Transparency in the Equity Market: Evidence from a Natural Experiment

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Abstract

Transparency has been promoted by the SEC as a measure that can reduce transaction costs and increase liquidity. However, theoretically, there are scenarios under which transparency might harm trading and some degree of opaqueness may be desirable for certain types of investors. The existing empirical evidence is still inconclusive as the benefits of transparency are not entirely positive across different markets. This paper contributes to the transparency literature by using the implementation of the National Market System (NMS) as an exogenous shock to the post-trade transparency (price information after a trade) in the equity market and measuring its effect on transaction costs. Our sample covers the period when new technology was first introduced on NASDAQ and the implementation of second tier firms in the NMS. The main finding of our study−that the improvement of information quality after a trade as a result of the stock being included in the NMS reduces the quoted spreads and return volatility−will help guide the creation of comprehensive policies that can effectively maintain a fair and orderly stock market.

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> “At the Commission level, there has been a lot of discussion about issues such as enhanced pre and post trade disclosures and transparency, and market structure issues relating to increased liquidity and the facilitation of electronic trading.”
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> Daniel M. Gallagher
> SEC Commissioner
> New York, NY
> March 10, 2015

1. Introduction

It has been the mission of the SEC *to protect investors, maintain fair, orderly, and efficient markets, and facilitate capital formation*. Unfortunately, the rules and regulation that have been created to fulfill the SEC’s mission have been sometimes met with opposition. For example, in 1982, when the SEC implemented the National Market System (NMS) to open up the opaque OTC market, several NASDAQ dealers initially opposed the measure, arguing that increased transparency would affect the riskiness of holding inventories (e.g. Mulherin, 1993). In this paper we provide evidence that market quality actually improved after the implementation of the NMS to counter this argument. Specifically, the transaction costs of firms that were heavily traded were reduced after 60 trading days, and the volatility of stock returns decreased after firms began trading on the NMS. The results are relevant and important to the study of market quality because these are the effects of post-trade transparency (information after a trade) in the equity market, which has not been rigorously studied in the literature. Most of the existing empirical research tests the effects of pre-trade transparency (information prior to a trade) in the equity market or post-trade transparency in the bond market.

We aim to make an important contribution to the market transparency literature by not only analyzing post-trade transparency in the equity market but also identifying the types of firms that are likely to be differentially affected. Easley, Hendershott, and Ramadori (2014) also study an event from 1980 to analyze the effects of transparency on liquidity and asset prices. In 1980, the NYSE implemented new technology that improved the speed of reporting trades and quotes. They found that stocks that benefitted from the new technology, experienced lower transaction costs and an increase in turnover. Furthermore, transparency has recently attracted the attention of academics, practitioners and regulators due to the prevalence of dark pools of money and their effect on price discovery (Ye, 2012; Zhu, 2014). Exchanges are also selling data that creates a preferential access to price information, which inhibits transparency and a fair market (Easley, O'Hara, and Yang, 2016).

At its onset, the NMS had 49 firms that satisfied the criteria specified by the SEC such as volume, market value, and price in June 1982. Afterwards, the NMS was expanded to include additional 2,883 firms till December 1989. Among the qualities that the NMS brought to the stock market was the availability of last-sale and high-and-low price trades of the firms that composed the NMS. The increasing transparency may protect investors and at the same time benefit market makers if there is an increase in volume. Baker and Edelman (1992) provide evidence of a decrease in transaction costs derived from the expansion of the NMS in 1983. Bessembinder, Maxwell, and Venkatamaran (2006) study the effects of increased transparency on the bond market after the Trade Reporting and Compliance Engine (TRACE) was introduced in 2002. They find an increase in liquidity and a decrease in transaction costs for bonds that were included in TRACE. In addition, there are indirect effects derived from increased transparency, such as a liquidity spillover, which generates similar economic effects but of less magnitude for bonds that were not part of TRACE. Edwards, Harris, and Piwowar (2007) and Goldstein, Hotchkiss, and Sirri (2007) also find a decrease in transaction costs after the increased transparency that TRACE brought to the bond market.

Although the NMS was designed to facilitate a transparent national market, market makers of the firms that became part of the NMS were not enthusiastic because the general availability of last-price information would reduce the profitability of trading these stocks. Therefore, regulation designed to transform an opaque market into a transparent one can be counterproductive if dealers cannot extract profits that will enable them to continue operating, resulting in a decrease in market depth and, subsequently, an increase in transaction costs. Indeed, several studies have attempted to understand the unintended consequences of transparency. Bloomfield and O'Hara (2000) utilize a laboratory experiment where they find that in an environment with opaque and transparent dealers, there is a dominating strategy of switching to an opaque position. Madhavan, Porter, and Weaver (2005) document that spreads and volatility increase and prices decrease after the event by studying the effects the Toronto Stock Exchange. If market makers have a choice of providing liquidity in either the NMS or the more opaque OTC market, a decline in liquidity is plausible. Unfortunately, there is not a single ideal market for the diverse needs of investors, and therefore, exchanges with different levels of transparency can coexist.

The existing results from the literature provide different conclusions about the benefits (or the costs) of increased disclosure. One possible explanation for this divergence is the advances in technology and processing of information (Boehmer, Saar, and Yu, 2005). However, these divergent results focus solely on pre-trade transparency. Other studies that focus on post-transparency are very limited in their scope (Baker and Edelman, 1992). This last study covers from 1982 to 1987 but limits its sample to those firms that were heavily traded during the period, which leaves them with a sample size of 461 firms, and does not control for changes in exogenous variables. Apparently the controversy over the NASDAQ trading procedures and the contrasting implications of different findings suggest that future empirical research should focus on estimating the benefits over the costs (or vice versa), which is precisely the objective of this study. We use the implementation of the NMS as an exogenous increase in the post-trade transparency in the stock market and measuring the (potentially causal) impact on market quality. This is a worthwhile question because it provides evidence of the net effects of post-trade transparency on the equity market.

Using a matched sample of stocks (i.e., being included and excluded in the NMS) we find a decrease in spreads when market transparency is enhanced (by comparing 60 trading days before and after the inclusion into the NMS). Our result is similar to that of Bessembinder, Maxwell, and Venkatamaran (2006) who report a reduction in execution costs but the magnitude is higher for the bonds eligible for TRACE transaction reporting than those not eligible. This is consistent with the liquidity externality suggested by Amihud, Mendelson, and Lauterbach (1997) that market has more information to value similar securities. More importantly, we find that the decrease in transaction costs, stock return volatility, and short-term abnormal returns is much larger for heavily traded stocks, which may be attributable to the fact that an increase on transparency will not further diminish trading costs for firms already trading at very low spreads. In a robustness check, we remove the stocks with spreads lower or equal to \$0.25 in the period prior to trading in the NMS because of the well-known propensity of dealers to implicitly collude to keep spreads at a minimum of \$0.25,[1] and the results confirm the significant reduction in the trading costs for heavily traded stocks.

[1] Since collusion would prevent spreads from narrowing below \$0.25 due to transparency changes.

The remainder of the paper is organized as follows. Section 2 discusses the related literature of transparency. Section 3 presents a description of the National Market System, a history of the regulatory initiatives that preceded it, and the implementation process that the SEC and the NASD established. Section 4 specifies the hypotheses of the project and Section 5 describes the data and the sample. Section 6 presents the results and the last section concludes.

2. Related literature

Our work is related to several strands of growing literature on market transparency. Madhavan (2000) refers to transparency as a major topic of debate in market microstructure. Typically, transparency is categorized as pre- or post- trade. Pre-trade transparency reveals information prior to a transaction. Madhavan (2000) refers to post-trade transparency as *public and timely dissemination of trade information*. Porter and Weaver (1998) define post-trade transparency as the *amount of trading information that is made publicly available on a timely basis following a completed transaction.* After reviewing the extant theoretical, empirical, and experimental literature on transparency, Madhavan concludes that different investors have heterogeneous market structure preferences. He summarizes four main findings: first, transparency is relevant and affects price discovery, second; complete transparency can reduce liquidity; third, some disclosure is better than no disclosure; fourth, changes in transparency affect different groups. This paper contributes to the empirical study of post-trade transparency by examining changes in market quality following the adoption of contemporaneous trade reporting for NASDAQ stocks included in the National Market System.

2.1. Theoretical research

A number of papers have theoretically examined the impact of various types of transparency on market quality. For example, Admati and Pfeiderer (1991) explore features of sunshine trading (defined as traders pre-announcing the size of their orders). The authors explore two characteristics of pre-announcement. First, by preannouncing an order, the market can coordinate supply and demand and thereby prepare to absorb the position. This preparedness could lower the price impact of the transaction. Second, identification of noise trades (orders that are not based on private information). If pre-announcement is done by this type of traders, the market understands that these transactions are uninformative and therefore the price impact should be minimal. However, they show that preannouncement reduces total expected trading costs. Furthermore, any costs that arise from announcing are offset by the decrease in expected trading costs. To add a new perspective to our understanding of market transparency, Chowdry and Nanda (1991) study the effects of market makers transmitting price information of a security trading at multiple locations. The objective is to identify informed trading which should help attract liquidity traders and increase liquidity in the market. Because market makers are competing to offer the lowest transaction costs, it is in their interest to display information that deters the costs of adverse selection. In this sense, providing price information after each trade on the NMS should help the price discovery process and thus lower transaction costs. They conclude that even in the absence of regulation, market-makers are motivated to disclose price information to deter informed trading.

It is generally believed that centralized and fragmented markets differ in the level of transparency. In centralized markets, trades are the result of multilateral information in which a quote is displayed to all market participants. After receiving this information, participants can improve the quote until they reach their reservation price. Fragmented markets differ in that trades are the result of bilateral negotiations with dealers; which makes the fragmented markets less transparent. Through simulation, Biais (1993) observes a reduction on the fixed entry price of centralized markets but with less volatility on the spreads of fragmented markets. These results are due to the structure of the market holding all other elements equal. Rather than favoring one market structure over other, Bias concludes that both markets coexist because computerization decreases the cost of entry in centralized markets but the spreads are less volatile in fragmented markets. A natural question that arises with respect to this finding is whether fragmented markets have a tendency to consolidate. Madhavan (1995) defines a consolidated market as a market where dealers have homogeneous beliefs that generates identical prices. In contrast in a fragmented market dealers do not disclose information and prices might be different across markets at the same time. Madhavan argues that there is a relationship between disclosure, fragmentation, and consolidation. This relationship exists because it is believed that traders gravitate to the most liquid and efficient market, therefore the primary market consolidates. However, markets that do not require disclosure, such as the foreign exchange market are not consolidated. Madhavan concludes that it is unlikely that markets will consolidate given the preference for nondisclosure amongst informed traders and large liquidity traders. Short-term noise traders also benefit from nondisclosure in the initial round. Dealers offer lower spreads at the beginning to obtain price information from the order flow, this information will be later used to extract rents in subsequent rounds of trading. Madhavan suggests that rules that require dealers to disclose should be relaxed to allow them to compete with dealers in markets that do not have post-trade transparency.

It remains an interesting question to examine whether the availability of different transparency levels across divergent trading structures influences the choice of market participation. Indeed, Pagano and Roell (1996) study the effects of adverse selection in exchanges that differ in their level of transparency. Their hypothesis is that access to transparency by market makers is a bigger driver of transaction costs for customers than access to information by customers themselves. Pagano and Roell define transparency as visibility of the order flow. There are four types of markets studied. First, the transparent call auction market where traders submit their orders simultaneously to a central auctioneer and where orders are cleared at a common price. In this model the size and direction of all orders are known to all participants. Second, a batch auction market where there is also simultaneous clearing of orders at a common price but prices are established with all participants having knowledge of the net order flow but not its composition. Third, a continuous auction exchange where prices are formed by observing the history of the order flow and market orders are filled one by one. The final market is of the dealership type, where an individual dealer satisfies each order and does not know the orders received by the rest of the dealers. In this market, prices are determined by each order.

Using the model of Easley and O’Hara (1987) with two trade sizes and security values (i.e., high vs. low), they suggest that, on average, noise traders benefit from greater transparency. After computing the possible combinations of orders arriving in the market, their probabilities, and the transparent auction price, they establish the insider's strategy based on different parameters. When the ratio of the size of large to small orders is at least two, the insider trades large blocks in both auction and dealer markets. But when this ratio is smaller than two, the insider is more likely to place large orders in the dealer market. Therefore, trading costs of noise traders are lower on average in the transparent auction market.

Although the general consensus from these theoretical studies discussed above is that transparency improves market quality, there are contrasting findings in the empirical literature. Previous empirical studies are categorized into two groups: changes in pre-trade transparency and changes in post-trade transparency. Even within the category of post-trade transparency which is more relevant to this paper, the transparency issues in the equity and bond markets are examined separately and hence the order of the literature review below. The reason is due to the fundamental differences in liquidity, trade size, and the role of company specific information.

2.2. Post-trade transparency in the equity market

There are a number of empirical studies that investigate the relationship between post-trade transparency and market quality. The most closely related to this paper is Baker and Edelman (1992) which examines increases in post-trade transparency following a 1982 rule change requiring NASDAQ dealers to report all trades within 90 seconds of consummation. The authors obtain NASDAQ price, bid and ask quotes, and volume data for a random sample of 461 stocks that began trade reporting between April 1982 and December 1987. They remove thinly traded stocks and their sample is reduced to 280 common stocks. They conduct univariate tests for changes in some market quality measure. Without controlling for exogenous factors, they find that quoted spreads decrease for 56.8 percent of the stocks in their sample, percentage spreads decrease for 66.1 percent of their sample stocks, and trading volume increases for 60 percent of the firms. Descriptive statistics show that average volume increases by 2,277 shares and the standard deviation of the percentage spreads decreases from 4.24 percent to 3.84 percent required trade reporting. Baker and Edelman perform a series of univariate tests to test the robustness of their conclusions. However, a more in depth analysis is required to strengthen their conclusions.

This paper expands the time period between 1982 and 1989 and increases the sample to 2,916 firms. Furthermore, rather than eliminating thinly traded firms as Baker and Edelman (1992), we divide the sample size by terciles. This enables us to study a sample size ten times larger and compare the least and most traded firms while controlling for volume, volatility, and price. Finally, to make sure that our results are not due to general changes in markets, we build a matching sample based on market size. This control is important because Gemmill (1996) finds, after controlling for market wide volatility, that reducing the delay in publication of large trades in the LSE does not affects spreads. This comparison between the original sample and the matching group allows us to confirm that our results are due to increased post-transparency rather than to any market wide effect.

In an attempt to understand the effect in international markets, Gemmill (1996) focuses on block trades in the London Stock Exchange (LSE) between 1989 and 1996 when the LSE made several changes to the timing of the disclosure of block trades. In 1986, the LSE required all trades to be disclosed within 5 minutes of trade consummation. However, traders complained arguing that disclosing information on large trades would disrupt their trades because competitors would adjust their quotes. In response, the LSE changed the rules and starting in 1989 traders were given 24 hours to disclose large trades. In 1991 the window was shortened to 90 minutes. As Gemmill points out, there are two main opposing views regarding timing of information disclosure. Market makers believe that the immediate publication of large trades would negatively affect liquidity. They think that revealing large inventory positions can be very risky and would damage liquidity. The opposing view voiced by the United Kingdom's Office of Fair Trading is that a lack of disclosure generates an extra profit to those that have information about block trades, and creates losses for all other participants. Despite the changes in the disclosure period, Gemmill did not find statistically significant changes in liquidity and price impact. Delaying information neither changes spreads nor liquidity. He concludes that changes in spreads are largely due to market volatility. Gemmill posits that market makers oppose immediate publication because this might develop an upstairs market that would compete with them as is the case in the NYSE.

One of the advantages of the LSE is the ability to accommodate large trades immediately. The immediacy of execution is appealing to institutional traders but increases the inventory risk of market makers who hold these stocks. To protect market makers against these risks two measures have been adopted by the LSE. The first measure is the delay of trade publication to allow market makers to hedge their risks. The second method is the development of the inter dealer broker (IDB) system, which allows market makers to accommodate inventory among themselves. Because these measures generate information asymmetry, the customer initiating the large trade is subsidized by the counterparty of the market maker's protecting trades. Another concern is the market maker that has information on the large trade might be tempted to make profits by taking a position in the options market while post-trade transparency is being delayed. Interestingly, Board and Sutcliffe (1996) find no relationship between trade size and spreads and that market makers are not fully positioning their trades, suggesting that they are not concerned about individual trades but rather on the overall effect on their inventories. Additionally, there is a small but consistent price impact from delayed post-trade transparency, which can be eliminated with immediate post-trade transparency. Still, it is impossible to draw a conclusion from this study due to the joint effect of delayed post-trade transparency and the lack of positioning by market makers.

The timing effect of trade reporting is also investigated in the U.S. stock market. In 1982, the SEC mandated reporting of all equity trades in NASDAQ's NMS within 90 seconds. If trades could not be reported within 90 seconds, dealers were required to append a "late" code to the trade. Porter and Weaver (1998) examine the occurrence of late trade reports on centralized exchanges (NYSE, AMEX, and regionals) with those on NASDAQ for the calendar year 1990. The authors find that NASDAQ dealers report far more trades as late compared with the centralized exchanges and that the late trades are concentrated after the market has closed. In fact they find that the average total dollar volume of late reporting after market close on NASDAQ *is more than 13 times the out-of sequence reporting for the combined centralized exchanges for the same time period*. This is in spite of the fact that the average daily dollar volume of trading on NASDAQ is only a quarter of all of the centralized exchanges. After testing alternative explanations such as abnormal volume or fast market conditions, Porter and Weaver conclude that the most likely explanation for late reporting is that dealers want to delay the release of strategic information.

Overall, the extant research on the relation between post-trade transparency and equity market quality, as reviewed in this section, is inconclusive. In the next section, we will review some important works focusing on the U.S. corporate bond market that report consistent findings of a positive link between post-trade transparency of bond prices and bond market quality.

2.3. Post-trade transparency in the bond market

In addition to those empirical papers that examine changes in equity market transparency, several recent papers analyze the impact on market quality of increased post-trade transparency on the trading costs of bonds. In particular, they test the effect on bonds after the implementation of the Trade Reporting and Compliance Engine TRACE. The program started contemporaneously reporting transactions in approximately 500 corporate bonds in July 2002. Bessembinder, Maxwell, and Venkatamaran (2006) hereafter BMV, study the impact of increased post-trade transparency on the bond market. Their dataset covers transactions made by insurance companies during 2002. They look at bonds that were required to report under TRACE and compare them to bonds that didn't. The time frame is six months before and after the implementation of TRACE. Their results show that increased post-trade transparency is associated with lower transaction costs. In their model, variance in the errors of bond valuation increases transaction costs for two reasons. First, there is an increase in inventory risk for market makers for which they must be compensated. Second, there is an increase in the market power of dealers who can extract larger benefits from uninformed customers. There is a covariance effect that can reduce the transaction costs for the bond that does not increase its trade reporting transparency but has similarities with the more transparent bond. With this model, the authors expect that TRACE would not only reduce the transaction costs on the bond reporting under TRACE but also other bonds that are not part of TRACE. This improvement in the trading environment is part of the liquidity spillover derived from the implementation of TRACE.

There are two main consequences from the trade reporting requirements of TRACE. First, there is a direct effect that will reduce the transaction costs for trades reporting under this system. Second, there is an indirect effect that will reduce transaction cost for bonds that are not reporting under TRACE. Bonds that are not increasing their information disclosure but have similar values to TRACE-reporting bonds will have a higher covariance with TRACE bonds and thus their transaction costs will decrease. There are two main reasons behind the influence of increased transparency in decreasing transaction costs. First, opaque markets benefit informed dealers when negotiating with customers. Therefore, an increase in transparency should lower the information asymmetry. In addition, improved transparency can reduce market makers cost, which can also lower transaction costs. Second, the information disclosed under TRACE can be monitored by the SEC and self-regulatory organizations. After several tests, the authors conclude that TRACE decreased transaction costs by 50% for eligible bonds and by 20% for non-eligible bonds. In general, BMV estimate annual transaction cost reductions for the entire bond market of $1 billion.

As an extension to the BMV study, Edwards, Harris, and Piwowar (2007) include all TRACE transaction data (of both active and inactive bonds) to analyze secondary trades for corporate bonds and find a reduction in transaction costs with improved transparency. In addition, they control for the changes in liquidity that might be unrelated to the event by comparing transaction costs of three groups during 2003: AAA bonds that became TRACE transparent, AAA bonds that did not become transparent, and BBB bonds that were also not transparent. They also include cross-sectional analysis through which they can incorporate additional features such as Rule 144A restrictions or whether the bond is a global or a foreign-issuer's bond and confirm that transparent bonds have lower transaction costs than opaque bonds.

Similar results are obtained by Goldstein, Hotchkiss, and Sirri (2007). They study the impact of TRACE on BBB-rated corporate bonds from 2002 to 2004. They find that spreads decrease with increased transparency, especially for intermediate trade sizes. Goldstein, Hotchkiss, and Sirri also study the impact of transparency on liquidity and transaction costs. However, their study focuses solely on BBB bonds that were traded between July 2002 and February 2004. They select120 firms and divide them in two groups: 90 of the most actively traded and 30 that were relatively inactive. These 120 firms began disclosing trading information in April 12, 2003. They build a matching sample of the 90 bonds based on industry, trading volume, bond age, and time to maturity. The matching sample does not disseminate information. In addition, they construct a control portfolio consisting of bonds with an average number of daily trades that are within the range of the trading volume of the original sample, this group does not disseminate information after April 2003. The control group allows them to study the effects of transparency in different liquidity settings.

When measuring the impact of transparency on trading volume, the authors do not find a significant change in volume due to increased transparency. In order to measure the impact in trading costs, Goldstein et al. (2007) apply two methodologies. The first method is a direct computation of the cost of a dealer round trip (DRT), which is the dealer's cost of purchasing a bond from a customer and selling the same bond to another customer. The results from this method show that spreads fall from $2.35 per $100 face value for trades up to 10 bonds to a spread of $0.50 for trades of $1,000 bonds or more. In addition, they find results similar to BMV with regards to a liquidity spillover. Spreads fall for both the bonds that disseminate information and those bonds that do not disseminate after April 2003, the date when bonds started disseminating public information. The authors categorize the bonds according to the number of trades. After April 2003 when the trade size is between 51 and 100 bonds, the spread decreases from $0.81 to $0.26 for the disseminated bonds. In the case of the non-disseminated matching group, the decrease in spreads is from $0.73 to $0.46. For the disseminated group, the decrease in spreads is significant across all trade sizes. The non-disseminated matching group also experiences a decrease in spreads but with weaker results. The non-disseminated control group experiences an increase in spreads at the smaller trade sizes but a decrease for the larger trades. The second method employed to measure trading costs is based on regression estimates of the transaction prices and the previous day's bid price. The results confirm the estimations based on the DRT methodology.

The consensus of the studies reviewed in this section is that the availability of posts-trade bond price information improves market quality. However, due to the differences in the trading volume between the bond market and the stock market, these results need to be carefully generalized.

2.4. Experimental studies

In addition to the above research mainly based on observational data, there is a series of experiments conducted under a controlled setting in which the authors test the effects of transparency on the market. Bloomfield and O'Hara (1999) use a laboratory experiment with Cornell students to test the effects of post-trade transparency on informational efficiency, spreads, and trader's welfare in a dealer market. There are three degrees of market transparency. The most transparent discloses market maker's quotes and trades after each round of trading, the semi-opaque discloses only quotes, and in the opaque there is no public information on trades or quotes. Therefore this paper only focuses on the effects of post-trade transparency, which is the public disclosure of information after trade execution. To measure the effects of trade transparency, the authors compare the results between the quote and trade transparent market with those of the quote transparent market. To measure the effects of quote transparency, the authors compare the results between the quote-transparent market and the opaque market. The experiment is composed of market makers that quote prices, computerized informed and uninformed traders, and two human active traders that need to raise or invest capital. There are five rounds of trading in which the subject must raise or invest a randomly and independently determined amount of capital. Their results provide sufficient evidence to reject the claim that transparency does not affects spreads and demonstrate that transparency improves market pricing. However, the increase in trade transparency also creates wider spreads as market makers are less willing to trade to obtain information. Overall, market makers benefit from increased trade transparency while informed and liquidity traders lose.

Bloomfield and O'Hara (2000) look at the competition between post-trade transparent and opaque markets to determine whether transparent markets can survive. The authors create a game theoretic model with two laboratory experiments to address the question. In the first experiment there are a fixed number of transparent and opaque dealers and participants trade securities for several rounds. On average, opaque dealers earn more than 6 times what their counterparts make but there are no statistical differences in the opening round earnings between both groups. Most of the differences in earnings happen in the second round and decrease in latter rounds. The distribution in the difference in profits between both groups across rounds is due to informational asymmetries. The second experiment endogenizes post-trade transparency in which the first dealer chooses whether he/she will be transparent or opaque. After observing the choice of the first dealer, the following dealers make decisions to be transparent or opaque. The results show unequivocal evidence that most dealers prefer opacity. It is interesting to compare the result of Bloomfield and O'Hara (1999) in which all dealers earn higher profits when market is transparent with that of Bloomfield and O'Hara (2000) in which only opaque dealers earn higher profits when market participants are a mixed of transparent and opaque dealers. The implication from this comparison is that an external body imposing transparency is necessary in order to guarantee the general welfare. Indeed, Congress ordered the SEC to impose transparency to assure an efficient market where information asymmetry is reduced.

In summary, there is no single market that can accommodate the needs of heterogeneous investors. Transparency can benefit uninformed traders by facilitating price discovery. However, other investors are more interested in speed of execution. There are some mechanisms such as preannouncement and communication between market makers across exchanges that may improve trading costs in the absence of government intervention. The NMS is a case of post trade transparency in the equity market that as we will show in the results section, has decreased transaction costs on NASDAQ.

2.5. Transparency and dark pools of money

The increased importance of private trading platforms from investment banks where traders can avoid fees from trading in exchanges has increased the focus on transparency. Trading in dark markets and cross networks, allows traders to maintain their anonymity prior to the trade. Dark pools can be defined as an equity trading market with no dissemination of information. In fact, the main difference between dark and lit markets lies in pre-trade transparency but not post-trade transparency (Comerton-Forde and Putniņš, 2015). The lack of pre-trade transparency in dark pools and the effect of dark pools of money on price discovery have attracted much attention recently as regulators are concerned about informed traders submitting toxic orders in dark markets to benefit from information asymmetry in the exchange. Zhu (2014) suggests the possibility of self-selection of the market in which dealers choose to execute orders. Informed traders are less likely to trade in the dark pool because they are positively correlated with the asset value and with each other, whereas liquidity traders are more likely to have their orders executed in the dark pool due to low correlation among them. Price discovery in the exchange will be improved due to this separating equilibrium that, over time, informed traders migrate to the exchange and liquidity traders remain in the dark pool. Consistent with this prediction, Consistent with this prediction, Ye (2012) develops a model with endogenous price and execution probability and finds that dark pools of money hamper price discovery.

Yes, empirical evidence is still mixed, including Comerton-Forde and Putniņš (2015) studying the Australian Stock Exchange (ASX) and Foley, Malinova, and Park (2013) analyzing dark orders on the Toronto Stock Exchange. The ASX has a transparent central limit order book but has two exceptions that reduce pre-trade transparency. Block trades between \$1 and \$5 million can be executed outside of the book and dark trades executed at or within best bid or ask price in Australian dark pools. They find that low levels of non-block trading can even be beneficial for price discovery but they don’t find evidence that block trades in the crossing network impede price discovery. Foley, Malinova, and Park (2013) find that the presence of dark trading increases spreads because market participants are more careful but once a dark trade has been executed, risk decreases and quoted spreads decrease.

The separation between the exchanges and the trading platforms as a result of dark pools has led recent research to focus on both market fragmentation and transparency. Degryse, De Jong, and Van Kervel (2014) study the Amsterdam Exchange which is fragmented in large and Mid-cap stocks and the dataset include both dark and lit trades. They find that liquidity improves when there is lit fragmentation but not when trades are executed in opaque fragmented markets. Although Greese (2016) does not find that any negative effects from dark trading or fragmentation, lit fragmentation decreases trading costs and depth except for small stocks.

3. The National Market System

In 1971, the SEC provided Congress with a report investigating the "Back Room Crisis" of the late 1960's, when the manual exchange system could not keep up with the exponential increase in trading volume and the technology at that time could not accommodate the overwhelming amount of paperwork that it generated. Although there is not much of significant negative impacts on the market for institutional trading (Jones, 1972), the market itself was becoming fragmented because institutions were placing orders on regional markets, which led to the idea of creating a central market system (Oesterle, 2004). The SEC's concept of central market entails not only merging the different elements of the market but also a set of rules to govern all market participants (Werner, 1975). The new market with uniform regulation, commission rates, equal access to markets, and centralized price and volume information allowed regional exchange specialists and third market makers of regional exchanges to compete with specialists from primary markets (Harriman, 1978; Poser, 1981). Both the House of Representatives and the Senate issued reports on the securities industry to make clear their desire for the creation of a national market. The House of Representatives requested "the linking together of geographically separated trading markets on a national basis so as to provide greater investor protection and a strengthened mechanism for the efficient and effective allocation of investment capital" (Calvin, 1984). The Senate also wanted to "…force all markets into a single mold" (Calvin, 1984). Although Congress did not define a national market system, it did provide with several provisions. Cohen (1978) summarizes five of them:

> i) economically efficient executions, (ii) fair competition, (iii) availability of information, (iv) offsetting of investors' orders, and (v) best execution.

The resulting process of hearings and reports culminated with the Securities Act Amendments of 1975. The Amendments gave the SEC the authority to facilitate a national system for clearing and settling of trades.

Given the complexities of establishing a national market, the SEC moved prudently with an evolutionary approach.[2] Amongst the advancements that took place before the beginning of the NMS are a consolidated transaction reporting system that provided market participants information on last-sale (Consolidated Tape), a composite quotation system CQS that displayed the bid and offers on seven exchanges, the OTC market, and the Intermarket Trading System that linked market centers and enabled the execution of trades across those markets.[3] In 1978, the clearing systems of the NYSE, AMEX, and NASD merged into the National Securities Clearing Corporation NSCC. The NSCC was envisioned as the central organization designed to eliminate duplicate post-trade efforts (Calvin, 1984).

The SEC followed through with the will of Congress and focused the implementation of the NMS on the OTC market. Through Rule 11 Aa2-1, the SEC mandated firms with the following quantitative standards to join the NMS.

> (i) net tangible assets of $2 million and capital and surplus of $1 million; (ii) 500,000 publicly held shares; (iii) $5 million market value of publicly held shares; (iv) a price per share for the preceding five business days of $10; (v) a 600,000 share average monthly trading volume for the preceding six months; and (vi) four dealers act as NASDAQ market makers for the preceding five business days (Warren, 1986).

The SEC also created a second tier of firms that would be incorporated to the NMS at a later date. Initially, the criteria for the second tier were the following:

> (1) the identical $2 million of net tangible assets and $1 million of capital and surplus; (2) 250,000 publicly held shares; (3) market value of $3 million; (4) a price of $5 or more on the five business days preceding application; (5) average monthly trading volume of 100,000 or more shares during the six months preceding application; and (6) at least four dealers act as NASDAQ market makers on each of the five business days preceding application (Seligman, 1984).

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[2] Williams (1979).
[3] Ibid. pp 9-10.

In 1982, the NMS was finally implemented. The project started with the incorporation of a first tier of strong firms. However, the following year less financially solid firms were incorporated into the NMS. The first tier consisted of 49 firms approved by the SEC that made publicly available last-sale price and volume within 90 seconds of execution instead of reporting at the end of the day (Smith, Selway III, McCormick, 1998). The fact that financially superior NASDAQ firms were selected as a pioneer group to implement the NMS should have some impact on the results. In particular, spreads should be thinner for this group than for the remaining stocks traded on NASDAQ given their high volume and lower risk.

4. Hypotheses

Although there is no clear consensus, in the literature, as to the impact of increased post-trade transparency on market quality, in this section, we will summarize the main theoretical predictions and empirical evidence on this subject and present our hypotheses. Turning first to spreads, a number of papers predict that an increase in post-trade transparency will narrow spreads (Chowdry and Nanda, 1991, Baker and Edelman, 1992, Board and Sutcliffe, 2000, Edwards, Harris, and Piwowar, 2007, Goldstein, Hotchkiss, and Sirri, 2007, Bessembinder, Maxwell, and Venkatamaran, 2006). In contrast, Madhavan (1995) and Bloomfield and O'Hara (1999) predict a widening of spreads if post-trade transparency increases, whereas Gemmill (1996) finds no relationship between the two. As the relationship between post-trade transparency and spread width remains an empirical issue, in our study, we test the following hypothesis:

H1: An increase in post-trade transparency reduces spreads.

A significant segment of the literature that explores the effects of market transparency on price, spread, or volume focuses mostly on transactions of large blocks (e.g., Holthausen et al. 1990; Board and Sutcliffe 1996, 2000). In contrast, our comprehensive dataset allows us to test the impact of transparency on trades of all sizes, giving more confidence in the results and more precise estimates of the effects in the equity market after a regulation-induced change in post-trade transparency than previous findings mainly based on univariate tests (Baker and Edelman, 1992). In one of the studies using block trade data, Gemill (1996) examines the impact of post-trade transparency on the volatility of returns of large equity trades but does not find statistically significant effects. While the change in the bid-ask spread reflects the level or magnitude of the impact on price, the change in volatility can give us a sense of the dispersion or uncertainty of the impact on returns. In an attempt to understand whether a deterioration of market transparency affects the cost of capital and return volatility, Easley, O'Hara, and Yang (2016) study the case that stock exchanges sell price data to traders as they believe this creates a differential access to information and hence decreases transparency. They argue that if traders can obtain proprietary price data from exchanges before it appears in the consolidated tape, these informed traders would benefit from "latency arbitrage." Indeed they find that preferential access to data increases both cost and volatility. While the main purpose of the NMS is to ensure market fairness and enhance competition, the fact that some traders can purchase proprietary data and execute orders before the rest of the market clearly creates a situation of unfair competition.[4] Therefore, to some extent the return volatility indirectly measures the fairness of the competition, and we explicitly test the following hypothesis:

H2: An increase in post-trade transparency will result in a decrease in return volatility.

It is important to note that for a stock traded at a small spread before the change in market transparency, the spread width does not have much room to decrease due to the coarse pricing grid. During the period of this study, NASDAQ's tick size was 1/8 ($0.125); hence all spread widths must be a multiple of 1/8. Interestingly, Christie and Schultz (1994) find that the pricing grid on NASDAQ stocks was actually in increments of $0.25 by examining 100 NASDAQ stocks and 100 NYSE / AMEX stock of similar price and equity value in 1991. Their finding that NASDAQ stocks are almost never quoted with a spread of $0.125 and that spreads of $0.375 and $0.625 are less common than their nearest even-eight spread neighbor suggests that market makers avoid bids or asks ending in odd-eights (1/8, 3/8, 5/8, and 7/8) and hence a de facto minimum spread of $0.25. Therefore, we remove firms that are already trading at spreads of $0.25 or less before moving to the NMS and test the following hypothesis.

[4] Cespa and Foucault (2014) consider a model in which it is optimal to charge a fee for data to avoid a structure with excessive price information. If one trader acquires price data, this creates a negative effect on all other traders. Therefore, charging for this data limits the access to information and hence reduces the profits of all other traders.

H3: Transparency has greater impact on spreads of firms that are trading with spreads greater than $0.25.

5. Data and methodology

We obtain the daily stock return data from CRSP for the period between June 1st, 1982 when NMS started and December 31st, 1989 when more than 50% of firms traded on the OTC market became part of the NMS (FINRA Manual 89-81). In fact around the time when the NMS was initiated, CRSP price data were collected from several different sources. