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Daniel G. Weaver, Ph.D.
Professor of Finance
Associate Director,
Whitcomb Center for Research in Financial Services
Levin Building, Room 111
Rutgers, The State University of New Jersey
94 Rockafellar Road
Piscataway, NJ 08854-0854

weaver.rutgers.edu
daniel_weaver@rbsmail.rutgers.edu

Tel: 01.732.445.5644
Fax: 01.732.455.2333

April 20, 2010

Elizabeth M. Murphy, Secretary
Securities and Exchange Commission
100 F Street, NE
Washington, DC 20549-1090

Re: Concept Release on Equity Market Structure, File No. S7-02-10

Dear Ms. Murphy:

I am writing this letter in response to the Commission's request for comments on the above concept release. In particular I would like to address the issue of order routing to non-displayed liquidity (dark pools and internalization.) These trades are then reported through a FINRA Trade Reporting Facility (TRF.) I will refer to these trades as off-exchange reporting. I have just completed a study of the impact of off-exchange reporting on market quality. I am attaching it for your reference. In the paper I provide a survey of existing theoretical and empirical work on the topic. I also conduct statistical tests to empirically examine the impact of off-exchange reporting on U.S. markets during the month of October 2009. The conclusion of both portions of the attached study is that off-exchange reporting hurts market quality.

First let me address the existing literature on off-exchange reporting. That literature has focused on internalization and the more general issue of preferencing. In reviewing the literature, I found no paper that concludes that preferencing/internalization (hereafter P/I) improves market quality. I found three empirical papers that empirically find that it is benign. One of the papers only examined the most liquid securities in the market so its findings cannot be applied to the market as a whole. The other two conclude that P/I did not have an impact on market quality.

A larger number of papers conclude, both theoretically and empirically, that P/I leads to a decline in market quality. As the Commission may recall, the large amount of preferenced order flow on NASDAQ in the early 1990s was cited by a number of papers as an institutional feature that reduced competition and allowed implicit collusion on NASDAQ to exist - leading to higher transaction costs for investors. Theoretical papers show that broker/dealers have an incentive to internalize small uninformed orders. Since non-discriminating broker/dealers have

fewer uninformed orders to spread their adverse selection costs over, then overall spreads widen.

Other than those mentioned already, the remaining empirical papers support the view that P/I reduces market quality. The authors of these studies find that P/I is directly related to spread width and volatility. They also find that P/I is inversely related to depth. In other words, increased levels of P/I are found to be associated with wider spreads, lower depth, and higher volatility.

One existing study the Commission should pay particular attention to was co-authored by a former student of mine, Albert Murphy. It examines efforts by the Toronto Stock Exchange (TSX), to reduce internalization which they felt was harming market quality. The TSX adopted a rule similar to the Commission proposed Trade-At Rule. In particular the TSX required broker/dealers to either improve on price or send orders to the order book for execution. The result was a dramatic improvement in market quality. The Larrymore and Murphy paper shows that among other improvements that followed the reduction in internalization on the TSX, displayed depth increased significantly. The simple logic to explain this is that liquidity begets liquidity - that is, more marketable orders sent to the order book will result in more limit orders submitted to trade with them. It can therefore be logically concluded that the currently observed increased levels of off-exchange reporting in the US is causing a reduction in displayed liquidity.

In the current study, I use the percentage of share volume reported through a FINRA TRF during October 2009 as a proxy for off-exchange reporting. Trades reported through TRFs include dark-pool trades, internalized trades, upstairs trades and ECNs such as Direct Edge. ECNs do display their quotes, allowing traders to interact with them, so the fact that ECNs may report through a TRF, reduces the ability of the study to tease out the impact of trades routed to non-displayed liquidity. However, including ECN trades improves the power of any statistical test of off-exchange reporting, since it will be harder to detect. I examine the impact of off-exchange reporting across all market segments as well as partitioned by the market segment stocks are listed on: AMEX; NASDAQ; and NYSE.

Except for a few exceptions, I find strong support for the existence of a negative relationship between the degree of off-exchange reporting and market quality. In particular, I find that higher levels of off-exchange reporting are associated with wider percentage spreads for a stock. After controlling for variables known to be associated with spreads I find this result for quoted, effective, and realized spreads. The impact of off-exchange reporting 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 $0.028 wider than a similar

stock with no TRF reporting. We show that this results in investors paying $10,272,693 more *per stock per year* due to off-exchange reporting.

Turning to price impact, the extant literature suggests that off-exchange reporting 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 out the liquidity at subsequent price levels. If this is the case then I should find that increased levels of off-exchange reporting 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 off-exchange reporting is directly related with price impact. In other words, as the percentage of off-exchange reporting increases, trades will have an increasing impact on prices. Finally, for all market segments, higher levels of off-exchange reporting are associated with higher levels of return volatility. I conclude that increased off-exchange reporting is associated with a degradation of market quality for all market segments in the United States.

Given the documented relationship between off-exchange reporting and market quality, I suggest that the Commission take steps to reduce off-exchange reporting. Adopting a Trade-At Rule would undoubtedly improve market quality as it did in Toronto.

Sincerely;

Daniel G. Weaver

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
01 732 445 5644
daniel_weaver@rbsmail.rutgers.edu

April 16, 2010

I thank the New York Stock Exchange for providing financial support and the TAQ data for this 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.

Off-Exchange Reporting and Market Quality in a Fragmented Market Structure

Abstract

It has been reported in the press that the amount of reporting through a trade reporting facility (TRF) for stocks in US markets has increased by 50% in the past year. Trades reported through a TRF include internalized trades, those executed in a dark pool, and ECNs such as Direct Edge. Previous literature on the impact of internalization on market quality has shown that at best the impact is benign and at worst harmful to market quality. Previous empirical studies have focused on rather concentrated markets. In contrast US markets today are increasingly fragmented, with a number of market centers competing for order flow. This study examines the impact of TRF reporting in a fragmented market structure. We find strong evidence that such off-exchange reporting is associated with a reduction in market quality. In particular we find that stocks with higher levels of off-exchange reporting have wider spreads (quoted, effective, and realized) after controlling for factors known to be influential. We also find that that increased off-exchange reporting is associated with more price impact per trade and higher volatility.

Off-Exchange Trading and Market Quality in a Fragmented Market Structure

1. INTRODUCTION

A recent article in Traders Magazine states that the amount of "internalization" in US markets has increased from 20% to 30% in the past year.[1] As pointed out in the Traders Magazine article, the definition of internalization has expanded to include dark pool and upstairs trades and is also known as off-exchange reporting. In addition, a recent Wall Street Journal article reports that markets are becoming increasingly fragmented, with NYSE market share declining to 37% from 70% two years earlier.[2] The question then is, given the increased fragmentation in US markets, what impact has the increase in off-exchange reporting had on market quality - if any? This study seeks to provide answers to that question.

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. Dutta and Madhavan (1997) and Kandel and Marx (1997) both cite preferencing as an institutional feature of NASDAQ in the 1990s that led to higher execution costs for investors. 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-

[1] See D'Antona (2010.)
[2] See Patterson (2010.)

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)]

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.[3] 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.[4] The effect was to allow firms to internalize orders at their firm. Kam, Panchapagesan, and Weaver (2003)

[3] Davies (2008) provides a good overview of MiFID.
[4] 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.[5]

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.

Given the above studies, we would expect the recent increase in off-exchange reporting in the US to negatively impact market quality. This paper examines the relationship between off-exchange reporting and market quality. We find, consistent with reports in the popular press, that low-priced stocks are most likely to be internalized. We then examine the impact on market quality. The methodology used is to regress the degree of off-exchange reporting for a stock on various measures of market quality, while controlling for other known relationships. We examine the relationship both overall and for each market segment: AMEX; NASDAQ; and NYSE.

