies, it should be noted that Degryse, de Jong, and van Kervel (2011) is based on Dutch stocks whereas the others are based on U.S. stocks. The European equity market structure differs in two key respects from the U.S. market: There is no single consolidated tape for the reporting of trades, and there is no trade-through rule enforcing execution at the best price across all trading venues. Consequently, the European market is not virtually consolidated in the same manner as the U.S. market (in which the consolidated tape has a linking effect across market centers), and therefore, the dynamic between fragmentation and market quality may differ between Europe and the United States. For

example, Degryse et al. find that visible fragmentation (competition between displayed venues) improves liquidity but dark trading does not, which differs from the conclusions of O'Hara and Ye (2011), who find beneficial effects from off-exchange trading.

In practice, there are a plethora of factors that influence the decision to execute in an undisplayed venue versus a public market, such as the type of order (and the immediacy associated with that order), the size of the order, the available liquidity and execution quality in various pools, and the need to obtain best execution for the client (these factors form some of the parameters of a firm's order-routing algorithm). In other words, consideration of the relationship between undisplayed liquidity and market quality is multifaceted. Consequently, it is difficult to positively identify causality from any empirical analysis of dark trading and market quality. But to determine whether there is an association between the variables of interest, we can perform regression analysis and test the null hypothesis that there is no relationship between the proportion of dark trading and market quality.

Building on the literature reviewed here, the following analysis examines the relationship between both internalization and dark pool activity, respectively, and market quality within a panel data setting. The data, descriptive statistics, and regression analysis are set out in Sections 5, 6, and 7, respectively.

5. Data

A sample of 450 stocks stratified across listing market and market capitalization was selected by CFA Institute. For each stock, data on market quality measures and off-exchange volumes were obtained on the 2nd through 6th Wednesdays²⁸ of each quarter from 1Q2009 through 2Q2011, resulting in a panel of observations on 450 stocks across 50 dates.²⁹

The period under review relates to a time of relative stability in the equity market, following the period of pronounced instability in the second half of 2008 associated with the financial crisis. Selection of this time period thus helps to minimize any systemic effects that may unduly influence the data. Furthermore, the time span also reflects a period by which the equity market had already fragmented significantly and by which the presence of high-frequency trading (HFT) was well established.³⁰ These considerations lessen the likelihood that the results could be affected by a structural change in the review period.³¹

To obtain our sample, we first selected the universe of securities listed on NYSE (including NYSE Arca), NYSE MKT, and NASDAQ, based on data from FactSet, and screened for U.S. common stocks only, excluding any inactive securities or secondary listings. From the resulting list, we then applied a further series of screens to obtain a sample of stocks with relatively standard characteristics. Specifically, screens were applied to exclude particularly high-priced stocks (any stocks that closed above \$500 in the review period³²), particularly low-priced stocks (any stocks that never closed above \$5 in the review period), and particularly low-volume stocks (any stocks with average daily volume of fewer than 1,000 shares).³³ This screening resulted in a population of 2,350 stocks.

²⁸Wednesdays were chosen to minimize the chances of selecting nontrading days or days with significant data announcements.

²⁹Some attrition arises because of the presence of stocks in the sample that were not listed until after the start of the review period, stocks that delisted during the review period, or missing/erroneous observations. Stocks that underwent ticker changes have been identified and kept in the sample. Overall, such attrition is immaterial for the analysis. The final total sample still contains in excess of 19,000 sets of observations.

³⁰For example, according to TABB Group estimates, the market share of HFT in the U.S. market was 61% in 2009, 56% in 2010, and 54% in 2011.

³¹The period under review comes after the time periods studied by Degryse et al. (2011), which is based on data from 2006 to 2009, and O'Hara and Ye (2011), which is based on data from January to June 2008. The former study deliberately spans a time period before the European market began to experience significant fragmentation (i.e., prior to implementation of MiFID in November 2007).

³²This approach is similar to that of Weaver (2010, 2011).

³³This approach is similar to that of O'Hara and Ye (2011).

Next, we classified stocks according to market capitalization, using the following parameters: small cap—less than \$1 billion, mid cap—greater than or equal to \$1 billion to less than \$5 billion, large cap—greater than or equal to \$5 billion.³⁴ We then sought to obtain a sample of 150 stocks from each market-capitalization category (to total 450 stocks), stratified across listing markets.

For the large-cap sample, there were no large-cap stocks listed on NYSE MKT in our screened population and only 59 such stocks listed on NASDAQ. We, therefore, selected all 59 NASDAQ stocks and randomly selected the balance of 91 from the NYSE listing segment in the screened population. To obtain our mid-cap sample, we selected all 4 such stocks listed on NYSE MKT in the screened population, along with 73 randomly selected stocks from each of the NASDAQ and NYSE listing segments. For the small-cap sample, 50 stocks were randomly selected from each listing segment in the screened population.

For each stock on each date, data were obtained from NASDAQ on the following variables:

1. Duration-weighted-average quoted spread, in dollars
2. Duration-weighted-average relative quoted spread, in basis points
3. Duration-weighted-average quoted depth, calculated as the average of bid depth and offer depth at the NBBO across all venues displaying quotes at the NBBO

Specifically, for a given time interval on day t , the bid–offer spread for stock i was calculated as

1. Quoted spread (\$) = $P_i^{\text{ASK}} - P_i^{\text{BID}}$
2. Relative spread (bp) = $\frac{P_i^{\text{ASK}} - P_i^{\text{BID}}}{(P_i^{\text{ASK}} + P_i^{\text{BID}}) / 2}$

Duration-weighted averages were then calculated for day t , based on the length of time that the quote was at the NBBO.

For a given time interval on day t , the average top-of-book depth for stock i was calculated as

3. Depth = $(\bar{D}_i^{\text{ASK}} + \bar{D}_i^{\text{BID}}) / 2$

³⁴Parameters were applied to average market capitalization over the review period.

where \bar{D} represents the average ask size and average bid size, respectively, at the top of the order book across all venues displaying at the NBBO. The duration-weighted average was then calculated for day t . Depth is measured in share terms and in dollar terms.³⁵ Conceptually, the depth measure represents the average size available at the best bid or the best offer.

The quoted spread, relative spread, and average top-of-book depth comprise the market quality measures to be examined. The remaining variables, for which data were also obtained from NASDAQ for each stock/date, include the following:

4. Volatility, measured by the daily price range divided by the closing price
5. Volatility, measured by the standard deviation of daily returns based on closing prices
6. Closing price
7. Market capitalization
8. Quote updates, measured by the number of messages sent to the central data consolidator updating the prices or quantities at the best bid or best offer
9. Number of trades
10. Total consolidated volume
11. Total volume reported to the NYSE TRF
12. Volume reported to the NASDAQ TRF from firms associated primarily with dark pools
13. Volume reported to the NASDAQ TRF from firms associated primarily with retail internalization
14. Volume of other OTC transactions reported to the NASDAQ TRF
15. Volume of technical trades reported to the NASDAQ TRF

³⁵Dollar depth is approximated by multiplying the duration-weighted average quantity by the duration-weighted average bid-ask midpoint price.

Technical trades are reported to the TRF with a special identifier. They are transactions that represent the transfer of shares to a customer account, which were previously traded elsewhere (i.e., non-price-forming trades). These trades do not represent real or addressable liquidity and thus are excluded from the subsequent analysis.

As the list of variables implies, trades reported to the NASDAQ TRF, which account for approximately 95% of all off-exchange trading in our sample, have been subcategorized. Using information on the identity of the party reporting a given trade, trades have been categorized according to the type of trading modality used. This categorization was performed by NASDAQ specifically for this study.³⁶ Several dark pools report trades using their own unique reporting identifier, so they can be positively identified. But in cases in which a unique reporting identifier is not used, the classification was based on knowledge of the type of activity that a given participant's reporting identifier is most typically associated with. We do not expect this element of judgment to materially affect the results.

A second caveat is that ECNs, which are displayed venues, also report trades through the TRF.³⁷ Consequently, to minimize the presence of displayed liquidity within our TRF data, trades from Direct Edge, the largest ECN prior to its conversion to an exchange in July 2010, have been removed. After July 2010, this adjustment is unnecessary. Matched order flow on the remaining ECNs is estimated to account for less than 1% of consolidated volume (as per Table 1). Consequently, any remaining "lit" volume within the TRF data is immaterial and should not affect the results.

