Internalization and Market Quality in a Fragmented Market Structure

(Formerly: Off-Exchange Reporting and Market Quality in a Fragmented Market Structure)

by

Daniel Weaver
Rutgers Business School
Rutgers University
94 Rockafeller Road
Piscataway, NJ 08854-8054
United States
01 848 445 5644
daniel_weaver@rbsmail.rutgers.edu

First version: April 15, 2010
This version: July 7, 2011

I thank Amber Anand, Anna Pomeranets, and Steven Poser for helpful comments and discussions. This paper also benefitted from comments made at a presentation at Goldman Sachs Electronic Trading group. I thank the New York Stock Exchange for providing financial support for an earlier version of this paper as well as the TAQ data for both versions of the study. I also thank the Whitcomb enter for Research in Financial Services for providing the remaining data needed for this study. All errors are my own.

Keywords: Dark pool; internalization; market quality; fragmentation.

JEL classification: G1; G14; G15

Internalization and Market Quality in a Fragmented Market Structure

Abstract

According to the SEC, US stock trading venues now include 10 public exchanges, more than 30 dark pools, and more than 200 internalizing broker-dealers. A large proportion of the 30 dark pools now largely facilitate internalization by their owners. According to published reports, over three quarters of the order flow executed through dark pools is likely internalized. As the number of trading venues has increased, so too has the percentage of order flow executed off-exchange. Today, one third of NYSE volume and one quarter of NASDAQ volume is reported off-exchange and is largely internalized order flow. This paper examines the impact of this dramatic increase in internalization on market quality. I find, after controlling for factors known to be influential, that internalization is directly related to spread width (quoted, effective, and realized). I also find that the percentage of volume internalized is directly associated with price impact per trade and volatility.

Internalization and Market Quality in a Fragmented Market Structure

1. INTRODUCTION

In a recent speech, U.S. Securities and Exchange Commission Chairman Mary L. Schapiro stated

> ...five years ago, the great majority of the capitalization of U.S. equities was traded on a listing market — the New York Stock Exchange — that executed nearly 80 percent of volume in those stocks. Today, the NYSE executes approximately 26 percent of the volume in its listed stocks. The remaining volume is split among more than 10 public exchanges, more than 30 dark pools, and more than 200 internalizing broker-dealers.[1]

Beginning in 2007, trades not executed on an exchange (i.e., dark pools, internalized trades, and ECNs) were required to be reported through a Trade Reporting Facility (TRF). Initially, a very significant portion of TRF trades originated on two ECNs that were soon to become exchanges - BATS and DirectEdge. Today over 90% of TRF trades are executed in dark pools or are internalized trades.[2] Also, a large proportion of dark pools largely facilitate internalization by their owners.[3] Published reports indicated that over three quarters of the order flow executed through dark pools is internalized. Finally, the percentage of trades reported through a TRF has

---

[1] See Shapiro (2010)

[2] For October 2010, there are three ECNs reporting trades through a TRF. Bloomberg TradeBook reports 2.01%, Lava Flow 5.66%, and TRAC reports 1.3% of TRF volume for a total ECN reported 8.97% of TRF executed share volume. Note that the corresponding percentages for *total* volume are: Bloomberg TradeBook 0.64%; Lava Flow 1.76%, and TRAC 0.41%.

[3] In traditional internalization, dealers fill customer orders from/for their own inventory, thus earning the spread. If the dealer limits her internalized flow to uniformed orders, she can earn excess rents due to smaller adverse selection costs. In an internalization dark pool, dealers send customer orders to a dark pool they have established. The dealers then sell access to that dark pool to traders who can earn excess rents by interacting with uniformed orders. In this case the dealer earns the smaller access fee, but faces no risk from inventory exposure.

increased two fold between 2008 and 2010. This paper examines the impact of this dramatic increase in internalized trades on the quality of US markets.

Internalization has traditionally been considered part of a broader category of order routing (or non-routing) called preferencing. A broker can decide to either trade a customer order from (for) the broker's inventory or send it to a pre-designated market maker for execution against that market maker's inventory. Chordia and Subrahmanyam (1995) and Easley, Keifer, and O'Hara (1996) develop theoretical models that show that dealers have an incentive to internalize uninformed orders. This discrimination in order routing, leads to wider spreads in the overall market to compensate for the increased percentage of informed traders in the non-internalized order flow. Chakravarty and Sarkar (2002) develop a model that suggests that internalization diminishes market quality by reducing market depth and price informativeness.

The empirical studies of internalization have shown that its impact on market quality has been at best benign [Battalio, Greene, and Jennings (1997); Hansch, Naik, and Viswanathan (1999); and Kam, Panchapagesan, and Weaver (2003)] or at worst harmful to market quality [Battalio, Greene, and Jennings (1998); Chung, Chuwonganant, and McCormick (2004); Grammig and Theissen (2005); Chung, Chuwonganant, and McCormick (2006); Larrymore and Murphy (2009)]

Given the above studies, the recent increase in internalization in US markets could have a benign or negative impact on market quality. This paper examines the relationship, if any, between the degree of internalization and market quality. I examine the relationship both overall and for each market segment: AMEX; NASDAQ; and NYSE. Since trades reported off-exchange are largely internalized trades then the percentage of trades reported off-exchange is a good measure of internalized trades. I first examine which stocks are internalized and find, consistent with reports in the popular press, that low-priced stocks are most likely to be internalized. I then examine the impact on market quality and find strong support for the existence of a negative relationship between the degree of internalization and market quality. In particular, for all three market segments internalization is associated with wider percentage spreads for that firm. After controlling for variables known to be associated with spreads I find this result for quoted, effective, and realized spreads. The impact of internalization on spread width is measurable. For example a NYSE listed stock with 40 percent of its volume reported through a TRF will on average have a dollar effective spread that is $0.0128 wider than a similar stock with no TRF reporting. I show that this results in investors paying $3,890,624 more *per stock per year* due to internalization.

Turning to price impact, the extant literature suggests that internalization reduces depth in the market. A reduction in available depth, both at the inside and away, increases the probability of orders "walking through the book" or taking the liquidity at subsequent price levels. If this is the case then I should find that increased levels of internalization are associated with increased price impact and volatility. That is exactly what I find. For all but AMEX stocks the percentage of share volume associated with internalization is directly related with price impact. In other words, as the percentage of internalization increases, average trades will have an increasing impact on prices. Finally, for all market segments, higher levels of internalization are associated with higher levels of return volatility. I conclude that increased internalization is associated with a degradation of market quality for all market segments in the United States.

This paper will be of interest to exchanges and regulators both domestic and global who are assessing the impact of internalization on market quality. In particular the SEC is currently considering a trade-at rule that would require market participants not publically displaying the best contra side of an order to either provide price improvement over the best displayed price or route the order to a venue displaying the best price. This paper will also be of interest to academics since the results of previous studies are mixed.

The remainder of this paper is organized as follows. The next section provides institutional background details both domestic and international. Section 3 reviews previous literature on internalization; Section 4 describes the data and the market quality measures I use. Section 5 presents the results, while Section 6 concludes.

2. INSITUTIONAL BACKGROUND

Until recently, the trend among exchanges has been to enact rules to reduce or prevent internalization. This has been especially true in Europe. The Paris Bourse enacted rules to require members to send all orders to the exchange for execution. The Italian equivalent of the SEC, CONSOB, required that all stock orders be sent to Borsa Italiana for execution. Grammig and Theissen (2005) report that in 2002 Deutsche Börse created Xetra Best, which allowed members to internalize orders, but required that the internalized orders receive price improvement. The above attempts to limit internalization were ended by the European Union's full implementation of the Markets in Financial Instruments Directive (MiFID) in 2007.[4] MiFID eliminates so-called concentration rules and creates systematic internalizers who are *not allowed* to offer price improvement to retail customers in the most liquid shares, but must publish quotes.

There have been two notable events related to internalization of order flow in North America. In the United States, the NYSE repealed its Rule 390 in 2000. The rule, similar to the Paris Bourse, required members to route orders in listed stocks to an exchange.[5] The effect was to allow firms to internalize orders at their firm. Kam, Panchapagesan, and Weaver (2003)

[4] Davies (2008) provides a good overview of MiFID.
[5] At the time of the repeal of 390 there were multiple exchanges trading the same stocks in the US. In France there was only the Paris Bourse.

conclude that following the rule's repeal, NYSE specialists narrowed quoted spreads (perhaps to make internalization less profitable), but that effective spreads did not change.[6]

The mid 1990s saw an increase in electronic order management systems in Canada. Concerned about the impact on market quality the Toronto Stock Exchange (TSX) convened a special committee that published a report in 1997 (see Toronto Stock Exchange Special Committee Report, 1997). As a result of that report the TSX issued what was to become known as the Price Improvement Rule in 1998. That rule, similar to the Deutsche Börse rule, requires all orders of 5,000 shares or less to receive price improvement to be internalized. Larrymore and Murphy (2009) find that following the passage of the rule market quality significantly improved.

Currently, the SEC is considering a trade-at rule that would require venues that are publically displaying the best bid or offer to either: 1. offer significant price improvement; or 2. route the order to a venue that is displaying the applicable bid or offer. The SEC rule is dissimilar to that of other exchanges in that a broker or venue is allowed to internalize if they are displaying the best bid and offer. In other markets internalization is only allowed if the order receives price improvement. In framing the potential need for such a rule the SEC questions whether current market quality has been hurt by the increase in undisplayed liquidity - of which internalization represents a large portion. This paper seeks to provide an answer to the SEC's question. In the next section I discuss the data used as well as the market quality metrics employed.

3. LITERATURE REVIEW

[6] Quoted spreads can narrow and effective spreads remain unchanged if the amount of price improvement declines. This is exactly what Kam, Panchapagesan, and Weaver (2003) found.

Glosten and Harris (1988) argue that there are three components to spread width: order processing costs; inventory costs; and adverse selection costs. The first two components are part of the cost of dealing in stocks and are passed along to traders. The third component arises due to the fact that occasionally dealers trade with traders who have superior information and dealers lose on those transactions. The costs associated with trading with these informed traders are spread out among the uninformed traders as another cost of doing business. A dealer accepting all orders will incur loses to informed traders, but will be able to pass those along to other traders and hence will earn an economic rent.

Dealers with public customers (or those that obtain order flow from other brokers) know the identities of their customers and can fairly easily separate informed orders from uninformed.[7] The impact of this economic discrimination is examined theoretically by Chordia and Subrahmanyam (1995) and Easley, Keifer, and O'Hara (1996). In both papers, the authors assume that order flow from uninformed traders is internalized or purchased by dealers. However, the dealers trade at the spread quoted by dealers that accept all orders, which includes adverse selection costs. These internalizing dealers are then able to earn excess economic rents since their adverse selection cost is lower than the non-discriminating dealer.