Except for a few exceptions, we find strong support for the existence of a negative relationship between the degree of off-exchange reporting and market quality. In particular, for all three market segments off-exchange reporting is associated with wider percentage spreads for that firm. After controlling for variables known to be associated with spreads we find this result for quoted, effective, and realized spreads. The impact of off-exchange reporting on spread width is measurable. For example a NYSE listed stock with 40 percent of its volume

[5] 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.

reported through a TRF will on average have a dollar effective spread that is $0.028 wider than a similar stock with no TRF reporting. We show that this results in investors paying $10,272,693 more *per stock per year* due to off-exchange reporting.

Turning to price impact, the extant literature suggests that off-exchange reporting 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 we should find that increased levels of off-exchange reporting are associated with increased price impact and volatility. That is exactly what we find. For all but AMEX stocks the percentage of share volume associated with off-exchange reporting is directly related with price impact. In other words, as the percentage of off-exchange reporting increases, average trades will have an increasing impact on prices. Finally, for all market segments, higher levels of off-exchange reporting are associated with higher levels of return volatility. We conclude that increased off-exchange reporting is associated with a degradation of market quality for all market segments in the United States.

The remainder of this paper is organized as follows. The next section reviews previous literature on off-exchange reporting Section 3 describes our data and the market quality measures we use. Section 4 presents our results, while Section 5 concludes.

2. LITERATURE REVIEW

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.[6] 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.

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.

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[7] on the Boston and Pacific Stock Exchanges, effectively internalizing them.[8] They

[6] 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.

[7] 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.

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 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

[8] 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.

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.

2. DATA & MARKET QUALITY MEASURES

For this study, we construct a sample of all NYSE/Euronext and NASDAQ/OMX exchange listed stocks that trade during October 2009.[9] The initial list of securities is obtained from the master file of the FTP version of the NYSE/TAQ database. The list of firms is merged with the CRSP database to determine security type. Consistent with previous studies, we only examine common stocks and thus exclude preferred stock, units, ADRs, REITs, closed end funds, SBIs, and ETFs. During October 2009, stocks could be listed on one of three market segments: the American and NYSE segments of NYSE/Euronext; and the NASDAQ segment of NADAQ/OMX. To be included in our 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

[9] To be included stocks must have been listed on just one market segment throughout the entire month.

above $500 a share are excluded. The resulting sample contains 339 stocks listed on the American, 1,450 on the NYSE, and 2,463 on NASDAQ.

CRSP data is used to determine the value of each firm in the sample on September 30, 2009. CRSP daily returns and volumes are used to construct our 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[10]

$$Dollar = Ask_t + Bid_t \quad (1)$$

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

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 50+ liquidity pools including dark pools/ATSs, broker trading desks, and ECNs. Thus, these

[10] 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. We follow this procedure.

trades include internalized trades and those executed through a dark pool. We will use TRF trades as a proxy for internalized trades.

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, we do not partition according to TRF name. By utilizing this field, we are able to identify TRF and exchange reported trades and determine the average number of trades reported through a TRF for each stock.

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:

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

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.

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:

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

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

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

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. We obtain the Rule 605 monthly report for all U.S. stocks (by order type and market center) for the period of our study from the NYSE. The NYSE also calculates a percentage effective spread for each order class and market center based on the value weighted average price (VWAP). We obtain those calculations as well.

The above measure is not without implementation problems. Not all orders are included in the effective spread calculation under Rule 605. Orders can be routed away from a receiving

exchange to another exchange which receives the order. When the order is executed, both the originating and receiving exchange will use the same effective spread, but both will count the shares as received by their exchange. The double counting problem should be minor compared to the problems mentioned above for trade-based measures.[11] Notwithstanding the double-counting errors, we estimate for each stock a share-weighted effective stock across market centers as follows:

$$Effective\ Spread_i = \sum_{MC=1}^{n} \frac{Executed_i^{MC}\ Effectiv\ e\ Spread_i^{MC}}{Executed^N} \quad (6)$$

where $Executed_i^{MC}$ is 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.

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 (5.) SEC Rule 605 defines realized spreads differently, using the quoted spread midpoint 5 minutes after an executed order is received by a market center:

$$Realized\ Spread_{i,t}^{MC} = \begin{cases} 2\left(P_{i,t} - \frac{Ask_{i,t+Bid_{i,t+5}}}{2}\right) for\ marketable\ \ buys \\ 2\left(\frac{Ask_{i,t+Bid_{i,t+5}}}{2} - P_{i,t}\right) for\ marketable\ \ sells \end{cases} \quad (7)$$

We use the SEC Rule 605 definition of realized spreads in this study. As with effective spreads, the aggregation methodology we employ for each stock is to weight the market center

[11] 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.

reported realized spread by the total shares executed reported by the market center for the period or

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

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.

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

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 we average the number over the number of trading days in October 2009. 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. We define return as the 15 minute intra-day return on a stock. Consistent with other studies we assume that the average 15 minute return is zero rather than introducing additional estimation error into our 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 2009. Recall that we exclude stocks that traded less than eleven days during the month. As a robustness check, we also define volatility as the standard deviation of daily return for October 2009 using CRSP daily holding period returns. In the next section we discuss the descriptive statistics for our sample as well as report the results of our statistical tests.

4. RESULTS

Table 1 presents descriptive statistics for our 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 spreads (quoted, effective, and realized). Turning to an examination of TRF trades, we find that nearly 50% of the share volume, reported for AMEX stocks are reported through a TRF, while less than 30% 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 venues. Our first step in this direction is to examine differences in average trade sizes. We find that TRF reported trades (Table 1) are much larger than exchange reported trades. In particular

TRF reported trades are on average 918 shares for AMEX listed stocks, while exchange reported trades for the same group are nearly half as large, 548 shares.

We next investigate what types of stocks are most likely to have their trades reported through a TRF. We rank the 4,252 firms in our sample according to the average daily percentage of volume reported through a TRF and form quartiles based on the ranks. We then examine the characteristics of firms in each quartile, Table 2. We find that the largest average daily percentage volume reported through a TRF is 79%. Therefore some stocks have virtually all of their volume executed off an exchange. The quartile with the largest percentage of TRF reported volume (4) has a minimum average of 47.61%. This quartile contains half of the AMEX segment firms and 1/3 of NASDAQ firms. In contrast, less than 5% 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, and widest percentage spreads (quoted, effective, and realized.) We 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, we will analyze any further results by market segment.

We therefore next examine the relationship between the percentage of trade volume reported through TRFs and market quality. We examine the relationship by employing regressions which allows us to control for factors known to impact market quality measures. We 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, we 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, we determine that, for spreads, including a linear specification of the percentage of volume reported through a TRF along with a squared specification of the same variable has generally the highest explanatory power. This is illustrated below in our model of quoted spread width.

$$S_i = \beta_0 + \beta_1 \overline{Price_i} + \beta_2 \overline{Volume_i} + \beta_3 \bar{\sigma}_i + \beta_4 \overline{\%TRF_i} + \beta_5 \overline{\%TRF_i^2} \quad (11)$$

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 reduce the possibility that outliers are driving our results, observations with a DFFITS statistic $>2\sqrt{\frac{p}{obs}}$, where *p* is the number of parameters and *obs* is the number of observations, are considered outliers and are excluded.[12]

The parameter values for the above regression are contained in Table 3. Examining the results for dollar quoted spread (Panel A) reveals that the parameter values for the control variables are of the expected signs and are statistically significant. Turning to the variables of interest, *%TRF* and *%TRF*^{2}*,* for dollar quoted spreads in Panel A, we observe that overall the parameter estimate for the linear specification, *%TRF,* is positive and significant, while the

[12] See Belsley, Kuh, and Welsch (1980)

squared specification is negative and significant.[13] This suggests that the percentage of share volume does indeed impact spread width, but that the impact declines as the percentage increases. Examining the results by market segment, reveals that the variables of interest for AMEX and NYSE listed stocks have the same sign as the overall results, but only the NYSE is significant. In contrast the parameter estimates are of opposite signs for NASDAQ stocks. We will find that this is the case for our other dollar spread measures as well - but not for our percentage spread measures.