Finally, upon receipt of the data, a further screen was conducted to remove significant outliers or clearly erroneous data. To that end, stocks with quoted spreads or relative spreads that were negative, greater than \$10, or greater than 5,000 bps (50%) were removed. Similarly, any observations for which total off-exchange volume exceeded total consolidated volume were removed.

³⁶Otherwise, only the aggregate TRF data are available.

³⁷These trades would reside within the residual OTC category.

6. Descriptive Statistics

Summary statistics for the key variables in the dataset are presented in **Appendix A**.

Beginning with the market quality measures, the mean dollar-quoted spread for the total sample is 11 cents. As one might expect given their relative riskiness, the mean quoted spread for small-cap stocks (29 cents) is much higher than that for large-cap stocks (2 cents). The same is true for relative spreads; the mean is 255 bps for small caps and 5 bps for large caps. Note that the data are skewed because the median is consistently lower than the mean, which is common among datasets of this type. Median relative spreads are 4 bps for large caps, 9 bps for medium caps, and 83 bps for small caps.

Analogously, average top-of-book depth (in shares and dollars) across all venues at the NBBO is significantly higher for large caps than for small caps. This result reflects the willingness of market makers to quote in relatively large sizes for larger, more liquid stocks, which have greater breadth of trading interest. Median depth for large-cap stocks is 1,663 shares or \$66,905, compared with 454 shares or \$5,964 for small-cap stocks.

The median closing price for the sample is \$24.14. Small-cap stocks have a lower price level (median of \$10.85) than large-cap stocks (median of \$36.73). Similarly, the median market capitalization of small-cap stocks in the sample is \$102 million, compared with \$11.3 billion for large-cap stocks.

Both volatility measures have similar means and medians. Average volatility is higher among small caps than among large caps, which is again consistent with expectations.

The number of quote updates and the quote-to-trade ratio both can be considered as proxies for algorithmic trading intensity. Algo trading is consistent with a high volume of message traffic as orders are entered, modified, and canceled rapidly in response to changing conditions. For the number of quote updates to the best bid or best offer per stock per day, the median is 267,286 updates for large caps and 3,865 updates for small caps, which reflects the higher level of trading interest in large-cap stocks. However, the quote-to-trade

ratio is higher for small caps (median ratio of 29.3) than for large caps (median ratio of 12.4); this result is driven by fewer daily trades among small caps (median trade count of 84) than among large caps (median trade count of 20,163).

The average trade size, approximated for each stock as the daily consolidated share volume divided by the daily number of trades, is similar among the different market-capitalization subsamples. The median average trade size is 178 shares for large caps and 162 shares for small caps. These trade sizes are very low by historical standards and reflect the pervasiveness of algos and the use of child orders to effect transactions. The average trade size is relatively flat over the review period under study (1Q2009 through 2Q2011).

Moving to off-exchange volumes, the table in Appendix A presents the aggregate off-exchange volume as a proportion of consolidated volume, along with the respective proportions for the NYSE TRF, dark pool volume reported through the NASDAQ TRF, internalized volume reported through the NASDAQ TRF, and other OTC volume reported through the NASDAQ TRF.

Looking first at the total proportion of off-exchange volume, the mean is 23% for the total sample, which appears reasonable compared with off-exchange volume figures commonly reported.³⁸ There is not much variation among the subsamples, with off-exchange volume proportions of 27% for the small-cap sample and 22% for both the mid- and large-cap samples.

In contrast, there is greater variation among subsamples for the proportions of dark pool volume and internalized volume, respectively. Large- and medium-capitalization companies experience relatively higher proportions of dark pool activity—with each averaging 8% of consolidated volume compared with just 3% for small caps—whereas small caps experience relatively higher proportions of internalized volume, averaging 19% compared with 7% for large caps and medium caps.

It is not surprising that internalization is relatively highest among small-cap stocks. As noted earlier, these stocks have relatively larger bid-offer spreads that enable OTC market makers to extract higher profits from dealing within the wider spread. In contrast, small-cap stocks trade less in dark pools compared with large- and mid-cap stocks, perhaps because their likelihood of execution is relatively lower in dark pools.

³⁸For example, U.S. SEC (2010) reports estimates that total undisplaced trading accounts for 25% of consolidated volume. Similarly, based on data from Thomson Reuters Equity Market Share Reporter, average off-exchange volume for all U.S. stocks was 27% over the review period. The fact that the average figure for our sample (23%) is lower than the Thomson Reuters figure is most likely a result of the exclusion of Direct Edge from off-exchange volume in our sample.

Figure 5. Relative Bid-Offer Spread, Subsamples, 1Q2009–2Q2011

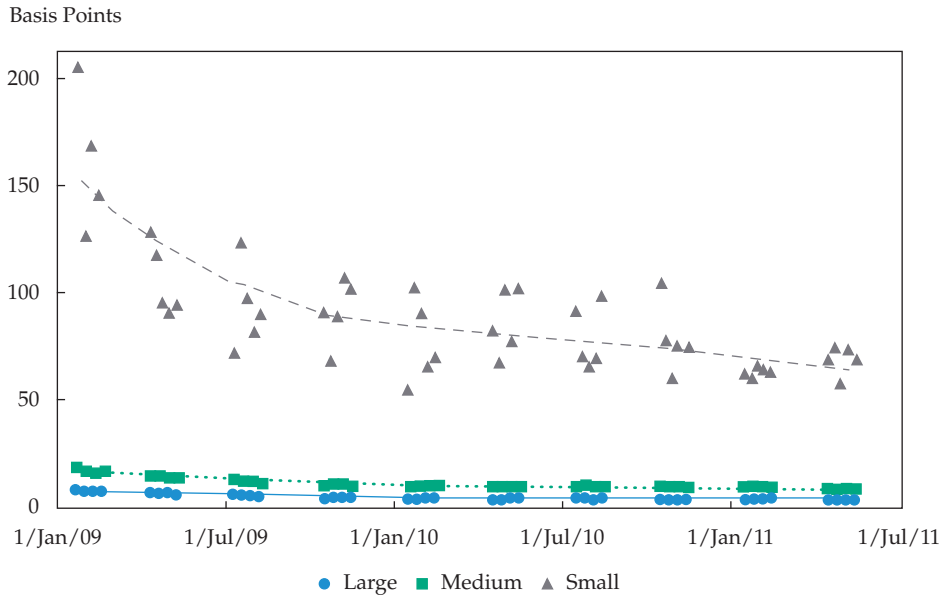
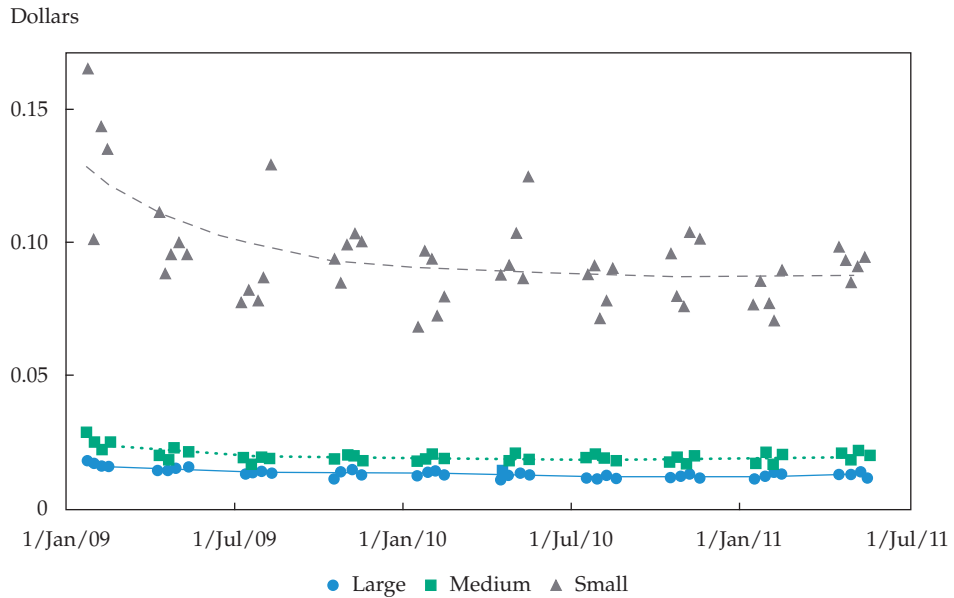


Figure 6. Quoted Bid-Offer Spread, Subsamples, 1Q2009–2Q2011



Average top-of-book depth is illustrated in [Figure 7](#) and [Figure 8](#), which plot depth (in shares and in dollars) over time for the median stock in the relevant sample. Average top-of-book depth in shares at the best bid or best offer is approximately the same at the end of the review period as it was at the start of the period for each subsample. Average top-of-book depth in dollars is slightly upward trending among each subsample, although the pattern is not consistent over the review period.