The authors of these two theoretical studies go on to show that the impact of internalization goes beyond earning excess rents. The internalizing of uninformed order flow by discriminating dealers reduces the number of uninformed orders for the non-discriminating dealers to spread their informed loses over. The result of this is a widening of spread charged by the non-discriminating dealer which in turn increases the excess economic rent for the discriminating dealer.

[7] For example, a dealer that purchases order flow can agree to only purchase small orders from retail customers which have a much lower probability of being informed.

The above can occur in any market structure which allows orders to be executed by brokers away from a central limit order book. Battalio, Greene, and Jennings (1998) find evidence in support of the discriminating dealer theory. In particular they examine the decision by Merrill Lynch's October 1987 decision to ***stop*** routing customer orders to Merrill-affiliated specialists[8] on the Boston and Pacific Stock Exchanges, effectively internalizing them.[9] They find that following Merrill's decision, spreads on the NYSE decline in comparison to a matched sample of unaffected stocks. Therefore, a reduction in internalization resulted in narrower spreads.

The impact of internalization on market quality has been theoretically examined on other dimensions as well. For example, Chakravarty and Sarkar (2002) develop a theoretical model (based on a Kyle (1985) model) that suggests internalization diminishes market quality by reducing market depth and price informativeness. They further argue that internalizing brokers will be attracted to thinly traded stocks with few informed traders. Kluger and Wyatt (2002) examine the impact of internalizing on order routing decisions in a laboratory dealer asset market. They show that if internalizing is allowed then it will become preferred by dealers over routing to other venues. They further show that in a dealer market this will lead to tacit collusion among dealers and hence wider spreads.

Internalization has been examined empirically by a number of authors. For example, Battalio, Greene, and Jennings (1997) examine execution quality for matched pairs of stocks following the decision by the Boston and Cincinnati Stock Exchanges to set up programs that allowed brokers to internalize order flow by sending it to affiliated market makers on the regional

[8] Unlike NYSE specialists, there were multiple affiliated specialists on the Boston and Pacific exchanges. Since their main purpose appears to be to allow internalization, they were specialists in name only.
[9] Prior to the repeal of NYSE Rule 390, members of the NYSE were prohibited from executing orders in exchange listed stocks away from an exchange. Since Merrill owned the BSE and PSE specialist firms there were internalizing without violating the rule. See Kam, Panchapagesan, and Weaver (2003) for a discussion of Rule 390. Kam, et al., find that effective spreads do not change following the repeal.

stock exchanges. They find no statistically significant change in quoted or effective spreads after an increase in internalized trades on the BSE and CSE.

Chung, Chuwonganant, and McCormick (2004) empirically examine the relationship between internalization and market quality on NASDAQ. They find that both quoted and effective spreads are directly related to the level of internalization in a stock. They further find that internalized trades have lower price impact suggesting that the trades contain less information. This is consistent with the clientele-pricing hypothesis of Battalio and Holden (2001). The authors argue that higher effective spreads for stocks with higher internalization may reflect investors' desire to seek immediacy rather than price improvement. In a related paper, Chung, Chuwonganant, and McCormick (2006) empirically examine the relationship between internalization and dealer quote aggressiveness on NASDAQ. They find that the degree of internalization does not impact the willingness of dealers to quote prices aggressively. However they do conclude that internalization is associated with lower depth and quoted size aggressiveness.

Grammig and Theissen (2005), examine internalization on the Deutsche Börse and find that, consistent with Chordia and Subrahmanyam (1995) and Easley, Keifer, and O’Hara (1996) internalized trades contain less information. This in turn reduces dealer’s adverse selection costs and makes the trades more profitable. This is shown to result in higher realized spreads for internalized trades versus non-internalized trades.

Hansch, Naik, and Viswanathan (1999) examine internalization and preferencing on the London Stock Exchange during August of 1994. They study the relationship between internalization/preferencing and several measures of market quality: quoted, effective, and realized spreads. They find no evidence of any relationship between the degree of internalization and these measures. However, for computational tractability they limit their sample to the 102 most liquid stocks. Anolli and Petrella (2007) show that internalization is lowest among liquid stocks. Therefore, the results of Hansch, Naik, and Viswanathan may be colored by their sample of liquid stocks, which may have relatively little internalization.

Larrymore and Murphy (2009) find that market quality improves after internalization is disallowed. In October of 1998, the Toronto Stock Exchange (TSX) enacted a price improvement rule that requires brokers to either improve on the best quoted prices at the exchange or route the order to the exchange for execution against customer limit orders. The rule applies to any order of 5,000 shares or less. The rule effectively banned internalization without price improvement. Larrymore and Murphy (2009) empirically examine the impact of this rule on TSE market quality. They find a statistically significant improvement in market quality following the rule change. In particular, they find that time-weighted quoted currency and percentage spreads declined by C$0.055 and 28 basis points respectively. Volume-weighted effective spreads declined by a statistically significant C$0.02. Not surprisingly they find that quoted depth increases significantly. Given that depth absorbs liquidity shocks they also find that return volatility declines.

In summary, theoretical and empirical studies of internalization's impact on market quality show that at best internalization is benign and at worse it is associated with a decline in market quality.

Three recent papers are closely related to this study. First, O'Hara and Ye (2011) examine the relationship between the percentage of a stock's volume reported through a trade reporting facility and market quality. Using data for the first six months of 2008 they construct a matched sample of 150 NASDAQ and 112 NYSE listed stocks that are similar except for the percentage of their trading reported through a TRF. The goal of their paper is to examine market fragmentation's impact on market quality. Therefore, they examine various metrics of market quality for their matched pairs. They find that stocks with higher TRF reporting have higher short-term volatility but lower spreads than their matched pairs. They also conclude that their measure of fragmentation is directly related to the degree of price efficiency, in that the stocks with higher TRF reporting exhibit more price efficiency than their matched pair.

O'Hara and Ye (2011) report that 27% of volume in their sample is reported through a TRF. Trades reported through a TRF may have originated from an Electronic Communication Network (ECN), dark pools, or represent internalized order flow. ECNs display quotes and are in many ways similar to exchanges. In fact since 2008 two former ECNs, BATS and DirectEdge, have been granted exchange status by the SEC. Therefore, O'Hara and Ye's data contains a large portion of "exchange" trades in their sample of off-exchange reported trades. While this allows the authors to examine the impact of increased competition among an increased number of trading venues, Using 2008 data will not allow me to examine the impact of internalization on market quality.

The data period used in this study is October 2010. In the intervening two years between the data period in O'Hara and Ye and the current study, BATS and DirectEdge began reporting their own trades directly to the tape rather than through a TRF, so "exchange" trades are removed from TRF data. In addition off-exchange reporting has grown greatly. Rosenblatt Securities reports that for October 2010, BATS and DirectEdge reported 19.1% of consolidated volume; dark pools trade an estimated 13.5% of volume and other TRF reported trades (internalized trades and other venues) represent an additional 18.24%.[10,11] Therefore, the reported percentage of 27% of consolidated volume in O'Hara and Ye's study has grown to an aggregated 50.83% for October 2010.

---

[10] Let There Be Light, November 23, 2010, Rosenblatt Securities Inc.

[11] For October 2010 three ECNs reported through a TRF: Bloomberg TradeBook; Lava Flow, and TRAC reported their trades through a TRF. Excluding volume executed through an ECN the 18.24% becomes 15.48% of consolidated volume.

Not only is the comparable proportion of off-exchange reported trades nearly twice as large for this paper's sample period versus the sample period examined by O'Hara and Ye (2011), the nature of dark pools has changed as well. A number of dark pools have been established to allow the internalization of order flow. Mittal (2008) classifies dark pools into: public crossing networks; internalization pools; those that only accept indications-of-interest; exchange-based pools; and crossing/internalization hybrids. Applying the Mittal classifications to the dark pool volumes for October 2010 reported by Rosenblatt Securities, reveals that 87.3% of dark pool volume can be attributed to internalization and hybrid pools.[12] Therefore, October 2010 data contains a much larger proportion of internalized trades than the sample period employed by O'Hara and Ye (2011). This difference allows me to conduct a cleaner test of the relationship between internalization and market quality, using TRF reported trades as a measure of internalized trades.[13]

The importance of the difference in make-up of TRF trades is illustrated in a recent paper by Degryse, de Jong, and van Kervel (2011). For a sample of 52 Dutch large and midcap stocks, the authors employ data that allows them to disaggregate trades into two groups: those that were executed on a lit venue; and those that were executed on a dark venue. The lit subsample includes exchanges and Multilateral Trading Facilities, the European equivalent of ECNs. The dark sample includes internalized trades as well as those execute on a crossing networks or dark pool. In the spirit of O'Hara and Ye (2011), the authors construct a Herfindahl-

[12] Mittal (2008) lists BNY Converge; Credit Suisse Crossfinder; Citi Match; Fidelity CrossStream; Goldman Sachs Sigma X; Bank of America Merrill Lynch MLXN; Morgan Stanley MS Pool; and UBS PIN as internalization dark pools. Knight Link, Barclays Liquidity Cross were begun after Mittal (2008) but are also considered internalization dark pools by the Aite Group as listed on their website. Mittal identifies LEVEL and BIDS as hybrid dark pools. If LEVEL and BIDS are excluded, the proportion of Rosenblatt reported dark pool activity that is internalized order flow drops to 75.7%.

[13] An earlier version of this paper employed October 2009 data. At that time DirectEdge was still not an exchange and therefore reported through a TRF. Conversations with industry people suggested that DirectEdge comprised about one quarter of TRF volume in October 2009. The results reported in the earlier version of this paper (using data including DirectEdge) were not as strong as those reported here. The difference between the current version and the previous version (as well as between the current version and O'Hara and Ye (2011)) provides further evidence that the results of previous studies may be due to the inclusion of "lit" exchanges in their data.

Hiirshman Index to determine the level of fragmentation for each of their sample stocks. Consistent with O'Hara and Ye (2011), they find that increased fragmentation is associated with narrower quoted and effective spreads as well as price impact. However, Degryse, de Jong, and van Kervel also find, consistent with this paper, that the percentage of trades executed in dark venues has the opposite effect on market quality. In particular they find that an increased proportion of trades executed in dark venues is associated with an increase in price impact as well as wider quoted and effective spreads.

The third study closely related to the present study, Buti, Rindi, and Werner (2010), examines the relationship between dark pool trading and market quality. The authors employ a data set that estimates the percentage of a stock's trading volume that is completed through a dark pool. In contrast to Degryse, de Jong, and van Kervel (2011), the authors conclude that higher levels of dark pool trading are associated with lower spreads, higher depth, lower volatility, and lower absolute returns.