To assist in understanding the relationship between *%TRF* and spread width, we generate graphs for increasing values of *%TRF* using the last two parameter estimates in Equation 11. The graphs overall and by market segment can be found in Figure 1. The graphs estimate the spread width that a stock with a certain level of TRF reporting will have compared to a stock that has the same price, volume, and volatility - but no TRF reporting. For example an AMEX listed stock with 40 percent of its volume reported through a TRF will on average has a dollar spread that is $0.04363 wider than a similar stock with no TRF reporting. Given that: 1) the average AMEX stock traded 317,049 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 317,049 * $0.04363 = $6,917 extra per day per stock or 250 * $6,917 = $1,729,250 per year per stock due to off-exchange reporting.

The above numbers are consistent with 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 off-exchange reporting has an adverse impact on market quality.

[13] Regressions were rerun excluding %TRF and the control variable parameter estimates compared to those reported in the table. The estimates were found to fairly stable which suggests a lack of multicollinearity between the %TRF variables and the other independent variables. We also calculate variance inflation factors and find them to be small as well.

Comparing the results for percentage quoted spread (Panel B) to those for dollar quoted spread reveals a pattern that will be consistent for each of our other spread measure. The overall results are now insignificant and the parameter estimates for the singular and squared specifications of %TRF have reversed signs for the NASDAQ and NYSE. As with dollar spreads, we turn to a graphical representation to understand the interdependency of %TRF and $\%TRF^2$ which are found in Figure 2. The graphs for all three market segments show that for virtually all levels of TRF reporting, percentage quoted spreads are wider than they would be for stocks with no TRF reporting. For the AMEX the maximum increase in spread width occurs at about a 40% TRF reporting level. This corresponds to the estimated percentage spread width being 160 bp wider than it would be for a similar stock with no TRF reporting. For NASDAQ stocks Figure 2 reveals that at a 30% TRF reporting level spreads will be 40 bp wider. For NYSE stocks the estimated impact graph shows that at a 20% TRF reporting level, NYSE percentage quoted spreads are estimated to be an insignificant 6 bp lower than stocks without TRF reporting but that at higher levels there are increasingly wider spreads resulting from TRF reporting.

The results for percentage quoted spreads are further evidence that off-exchange reporting levels are negatively related to market quality. As off-exchange reporting goes up, market quality goes down. These results are consistent with previous empirical studies of internalization which focus on a broad sample of stocks.

We next examine effective spread using the following model:

$$S_i = \beta_0 + \beta_1 \overline{Price_i} + \beta_2 \overline{Volume_i} + \beta_3 \bar{\sigma}_i + \beta_4 \overline{\%TRF_i} + \beta_5 \overline{\%TRF_i^2} \qquad (12)$$

where S_i is either dollar or percentage effective spread for stock *i*; and the other variables are as defined above. Recall that we obtain the effective spread estimates from each market center's

SEC required Rule 605 filing and weight it by the percentage of share volume that center represents. We repeat Equation (6) here as a reference:

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

where $Executed_i^{MC}$ is 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. As with quoted spreads, if the dependent variable is percentage quoted spread then price is excluded as an independent variable. Also as with qupoted spreads observations with a DFFITS statistic $>2\sqrt{\frac{p}{obs}}$ are considered outliers and are excluded.

The parameter estimates can be found in Table 4. Panel A contains the estimates for dollar effective spreads and Panel B those for percentage effective spreads. As with quoted spreads, the parameter estimates for the control variables are of the expected sign and significant. The parameter estimates for the variables of concern, %TRF and $\%TRF^2$, with the exception of the parameter estimates for the overall segment for percentage effective spreads, all of the parameter estimates are of the same sign as for quoted spreads. The parameter estimates for the overall percentage effective spread regression are still insignificant. Comparing the graphs for the %TRF parameter estimates in Figures 3 and 4 reveals patterns that are essentially the same as those reported in Figures 1 and 2 for quoted spreads. As with quoted spreads the graph for dollar NASDAQ spreads show that increasing the percentage of volume reported through a TRF reduces dollar spreads, while the graph for percentage NASDAQ spreads shows the opposite effect. This is a puzzle for which we have no explanation and suggest further investigation of. Notwithstanding the puzzle of NASDAQ dollar spreads, the results in Table 4 and Figures 3 and 4 provide additional evidence for the notion that increased off-exchange reporting is associated with reduced market quality.

As with quoted spreads the cost to investors of increased off-exchange reporting can be estimated for effective dollar spreads. At the off-exchange reporting level of 40%, investors in NYSE stocks investors face increased transaction costs of 2,937,387 * $0.013989 = $41,090 extra per day per stock or 250 * $41,090 = $10,272,693 *per stock per year*. Thus, it can be seen that even small increases in per trade costs due to off-exchange reporting, can quickly accumulate to very large economic costs.

We next examine realized spreads using the same regression methodology outlined for quoted and effective spreads. The results are contained in Table 5. As before, Panel A contains the parameter estimates for dollar realized spreads and Panel B those for percentage realized spreads. The signs and significance levels of the parameter estimates in both panels are qualitatively similar to those reported in Table 3 for quoted spreads and Table 4 for effective spreads. Additionally, the graphs of the %TRF and $\%TRF^2$ parameter estimates for realized spread in Figures 5 and 6 are qualitatively similar to those presented for our other two spread measures. Thus, we have more evidence suggesting that increased off-exchange reporting 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 we do not have order data, we cannot construct depth away from the inside. Therefore, we do not examine depth directly, but rather examine two measures that are directly related to total depth: price impact and volatility. The first measure we examine, relative to the degree of off-exchange reporting, is price impact:

$$A_i = \beta_0 + \beta_1 \overline{\%TRF_i} \qquad (13)$$

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. Note that for both the Amihud price impact measure and volatility we find that the model specification excluding the %TRF^2 term provides more explanatory power than including it. Therefore we employ the more powerful model specification for our last two tests. we also therefore do not need to construct graphs since the intuitive interpretation is direct.

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 we would expect the parameter estimate for %TRF in the above to be positive and significant. The results for the regressions are contained in Table 6. Examining the parameter estimates for the different market segments, we find that indeed they are positive and statistically significant - except for AMEX stocks.

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

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

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 7, reveals that overall and for every market segment the parameter estimate for %TRF is positive and statistically significant. This

suggests that off-exchange reporting reduces available depth and that liquidity shocks cause an increase in volatility.

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

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

5. CONCLUSION

Equity markets in the United States are becoming increasing fragmented at the same time that we are witnessing a dramatic rise in off-exchange reporting (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 internalizations impact on market quality show that at best internalization is benign and at worse it is associated with a decline in market quality.

Given the results of previous studies, we would expect the recent increase in off-exchange reporting in the US to negatively impact market quality. Using the percentage of share volume reported through a Trade Reporting Facility (TRF), this paper examines the relationship between off-exchange reporting and market quality. The main methodology used is to regress the degree of off-exchange reporting for a stock on various measures of market quality, while controlling for other known relationships. We examine the relationship both overall and for each market segment: AMEX; NASDAQ; and NYSE.

Except for a few exceptions, we find strong support for the existence of a negative relationship between the degree of off-exchange reporting and market quality. In particular, for all three market segments off-exchange reporting is associated with wider percentage spreads for that firm. After controlling for variables known to be associated with spreads we find this result for quoted, effective, and realized spreads. The impact of off-exchange reporting on spread width is measurable. For example an AMEX listed stock with 40 percent of its volume reported through a TRF will on average has a dollar spread that is $0.04363 wider than a similar stock with no TRF reporting. We show that this results in investors paying $1,729,250 more per year per stock due to off-exchange reporting.

For all but AMEX stocks the percentage of share volume associated with off-exchange reporting is directly related with price impact. In other words, as the percentage of off-exchange reporting increases, average trades will have an increasing impact on prices. Finally, for all market segments, higher levels of off-exchange reporting are associated with higher levels of

return volatility. We conclude that increased off-exchange reporting is associated with a degradation of market quality for all market segments in the United States.