[Figure 9](#) and [Figure 10](#) plot the median market shares of internalization and dark pools for the respective subsamples over the review period. The charts show an upward trend for each sample, reflecting growth in undisplayed trading for all stocks. As noted earlier, internalization is higher among small-cap stocks relative to large- and medium-cap stocks, whereas for dark pools, the opposite is true.

Next, to add further color to the key variables, the data have been sorted into quintiles of dark trading activity and summarized in [Table 3](#). The table presents the median quoted spread, median relative spread, and median dollar depth for each quintile of dark pool activity and internalization activity, respectively.

Figure 7. Depth in Shares, Subsamples, 1Q2009–2Q2011

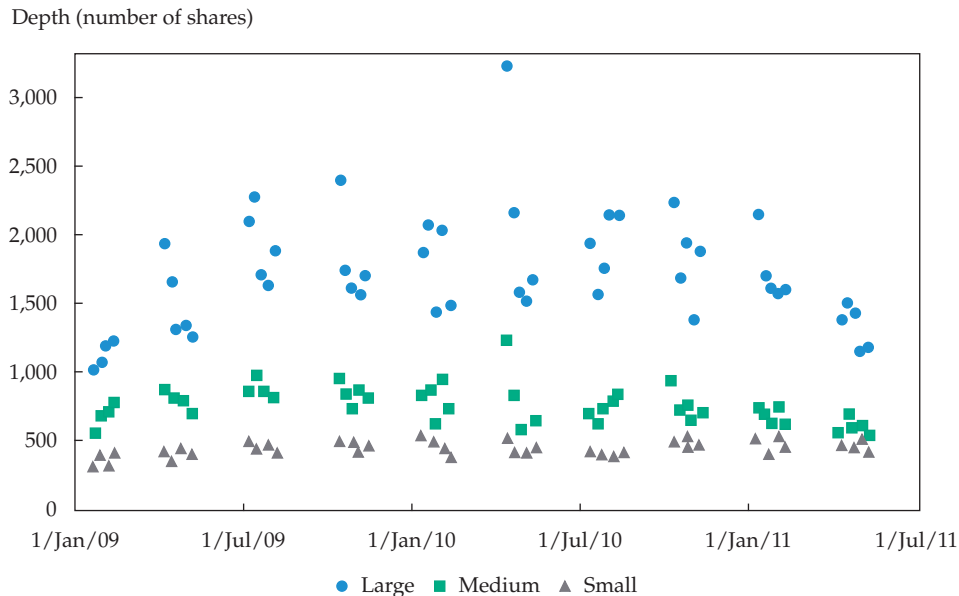


Figure 8. Depth in Dollars, Subsamples, 1Q2009–2Q2011

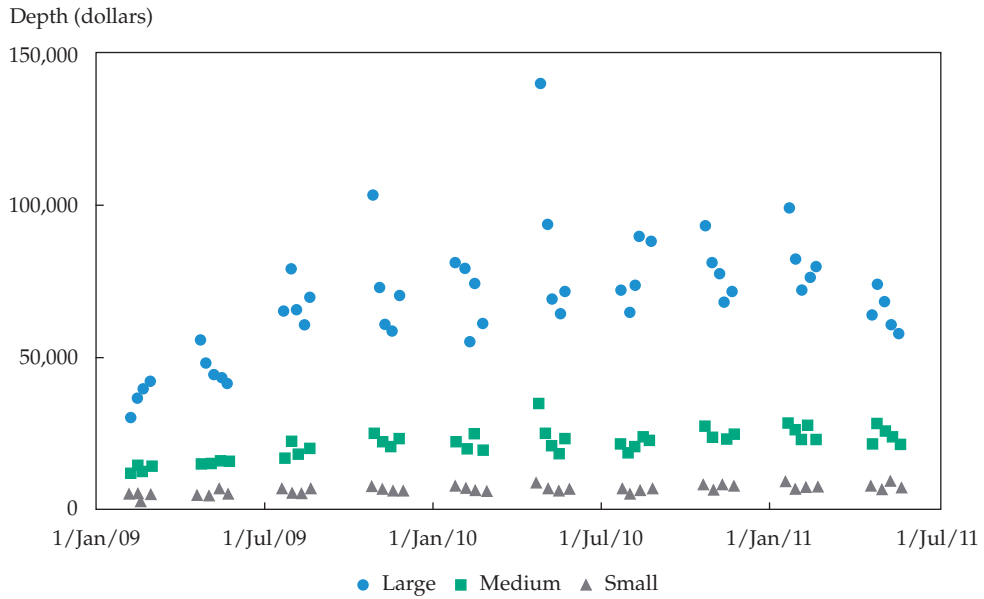


Figure 9. Internalization as a Proportion of Total Volume, Subsamples, 1Q2009–2Q2011

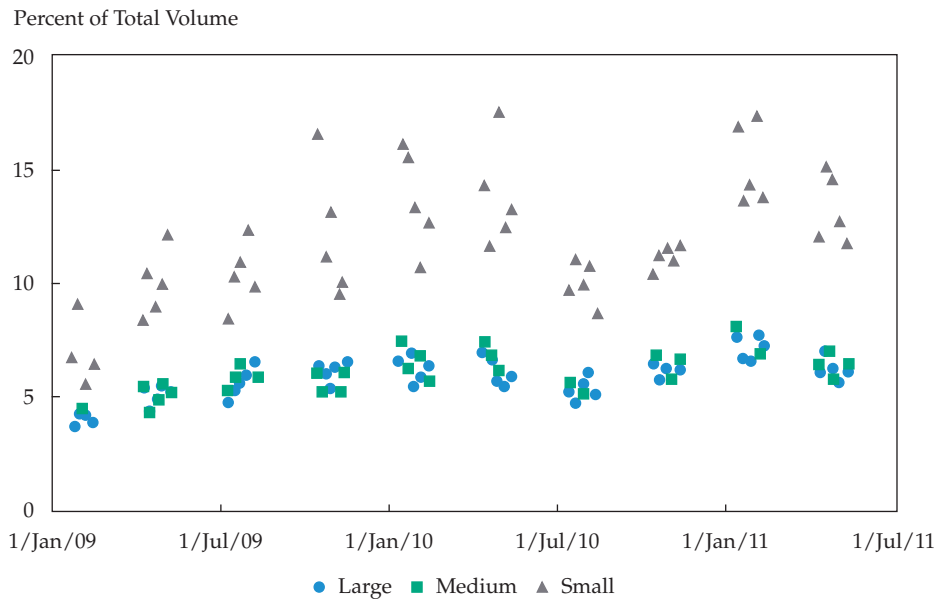
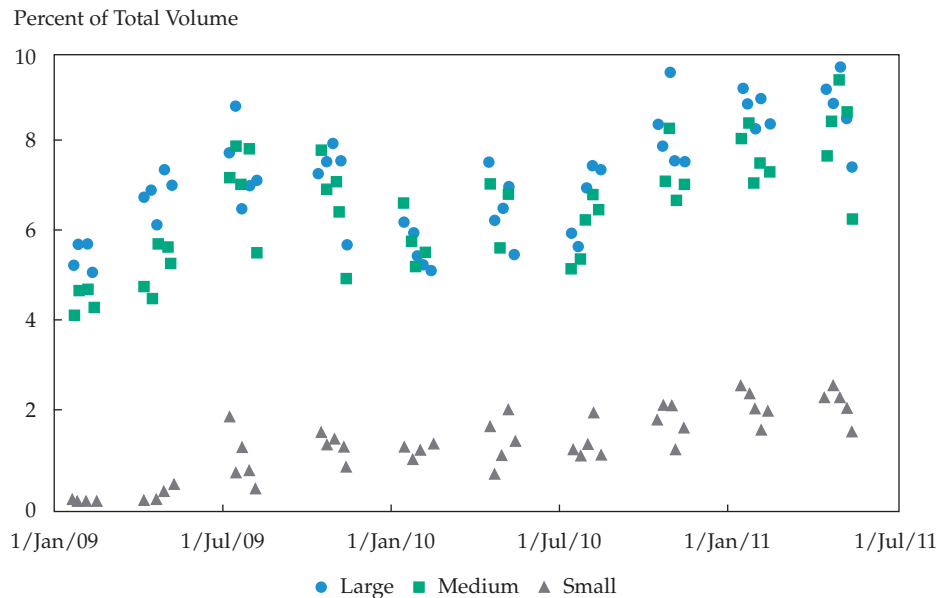


Figure 10. Dark Pools as a Proportion of Total Volume, Subsamples, 1Q2009–2Q2011



There are two main observations from Table 3. First, spreads are generally increasing and depth is generally decreasing through the quintiles. Second, the composition of stocks changes through the respective quintiles, such that (1) small-cap observations are more dispersed among the internalization quintiles than among the dark pool quintiles and (2) the proportion of small-cap observations increases through the respective quintiles. Therefore, it could be that the inferior market quality of stocks in the upper quintiles is being driven by such factors as firm size, or other stock-specific characteristics, rather than by the proportion of dark trading activity. We will control for this possibility in the subsequent regression analysis.