As Buti, Rindi, and Werner (2010) point out there is no publicly available dataset of dark pool volume. Therefore, they use a proxy for overall dark pool trading which is the self-reported volume of each stock that is traded in a dark pool for each day during 2009. The self-reported volume is determined by summing the volume of eleven dark pools that volunteered to participate in the study. At the time of their study the authors report that the eleven self-reporting dark pools comprise about one third of the total number of dark pools operating. Mittal (2008) argues that dark pools that report through a TRF are not all the same.[14] Public crossing networks such as POSIT were originally designed to allow block trading. In contrast, a number of dark pools such as Credit Suisse Crossfinder and Goldman Sachs Sigma X were established to facilitate internalization of order flow. While the extant literature suggests that internalization

[14] Hidden order types such as iceberg orders are of a similar flavor as dark pool quotes, but are reported through an exchange. In this study I treat iceberg orders as visible quotes.

may adversely impact market quality, the same is not true of other types of dark pools. Therefore, Buti, Rindi, and Werner point out that the applicability of their findings is dependent upon the make-up of their dark pool sample.

4. DATA & MARKET QUALITY MEASURES

DirectEdge began reporting trades as an exchange in late July 2010. Prior to that date DirectEdge reported trades as off-exchange even though they are essentially exchange trades. Therefore, to obtain the truest estimate of off-exchange trading, I choose data after July 2010. Accordingly, I construct a sample of all NYSE/Euronext and NASDAQ/OMX exchange listed US stocks that trade during October 2010.[15] The initial list of securities is obtained from the master file of the FTP version of the NYSE/TAQ database.[16] A single month was chosen due to data constraints.[17] The list of firms is merged with the CRSP database to determine security type. Consistent with previous studies, I only examine common stocks and thus exclude preferred stock, units, ADRs, REITs, closed end funds, SBIs, and ETFs. During October 2010, stocks could be listed on one of three market segments: the American and NYSE segments of NYSE/Euronext; and the NASDAQ segment of NASDAQ/OMX. To be included in my sample, stocks must be listed on a single market segment throughout the month and have had trades on at least 11 days during the month. Stocks trading above $500 a share are excluded. The resulting sample contains 301 stocks listed on the American, 1,456 on the NYSE, and 2,383 on NASDAQ.

[15] To be included stocks must have been listed on just one market segment throughout the entire month.
[16] The FTP version of TAQ is more detailed than the DVD version. For example times are in accurate to the millisecond and there are a number of extra fields including where a trade was reported.
[17] The quote to trade ratio has grown dramatically in recent years. By October 2010 the FTP TAQ quote file is 20 gigabytes per day.

CRSP data is used to determine the value of each firm in the sample on September 30, 2010. CRSP daily returns and volumes are used to construct low frequency market quality measures for price impact and volatility. The TAQ Quote and NBBO files are used to obtain dollar and percentage quoted spreads for each stock at time *t* as[18]

$$Dollar = Ask_t - Bid_t \tag{1}$$

$$Percentage = \frac{2(Ask_t - Bid_t)}{Ask_t + Bid_t} \tag{2}$$

NBBO quotes time-stamped between 9:30 AM and 4:00 PM are included. One-sided, zero price, crossed, and locked quotes are excluded. Percentage spreads over 50% are considered an error and are excluded as well. Dollar and percentage quoted spreads are averaged using the time the quote was valid as its weight.

Trades for each stock are obtained from the FTP version of the TAQ trade file. Only regular trades and intermarket sweep orders are included in this study. The purpose of this paper is to examine the impact of internalization on market quality. Internalized trades do not occur on an exchange. The Financial Industry Regulatory Authority (FINRA) allows exchanges to create Trade Reporting Facilities (TRFs) through which non-exchange executed trades can be reported. The TRFs, though affiliated with an exchange, are facilities of FINRA and represent 230+ liquidity pools including dark pools/ATSs and broker trading desks. Thus, these trades include internalized trades and those executed through a dark pool. Recall that over 85% of dark pool volume is executed through an internalization or hybrid pool. I will use TRF trades as a measure of internalized trades.

[18] The TAQ NBBO file does not record an observation if a single exchange is alone at the BBO. Therefore, to include all BBO quotes, those quotes in the TAQ Quote file that have a National BBO Indicator equal to 1 must be extracted and merged with the NBBO file to capture all quotes. I follow this procedure.

The FTP version of the TAQ trade file contains a field that identifies which TRF a trade is reported through. During the period of this study, there were two active TRFs: the NYSE and NASDAQ. An examination of the frequency of trade reports by TRF reveals that over 97% of the trades reported through a TRF, used the NASDAQ TRF. Therefore, I do not partition according to TRF name. By utilizing this field, I am able to identify TRF and exchange reported trades and determine the average number of trades reported through a TRF for each stock.[19]

Trades can occur at prices inside or outside the quoted spread. Therefore, quoted spreads may not be good measures of actual transaction costs. Peterson and Fialkowski (1994) recommend using effective dollar spreads which compare a trade price to the midpoint of the quoted spread in effect at the time the trade arrived at a market center:

$$\$Effective\ Spread_t = 2\left|P_t - \frac{Ask_t + Bid_t}{2}\right| \tag{3}$$

where P_t is the trade price at time t, and $\frac{Ask_t + Bid_t}{2}$ is the midpoint of the NBBO quoted spread at time *t*. Effective spreads are then share-weighted. Percentage spreads are a percentage of the quote midpoint at time t. historically; market microstructure studies compare observed trade prices to the midpoint of quotes using a stationary time lag to estimate when the order arrived at a market center. Given the speed of today's market, I use a 1/10th of one second time lag.

The Peterson and Fialkowski (1994) effective spread measure assumes that buys(sells) occur at or above(bellow) the quoted spread midpoint, which may or may not be true. Therefore some authors have advocated using a signed effective dollar spread measure as follows:

[19] Rule 605 data could have been used to determine the percentage of volume reported off-exchange. However, that volume data contains double counting volume errors due to venues routing orders to other venues - and both venues counting the volume as executed on their venue. TAQ TRF data numbers do not contain double counted volume and are thus provide a more accurate estimate of off-exchange volume.

$$\$Effective\ Spread_{i,t} = \begin{cases} 2\left(P_{i,t} - \frac{Ask_{i,t}+Bid_{i,t}}{2} \right) for\ buys \\ 2\left(\frac{Ask_{i,t}+Bid_{i,t}}{2} - P_{i,t} \right) for\ sells \end{cases} \tag{4}$$

However, TAQ data do not indicate which trades are buyer or seller initiated. Lee and Ready (1991) construct an algorithm to determine whether a trade is buyer or seller initiated. Unfortunately, Lee and Radhakrishna (2000) report that the Lee and Ready algorithm misclassifies 24% of trades that have clearly marked trade indicators. Thus using trade based effective spread measures present challenges. However, SEC Rule 605 requires every market center to calculate the effective spread for every order that arrives based on the following formula:

$$\$Effective\ Spread_{i,t}^{MC} = \begin{cases} 2\left(P_{i,t} - \frac{Ask_{i,t}+Bid_{i,t}}{2} \right) for\ marketable\ buys \\ 2\left(\frac{Ask_{i,t}+Bid_{i,t}}{2} - P_{i,t} \right) for\ marketable\ sells \end{cases} \tag{5}$$

where P_t is the price an order is executed at, and $\frac{Ask_t+Bid_t}{2}$ is the midpoint of the NBBO quoted spread at the time the order arrives at market center *MC*. The above formula removes errors in order typing and timing that exist for trade-based measures. Each market is required to monthly publish, for each stock, the above measure as well as the number of shares executed.

The Rule 605 effective spread estimate is not without implementation problems. Not all orders are included in the effective spread calculation under Rule 605.[20] Orders can be routed away from a receiving market center to another market center which then executes it. When the order is executed, both the originating and receiving market center will use the same effective spread, but both will count the shares as received by their market center. To the extent that

[20] Goyenko, Holden, and Trzcinka (2009) provide a good discussion of the pros and cons of using Rule 605 data versus trade-based TAQ data measures.

orders are routed to market centers displaying narrower quotes, this doubling counting will cause downward bias in the reported versus actual average effective spread. In addition, Rule 605 data does not include most intermarket sweep orders. Since these orders walk the book they typically have wider effective and realized spreads than regular orders. Not including them causes the Rule 605 measures to be further downward biased relative to TAQ measures. Notwithstanding the downward bias, I obtain Rule 605 reports for all U.S. stocks (by order type and market center) for October 2010 from the NYSE and estimate for each stock a share-weighted effective stock across market centers as follows:

$$Effective\ Spread_i \ = \sum_{MC=1}^{n} \frac{Executed_i^{MC} Effective\ Spread_i^{MC}}{Executed^N} \tag{6}$$

where $Executed_i^{MC}$ is the total number of shares of stock *i* executed at market center MC for the month (either dollar or percentage); and $Executed^N$is the total number of shares of stock *i* executed by all market centers in a month.[21] I therefore include two measures of dollar effective spread: trade based and Rule 605 derived. The NYSE also calculates a percentage effective spread for each order class and market center based on the value weighted average price (VWAP). I obtain those calculations as well in addition to the trade based measure.

Haung and Stoll (1996) argue that effective spread may not be a good measure of execution costs, since effective spreads assume that the midpoint of the quoted spread is stationery after a trade. They argue for the use of realized spreads, which explicitly take into account the information in a trade, which then moves prices. Their method is to use a subsequent price instead of the contemporaneous spread midpoint in Equation (3). SEC Rule 605 defines realized spreads using the quoted spread midpoint 5 minutes after an executed order is received by a market center. I adopt the 5 minute rule to calculate realized spreads in

[21] Since market venues calculate effective spreads for all trades executed, whether on the venue or routed away, I use the total number of shares executed as the weight.

this paper. Similar to effective spreads I calculate relative spreads using both TAQ trade-based and Rule 605 data. When using TAQ data I define dollar realized spreads as:

$$\$Realtive\ Spread_t = 2\left|P_t - \frac{Ask_{t+5}+Bid_{t+5}}{2}\right| \tag{7}$$

where P_t is the trade price at time t, and $\frac{Ask_t+Bid_t}{2}$ is the midpoint of the NBBO quoted spread at time *t+5 minutes*. Relative spreads are then share-weighted. Percentage spreads are a percentage of the quote midpoint at time t+5. Rule 605 defines realized dollar spreads as:

$$\$Realized\ Spread_{i,t}^{MC} = \begin{cases} 2\left(P_{i,t} - \frac{Ask_{i,t}+Bid_{i,t+5}}{2}\right) for\ marketable\ buys \\ 2\left(\frac{Ask_{i,t}+Bid_{i,t+5}}{2} - P_{i,t}\right) for\ marketable\ sells \end{cases} \tag{8}$$

As with the Rule 605 definition of effective spreads, the aggregation methodology I employ for each stock is to weight the market center reported realized spread by the total shares executed reported by the market center for the period or

$$\$Realized\ Spread_i \ = \sum_{MC=1}^{n} \frac{Executed_i^{MC} Realized\ Spread_i^{MC}}{Executed^N} \tag{8}$$

where $Executed_i^{MC}$ the number of shares of stock *i* executed at market center MC for the month (either dollar or percentage); and $Executed^N$ is the total number of shares of stock *i* executed by all market centers in a month.