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Table 1

Descriptive Statistics by Market Segment

This table contains October 2009 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, 2009. 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 spread are relative to the contemporaneous quote midpoint. Effective dollar spreads are calculated using SEC Rule 605 and are defined as $\$Effective\ Spread_{i,t}^{MC} = \begin{cases} 2\left(P_{i,t} - \frac{Ask_{i,t}+Bid_{i,t}}{2}\right) for\ marketable\ \ buys \\ 2\left(\frac{Ask_{i,t}+Bid_{i,t}}{2} - P_{i,t}\right) for\ marketable\ \ sells \end{cases}$, 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 spreads 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	339	2,463	1,450
Value	$24,316,808	$123,616,405	$706,561,597
Price	$6.42	$13.13	$28.19
Trade Size	645	292	193
Share Volume	317,049	791,827	2,937,387
Number of Trades	676	3,129	11,109
TRF Trade Size	918	401	282
Exchange Trade Size	548	246	169
% of Volume Reported through a TRF	47.3%	42.0%	28.8%
Time-Weighted $ Quoted Spread	$0.064	$0.086	$0.035
Time-Weighted % Quoted Spread	1.67%	1.42%	0.21%
Share-weighted $ Effective Spread	$0.057	$0.066	$0.027
Share-weighted % Effective Spread	1.61%	1.17%	0.17%
Share-weighted $ Realized Spread	$0.018	$0.031	$0.005
Share-weighted % Realized Spread	0.54%	0.59%	0.41%
Amihud Price Impact	2.899E-6	6.313E-6	4.901E-8
Standard Deviation of Intra-day Return	0.010	0.008	0.005
Standard Deviation of Daily Return	0.042	0.037	0.029

Table 2

Descriptive Statistics by TRF Quartile

This table contains October 2009 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 spread are relative to the contemporaneous quote midpoint. Effective dollar spreads are calculated using SEC Rule 605 and are defined as $\$Effective\ Spread_{i,t}^{MC} = \begin{cases} 2\left(P_{i,t} - \frac{Ask_{i,t}+Bid_{i,t}}{2}\right) for\ marketable\ \ buys \\ 2\left(\frac{Ask_{i,t}+Bid_{i,t}}{2} - P_{i,t}\right) for\ marketable\ \ sells \end{cases}$, 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 an order is received by a market center. Effective spread is share-weighted across market centers. Percentage effective spreads 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	1,063	1,063	1,063	1,062
Minimum % of Trade Volume Reported Through a TRF	6.7%	27.31%	35.31%	47.61%
Maximum % of Trade Volume Reported Through a TRF	27.31%	35.31%	47.61%	78.63%
Number of AMEX firms	16	34	115	174
Number of NASDAQ firms	283	606	751	822
Number of NYSE firms	764	423	197	66
Value	$617,701,522	$460,135,520	$156,691,278	$122,257,340
Price	$33.67	$22.14	$11.17	$4.11
Trade Size	162	200	315	469
Share Volume	1,376,814	2,039,197	1,880,643	645,787
Number of Trades	7,948	8,903	4,715	1,053
Time-Weighted $ Quoted Spread	$0.08	$0.06	$0.07	$0.06
Time-Weighted % Quoted Spread	0.33%	0.55%	1.20%	2.02%
Share-weighted $ Effective Spread	$0.052	$0.047	$0.058	$0.052
Share-weighted % Effective Spread	0.23%	0.43%	1.04%	1.75%
Share-weighted $ Realized Spread	$0.018	$0.019	$0.025	$0.024
Share-weighted % Realized Spread	0.09%	0.19%	0.48%	0.83%
Amihud Price Impact	2.97E-7	4.02E-6	4.11E-6	7.184E-6
Standard Deviation of Intra-day Return	0.004	0.006	0.008	0.011
Standard Deviation of Daily Return	0.024	0.029	0.036	0.049

Table 3
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 2009. Stocks traded at least 11 days during October. The following model is used to control for factors known to be related to spreads:

$$S_i = \beta_0 + \beta_1 \overline{Price_i} + \beta_2 \overline{Volume_i} + \beta_3 \bar{\sigma}_i + \beta_4 \overline{\%TRF_i} + \beta_5 \overline{\%TRF_i^2}$$

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. Outliers with a DFFITS statistic >$2\sqrt{\frac{5}{obs}}$ are excluded. Panel A (B) contains the results for dollar (percentage) spreads. *t* statistics are in italics.

A. Dollar Quoted Spreads

Market Segment	Intercept	Price	Volume	σ	%TRF	%TRF²	*Adjusted R²*
Overall n=4,140	0.294 *30.21****	0.002 *31.11****	-0.026 *-61.61****	2.844 *12.26****	0.168 *4.57****	-0.251 *-5.92****	*0.521*
AMEX n=321	0.139 *4.32****	0.006 *12.73****	-0.016 *-15.81****	1.205 *3.17****	0.153 *1.22*	-0.111 *-0.84*	*0.609*
NASDAQ n=2,400	0.492 *28.00****	0.002 *13.89****	-0.033 *-47.40****	3.236 *9.06****	-0.289 *-4.28****	0.191 *2.59****	*0.521*
NYSE n=1,394	0.122 *22.92****	0.0007 *23.21****	-0.011 *-43.46****	2.366 *11.09****	0.170 *6.42****	-0.263 *-6.77****	*0.614*
			B. Percentage Quoted Spreads				
Overall n=4,050	0.033 *29.13****		-0.0028 *-55.23****	1.741 *51.51****	-0.004 *-0.97*	-0.0013 *-0.25*	*0.693*
AMEX n=315	0.032 *6.59****		-0.004 *-25.49****	1.754 *29.71****	0.076 *3.72****	-0.093 *-4.28****	*0.814*
NASDAQ n=2,316	0.038 *19.17****		-0.004 *-45.40****	2.358 *44.90****	0.028 *3.59****	-0.046 *-5.17****	*0.725*
NYSE n=1,398	0.009 *29.15****		-0.001 *-42.79****	0.307 *24.09****	-0.008 *-4.76****	0.022 *8.70****	*0.749*

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

Table 4

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 2009. Stocks traded at least 11 days during October. Effective dollar spreads are calculated using SEC Rule 605 and are defined as $\$Effective\ Spread_{i,t}^{MC} = \begin{cases} 2\left(P_{i,t} - \frac{Ask_{i,t}+Bid_{i,t}}{2}\right) for\ marketable\ \ buys \\ 2\left(\frac{Ask_{i,t}+Bid_{i,t}}{2} - P_{i,t}\right) for\ marketable\ \ sells \end{cases}$, 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 are relative to the monthly value weighted average price. The following model is used to control for factors known to be related to spreads:

$$S_i = \beta_0 + \beta_1\overline{Price}_i + \beta_2\overline{Volume}_i + \beta_3\bar{\sigma}_i + \beta_4\overline{\%TRF}_i + \beta_5\overline{\%TRF}_i^2$$

where S_i is either dollar or percentage share-weighted effective 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. Outliers with a DFFITS statistic >$2\sqrt{\frac{5}{obs}}$ are excluded. Panel A (B) contains the results for dollar (percentage) spreads. *t* statistics are in italics.

Market Segment	Intercept	Price	Volume	σ	%TRF	%TRF²	*Adjusted R²*
A. Dollar Effective Spreads							
Overall n=4,126	0.217 *32.31****	0.001 *20.36****	-0.018 *-63.39****	1.882 *11.57****	0.133 *5.26****	-0.191 *-6.58****	*0.516*
AMEX n=319	0.088 *2.90****	0.005 *11.91****	-0.015 *-16.17****	1.790 *4.75****	0.291 *2.47***	-0234 *1.91**	*0.582*
NASDAQ n=2,388	0.316 *27.43****	0.002 *16.65****	-0.023 *-49.89****	2.635 *11.22****	-0.075 *-1.68**	0.011 *0.23*	*0.548*
NYSE n=1,400	0.086 *19.73****	0.0005 *21.89****	-0.008 *-39.77****	2.065 *11.70****	0.155 *7.14****	-0.212 *-6..68***	*0.572*
B. Percentage Effective Spreads							
Overall n=4,078	0.024 *26.77****		-0.002 *-54.71****	1.505 *55.65****	0.00005 *0.01*	-0.006 *-0.14*	*0.722*
AMEX n=323	0.034 *6.08****		-0.004 *-22.42****	1.691 *23.10****	0.060 *2.57***	-0.070 *-2.84****	*0.743*
NASDAQ n=2,334	0.027 *17.97****		-0.003 *-45.48****	1.890 *46.87****	0.023 *3.96****	-0.030 *-4.51****	*0.745*
NYSE n=1,400	0.007 *25.81****		-0.0005 *-37.29****	0.272 *23.60****	0.010 *-7.16****	0.027 *12.32****	*0.748*

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

Table 5
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 2009. Stocks traded at least 11 days during October. Realized dollar spreads are calculated using SEC Rule 605 and are defined as $\$Realized\ Spread_{i,t}^{MC} = \begin{cases} 2\left(P_{i,t} - \frac{Ask_{i,t+5} + Bid_{i,t+5}}{2}\right) for\ marketable\ \ buys \\ 2\left(\frac{Ask_{i,t+5} + Bid_{i,t+5}}{2} - P_{i,t}\right) for\ marketable\ \ sells \end{cases}$, 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 are relative to the monthly value weighted average price. The following model is used to control for factors known to be related to spreads:

$$S_i = \beta_0 + \beta_1 \overline{Price_i} + \beta_2 \overline{Volume_i} + \beta_3 \bar{\sigma}_i + \beta_4 \overline{\%TRF_i} + \beta_5 \overline{\%TRF_i^2}$$

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. Outliers with a DFFITS statistic >$2\sqrt{\frac{5}{obs}}$ are excluded. Panel A (B) contains the results for dollar (percentage) effective spreads. *t* statistics are in italics.

Market Segment	Intercept	Price	Volume	σ	%TRF	%TRF²	*Adjusted R²*
A. Dollar Realized Spreads							
Overall n=4,113	0.09617 *25.84****	0.00036 *12.59****	-0.008 -51.02***	0.646 *7.00****	0.019 *4.54****	-0.088 *-5.41****	*0.406*
AMEX n=322	-0.003 *-0.21*	0.002 *11.14****	-0.004 *-8.93****	0.541 *3.10****	0.174 *3.23***	-0.156 *-2.79****	*0.446*
NASDAQ n=2,380	0.157 *23.49****	0.001 *13.90****	-0.012 *-43.64****	1.163 *8.40****	-0.020 *-0.79*	-0.010 *-0.37*	*0.476*
NYSE n=1,413	0.019 *9.77****	0.0001 *17.05****	-0.002 *-21.36****	0.288 *3.51****	0.032 *3.13****	-0.025 *-1.65**	*0.327*
B. Percentage Realized Spreads							
Overall N=4,059	0.012 *19.67****		-0.001 *-39.67****	0.681 *39.24****	-0.001 *-0.57*	0.001 *0.49*	*0.566*
AMEX N=320	0.006 *1.92**		-0.001 *-8.75****	0.702 *15.05****	0.027 *2.12***	-0.035 *-2.55***	*0.471*
NASDAQ N=2,328	0.014 *13.44****		-0.002 *-34.13****	0.872 *31.99****	0.003 *3.14****	-0.164 *-3.50****	*0.596*
NYSE N=1,405	0.002 *15.16****		-0.0001 *-18.89****	0.038 *6.13****	-0.005 *-6.09****	0.012 *9.51****	*0.419*

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

Table 6

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 we average the number over the number of days traded in October 2009. 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 >$2\sqrt{\frac{1}{obs}}$ are excluded. *t* statistics are in italics.

Market Segment	Intercept	%TRF	*Adjusted R^2*
Overall n=4,226	-1.01E-6 *-3.19****	6.23E-6 *7.89****	*0.002*
AMEX n=324	0.000002 *2.22****	-7.82E-7 *-0.47*	*0.002*
NASDAQ n=2,443	-1.49E-7 *-0.21*	5.60E-6 *3.45****	*0.004*
NYSE n=1,450	-9.15E-8 *-1.16*	4.88E-7 *1.86**	*0.002*

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

Table 7

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 2009. 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. Outliers with a DFFITS statistic >$2\sqrt{\frac{2}{obs}}$ are excluded.Results are reported overall as well as by market segment. *t* statistics are in italics.

Market Segment	Intercept	NumTrades	%TRF	*Adjusted R^2*
Overall n=4,088	0.0006 *4.31****	-2.43E-8 *-6.80****	0.017 *50.54****	*0.414*
AMEX n=329	0.003 *2.75****	-1.77E-7 *-1.04*	0.015 *6.47****	*0.110*
NASDAQ n=2,359	0.0004 *1.69**	-4.54E-8 *-5.77****	0.017 *35.29****	*0.371*
NYSE n=1,405	0.001 *6.35***	-1.01E-8 *-4.09****	0.014 *23.87****	*0.291*

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

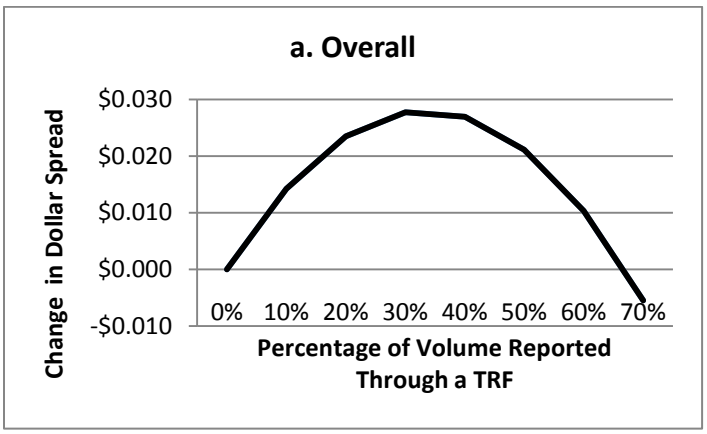
Figure 1

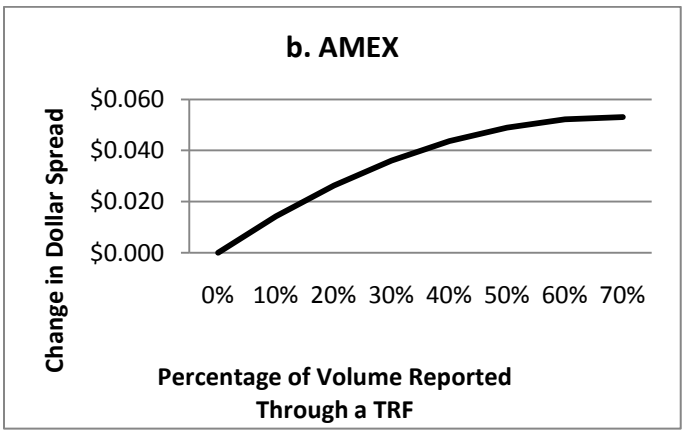
Expected Dollar Quoted Spreads

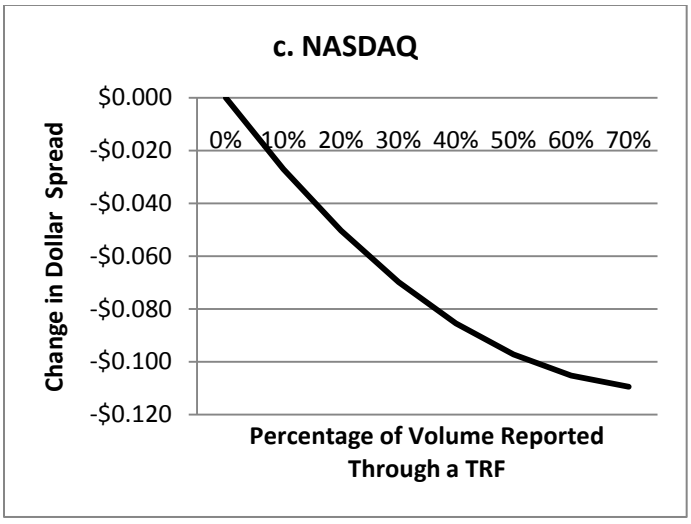
This figure illustrates the impact of reporting trades through a Trade Reporting Facility (TRF) on spread width. Percentage values of TRF reported volume are applied to the last two parameters of the following regression (holding the other parameters constant.)

$$S_i = \beta_0 + \beta_1 \overline{Price_i} + \beta_2 \overline{Volume_i} + \beta_3 \bar{\sigma}_i + \beta_4 \overline{\%TRF_i} + \beta_5 \overline{\%TRF_i^2}$$

where S_i is the dollar 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. The graph indicates the expected spread level for a stock with a portion of its volume reported through a TRF relative to a stock with the same price, volume, and volatility, but all trades reported through an exchange. Results are reported overall as well as by market segment.