Table 3. Market Quality Statistics by Quintile of Dark Trading Activity

Quintile		Median Quoted Spread (\$)	Median Relative Spread (bp)	Median Depth (\$)	No. of Observations Large	No. of Observations Medium	No. of Observations Small
<i>Proportion of dark pool activity</i>							
≤20%	1	0.02	8.66	24,586	7,010	6,889	5,653
>20%, ≤40%	2	0.02	8.61	20,168	117	246	95
>40%, ≤60%	3	0.06	22.08	10,790	2	21	21
>60%, ≤80%	4	—	—	—	—	—	—
>80%, ≤100%	5	0.11	218.80	1,268	—	—	2
<i>Proportion of internalization activity</i>							
≤20%	1	0.02	7.55	28,328	7,020	6,947	3,777
>20%, ≤40%	2	0.05	57.04	7,107	109	201	1,167
>40%, ≤60%	3	0.12	171.38	4,367	—	8	523
>60%, ≤80%	4	0.21	262.17	4,170	—	—	163
>80%, ≤100%	5	0.41	470.03	4,570	—	—	141

Finally, to check that the trends identified in this section are not driven purely by sample selection or by the type of dataset used, a time series of daily observations on spreads and total off-exchange volume was constructed using separate data. Specifically, data on bid–offer spreads for the top 10 stocks in the S&P 500 Index and Russell 2000 Index (proxies for large caps and small caps, respectively) were obtained from FactSet Research Systems. Data on total off-exchange volume were obtained from Thomson Reuters Equity Market Share Reporter. Average spreads for each sample and total off-exchange volume are shown in **Appendix B**. Figure B1 in the appendix shows the same trends as those illustrated in the preceding figures, thereby providing some verification that our results are not unduly influenced by the specific dataset used.

7. Analysis

In this section, the relationship between dark trading and market quality is examined via regression analysis. Specifically, internalization and dark pool volumes—the independent variables of interest—and other explanatory variables are regressed against bid–offer spreads and depth (the dependent variables of interest), respectively. We test the hypothesis that there is no relationship between the proportions of dark trading and market quality.

7.1. Methodology

The regression specification controls for factors known to affect market quality to enable the effects of dark pool activity and internalization to be cleanly captured. Specifically, volatility measured by the standard deviation of daily returns, market capitalization, and price are included as control variables.⁴²

Volatility (information-based volatility) is controlled for because higher volatility is thought to increase spreads and reduce depth.⁴³ Intuitively, the risk of holding inventory is greater the more volatile the stock. Market makers compensate for this risk by widening the spread or by quoting in smaller sizes. In other words, higher volatility is associated with lower liquidity.

Market capitalization is a standard control variable that is included to account for the fact that larger companies are more heavily traded and hence exhibit higher liquidity. Therefore, market capitalization should be negatively related to bid–offer spreads and positively related to depth.

⁴²Two other control variables that were considered are the natural logarithm of average trade size and the natural logarithm of the quote-to-trade ratio (Q/T). Regarding the former, the trend line for average trade size is flat over the review period; as such, it is not expected to have a significant explanatory effect on the market quality measures under consideration. For robustness, separate regressions have been estimated that include this variable; the same findings are obtained irrespective of whether average trade size is included or not. The Q/T , which measures the number of quote updates to the best bid or best offer per trade, represents a proxy for the intensity of algorithmic trading. The literature on algorithmic trading suggests that higher algorithmic trading intensity improves liquidity (see, for example, Hendershott, Jones, and Menkveld 2011; Boehmer, Fong, and Wu 2012). Separate regressions have also been estimated that include this variable; again, the results are unaffected by the inclusion of the Q/T .

⁴³See, for example, Chordia, Roll, and Subrahmanyam (2000), who examine various liquidity measures based on a sample of NYSE-listed stocks. They find (among other things) that higher volatility is positively related to bid–offer spreads and negatively related to depth.

The price level is a scaling factor and is important for at least two reasons. First, stocks with higher price levels typically have higher quoted spreads to reflect the risk associated with greater dollar exposure (in other words, wider spreads for higher-priced stocks normalize the relative spread, or basis point cost, among stocks with different price levels). Second, the tick size has a lower bound of 1 cent, which is the minimum price variation (MPV) for stocks priced above \$1.⁴⁴ For certain very liquid, low-priced stocks, the spread nearly always equates to the minimum tick size. For such stocks, therefore, variability in the relative spread could be driven mainly by changes in the price level; consequently, price must be controlled for in the regression.

The regression specification also includes squared terms of the explanatory variables of interest—namely, the proportions of internalized volume and dark pool volume, respectively. The squares of these terms are included to account for the possibility of a nonlinear relationship between dark trading and market quality.⁴⁵

Table 4 summarizes the variables used in the regression.

Table 4. Summary of Regression Methodology		
Dependent Variable	Independent Variables	
	Control Variables	Dark Trading Variables
Market quality measure	Volatility (standard deviation)	Proportion of internalization (percent of consolidated volume)
	Market capitalization	Proportion of internalization squared
	Price	Proportion of dark pool activity (percent of consolidated volume)
		Proportion of dark pool activity squared

The market quality variables are, respectively, (1) quoted bid–offer spread, (2) relative bid–offer spread, and (3) average top-of-book dollar depth, as formally described in Section 5.

Each variable contains observations for each stock on each date. We take the natural logarithms of the dependent variables and the control variables to mitigate the effect of different scaling among the data. To control for other stock-specific factors, we demean all variables

⁴⁴There are no stocks with a price of less than \$1 in our sample.

⁴⁵Inclusion of squared terms of the market share variables is consistent with the approach of Weaver (2010), Buti et al. (2010a), and Degryse et al. (2011).

and use fixed-effects estimation.⁴⁶ This approach ensures that any variation we identify is the result of variability only in dark trading relative to each stock's own average. In other words, for each stock we are concerned only with the differences from the mean for that stock, thereby removing so-called unobservable heterogeneity bias that could otherwise explain why certain stocks always experience lower or higher spreads (depth) than other stocks.

Formally, the regression equation is expressed as

$$\begin{aligned} \ln MQ_{i,t} = & \alpha + \beta_1 \ln(\sigma)_{i,t} + \beta_2 \ln(\text{mkt_cap})_{i,t} + \beta_3 \ln(\text{price})_{i,t} \\ & + \beta_4 (\% \text{internal})_{i,t} + \beta_5 (\% \text{internal})_{i,t}^2 + \beta_6 (\% \text{dark_pool})_{i,t}, \\ & + \beta_7 (\% \text{dark_pool})_{i,t}^2 + \varepsilon_{i,t} \end{aligned}$$

where for stock i on day t ,

- $MQ_{i,t}$ represents each of the market quality variables described in Section 5, respectively (quoted spread, relative spread, and dollar depth);
- $\sigma_{i,t}$ represents the standard deviation of daily price changes over the month up to day t ;
- mkt_cap represents the market capitalization;
- price represents the closing price; and
- $\% \text{internal}$ and $\% \text{dark_pool}$ represent internalization and dark pool volumes as proportions of consolidated volume, respectively.

The control variables are all commonly used, exogenous variables in market microstructure studies of this type. The regression model should, therefore, enable an unbiased analysis of the association between the dark trading variables and market quality measures. We can infer the nature of that association by interpreting the regression coefficients.

The regression results are presented in **Appendix C** and are summarized in Section 7.2.

⁴⁶This approach is common among panel regressions of this type and is supported by diagnostic tests.

7.2. Results

For the total sample, the coefficients for the control variables all exhibit the expected signs with respect to quoted bid–offer spreads, relative bid–offer spreads, and dollar depth. Specifically, volatility is positively related to spreads (spreads widen as volatility increases) and negatively related to depth (higher volatility reduces the average dollar size available at the best bid or offer). Market capitalization is negatively related to spreads and positively related to depth, as expected; in other words, larger companies exhibit higher liquidity. The price level also exhibits the expected relationships with respect to bid–offer spreads. First, the quoted spread increases as the price level increases (to normalize the spread per dollar). Second, the relative spread increases as the price level decreases, which accounts for the effect of the quoted spread converging to the minimum tick size at low price levels. The price level is not, however, statistically significant with respect to dollar depth.⁴⁷

More pertinently, the coefficients for %internal and %dark_pool are negative for quoted spreads and relative spreads, indicating that spreads decrease as dark trading increases. Analogously, depth increases as the proportions of internalization and dark pool activity increase. Collectively, these results suggest that increases in dark trading are associated with improvements in market quality.

Note that the coefficients switch signs for the squares of %internal and %dark_pool, respectively. That is, bid–offer spreads increase and dollar depth decreases as the squares of %internal and %dark_pool increase, although the coefficients for the square of %dark_pool are not statistically significant with respect to spreads. Overall, these findings indicate that the relationship between dark trading and market quality measures is likely quadratic. That is, market quality initially improves but then declines as dark trading increases. This result is considered further in Section 7.3.

To check the consistency of these findings, the same regression is estimated again for each market-capitalization subsample. The regression results are also included in Appendix C. For each subsample, the results are generally the same: Market quality initially improves but then declines as dark trading increases. For large caps and medium caps, dark pool activity has a relatively stronger effect on market quality than internalization, whereas for small caps, internalization has a relatively stronger effect. This result is perhaps not surprising; as noted in Section 6, dark pools are relatively more active among large- and medium-cap stocks whereas internalization is relatively more prevalent among small-cap stocks.

⁴⁷If price-inverse is used instead of the natural logarithm of price (two broadly similar measures), the effect of price on dollar depth becomes statistically significant.

For each of the large-, medium-, and small-cap regressions, the control variables exhibit the same expected relationships with respect to the dependent variables and are generally strongly significant. The coefficients of the dark trading variables are also generally significant and exhibit the same signs as documented for the total sample—that is, market quality improves in the linear term but declines in the squared term. Dark pool activity (both linear and squared terms) is strongly significant on quoted spreads, relative spreads, and dollar depth in the large- and medium-cap regressions. Internalization (both linear and squared terms) is statistically significant on relative spreads in all of the market-capitalization subsamples, with the strongest effect in the small-cap regression.

Taken together, these findings suggest that a higher incidence of dark trading is associated with improvements in market quality, although the improvements are not indefinite. This conclusion differs from that of Weaver (2010, 2011) but is consistent with the findings of Buti, Rindi, and Werner (2010a, 2010b) and O'Hara and Ye (2011). Buti et al. (2010b) predict that dark pool activity is higher when limit order book depth is high and when spreads are narrow. For such stocks, an order submitted to the limit order book has to be more aggressive to gain execution priority. As a result, the alternative of a mid-quote execution in a dark pool (with relatively low execution uncertainty given liquidity factors) becomes relatively more attractive.

The reasons these results are different from those of Weaver (2010, 2011) are not clear, though they could be related to the fact that Weaver uses a cross-sectional regression over a much shorter time period (one month). The fact that Weaver (2010, 2011) uses aggregate TRF data is not thought to be a factor inasmuch as there is no clear difference between internalization and dark pools and their respective relationships with the market quality variables.

To further validate the robustness of our results, we ran a second set of regressions using the generalized method of moments (GMM) approach incorporating the second lags of the dependent and independent variables as instruments.⁴⁸ This approach helps to reduce any endogeneity issues—namely, that the dependent and independent variables could influence each other. The GMM regressions exhibit the same relationships; although statistical significance is less uniform (significance is strongest for dark pool activity on quoted and relative spreads but is less consistent among other variables), this result is not unexpected given fewer observations used. Overall, the GMM regressions provide comfort about the model specification used.

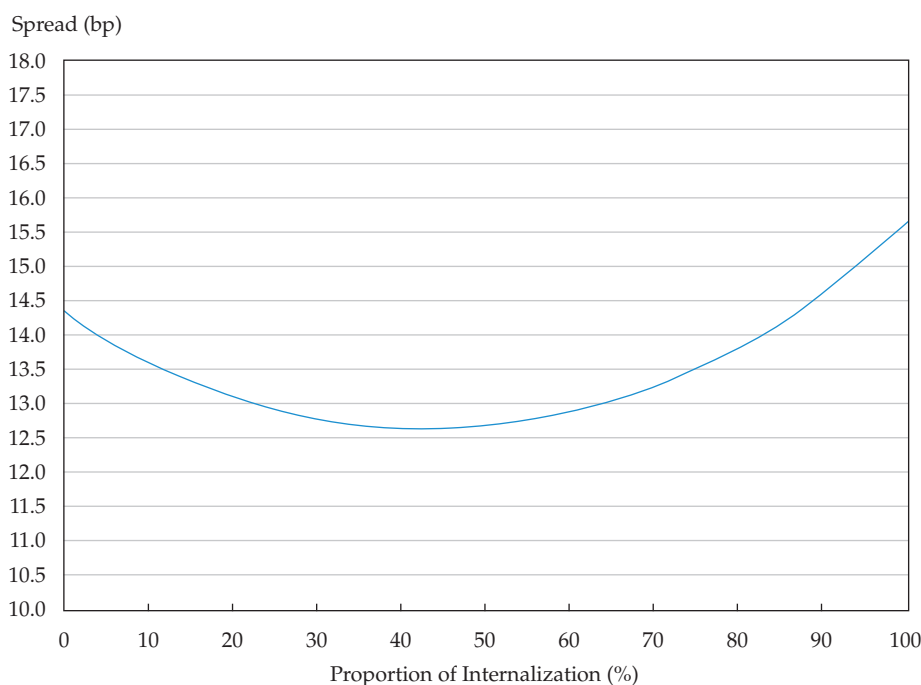
⁴⁸To run the GMM regressions, we first averaged observations in each quarter to collapse the sample into 10 quarterly sets of observations.

7.3. Threshold Effect

As noted in Section 7.2, the coefficients for %internal and %dark_pool and their squares imply the existence of a turning point in the relationship between dark trading and market quality. That is, market quality initially improves as dark trading increases but declines beyond a certain threshold.

This effect is illustrated in **Figure 11**. The chart plots the relative bid–offer spread (in basis points) predicted by the regression equation for different proportions of internalization. The relationship between internalization and the relative spread is the focus for two reasons. First, the regressions with relative spread as the dependent variable exhibit the strongest explanatory power; and second, the effect of internalization on the relative spread, in both linear and squared terms, is statistically significant throughout all of the samples, so it exhibits the most consistency.

Figure 11. Estimated Relationship between Internalization and Bid–Offer Spreads



The plot is based on the regression output for the total sample (in Table C1 in Appendix C) and is obtained by fitting different proportions of internalization activity into the regression while holding all other variables constant at their sample means. Therefore, the plot is effectively a two-dimensional slice through the regression for internalization to enable a visual representation of the relationship under consideration.

The estimated turning point in the relationship between internalization and relative bid–offer spreads predicted by the model is 43.2%, as shown in Figure 11. That is, beyond a market share of approximately 43%, internalization is associated with deteriorating market quality.

To check the robustness of these findings, the same procedure was followed for different regression models. An array of possible values for the turning point in the relationship between dark trading activity (internalization and dark pools, respectively) and relative spreads is shown in Table 5. These values have been estimated using the regression output outlined in Appendix C. Note that the values presented are just point estimates predicted by the model assuming all else equal as dark trading activity increases. The turning points should not, therefore, be considered as definitive numbers; rather, they are an indication of the approximate level or range at which increases in the market share of dark trading cease to be associated with improvements in market quality.

Table 5. Estimated Turning Points in the Relationship between Internalization and Dark Pool Activity and Relative Bid–Offer Spreads

	Sample			
	Total	Large	Medium	Small
Internalization	43.2%	12.6%	18.9%	44.4%
Dark pools	37.8%	19.3%	22.5%	63.9%

Note: Figures in bold indicate calculations based on statistically significant coefficients.

From a policy perspective, the relationship between aggregate undisplayed trading and market quality is also of interest. Accordingly, a separate regression was estimated that is analogous to that specified in Section 7.1 but with %internal and %dark_pool and their respective squares substituted by a single undisplayed trading variable, %undisplayed,⁴⁹ capturing aggregate dark trading. The regression results are presented in Appendix D.

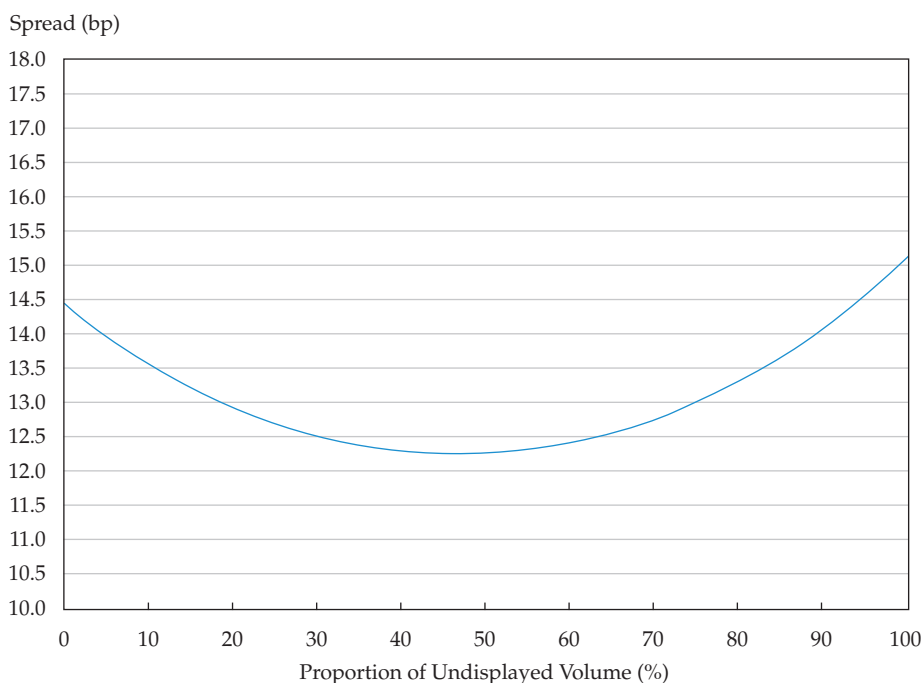
⁴⁹%undisplayed includes dark pools, internalization, other OTC transactions reported to the NASDAQ TRF, and off-exchange volume reported to the NYSE TRF.

Varying the proportions of aggregate undisplayed trading while holding the other parameters constant at their sample means yields the relationship between relative bid–offer spreads and dark trading that is shown in **Figure 12**. It shows that the estimated turning point in the relationship between aggregate undisplayed trading and relative bid–offer spreads is 46.7%.

Taking all these findings together, a conservative assessment would be that when the majority of trading in a stock (>50%) occurs in undisplayed venues, market quality will likely deteriorate.

One possible explanation is that initially, competition for order flow among on- and off-exchange venues causes more aggressive quoting in the limit order book. While lit markets dominate (dark market share <50%), this competition helps to reduce bid–offer spreads. But when dark markets dominate, such that most orders are filled away from lit markets, a mass of investors could withdraw quotes because of the reduced likelihood of those orders being filled on acceptable terms. Consequently, limit order submission declines and displayed spreads begin to widen, resulting in deteriorating market quality. That is, the effect by which investors become disincentivized from displaying orders dominates when dark trading dominates.

Figure 12. Estimated Relationship between Aggregate Undisplayed Trading and Bid–Offer Spreads



Put another way, if the majority of order flow is filled away from pre-trade transparent markets, liquidity providers will likely quote in smaller sizes or at wider spreads to compensate themselves for the greater risk of adverse selection, reduced ability to gauge market activity, or greater difficulty of maintaining inventory at target levels.

The implication of these findings is that competition (or fragmentation) is beneficial for investors. The introduction of dark pools and growth in internalization has eroded exchange monopolies and improved market quality. But once competition reverses (i.e., markets tend toward dark monopoly), the benefits become eroded.

7.4. Further Considerations

One phenomenon not captured by the model is the presence of HFT envelope liquidity. Such liquidity typically represents floating orders used by HFT firms that reside at or around the NBBO to profit from various short-term trading opportunities, including, but not limited to, liquidity rebate capture, market fragmentation arbitrage, and other types of statistical arbitrage. This type of envelope trading is prevalent mainly in large-cap stocks.

Although HFT volume is flat to declining over the review period, we must consider the possibility that the presence of HFT envelope liquidity could have increased.⁵⁰ If so, the quoting intensity of such market participants behind the NBBO (leaning on the best quotations) could have an effect on bid-offer spreads that is not captured by the model. We suggest that this is an area for further research.

⁵⁰As noted in Section 5, the market share of HFT in the U.S. market was 61% in 2009, 56% in 2010, and 54% in 2011 according to TABB Group estimates.

8. Conclusions and Policy Considerations

The U.S. equity market structure has evolved dramatically over the last decade. Increasing technological sophistication, fragmentation, and competition for order flow between displayed and dark trading venues have served to lower indirect trading costs in the form of bid–offer spreads and have generally led to an improvement in market quality. To ensure these gains are preserved, competition should be encouraged.

Within this fragmented market structure, dark trading—in the form of broker/dealer internalization and dark pools—has grown significantly. Dark pools have helped to reduce information leakage, minimize market impact, and increase investor choice. Along with the development of algorithms and smart order routing, dark trading facilities have helped investors optimize their order execution capabilities.

Moreover, the results presented here suggest that dark trading does not harm market quality at its current levels. Increases in internalization and dark pool activity are initially found to be associated with lower bid–offer spreads and higher depth. Consequently, the proliferation of dark trading venues can be considered a positive development overall.

However, the gains from dark trading are not indefinite. The results from this study suggest that if a majority of trading in a given stock takes place in undisplayed venues, spreads will likely increase and market quality will deteriorate. If the majority of order flow is filled away from pre-trade transparent markets, investors could withdraw quotes because of the reduced likelihood of those orders being filled. As investors become disincentivized from displaying orders, bid–offer spreads are likely to widen. Therefore, competition should be maintained to encourage aggressive quoting in displayed order books and a predominance of dark trading should be avoided.

Dark trading is estimated to account for approximately 31% of consolidated volume as of March 2012⁵¹ —a growth of approximately 48% since the start of 2009.⁵² Based on these trends, it would be prudent for authorities to monitor these developments closely. Although a wholesale revision of the market structure regulatory framework is not necessary, certain improvements are needed to ensure a level playing field among venues and to support competition.

To that end, public policy initiatives should focus on internalization. First, broker/dealer internalization constitutes the majority of undisplayed trading. Second, it accounts for the vast majority of marketable retail orders, which are relatively less well-informed. As such, retail internalization has the greatest propensity to intensify the degree of informed order flow on exchanges, as noted in the literature, which, in turn, can increase adverse selection risk and can disincentivize investors from posting limit orders in public markets if there is too much internalization.

Therefore, to strengthen competition among venues and reduce the probability of dark trading becoming predominant, internalization should be subjected to an appropriate regulatory framework. As the literature suggests, such an approach can lead to increased market quality.⁵³ Encouraging broker preferencing to provide meaningful price improvement or to route orders to an exchange should help prevent excessive privatization of order flow away from public markets. Fundamentally, the interaction of diverse types of order flow within public markets is important to support price discovery and to uphold market integrity.

Accordingly, considering the findings of our research and the current policy proposals outlined in Section 3, both in the United States and internationally, we recommend the following considerations.

1. Require internalization of retail orders to provide meaningful price improvement.

Meaningful price improvement could be defined as the minimum price variation (MPV) or half the MPV if the displayed spread between the best bid and offer equates to the MPV.⁵⁴

This proposal would require broker/dealers to either internalize marketable retail order flow with significant price improvement, thereby generating economically meaningful savings for retail investors, or route the order flow to an exchange to execute against the displayed quotations in the order book. This approach would provide some protection to market

⁵¹Based on the data presented in Section 2, Table 1.

⁵²Based on off-exchange market share of 21.3% at the start of 2009 per Thomson Reuters Equity Market Share Reporter. Note that this understates the actual growth in dark trading because of the inclusion of Direct Edge (a displayed venue) in off-exchange volume data prior to July 2010.

⁵³See Larrimore and Murphy (2009).

⁵⁴The MPV in U.S. markets is 1 cent for stocks priced above \$1 and 0.01 cents for stocks priced less than \$1.

participants posting limit orders by limiting the scope for OTC market makers to step in front of those orders by simply matching the best prices posted in displayed markets or by providing only nominal price improvement. It would thus minimize any disincentive to post displayed limit orders and would uphold market integrity.

This consideration is, in the context of retail orders, consistent with the proposals of CSA/IIROC and ASIC.

2. Monitor growth in the proportion of dark trading volume, and take appropriate measures.

Regulators should monitor developments with respect to internalization and dark pool activity. Regulators should consider introducing measures to restrict the use of dark orders and dark trading facilities if such activity becomes excessive, such as if the share of dark trading exceeds 50%. One possible measure would be to lower the threshold at which ATSS must display orders and meet general access requirements from the current level of 5% of the trading volume in a given stock.

This proposal is consistent with the IOSCO principles and is analogous to the recommendations of CSA/IIROC and ASIC to monitor growth in dark liquidity.

3. Improve reporting and disclosure around the operations of dark trading facilities.

Insufficient information about the operations of dark pools, internalization pools, the types of orders that are accepted within those systems, and the process by which orders are matched makes it difficult for investors to make informed decisions about whether or how to utilize dark trading facilities. It also makes it harder for regulators to monitor their growth (the second consideration) and to evaluate how dark pools affect price discovery and liquidity. Dark trading facilities should, therefore, voluntarily reveal greater information about their operating mechanics and report more information on the volumes they execute. Such disclosures would improve transparency and enable all stakeholders to better understand their relative benefits and drawbacks.

Implementation of these considerations would help protect displayed orders while offering meaningful savings to retail investors executing away from public markets, maintain competition, and further transparency. More fundamentally, these measures would enhance market integrity and underpin investor confidence in the equity market structure.

Appendix A

Descriptive statistics for the data described in Section 5 are presented in **Table A1**.

Table A1. Summary Statistics		Total	Small Caps	Medium Caps	Large Caps
Quoted spread (\$)	Mean	0.11	0.29	0.05	0.02
	Median	0.02	0.09	0.02	0.01
	Std. Dev.	0.36	0.60	0.17	0.03
Relative spread (bps)	Mean	79.95	254.59	13.29	5.47
	Median	8.67	83.49	9.14	4.11
	Std. Dev.	243.25	396.90	43.05	48.97
Depth (shares)	Mean	5,362	908	4,207	10,128
	Median	818	454	751	1,663
	Std. Dev.	21,375	1,518	12,956	32,788
Depth (\$)	Mean	219,613	8,611	414,561	194,736
	Median	24,289	5,964	21,393	66,905
	Std. Dev.	14,900,000	30,822	24,900,000	1,774,293
Price (\$)	Mean	30.67	15.55	32.35	41.22
	Median	24.14	10.85	24.92	36.73
	Std. Dev.	31.38	15.89	38.35	28.13
Market capitalization (\$ millions)	Mean	9,800	245	2,300	25,100
	Median	2,240	102	1,940	11,300
	Std. Dev.	26,800	296	1,380	40,700
Standard deviation (daily returns)	Mean	0.03	0.03	0.03	0.02
	Median	0.02	0.03	0.02	0.02
Range scaled by price	Mean	0.03	0.04	0.03	0.03
	Median	0.03	0.04	0.03	0.02

(Continued)

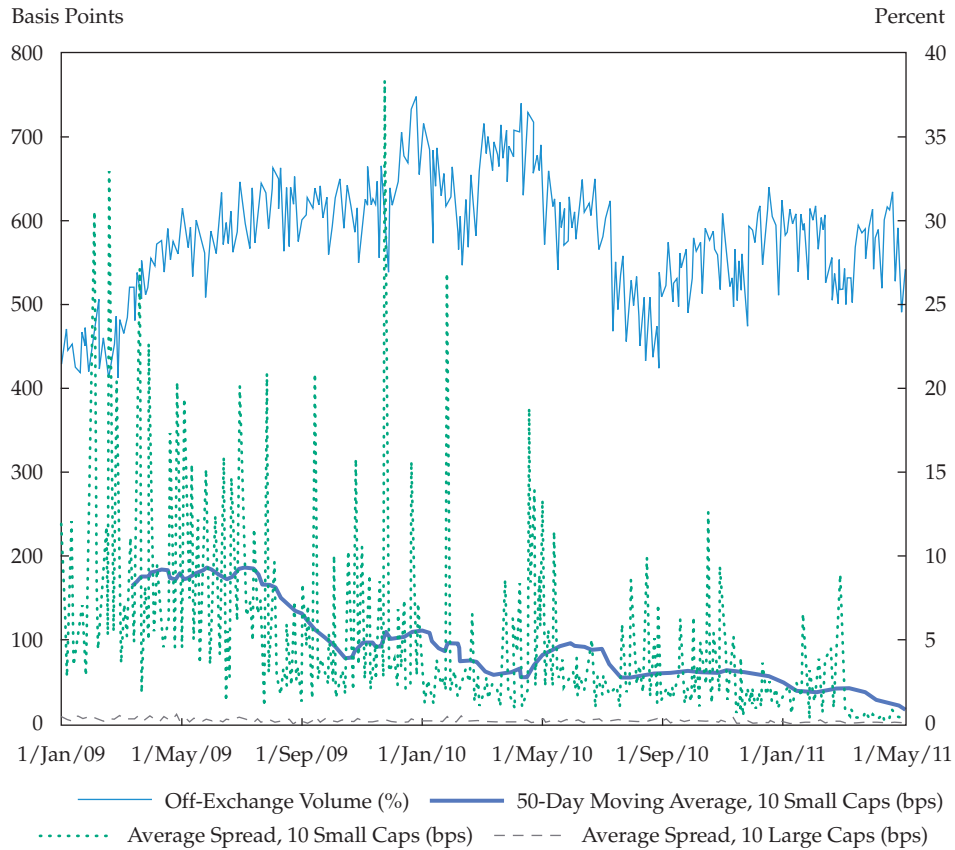
Table A1. Summary Statistics (continued)		Total	Small Caps	Medium Caps	Large Caps
Quote updates	Mean	181,816	20,261	120,711	373,933
	Median	92,690	3,865	81,321	267,286
	Std. Dev.	263,139	41,855	128,887	339,013
Number of trades	Mean	16,168	887	8,795	35,939
	Median	5,727	84	4,781	20,163
	Std. Dev.	36,159	2,190	13,395	53,480
Quote-to-trade ratio	Mean	49.4	108.5	37.4	13.7
	Median	16.0	29.3	16.9	12.4
	Std. Dev.	1,239.9	2,247.8	479.9	6.3
Average trade size (share volume/no. trades)	Mean	198	213	178	204
	Median	167	162	159	178
	Std. Dev.	270	485	66	96
Proportion of off-exchange volume	Mean	0.23	0.27	0.22	0.22
	Median	0.21	0.23	0.21	0.21
	Std. Dev.	0.14	0.23	0.10	0.08
Proportion of NYSE TRF volume	Mean	0.01	0.01	0.02	0.02
	Median	0.01	0.00	0.01	0.01
	Std. Dev.	0.02	0.02	0.02	0.02
Proportion of dark pool volume	Mean	0.07	0.03	0.08	0.08
	Median	0.06	0.01	0.07	0.07
	Std. Dev.	0.06	0.06	0.06	0.04
Proportion of internalized volume	Mean	0.10	0.19	0.07	0.07
	Median	0.06	0.12	0.06	0.06
	Std. Dev.	0.13	0.21	0.05	0.04
Proportion of other OTC volume	Mean	0.05	0.04	0.05	0.05
	Median	0.03	0.01	0.03	0.04
	Std. Dev.	0.08	0.11	0.06	0.05

Appendix B

Average bid–offer spreads for the top 10 stocks in the S&P 500 Index and Russell 2000 Index are plotted for each day during 1 January 2009–1 July 2011. Also shown is the total off-exchange volume for S&P 500 stocks during the review period. Bid–offer spreads are based on data from FactSet Research Systems and off-exchange volume is based on data attributed to FINRA as reported by Thomson Reuters Equity Market Share Reporter.

Figure B1 exhibits the same trends as those identified in our dataset described in Section 6. Relative spreads are of a similar magnitude to those in our dataset and have approximately halved over the review period, starting at approximately 175 bps for Russell 2000 stocks and approximately 8 bps for S&P 500 stocks—in-line with the respective large-cap and small-cap figures for our sample shown in Figure 5. Off-exchange volume has generally trended upward, interrupted only in the few months following the “flash crash” of 6 May 2010. Note that Direct Edge drops out of the figures after July 2010 (when it converted to an exchange), thereby accentuating the fall in off-exchange volume around this time. In other words, the underlying upward trend in undisplayed volume is slightly smoother (and starts from a lower point) than the trend depicted in Figure B1, which is consistent with the undisplayed trading trends described in Section 6 and the statistics presented in Appendix A.

Figure B1. Bid-Offer Spreads and Off-Exchange Volume, Alternative Sample



Source: Calculations are based on data from FactSet Research Systems and Thomson Reuters Equity Market Share Reporter.

Appendix C

The tables show the results of the regression specified in Section 7. The results for each of the market quality measures (the dependent variables) under consideration are presented in the respective columns against the explanatory variables.⁵⁵

The results are presented in **Table C1** for the total sample and in **Table C2, C3,** and **C4** for the subsamples. Heteroskedasticity and autocorrelation robust standard errors are shown in parentheses. Asterisks denote statistical significance at the 10%, 5%, and 1% levels, respectively (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$).

⁵⁵The regression output is reformulated such that the reported constant (intercept) represents the average value of the fixed effects.

Table C1. Regression of Market Quality Variables on Internalization and Dark Pool Activity, Total Sample

	ln(Quoted spread)	ln(Relative spread)	ln(Dollar depth)
Constant	1.88** (0.94)	11.26*** (0.96)	0.67 (2.12)
ln(σ)	0.23*** (0.01)	0.24*** (0.01)	-0.21*** (0.02)
ln(mkt_cap)	-0.32*** (0.05)	-0.33*** (0.05)	0.41*** (0.12)
ln(price)	0.78*** (0.05)	-0.21*** (0.05)	-0.07 (0.13)
%internal	-0.54*** (0.10)	-0.57*** (0.10)	0.49*** (0.13)
(%internal) ²	0.61*** (0.13)	0.66*** (0.12)	-0.38** (0.16)
%dark_pool	-0.55*** (0.15)	-0.56*** (0.16)	1.54*** (0.14)
(%dark_pool) ²	0.71 (0.55)	0.74 (0.56)	-2.86*** (0.35)
Observations	19,310	19,328	19,328
Adjusted R ²	0.183	0.399	0.169
F-statistic	87.28	257.97	121.66

Table C2. Regression of Market Quality Variables on Internalization and Dark Pool Activity, Large Caps

	ln(Quoted spread)	ln(Relative spread)	ln(Dollar depth)
Constant	0.85 (1.77)	9.99*** (1.76)	-1.19 (2.64)
ln(σ)	0.17*** (0.02)	0.18*** (0.02)	-0.37*** (0.04)
ln(mkt_cap)	-0.29*** (0.09)	-0.29*** (0.09)	0.57*** (0.13)
ln(price)	0.70*** (0.10)	-0.29*** (0.10)	-0.76*** (0.16)
%internal	-1.51*** (0.57)	-1.47** (0.57)	3.06*** (0.76)
(%internal) ²	5.91* (3.22)	5.82* (3.21)	-3.00 (3.78)
%dark_pool	-0.84*** (0.23)	-0.87*** (0.23)	3.06*** (0.48)
(%dark_pool) ²	2.18*** (0.82)	2.25*** (0.83)	-7.12*** (1.92)
Observations	6,829	6,830	6,830
Adjusted R^2	0.216	0.533	0.254
F -statistic	18.09	153.41	53.50

Table C3. Regression of Market Quality Variables on Internalization and Dark Pool Activity, Medium Caps

	ln(Quoted spread)	ln(Relative spread)	ln(Dollar depth)
Constant	3.41* (1.80)	13.00*** (1.80)	-3.63 (2.87)
ln(σ)	0.19*** (0.02)	0.19*** (0.02)	-0.21*** (0.03)
ln(mkt_cap)	-0.42*** (0.10)	-0.43*** (0.10)	0.65*** (0.16)
ln(price)	0.80*** (0.12)	-0.19 (0.12)	-0.36* (0.18)
%internal	-0.52* (0.28)	-0.72** (0.29)	1.22*** (0.44)
(%internal) ²	1.41 (1.05)	1.90* (1.08)	-1.30 (1.43)
%dark_pool	-0.92*** (0.13)	-0.90*** (0.14)	1.69*** (0.25)
(%dark_pool) ²	2.03*** (0.37)	2.00*** (0.38)	-3.46*** (0.68)
Observations	6,899	6,904	6,904
Adjusted R ²	0.236	0.571	0.231
F-statistic	27.02	155.67	48.48

Table C4. Regression of Market Quality Variables on Internalization and Dark Pool Activity, Small Caps

	ln(Quoted spread)	ln(Relative spread)	ln(Dollar depth)
Constant	1.63 (1.14)	10.90*** (1.18)	2.89** (1.34)
ln(σ)	0.31*** (0.03)	0.32*** (0.03)	-0.15*** (0.02)
ln(mkt_cap)	-0.25*** (0.07)	-0.25*** (0.07)	0.23*** (0.08)
ln(price)	0.79*** (0.05)	-0.19*** (0.06)	0.39*** (0.09)
%internal	-0.60*** (0.12)	-0.64*** (0.12)	0.21 (0.13)
(%internal) ²	0.68*** (0.15)	0.72*** (0.14)	-0.08 (0.16)
%dark_pool	-0.42** (0.20)	-0.46** (0.20)	0.44** (0.19)
(%dark_pool) ²	0.30 (0.57)	0.36 (0.58)	-1.04*** (0.30)
Observations	5,582	5,594	5,594
Adjusted R ²	0.173	0.250	0.155
F-statistic	64.40	53.80	57.52

Appendix D

The following table reports the results of the regression with aggregate undisplayed trading as the independent variable of interest in place of internalization and dark pools, respectively. Formally, the regression equation is expressed as

$$\ln MQ_{i,t} = \alpha + \beta_1 \ln(\sigma)_{i,t} + \beta_2 \ln(\text{mkt_cap})_{i,t} + \beta_3 \ln(\text{price})_{i,t} \\ + \beta_4 (\%undisplayed)_{i,t} + \beta_5 (\%undisplayed)_{i,t}^2 + \varepsilon_{i,t}$$

where $MQ_{i,t}$ represents each of the market quality variables respectively (quoted spread, relative spread, and dollar depth).

The results are presented for the total sample in **Table D1**. Heteroskedasticity and autocorrelation robust standard errors are shown in parentheses. Asterisks denote statistical significance at the 10%, 5%, and 1% levels, respectively (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$).

Table D1. Regression of Market Quality Variables on Aggregate Undisplayed Trading, Total Sample

	ln(Quoted spread)	ln(Relative spread)	ln(Dollar depth)
Constant	1.83* (0.94)	11.20*** (0.97)	0.66 (2.17)
ln(σ)	0.23*** (0.01)	0.23*** (0.01)	-0.21*** (0.02)
ln(mkt_cap)	-0.32*** (0.05)	-0.33*** (0.05)	0.41*** (0.12)
ln(price)	0.78*** (0.05)	-0.21*** (0.05)	-0.07 (0.14)
%undisplayed	-0.68*** (0.08)	-0.70*** (0.08)	0.81*** (0.11)
(%undisplayed) ²	0.72*** (0.11)	0.75*** (0.11)	-0.70*** (0.15)
Observations	19,310	19,328	19,328
Adjusted R^2	0.187	0.401	0.168
F -statistic	116.66	389.15	162.24

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