The realized spread measure was originally developed by Huang and Stoll (1996) as a measure of dealer profits since dealers profit from price reversals. However, from an investor's standpoint, realized spread is another measure of execution costs - one that takes into account post-trade slippage in price. In other words, while a price reversal increases dealer profits it serves as an additional execution cost for investors.

Since realized spreads incorporate how much information is in a trade and effective spreads do not, the difference between effective and realized spreads could be used as a measure of how much the price moved due to information or price impact. Goyenko, Holden, and Trzcinka (2009) examine the efficacy of a number of high frequency and low frequency price impact measures. They find that the Amihud (2002) low frequency measure of price impact performs best. The Amihud measure uses daily returns and volumes to estimate the average price response generated by $1 of volume.

$$Amihud_i = \frac{\sum_{t=1}^{n} \frac{|r_{i,t}|}{Volume_{i,t}}}{n} \tag{9}$$

where $|r_{i,t}|$ is the absolute value of the return on stock *i* for day *t*; and $Volume_{i,t}$ is the dollar volume for stock *i* on day *t*. The ratio is average over all non-zero volume days in a period. For this study I average the number over the number of trading days in October 2010. Dollar volume is defined, as in Amihud (2002), as the closing price times share volume for the day.

The final market quality measures employed in this study is return volatility. I define return as the 15 minute intra-day return on a stock. Consistent with other studies I assume that the average 15 minute return is zero rather than introducing additional estimation error into the measure. Then the standard deviation of return for stock *i* on day *t* is

$$\sigma_{i,t} = \sqrt{\frac{\sum_{j=1}^{26} r_{i,j}^2}{25}} \tag{10}$$

where $r_{i,j}$ is the return on stock *i* for the *jth* 15 minute trading period of day *t.* The volatility measure is averaged over all days a stock traded in October 2010. Recall that I exclude stocks that trade less than eleven days during the month. As a robustness check, I also define volatility as the standard deviation of daily return for October 2010 using CRSP daily holding period returns. In the next section I discuss the descriptive statistics for the sample as well as report the results of my statistical tests.

5. RESULTS

Table 1 presents descriptive statistics for the sample broken down by market segment. Examining Table 1 reveals, not surprisingly, that firms in the NYSE segment are far larger, with higher prices, and more trades than firms in either of the two other segments. Both the intraday and daily volatility measures are lowest on the NYSE market segment. It is not surprising then that the NYSE has the lowest percentage spreads (quoted, effective, and realized). Turning to an examination of TRF trades, I find that nearly 40% of the share volume, reported for AMEX stocks are reported through a TRF, while less than 25% of NYSE share volume is reported in a similar manner.

In order to examine the impact of reporting trades through a TRF versus an exchange it is necessary to identify any differing characteristics between trades from the two reporting market centers. My first step in this direction is to examine differences in average trade sizes. I find that TRF reported trades (Table 1) are much larger than exchange reported trades. In particular TRF reported trades are on average 817 shares for AMEX listed stocks, while exchange reported trades for the same group are less than half as large, 393 shares.

Table 1 also lists average market quality measures by listed exchange. As documented by a number of studies I find that the NYSE has smaller spreads than the AMEX or NASDAQ. Comparing the TAQ and Rule 605 averages for effective and realized spreads I find in all cases Rule 605 measures of spread are smaller than TAQ based measures. This may be due to the inability of TAQ based measures to accurately identify the corresponding quote for a trade. It may also be due to a downward bias in Rule 605 measures. However, I will demonstrate that in tests of the relationship between the level of TRF reporting and spreads that my results are robust to whichever spread average is employed.

I next investigate what types of stocks are most likely to have their trades reported through a TRF. I first rank the 4,140 firms in the sample according to the average daily percentage of volume reported through a TRF and form quartiles based on the ranks. I then examine the characteristics of firms in each quartile which are reported in Table 2. I find that all stocks have some level of reporting while the largest average daily percentage volume reported through a TRF is 62%. Therefore some stocks have the lion's share of their volume executed off an exchange. The quartile with the largest percentage of TRF reported volume (4) has a minimum average of 37.47%. This quartile contains over half of the AMEX segment firms and nearly one third of NASDAQ firms. In contrast, less than 10% of NYSE firms are in the quartile. Quartile 4 is also distinguished from the other quartiles by having the lowest average trade price, lowest trading activity (as measured by the number of trades), and widest percentage spreads (quoted, effective, and realized). I conclude that low-priced, illiquid stocks are more likely to have trades reported through a TRF. Because NYSE firms are mostly in the bottom two quartiles and AMEX and NASDAQ firms in the top two quartiles, I will analyze any further results by market segment.

Given that Table 2 reveals that stocks with the largest percentage of TRF trades have the widest percentage spreads, the question that immediately comes to the fore is: Do trades reported through a TRF have wider spreads than those not reported through a TRF? To answer this question, for each stock in the sample, I calculate the TAQ share-weighted average effective and realized spreads for TRF and non-TRF trades. I then determine the difference between the two types of trades and calculate a matched-pairs t statistic to measure statistical significance. The results are presented in Table 3. Panel A presents the results for dollar (A.1.) and percentage (A.2.) effective spreads overall and by market segment. Overall, for both dollar and percentage effective spreads, investors pay wider spreads for trades executed off an exchange. In particular dollar (percentage) effective spreads are on average \$0.005 (4 basis points) wider if executed off-exchange. The results are statistically significant at acceptable levels. Five of the six segment/type groups exhibit TRF reported spreads that are greater than exchange reported trades. Of those five, 3 are significant.

Examining the results for realized spreads in Panel B, I find that all of the differences are positive and statistically significant. The findings reported in Table 3 suggest that investors face wider spreads for off-exchange trades than they do for exchange reported trades.

I next examine the relationship between the percentage of trade volume reported through TRFs and various measures of market quality. I examine the relationship by employing regressions which allows us to control for factors known to impact market quality measures. I test the hypothesis:

> H_0: The proportion of a stock's volume reported through a TRF has no impact on market quality.

Testing the hypothesis requires not only examining the statistical significance of any relationship, but also the shape of that relationship. The extant empirical literature on internalization provides no guidance. D'Antona (2010) reports that NASDAQ economists have found, in unpublished reports, that market quality is impaired when the percentage of share volume reported through a TRF reaches 40%. This suggests a threshold effect. The relationship could be linear or curvilinear. Accordingly, I try multiple model specifications in an attempt to identify any existing relationship between the level of TRF reporting and market quality.

After testing specifications with threshold dummies and solely linear relationships, I determine that, for spreads, a linear specification of the percentage of volume reported through a TRF is the most efficacious.[22] This is illustrated below in my model of quoted spread width.

[22] Introducing a quadratic term into the regressions increases the adjusted R^2 by much less than 1% but introduces multicollinearity into the equation.

$$S_i = \beta_0 + \beta_1\overline{Price}_i + \beta_2\overline{Volume}_i + \beta_3\bar{\sigma}_i + \beta_4\overline{\%TRF}_i \tag{11}$$

where S_i is either dollar or percentage time-weighted quoted spread for stock *i*; $\overline{Price}_i$ is the average price; $\overline{Volume}_i$ is the average daily volume; $\bar{\sigma}_i$ is the average intraday standard deviation of 15 minute stock returns; and $\overline{\%TRF}_i$ is the average daily percentage of share volume reported through a trade reporting facility. If the dependent variable is percentage spread then price is not included as an independent variable since employing the percentage spread already accounts for price. To determine if outliers are driving the results, I exclude observations with a DFFITS statistic $>2\sqrt{\frac{p}{obs}}$, where *p* is the number of parameters and *obs* is the number of observations (see Belsley, Kuh, and Welsch (1980)).

The parameter values for the above regression are contained in Table 4. Examining the results for dollar quoted spread (Panel A) reveals that the parameter values for the control variables are generally of the expected signs and are statistically significant. Turning to the variable of interest, *%TRF,* for dollar quoted spreads in Panel A, I observe that overall the parameter estimate is positive and significant. Examining the results by market segment reveals that all three of the segments, the AMEX, NASDAQ, and the NYSE listed stocks have the same sign as the overall results and are statistically significant. This suggests that the percentage of share volume reported off-exchange does indeed impact spread width.

The parameter estimate for *%TRF* can be used to estimate the dollar impact of internalization on spreads. For example a NYSE listed stock with 40 percent of its volume reported through a TRF will on average have a dollar spread that is $0.0128 wider than a similar stock with no TRF reporting. Given that: 1) the average NYSE stock traded 2,431,640 shares a day during October; 2) assuming that trades occur at the quotes; and 3) that investors pay one half of the spread; this would result in investors paying 2,431,640 * $0. 0.0128/2 = $15,562.49

extra per day per stock or 250 * $15,563.49 = $3,890,624 per year per stock due to internalization.

The above numbers are smaller than Larrymore and Murphy (2009) who report that quoted dollar spreads dropped by an average C$0.055 following the TSX's efforts to reduce internalization. This is the first piece of evidence in this study suggesting that internalization has an adverse impact on market quality.

Comparing the results for percentage quoted spread (Panel B) reveals statistically significant results, of the predicted sign, overall and for the NASDAQ and NYSE market segments. The *%TRF* parameter estimate for the AMEX market segment is of the opposite sign and statistically insignificant. The *%TRF* parameter estimate for NYSE-listed stocks indicates that a stock that has 40% of its volume reported off exchange will have a percentage quoted spread that is 20 basis points wider than a similar stock with no internalization. The results for percentage quoted spreads are further evidence that internalization levels are negatively related to market quality. As internalization goes up, market quality appears to go down. These results are consistent with previous empirical studies of internalization which focus on a broad sample of stocks.

However, the findings in this paper stand in stark contrast to O'Hara and Ye (2011) who find a positive impact on market quality associated with off-exchange trading. Recall that O'Hara and Ye use data that includes BATS and DirectEdge trades, both of which have since become exchanges. My data are for a period in which BATS and DirectEdge report their trades as exchanges. The difference in results between O'Hara and Ye and this paper suggests that the inclusion of exchange-like venues may have impacted O'Hara and Ye's results. As discussed earlier, Degryse, de Jong, and van Kervel (2011) present results that suggest that fragmentation (competition) has a positive impact on market quality while dark pool and internalized trades have a negative impact. Therefore, the results of Table 4 are consistent with the findings of Degryse, de Jong, and van Kervel for dark pools.

The results of this study (as well as those of Degryse, de Jong, and van Kervel (2011)) also stand in stark contrast to Buti, Rindi, and Werner (2010) who conclude that off-exchange trading through dark pools *improves* market quality. As mentioned earlier, dark pools are created for different purposes. Some are designed to allow block trading while others are designed to facilitate internalization. The Buti et al. sample covers voluntary reporting by about one third of the dark pools in operation during the time of their study. Assuming that the voluntary numbers are accurate, the Buti et al. sample may cover mostly block trading dark pools. The data employed for this study includes all dark pools as well as internalized trades. The difference in results between this study and Buti et al. may reflect different impacts on market quality between block trading and internalization.[23]

I next examine effective spread using the following model:

$$S_i = \beta_0 + \beta_1 \overline{Price}_i + \beta_2 \overline{Volume}_i + \beta_3 \bar{\sigma}_i + \beta_4 \overline{\%TRF}_i \tag{12}$$

where S_i is either dollar or percentage share-weighted effective spread (TAQ or Rule 605) for stock *i*; and the other variables are as defined above. As with quoted spreads, if the dependent variable is percentage effective spread then price is excluded as an independent variable. The parameter estimates can be found in Table 5. Panel A contains the estimates for dollar effective spreads and Panel B those for percentage effective spreads. Table x.1 (x.2) lists the parameter estimates for the TAQ (Rule 605) measure.

As with quoted spreads, the parameter estimates for the control variables are of the expected sign and generally significant. For both the TAQ and Rule 605 measure, the

[23] Buti, Rindi, and Werner (2010) point this out in their footnote 8.

parameter estimates for the variables of concern, %TRF and are of the same sign as for quoted spreads and except for the NYSE TAQ measure statistically significant. The parameter estimates for the percentage effective spread regressions exhibit a pattern similar to that observed for percentage quoted spreads. Overall and for the NASDAQ and NYSE segments the parameter estimate is positive and significant. For the AMEX segment, the estimate is not statistically significant.

As with quoted spreads the cost to investors of increased internalization can be estimated for effective dollar spreads. At the internalization level of 40%, investors in NASDAQ stocks face increased transaction costs of 702,240 * $0.018/2 = $6,320.16 extra per day per stock or 250 * $6,320.16= $1,580,040 *per stock per year*. Thus, it can be seen that even small increases in per trade costs due to internalization, can quickly accumulate to very large economic costs.

I next examine realized spreads using the same regression methodology outlined for quoted and effective spreads. The results are contained in Table 6. As before, Panel A contains the parameter estimates for dollar realized spreads and Panel B those for percentage realized spreads. Also, Panels .1 and .2 contain the results for TAQ and Rule 605 measures respectively. The parameter estimates for the Rule 605 measures as well as the TAQ percentage realized spread measure are qualitatively similar to those reported in Table 4 for quoted spreads and Table 5 for effective spreads. The results for the TAQ dollar realized spread for NYSE listed stocks are not consistent with the remaining results in that the parameter estimate for *%TRF* is negative and statistically significant which in turn appears to cause the overall estimate to be of the expected sign, but statistically insignificant. On the whole though, the results reported in Table 6 provide additional evidence suggesting that increased internalization adversely impacts market quality.

As mentioned earlier, a reduction in available depth, both at the inside and away, increases the probability of orders "walking through the book" or taking the liquidity at subsequent price levels. Therefore a discussion of just inside depth would provide little insight. Since I do not have order data, I cannot construct depth away from the inside.[24] Therefore, I do not examine depth directly, but rather examine two measures that are directly related to total depth: price impact and volatility. The first measure I examine, relative to the degree of internalization, is price impact:

$$A_i = \beta_0 + \beta_1 \overline{\%TRF_i} \tag{13}$$

where A_i is the Amihud price impact measure for stock *i* and $\overline{\%TRF_i}$ is the average daily percentage of share volume reported through a trade reporting facility.

Chung, Chuwonganant, and McCormick (2004) find that internalized trades have lower price impact suggesting that the trades contain less information. However, Larrymore and Murphy (2009) find that internalization reduces depth, which in turn increases price impact for all trades. Therefore, if internalization lowers depth as theorized by Chakravarty and Sarkar (2002), then I would expect the parameter estimate for %TRF in the above to be positive and significant. The results for the regressions are contained in Table 7. Examining the parameter estimates for the different market segments, I find that indeed they are positive and statistically significant overall and for the two larger market segments. The parameter estimate for AMEX stocks departs from results already reported by being negative and statistically significant.

The final measure of market quality I examine is volatility. As shown by Jones, Kaul, and Lipson (1994), volatility is directly related to the number of trades. Accordingly I regress the following model:

---

[24] See Degryse, de Jong, and van Kervel (2011) for a discussion of the impact of fragmented and dark pool trading on order book depth.

$$\sigma_i = \beta_0 + \beta_1 \overline{NumTrades_i} + \beta_2 \overline{\%TRF_i} \tag{14}$$

where σ_i is the average daily standard deviation of 15 minute returns for stock *i*; $\overline{NumTrades_i}$ is the average daily number of trades; and $\overline{\%TRF_i}$ is the average daily percentage of share volume reported through a trade reporting facility.

Examining the parameter values for %TRF in Table 8, reveals that overall and for every market segment the parameter estimate for %TRF is positive and statistically significant. This suggests that internalization reduces available depth and that liquidity shocks cause an increase in volatility. My finding of a direct relationship between internalization and short term volatility is consistent with the findings of O'Hara and Ye (2011) but not with the findings of Buti, Rindi, and Werner (2010).

As a robustness check, I rerun the regressions using the standard deviation of daily return using CRSP data. The results are qualitatively similar to those reported here. The results are not reported here, but are available on request.

Taken together, the results of this study suggest that internalization is associated with a reduction in market quality. In particular spreads will widen, trades will have more price impact and volatility will increase.

6. CONCLUSIONS AND DISCUSSION

Equity markets in the United States are becoming increasingly fragmented at the same time that we are witnessing a dramatic rise in the internalization of customer order flow.

Theoretical studies of internalization assume that order flow from uninformed traders is internalized or purchased by dealers. The internalizing of uninformed order flow by discriminating dealers reduces the number of uninformed orders for the non-discriminating dealers to spread their informed loses over. The result of this is a market wide increase in spread. These theoretical studies also suggest that internalization diminishes market quality by reducing market depth and price informativeness.

Internalization has been examined empirically by a number of authors. While some papers find no relationship between internalization and market quality, others find that internalization reduces market quality. For example, studies have found that quoted, effective, and realized spreads are directly related to the level of internalization in a stock. Others have found reduced market depth and increased volatility associated with higher levels of internalization. In summary, theoretical and empirical studies of internalization's impact on market quality show that at best internalization is benign and at worse it is associated with a decline in market quality.

Using the percentage of share volume reported through a Trade Reporting Facility (TRF) as a measure of internalized order flow, this paper examines the relationship between internalization and market quality. The main methodology used is to regress the degree of internalization for a stock on various measures of market quality, while controlling for other known relationships. I examine the relationship both overall and for each market segment: AMEX; NASDAQ; and NYSE.

Except for a few exceptions, I find strong support for the existence of a negative relationship between the degree of internalization and market quality. In particular, for all three market segments internalization is associated with wider percentage spreads for that firm. After controlling for variables known to be associated with spreads I find this result for quoted, effective, and realized spreads. The impact of internalization on spread width is measurable. For example an NYSE listed stock with 40 percent of its volume reported through a TRF on average has a dollar spread that is $0.0128 wider than a similar stock with no TRF reporting. I show that this results in investors paying $3,890,624 more per year per stock due to internalization.

For all but AMEX stocks the percentage of share volume associated with internalization is directly related with price impact. In other words, as the percentage of internalization increases, average trades will have an increasing impact on prices. Finally, for all market segments, higher levels of internalization are associated with higher levels of return volatility. I conclude that increased internalization is associated with a degradation of market quality for all market segments in the United States.

This paper has importance in the regulatory discussion of the possible imposition of a trade-at rule for US markets. The trade-at rule delineated in the SEC Concept Release on Equity Market Structure requires market venues not publically displaying the NBBO to either route the order to a venue that is publically displaying the NBBO or execute the order internally with significant price improvement.[25] The SEC trade-at rule is different from the price-improvement rule enacted by the Toronto Stock Exchange and studied by Larrymore and Murphy (2009). The Toronto rule only allows internalization if there is price improvement. The SEC rule is also different than the European Union's systematic internalizers rules, detailed in Article 27 of the 2004 Markets in Financial Instruments Directive (MiFID) which does not require price improvement for the internalization of retail orders as long as the internalizer is displaying quotes.[26] The results of this study suggest that market quality is diminished by the current level of internalization in the US and that a trade-at rule of the form the SEC is proposing will improve US market quality.

[25] The SEC Concept Release on page 3613 defines significant price improvement as the minimum allowable quoting increment - currently $0.01.

[26] Article 27 states: However, they may execute those orders at a better price in justified cases provided that this price falls within a public range close to market conditions and provided that the orders are of a size bigger than the size customarily undertaken by a retail investor.

References

Amihud, Y., 2002, Illiquidity and stock returns: cross-section and time-series effects, *Journal of Financial Markets* 5 pp. 31–56.

Anolli, M., and G. Petrella, 2007, Internalization in European equity markets following the adoption of the EU MiFID Directive, *Working paper*, Catholic University of Milan.

Battalio, R., 1997, Third market broker-dealers: Cost competitors or cream skimmers? *Journal of Finance* 52, 341–52.

Battalio, R., J. Greene, and R. Jennings, 1997, Do competing specialists and preferencing dealers affect market quality?, *Review of Financial Studies*, 10, 969-993.

Battalio, R., J. Greene, and R. Jennings, 1998, Order flow distribution, bid-ask spreads, and liquidity costs: Merrill Lynch's decision to cease routinely routing orders to regional stock exchanges, *Journal of Financial Intermediation* 7, 338–58.

Battalio, R., and C. Holden, 2001. A simple model of payment for order flow, internalization, and total trading costs. Journal of Financial Markets 4, 33–71.

Belsley, D.A., E. Kuh, and R.E. Welsch, 1980, *Regression Diagnostics*, New York: John Wiley & Sons, Inc.

Buti, S., B. Rindi, and I.M. Werner, 2010, Diving into Dark Pools, working paper, Ohio State University.

Chakravarty, S., and A. Sarkar, 2002, A model of broker's trading, with applications to order flow internalization, *Review of Financial Economics* 11, 19–36.

Chordia, T., R. Roll, and A. Subrahmanyam, 2000, Co-movements in bid-ask spreads and market depth, *Financial Analysts Journal* 56, 23–27.

Chordia, T., and A. Subrahmanyam, 1995, Market making, the tick size, and payment-for-order flow: Theory and evidence, *Journal of Business* 68, 543–75.

Chung, K., C. Chuwonganant, and D. T. McCormick, 2004, Order preferencing and market quality on NASDAQ before and after decimalization, *Journal of Financial Economics* 71, 581–612.

Chung, K., Chuwonganant, C., & McCormick, D. (2006). Does internalization diminish the impact of quote aggressiveness on dealer market share? *Journal of Financial Intermediation*, *15*(1), 108-131.

D'Antona Jr., J., 2010 (March), Off-Board Trading: NASDAQ Frets Over Internalization, *Traders Magazine*.

Davies, R. J. (2008), MiFID and a changing competitive landscape, *Working paper*, Babson College.

Degryse, H., F. de Jong, and V. van Kervel, 2011, The impact of dark and visible fragmentation on market quality, Working paper, Tilburg University.

Dutta, P., and A. Madhavan, 1997, Competition and Collusion in Dealer Markets. *Journal of Finance*, *52*, 245-276.

Easley, D., N. M. Kiefer, and M. O'Hara, 1996, Cream-skimming or profit-sharing? The curious role of purchased order flow, *Journal of Finance* 51, 811–33.

Glosten, L., Harris, L., 1988. Estimating the components of the bid–ask spread. Journal of Financial Economics 21, 123–142.

Goyenko, R.Y**., C.** Holden**,** and C. W., Trzcinka, C. A., 2009, Do liquidity measures measure liquidity? *Journal of Financial Economics*, 92, 153-181.

Grammig, J. and E. Theissen, 2005, Is Best Really Better? Internalization in Xetra BEST, *Working Paper,* University of Tübingen.

Hansch, O., N. Y. Naik, and S. Viswanathan, 1999, Preferencing, internalization, best execution, and dealer profits, *Journal of Finance* 54, 1799–1828.

Huang, R., Stoll, H., 1996. Dealer versus auction markets: a paired comparison of execution costs on NASDAQ and the NYSE. Journal of Financial Economics 41, 313–357.

Jain, P., 2004, Institutional design and liquidity on stock exchanges around the world, Working Paper, University of Memphis.

Jones, C. M., G. Kaul, and M. L. Lipson, 1994, Transactions volume, and volatility, *Review of Financial Studies* 7, 631–51.

Kandel, E., and L. Marx, 1997, Nasdaq market structure and spread patterns. *Journal of Financial Economics*, *45*, 61-89.

Kam, T., V. Panchapagesan, and D.G. Weaver, 2003, Competition between Markets: The Repeal of Rule 390, *Journal of Banking and Finance,* 27, 1711-1736.

Kluger, B. D., and S. B. Wyatt, 2002, Preferencing, internalization of order flow, and tacit collusion: Evidence from experiments, *Journal of Financial and Quantitative Analysis* 37, 449–69.

Lee, C. M., B. Mucklow, and M. J. Ready, 1993, Spreads, depths, and the impact of earnings information: An intraday analysis, *Review of Financial Studies* 6, 345–74.

Lee, C., Radhakrishna, B., 2000. Inferring investor behavior: evidence from TORQ data. Journal of Financial Markets 3, 83–112.

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

Larrymore, N. L. and A. Murphy, 2009, Internalization and Market Quality: An Empirical Investigation, *Journal of Financial Research*, 32, 337–363.

Mittal, H, 2008, Are You Playing in a Toxic Dark Pool? A Guide to Preventing Information Leakage, Investment Technology Group, Inc.

O'Hara, M and M. Ye, 2011, Is Market Fragmentation Harming Market Quality? *Journal of Financial Economics* 100, 459-474.

Patterson, S., 2010 (March 29), Faster, Faster: High Tech Hits the NYSE Floor, *Wall Street Journal,* C1.

Peterson, M. A., and D. Fialkowski, 1994, Posted versus effective spreads, *Journal of Financial Economics* 35, 269–92.

Peterson, M. A., and E. R. Sirri, 2003, Order preferencing and market quality on U.S. equity exchanges, *Review of Financial Studies* 16, 385–415.

Schapiro, M. L., 2010, Strengthening Our Equity Market Structure, Speech before the Economic Club of New York, New York, New York, September 7, 2010.

SEC, 2010, Concept Release on Equity Market Structure; Proposed Rule, 17 CFR Part 242, *Federal Register,* 75, No. 13 / Proposed Rules, 3594-3614.

Stoll, H. R., 1989, Inferring the components of the bid-ask spread: Theory and empirical evidence, *Journal of Finance* 44, 115–34.

Toronto Stock Exchange Special Committee Report, 1997, Market Fragmentation: Responding to the Challenge.

Table 1

Descriptive Statistics by Market Segment

This table contains October 2010 descriptive statistics for common stocks traded on the NYSE/Euronext and NASDAQ/OMX markets. Included stocks trade at least 11 days during October. Results are broken down by market segment. Firm values are determined as of September 30, 2010. Share volume, number of trades, the percentage of share volume reported through a trade reporting facility, and standard deviation of 15 minute returns (σ) are firm average daily numbers which are then averaged across firms. The standard deviation of daily return is based on daily returns for the month of October. The remaining measures are averaged monthly for each firm then averaged across firms. Quoted spreads are time weighted. Percentage quoted spreads are relative to the contemporaneous quote midpoint. Effective dollar spreads are calculated using two methods. The first method uses a stationary offset to the trade time reported in the TAQ data. In this case $\$Effective\ Spread_t = 2\left|P_t - \frac{Ask_t + Bid_t}{2}\right|$, where P_t is the trade price at time t, and $\frac{Ask_{i,t}+Bid_{i,t}}{2}$ is the midpoint of the NBBO one tenth of a second prior to the order being executed. Percentage spreads using TAQ data are relative to the midpoint of the NBBO. Effective dollar and percentage spreads are trade share-weighted. The second method employs SEC Rule 605 data in which case $\$Effective\ Spread_{i,t}^{MC} = \begin{cases} 2\left(P_{i,t} - \frac{Ask_{i,t}+Bid_{i,t}}{2}\right) for\ marketable\ buys \\ 2\left(\frac{Ask_{i,t}+Bid_{i,t}}{2} - P_{i,t}\right) for\ marketable\ sells \end{cases}$, where P_t is the trade price at time t, and $\frac{Ask_{i,t}+Bid_{i,t}}{2}$ is the midpoint of the NBBO at the time the order is received by a market center. Effective spread is then share-weighted across market centers. Percentage effective spreads using Rule 605 data are relative to the monthly value weighted average price. Realized spreads are calculated as effective spreads except that the spread midpoint 5 minutes after order arrival is used instead of contemporaneous midpoints. The Amihud price impact measure is defined as $Amihud_i = \frac{\sum_{t=1}^{n} \frac{|r_{i,t}|}{Volume_{i,t}}}{n}$ where $|r_{i,t}|$ is the absolute value of the return on stock *i* for day *t*; and $Volume_{i,t}$ is the dollar volume for stock *i* on day *t*.

(Table on next page)

Table 1 (continued)
Descriptive Statistics by Market Segment

		Market Segment		
		AMEX	NASDAQ	NYSE
Number of Firms		301	2,383	1,456
Value		$30,303,775	$136,817,423	$767,245,758
Price		$7.29	$15.11	$31.49
Trade Size		490	266	188
Daily Share Volume		320,961	702,240	2,431,640
Number of Trades		874	2,934	8,848
TRF Trade Size		817	449	284
Exchange Trade Size		393	219	168
% of Volume Reported through a TRF		39.1%	32.8%	24.9%
Time-Weighted $ Quoted Spread		$0.066	$0.074	$0.036
Time-Weighted % Quoted Spread		1.49%	1.03%	0.17%
Share-weighted $ Effective Spread	TAQ	$0.063	$0.072	$0.055
	605	$0.039	$0.030	$0.016
Share-weighted % Effective Spread	TAQ	1.55%	0.98%	0.25%
	605	0.94%	0.49%	0.09%
Share-weighted $ Realized Spread	TAQ	$0.071	$0.101	$0.114
	605	$0.009	$0.011	-$0.004
Share-weighted % Realized Spread	TAQ	1.70%	1.18%	0.45%
	605	0.13%	0.24%	-0.08%
Amihud Price Impact		4.027E-6	1.846E-6	1.950E-8
Standard Deviation of Intra-day Return		0.009	0.006	0.004
Standard Deviation of Daily Return		0.038	0.029	0.019

Table 2

Descriptive Statistics by TRF Quartile

This table contains October 2010 descriptive statistics for common stocks traded on the NYSE/Euronext and NASDAQ/OMX markets. Included stocks trade at least 11 days during October. Quartiles are formed by ranking all stocks by the average daily percentage of share volume reported through a trade reporting facility (TRF). Share volume, number of trades, the percentage of share volume reported through a trade reporting facility, and standard deviation of 15 minute returns (σ) are firm average daily numbers which are then averaged across firms. The standard deviation of daily return is based on daily returns for the month of October. The remaining measures are averaged monthly for each firm then averaged across firms. Quoted spreads are time weighted. Percentage quoted spreads are relative to the contemporaneous quote midpoint. Effective dollar spreads are calculated using two methods. The first method uses a stationary offset to the trade time reported in the TAQ data. In this case $\$Effective\ Spread_t = 2\left|P_t - \frac{Ask_t + Bid_t}{2}\right|$, where P_t is the trade price at time t, and $\frac{Ask_{i,t}+Bid_{i,t}}{2}$ is the midpoint of the NBBO one tenth of a second prior to the order being executed. Percentage spreads using TAQ data are relative to the midpoint of the NBBO. Effective dollar and percentage spreads are trade share-weighted. The second method employs SEC Rule 605 data in which case $\$Effective\ Spread_{i,t}^{MC} = \begin{cases} 2\left(P_{i,t} - \frac{Ask_{i,t}+Bid_{i,t}}{2}\right) for\ marketable\ buys \\ 2\left(\frac{Ask_{i,t}+Bid_{i,t}}{2} - P_{i,t}\right) for\ marketable\ sells \end{cases}$, where P_t is the trade price at time t, and $\frac{Ask_{i,t}+Bid_{i,t}}{2}$ is the midpoint of the NBBO at the time the order is received by a market center. Effective spread is then share-weighted across market centers. Percentage effective spreads using Rule 605 data are relative to the monthly value weighted average price. Realized spreads are calculated as effective spreads except that the spread midpoint 5 minutes after order arrival is used instead of contemporaneous midpoints. The Amihud price impact measure is defined as $Amihud_i = \frac{\sum_{t=1}^{n} \frac{|r_{i,t}|}{Volume_{i,t}}}{n}$ where $|r_{i,t}|$ is the absolute value of the return on stock *i* for day *t*; and $Volume_{i,t}$ is the dollar volume for stock *i* on day *t*.

(Table on next page)

Table 2 (continued)
Descriptive Statistics by TRF Quartile

		Quartile 1	2	3	4
Number of Firms		1,035	1,035	1,035	1,035
Minimum % of Trade Volume Reported Through a TRF		3.2%	22.76%	29.17%	37.47%
Maximum % of Trade Volume Reported Through a TRF		22.37%	29.17%	37.47%	62.07%
Number of AMEX firms		13	26	82	180
Number of NASDAQ firms		398	525	709	751
Number of NYSE firms		624	484	244	104
Value		$686,616,100	$430,728,002	$341,362,160	$44,494,433
Price		$34.48	$25.60	$14.93	$6.20
Trade Size		152	193	266	407
Share Volume		716,838	2,406,050	1,761,767	1,246,276
Number of Trades		4,402	7,112	6,108	1,835
Time-Weighted $ Quoted Spread		$0.06	$0.05	$0.06	$0.07
Time-Weighted % Quoted Spread		0.28%	0.41%	0.87%	1.47%
Share-weighted $ Effective Spread	TAQ	$0.076	$0.064	$0.062	$0.062
	605	$0.023	$0.020	$0.026	$0.034
Share-weighted % Effective Spread	TAQ	0.31%	0.44%	0.86%	1.45%
	605	0.11%	0.18%	0.43%	0.81%
Share-weighted $ Realized Spread	TAQ	$0.132	$0.113	$0.094	$0.075
	605	$0.004	$0.004	$0.007	$0.008
Share-weighted % Realized Spread	TAQ	0.48%	0.64%	1.06%	1.67%
	605	0.019%	0.04%	0.09%	0.32%
Amihud Price Impact		1.43E-7	4.70E-7	2.26E-6	2.572E-6
Standard Deviation of Intra-day Return		0.004	0.004	0.006	0.008
Standard Deviation of Daily Return		0.018	0.022	0.028	0.037

Table 3
Comparison Of Effective And Realized Spreads Reported Through An Exchange Or Through A TRF

This table compares the spreads of common stocks reported through an exchange with those reported through a trade reporting facility during October 2010. Included stocks trade at least 11 days during October 2010. Results are reported overall as well as by market segment. Panel A contains the results for effective spreads where dollars are calculated as $\$Effective\ Spread_t = 2\left|P_t - \frac{Ask_t + Bid_t}{2}\right|$, where P_t is the trade price at time t, and $\frac{Ask_{i,t}+Bid_{i,t}}{2}$ is the midpoint of the NBBO one tenth of a second prior to the order being executed. Percentage spreads are relative to the midpoint of the NBBO. Effective dollar and percentage spreads are share-weighted. Panel B contains the results for realized spreads which are calculated as effective spreads except that the spread midpoint 5 minutes after order arrival is used instead of contemporaneous midpoints. For each stock, I compute the difference in spread between on and off exchange trades and report a matched pair t statistic.

A. Effective Spread				
A.1. Dollar Effective Spread				
Market Segment	**Exchange Reported**	**Off-Exchange Reported**	**Matched Pair Difference**	**t-Statistic**
Overall	\$0.064	\$0.069	\$0.005	6.29***
AMEX	\$0.063	\$0.065	\$0.002	1.33
NASDAQ	\$0.069	\$0.077	\$0.007	5.66***
NYSE	\$0.056	\$0.057	\$0.001	3.12**
A.2. Percentage Effective Spread				
Overall	0.73%	0.77%	4 bp	3.73***
AMEX	1.57%	1.48%	-9 bp	-3.61***
NASDAQ	0.93%	1.00%	8 bp	4.44***
NYSE	0.24%	0.24%	.1 bp	1.24
B. Realized Spread				
B1. Dollar Realized Spread				
Market Segment	**Exchange Reported**	**Off-Exchange Reported**	**Matched Pair Difference**	**t-Statistic**
Overall	\$0.102	\$0.109	\$0.007	8.29***
AMEX	\$0.068	\$0.076	\$0.008	4.12***
NASDAQ	\$0.099	\$0.107	\$0.008	5.91***
NYSE	\$0.113	\$0.118	\$0.005	9.43**
B2. Percentage Realized Spread				
Overall	0.93%	0.99%	7 bp	6.52***
AMEX	1.68%	1.73%	5 bp	3.04***
NASDAQ	1.13%	1.23%	10 bp	5.654***
NYSE	0.45%	0.47%	2 bp	9.62***

****, **,* Denote significant at the 0.01, 0.05 and the 0.10 level respectively

Table 4
Relationship Between Quoted Spreads and the Percentage of Share Volume Reported Through a TRF

The table reports the results of a regression to test the relationship between time-weighted average quoted spread and the percentage of a stock's volume reported through a Trade Reporting Facility (TRF). Included are common stocks traded on the NYSE/Euronext and NASDAQ/OMX markets for October 2010. Stocks traded at least 11 days during October. The following model is used to control for factors known to be related to spreads:

$$S_i = \beta_0 + \beta_1\overline{Price}_i + \beta_2\overline{Volume}_i + \beta_3\bar{\sigma}_i + \beta_4\overline{\%TRF}_i$$

where S_i is either dollar or percentage time-weighted quoted spread for stock *i*; $\overline{Price}_i$ is the average price; $\overline{Volume}_i$ is the average daily volume; $\bar{\sigma}_i$ is the average intraday standard deviation of 15 minute stock returns; and $\overline{\%TRF}_i$ is the average daily percentage of share volume reported through a trade reporting facility. Results are reported overall as well as by market segment. Panel A (B) contains the results for dollar (percentage) spreads. Outliers with a DFFITS statistic $>2\sqrt{\frac{5}{obs}}$ are excluded. *t* statistics are in italics.

A. Dollar Quoted Spreads

Market Segment	Intercept	Price	Volume	σ	%TRF	*Adjusted R^2*
Overall n=4,011	0.266 *52.70******	0.001 *32.66******	-0.022 *-62.70******	1.354 *5.74******	0.047 *5.86******	*0.524*
AMEX n=287	0.221 *11.77******	0.004 *11.68******	-0.020 *-14.98******	-0.237 *-1.04*	0.083 *2.83******	*0.606*
NASDAQ n=2,296	0.315 *42.26******	0.002 *22.92******	-0.027 *-49.34******	2.113 *6.44******	0.041 *3.41******	*0.536*
NYSE n=1,400	0.147 *29.86******	0.001 *22.78******	-0.012 *-35.81******	3.940 *9.74******	0.032 *4.08******	*0.542*

B. Percentage Quoted Spreads

Market Segment	Intercept	Price	Volume	σ	%TRF	*Adjusted R^2*
Overall n=3,904	0.022 *41.58******		-0.0021 *-55.95******	1.508 *48.49******	0.003 *3.64******	*0.701*
AMEX n=277	0.048 *22.02******		-0.004 *-24.52******	1.864 *21.06******	-0.008 *-2.04****	*0.777*
NASDAQ n=2,197	0.032 *39.53******		-0.003 *-51.03******	1.833 *42.56******	0.003 *2.23****	*0.739*
NYSE n=1,391	0.007 *39.70******		-0.001 *-49.70******	0.396 *28.76******	0.005 *18.55******	*0.757*

***, **, * Denote significant at the 0.01, 0.05 and the 0.10 level respectively.

Table 5
Relationship Between Effective Spreads and the Percentage of Share Volume Reported Through a TRF

The table reports the results of a regression to test the relationship between average effective spread and the percentage of a stock's share volume reported through a Trade Reporting Facility (TRF). Included are common stocks traded on the NYSE/Euronext and NASDAQ/OMX markets for October 2010. Stocks traded at least 11 days during October. Effective dollar spreads are calculated using two methods. The first method uses a stationary offset to the trade time reported in the TAQ data. In this case $\$Effective\,Spread_t = 2\left|P_t - Askt+Bidt2\right.$, where P_t is the trade price at time t, and $Aski,t+Bidi,t2$ is the midpoint of the NBBO one tenth of a second prior to the order being executed. Percentage spreads using TAQ data are relative to the midpoint of the NBBO. Effective dollar and percentage spreads are trade share-weighted. The second method employs SEC Rule 605 data in which case $\$Effective\,Spread_{i,t}^{MC} = \begin{cases} 2\left(P_{i,t} - \frac{Ask_{i,t}+Bid_{i,t}}{2}\right) for\ marketable\ buys \\ 2\left(\frac{Ask_{i,t}+Bid_{i,t}}{2} - P_{i,t}\right) for\ marketable\ sells \end{cases}$, where P_t is the trade price at time t, and $\frac{Ask_{i,t}+Bid_{i,t}}{2}$ is the midpoint of the NBBO at the time the order is received by a market center. Effective spread is share-weighted across market centers. Percentage effective spreads using Rule 605 data are relative to the monthly value weighted average price. The following model is used to control for factors known to be related to spreads:

$$S_i = \beta_0 + \beta_1\overline{Price}_i + \beta_2\overline{Volume}_i + \beta_3\bar{\sigma}_i + \beta_4\overline{\%TRF}_i$$

where S_i is either dollar or percentage share-weighted effective spread (TAQ or 605) for stock i; $\overline{Price}_i$ is the average price; $\overline{Volume}_i$ is the average daily volume; $\bar{\sigma}_i$ is the average intraday standard deviation of 15 minute stock returns; and $\overline{\%TRF}_i$ is the average daily percentage of share volume reported through a trade reporting facility. Results are reported overall as well as by market segment. Panel A (B) contains the results for dollar (percentage) spreads. Outliers with a DFFITS statistic $>2\sqrt{\frac{5}{obs}}$ are excluded. *t* statistics are in italics.