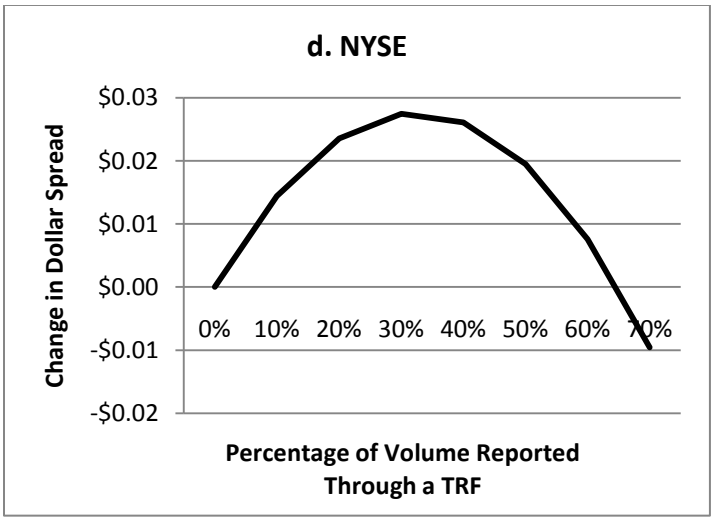


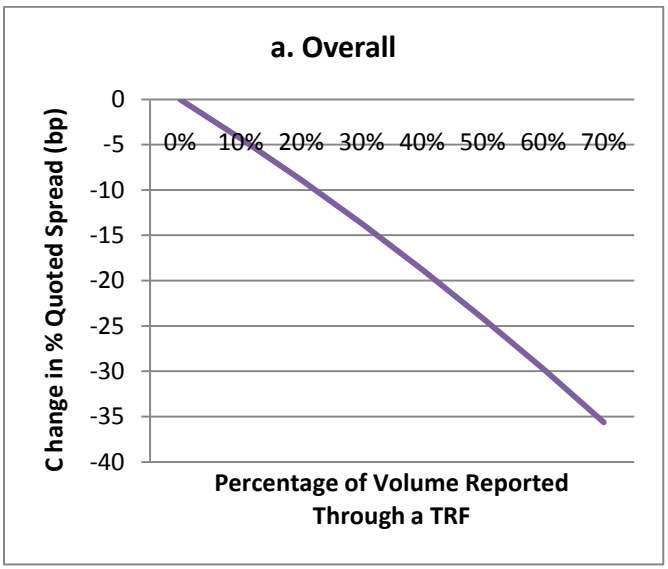
Figure 2

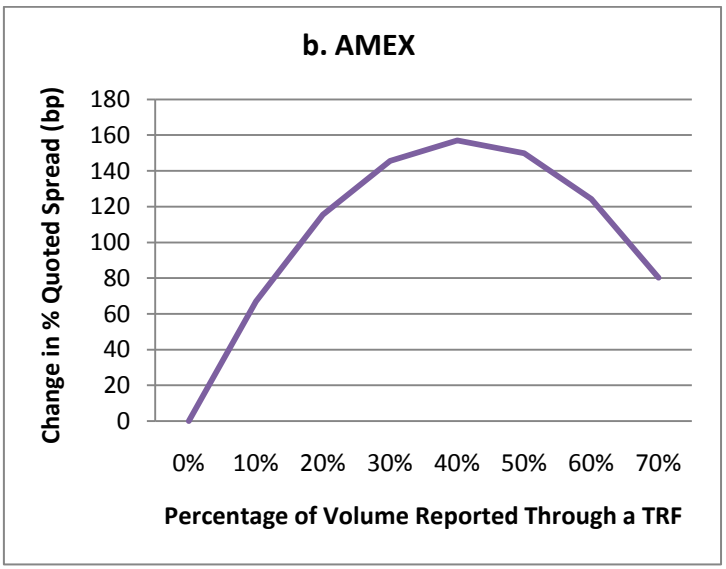
Expected Percentage Quoted Spreads

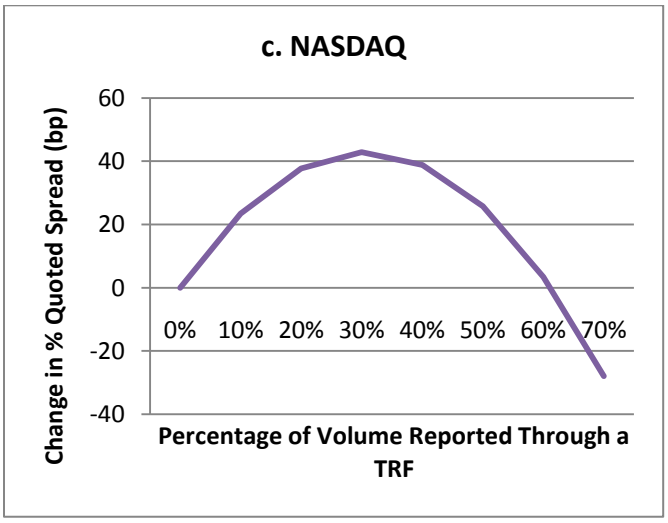
This figure illustrates the impact of reporting trades through a Trade Reporting Facility (TRF) on spread width. Percentage values of TRF reported volume are applied to the last two parameters of the following regression (holding the other parameters constant.)

$$S_i = \beta_0 + \beta_1 \overline{Price_i} + \beta_2 \overline{Volume_i} + \beta_3 \bar{\sigma}_i + \beta_4 \overline{\%TRF_i} + \beta_5 \overline{\%TRF_i^2}$$

where S_i is the 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. The graph indicates the expected spread level for a stock with a portion of its volume reported through a TRF relative to a stock with the same price, volume, and volatility, but all trades reported through an exchange. Results are reported overall as well as by market segment.







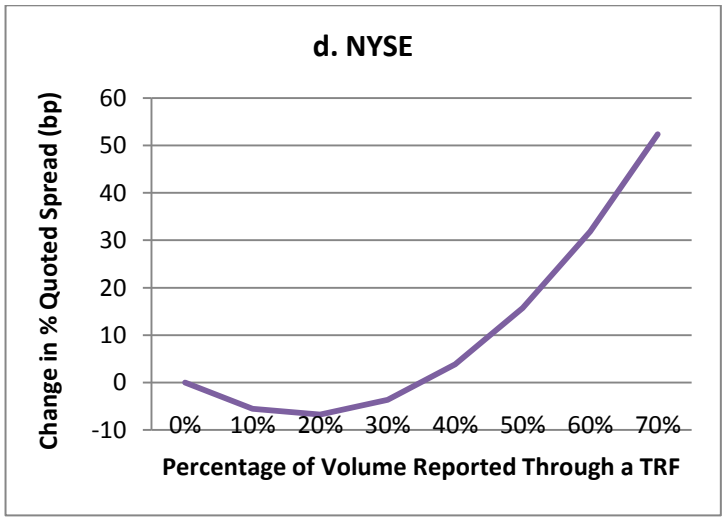


Figure 3

Expected Dollar Effective Spreads

This figure illustrates the impact of reporting trades through a Trade Reporting Facility (TRF) on spread width. Percentage values of TRF reported volume are applied to the last two parameters of the following regression (holding the other parameters constant.)

$$S_i = \beta_0 + \beta_1 \overline{Price_i} + \beta_2 \overline{Volume_i} + \beta_3 \bar{\sigma}_i + \beta_4 \overline{\%TRF_i} + \beta_5 \overline{\%TRF_i^2}$$

where S_i is the dollar share-weighted effective 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. The graph indicates the expected spread level for a stock with a portion of its volume reported through a TRF relative to a stock with the same price, volume, and volatility, but all trades reported through an exchange. Results are reported overall as well as by market segment.

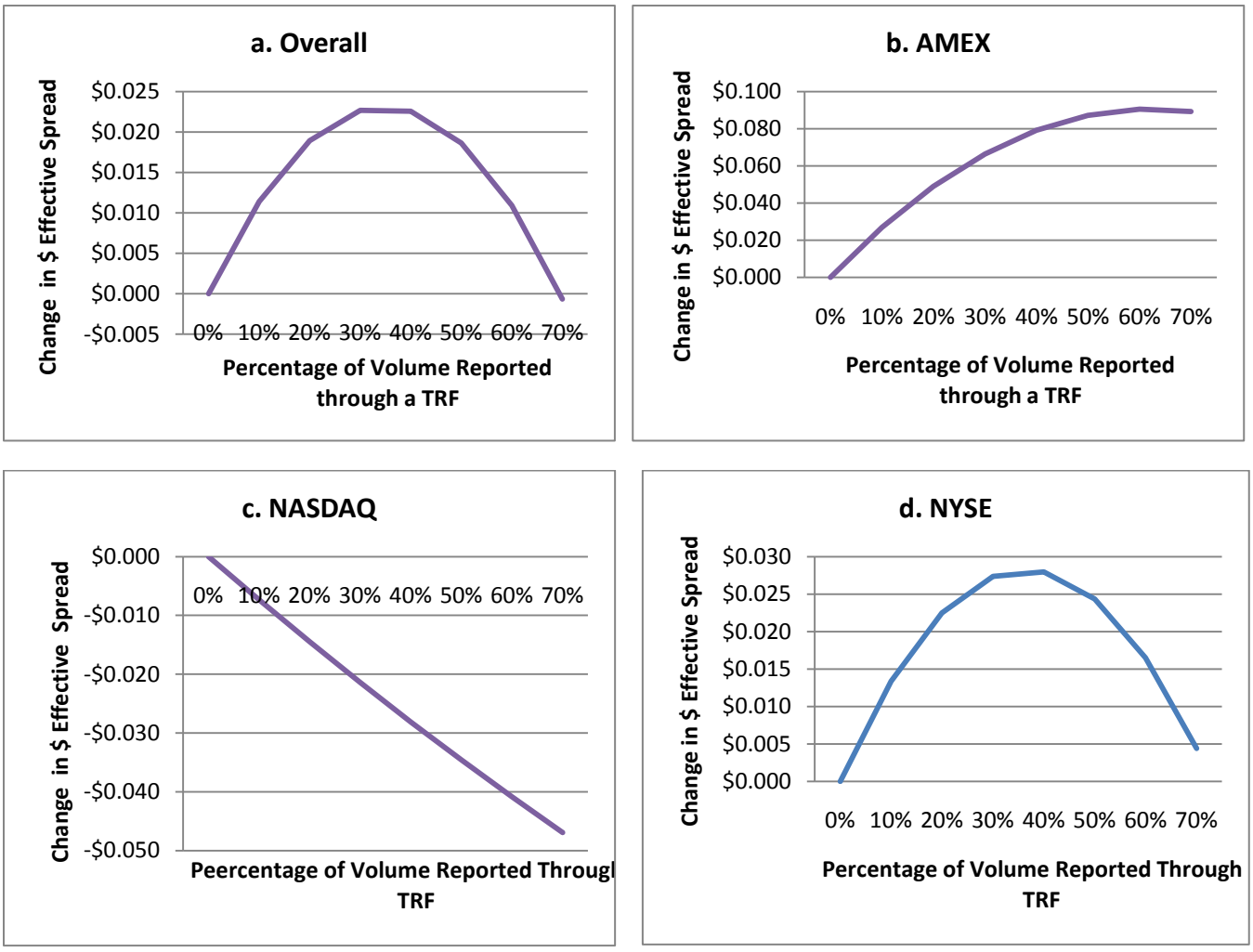


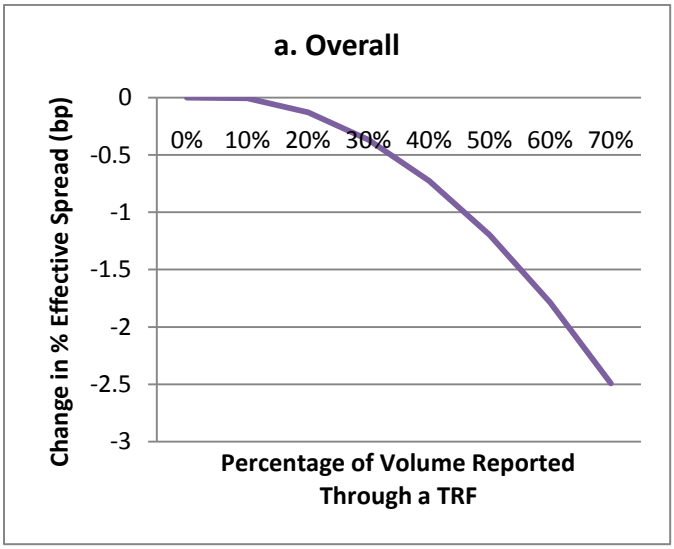
Figure 4

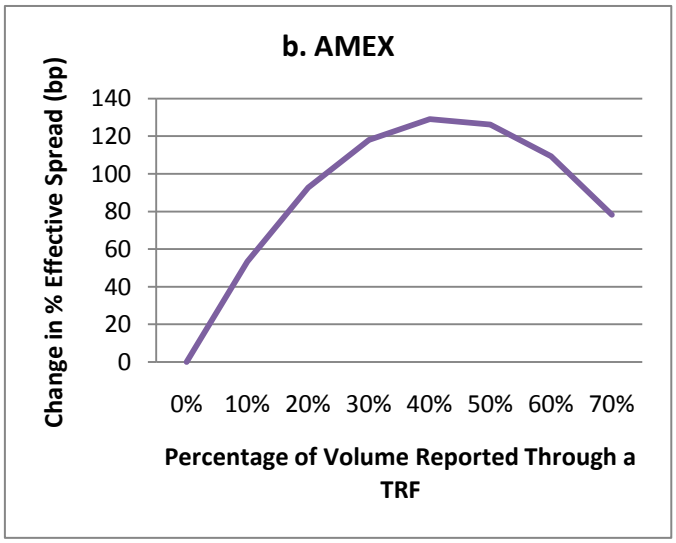
Expected Percentage Effective Spreads

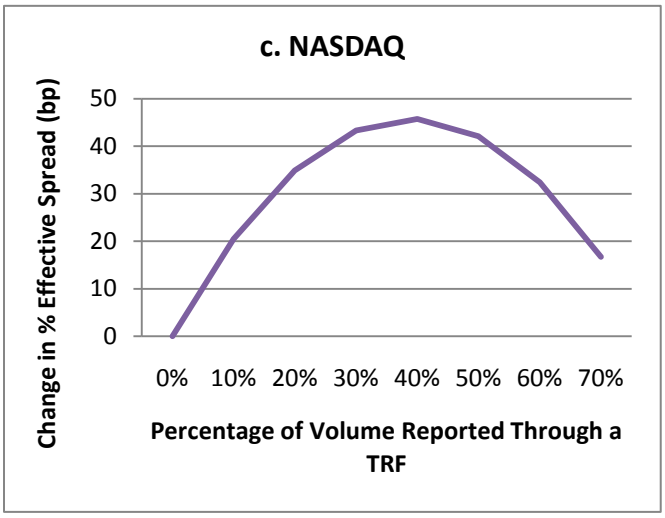
This figure illustrates the impact of reporting trades through a Trade Reporting Facility (TRF) on spread width. Percentage values of TRF reported volume are applied to the last two parameters of the following regression (holding the other parameters constant.)

$$S_i = \beta_0 + \beta_1 \overline{Price_i} + \beta_2 \overline{Volume_i} + \beta_3 \bar{\sigma}_i + \beta_4 \overline{\%TRF_i} + \beta_5 \overline{\%TRF_i^2}$$

where S_i is the share-weighted percentage effective 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. The graph indicates the expected spread level for a stock with a portion of its volume reported through a TRF relative to a stock with the same price, volume, and volatility, but all trades reported through an exchange. Results are reported overall as well as by market segment.







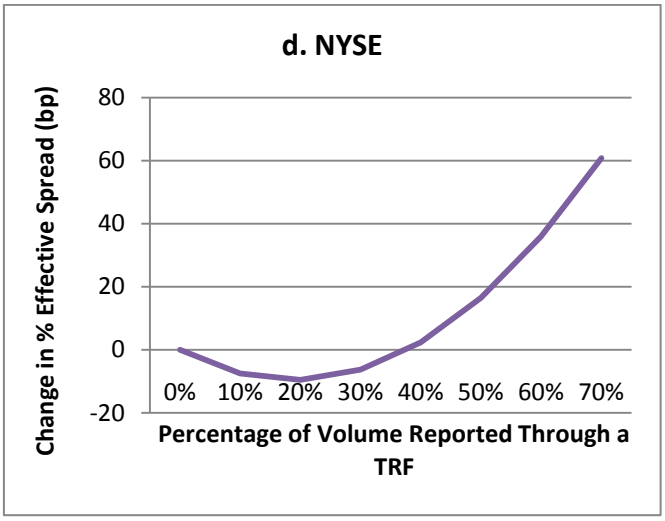


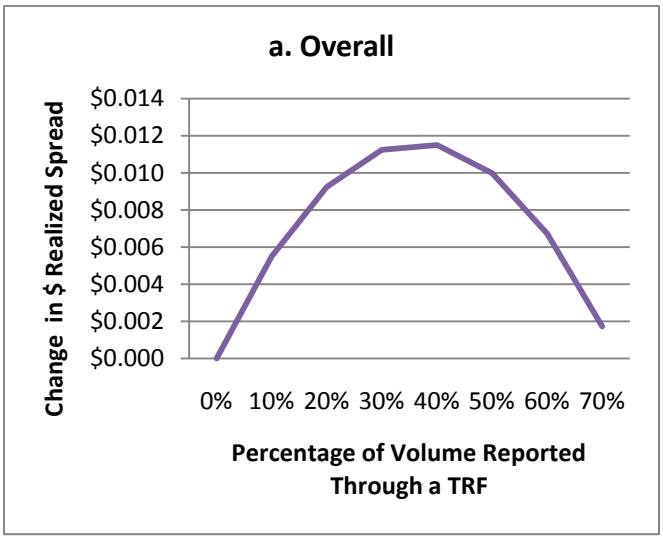
Figure 5

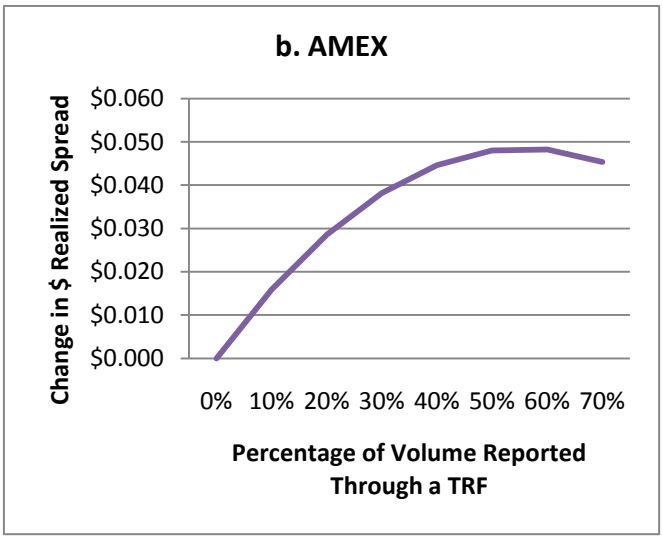
Expected Dollar Realized Spreads

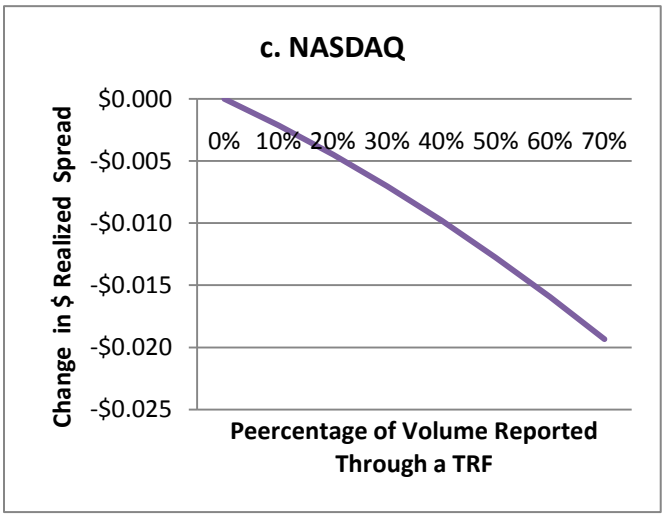
This figure illustrates the impact of reporting trades through a Trade Reporting Facility (TRF) on spread width. Percentage values of TRF reported volume are applied to the last two parameters of the following regression (holding the other parameters constant.)

$$S_i = \beta_0 + \beta_1 \overline{Price_i} + \beta_2 \overline{Volume_i} + \beta_3 \bar{\sigma}_i + \beta_4 \overline{\%TRF_i} + \beta_5 \overline{\%TRF_i^2}$$

where S_i is the share-weighted dollar 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. The graph indicates the expected spread level for a stock with a portion of its volume reported through a TRF relative to a stock with the same price, volume, and volatility, but all trades reported through an exchange. Results are reported overall as well as by market segment.







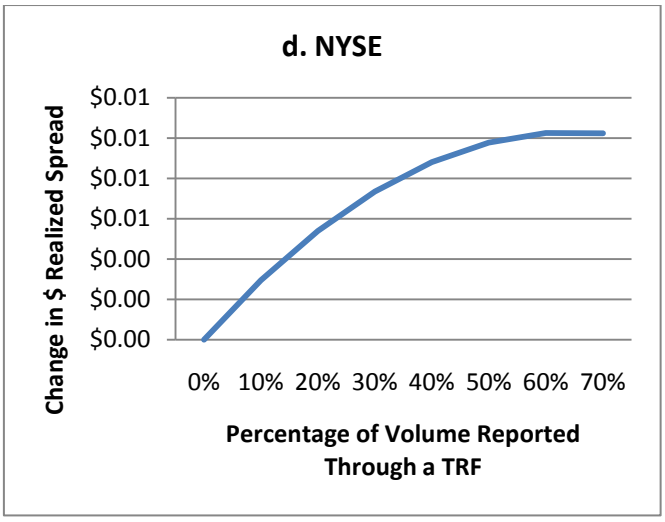


Figure 6

Expected Percentage Realized Spreads

This figure illustrates the impact of reporting trades through a Trade Reporting Facility (TRF) on spread width. Percentage values of TRF reported volume are applied to the last two parameters of the following regression (holding the other parameters constant.)

$$S_i = \beta_0 + \beta_1 \overline{Price_i} + \beta_2 \overline{Volume_i} + \beta_3 \bar{\sigma}_i + \beta_4 \overline{\%TRF_i} + \beta_5 \overline{\%TRF_i^2}$$

where S_i is the share-weighted percentage 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. The graph indicates the expected spread level for a stock with a portion of its volume reported through a TRF relative to a stock with the same price, volume, and volatility, but all trades reported through an exchange. Results are reported overall as well as by market segment.