(Table on next page)

Table 5 (continued)
Relationship Between Effective Spreads and the Percentage of Share Volume Reported Through a TRF

Market Segment	Intercept	Price	Volume	σ	%TRF	*Adjusted R^2*
A.1 Dollar Effective Spreads - TAQ						
Overall n=3,994	0.181 *42.30****	0.002 *48.08****	-0.015 *-49.97****	1.943 *9.67****	0.038 *5.64****	*0.502*
AMEX n=286	0.163 *10.42****	0.004 *14.00****	-0.014 *-12.57****	0.023 *0.05*	0.047 *1.99***	*0.614*
NASDAQ n=2,296	0.211 *37.69****	0.002 *42.13****	-0.018 *-44.20****	2.265 *9.93****	0.045 *5.06****	*0.577*
NYSE n=1,401	0.062 *9.84****	0.001 *36.03****	-0.007 *-14.79****	8.292 *15.63****	0.006 *0.59*	*0.526*
A.2 Dollar Effective Spreads - 605						
Overall n=4,002	0.101 *50.30****	0.001 *29.25****	-0.009 *-62.31****	0.689 *7.23****	0.038 *12.14****	*0.526*
AMEX n=285	0.121 *11.46****	0.003 *11.44****	-0.012 *-15.71****	0.071 *0.22*	0.057 *3.52****	*0.618*
NASDAQ n=2,294	0.115 *40.06****	0.001 *21.02****	-0.010 *-49.73****	1.043 *8.16****	0.045 *9.80****	*0.546*
NYSE n=1,408	0.056 *23.86****	0.0004 *29.95****	-0.005 *-33.05****	2.527 *13.47****	0.032 *8.71****	*0.565*

Table 5 (continued)
Relationship Between Effective Spreads and the Percentage of Share Volume Reported Through a TRF

B.1 Percentage Effective Spreads - TAQ					
Overall n=3,909	0.014 32.70***	-0.001 -49.13***	1.602 66.66***	0.005 7.82***	0.765
AMEX n=282	0.035 18.26***	-0.003 -20.57***	2.056 25.16***	-0.007 -2.19**	0.780
NASDAQ n=2,221	0.019 31.52***	-0.002 -45.06***	1.771 60.58***	0.007 7.00***	0.800
NYSE n=1,381	0.004 17.71***	-0.0004 -25.02***	0.628 33.16***	0.005 13.65***	0.642
B.2 Percentage Effective Spreads - 605					
Overall n=3,952	0.089 32.23***	-0.009 -50.07***	7.847 48.16***	0.053 12.13***	0.699
AMEX n=281	0.271 18.24***	-0.025 -21.68***	11.764 20.59***	-0.002 -0.06	0.748
NASDAQ n=2,251	0.123 30.46***	-0.014 -45.50***	8.859 41.25***	0.065 10.24***	0.726
NYSE n=1,397	0.028 27.15***	-0.003 -39.48***	2.267 26.94***	0.039 22.91***	0.706

***, **, * Denote significant at the 0.01, 0.05 and the 0.10 level respectively.

Table 6
Relationship Between Realized Spreads and the Percentage of Share Volume Reported Through a TRF

The table reports the results of a regression to test the relationship between average realized spread and the percentage of a stock's share volume reported through a Trade Reporting Facility (TRF). Included are common stocks traded on the NYSE/Euronext and NASDAQ/OMX markets for October 2010. Stocks traded at least 11 days during October. Realized dollar spreads are calculated using two methods. The first method uses a stationary offset to the trade time reported in the TAQ data. In this case $\$Realized\ Spread_{i,t} = 2 * abs\left(P_t - \frac{Ask_{i,t}+Bid_{i,t}}{2}\right)$, where P_t is the trade price at time t, and $\frac{Ask_{i,t}+Bid_{i,t}}{2}$ is the midpoint of the NBBO five minutes after the trade is executed. Percentage spreads are relative to the midpoint of the NBBO five minutes after the trade is executed. Realized dollar and percentage spreads are trade share-weighted. The second method employs SEC Rule 605 data in which case $\$Realized\ Spread_{i,t}^{MC} = \begin{cases} 2\left(P_{i,t} - \frac{Ask_{i,t+5}+Bid_{i,t+5}}{2}\right) for\ marketable\ buys \\ 2\left(\frac{Ask_{i,t+5}+Bid_{i,+5t}}{2} - P_{i,t}\right) for\ marketable\ sells \end{cases}$, where P_t is the trade price at time t, and $\frac{Ask_{i,t+5}+Bid_{i,t+5}}{2}$ is the midpoint of the NBBO quoted spread five minutes after an order is received by a market center. Realized spread is share-weighted across market centers. Percentage realized spreads using Rule 605 data are relative to the monthly value weighted average price. The following model is used to control for factors known to be related to spreads:

$$S_i = \beta_0 + \beta_1 \overline{Price}_i + \beta_2 \overline{Volume}_i + \beta_3 \bar{\sigma}_i + \beta_4 \overline{\%TRF}_i$$

where S_i is either dollar or percentage share-weighted realized spread for stock i; $\overline{Price}_i$ is the average price; $\overline{Volume}_i$ is the average daily volume; $\bar{\sigma}_i$ is the average intraday standard deviation of 15 minute stock returns; and $\overline{\%TRF}_i$ is the average daily percentage of share volume reported through a trade reporting facility. Results are reported overall as well as by market segment. Panel A (B) contains the results for dollar (percentage) realized spreads. Outliers with a DFFITS statistic $>2\sqrt{\frac{5}{obs}}$ are excluded. *t* statistics are in italics.

(Table on next page)

Table 6 (continued)
Relationship Between Realized Spreads and the Percentage of Share Volume Reported Through a TRF

Market Segment	Intercept	Price	Volume	σ	%TRF	*Adjusted R^2*
A.1. Dollar Realized Spreads - TAQ						
Overall n=3,951	0.114 *23.15******	0.003 *78.55******	-0.009 -27.99***	4.606 *18.31******	0.011 *1.43*	*0.656*
AMEX n=284	0.141 *9.60******	0.005 *17.66******	-0.011 *-10.85******	-0.219 *-0.38*	0.034 *1.57*	*0.682*
NASDAQ n=2,264	0.128 *21.13******	0.004 *66.76******	-0.013 *-28.48******	4.646 *17.30******	0.047 *4.79******	*0.693*
NYSE n=1,376	-0.036 *-4.75******	0.0032 *76.54******	-0.001 *-2.71******	19.272 *29.49******	-0.033 *-2.79******	*0.831*
A.2. Dollar Realized Spreads - 605						
Overall n=4,119	0.055 *29.46******	0.0002 *12.46******	-0.005 -39.03***	-0.049 *-0.58*	0.029 *9.77******	*0.294*
AMEX n=281	0.026 *6.85******	0.0007 *8.59******	-0.003 *-11.77******	-0.043 *-0.38*	0.029 *4.99******	*0.459*
NASDAQ n=2,341	0.058 *28.74******	0.0002 *10.39******	-0.005 *-35.76******	0.139 *1.56*	0.023 *6.88******	*0.365*
NYSE n=1,452	0.019 *7.79******	0.0001 *12.11******	-0.002 *-13.28******	0.134 *0.72*	0.026 *6.59******	*0.171*

Table 6 (continued)
Relationship Between Realized Spreads and the Percentage of Share Volume Reported Through a TRF

B.1. Percentage Realized Spreads - TAQ						
Overall n=3,924	0.009 *25.33****		-0.001 *-38.81****	1.889 *90.77****	0.004 *6.18****	*0.817*
AMEX n=283	0.026 *15.43****		-0.002 *-16.97****	2.141 *32.13****	-0.007 *-2.46***	*0.825*
NASDAQ n=2,218	0.014 *25.02****		-0.002 *-36.35****	1.978 *65.34****	0.006 *6.60****	*0.803*
NYSE n=1,386	0.002 *7.70****		-0.0002 *-13.04****	1.186 *72.15****	0.003 *10.30****	*0.837*
B. Percentage Realized Spreads - 605						
Overall n=4,130	0.073 *20.40****		-0.007 *-28.40****	1.655 *10.33****	0.036 *6.66****	*0.262*
AMEX n=288	0.079 *8.14****		-0.008 *-9.85****	0.781 *2.24***	0.036 *2.11***	*0.253*
NASDAQ n=2,377	0.095 *18.34****		-0.009 *-25.46****	2.171 *9.68***	0.055 *6.69****	*0.309*
NYSE n=1,453	0.015 *9.48****		-0.001 *-11.60****	0.015 *0.13*	0.010 *3.94****	*0.090*

***, **, * Denote significant at the 0.01, 0.05 and the 0.10 level respective.

Table 7

Relationship Between Price Impact and the Percentage of Share Volume Reported Through a TRF

The table reports the results of a regression to test the relationship between the Amihud price impact measure and the percentage of a stock's share volume reported through a Trade Reporting Facility (TRF). The Amihud measure uses daily returns and volumes to estimate the average price response generated by $1 of volume and is defined as $Amihud_i = \frac{\sum_{t=1}^{n} \frac{|r_{i,t}|}{Volume_{i,t}}}{n}$ where $|r_{i,t}|$ is the absolute value of the return on stock *i* for day *t*; and $Volume_{i,t}$ is the dollar volume for stock *i* on day *t*. The ratio is average over all non-zero volume days in a period. For this study I average the number over the number of days traded in October 2010. Dollar volume is defined, as in Amihud (2002), as the closing price times share volume for the day. Stocks traded at least 11 days during October. The following model is used to examine the relationship between price impact and internalization:

$$A_i = \beta_0 + \beta_1 \overline{\%TRF_i}$$

where A_i is the Amihud price impact measure for stock *i* and $\overline{\%TRF_i}$ is the average daily percentage of share volume reported through a trade reporting facility. Results are reported overall as well as by market segment. Outliers with a DFFITS statistic $>2\sqrt{\frac{5}{obs}}$ are excluded. *t* statistics are in italics.

Market Segment	Intercept	%TRF	*Adjusted R^2*
Overall n=4,096	-6.211E-7 *-5.74****	3.83E-6 *11.32****	*0.030*
AMEX n=296	3.22E-6 2.22**	-3.37E-6 *-0.93*	*0.004*
NASDAQ n=2,383	-7.50E-7 *-3.31****	5.01E-6 *7.55****	*0.023*
NYSE n=1,456	-1.12E-8 *-0.94*	1.24E-7 *2.69****	*0.004*

***, **, * Denote significant at the 0.01, 0.05 and the 0.10 level respectively.

Table 8

Relationship Between Volatility and Percentage of Share Volume Reported Through a TRF

The table reports the results of a regression to test the relationship between average intra-daily volatility and the percentage of a stock's trades are reported through a Trade Reporting Facility (TRF). Included are common stocks traded on the NYSE/Euronext and NASDAQ/OMX markets for October 2010. Stocks traded at least 11 days during October. The following model is used to control for factors known to be related to volatility:

$$\sigma_i = \beta_0 + \beta_1 \overline{NumTrades_i} + \beta_2 \overline{\%TRF_i}$$

where σ_i is the average intra-daily standard deviation of 15 minute returns for stock i; $\overline{NumTrades_i}$ is the average daily number of trades; and $\overline{\%TRF_i}$ is the average daily percentage of share volume reported through a trade reporting facility. Results are reported overall as well as by market segment. Outliers with a DFFITS statistic $>2\sqrt{\frac{5}{obs}}$ are excluded. *t* statistics are in italics.

Market Segment	Intercept	NumTrades	%TRF	*Adjusted R^2*
Overall n=3,966	0.0009 *8.55****	-4.40E-8 *-13.22****	0.015 *43.40****	*0.358*
AMEX n=288	0.005 *5.05****	-2.68E-7 *-2.48*	0.009 *4.23****	*0.071*
NASDAQ n=2,292	0.0011 *6.12****	-5.01E-8 *-6.92****	0.015 *28.47****	*0.284*
NYSE n=1,456	0.002 *18.10****	-1.77E-8 *-6.02****	0.006 *12.79****	*0.113*

***, **, * Denote significant at the 0.01, 0.05 and the 0.10 level respectively.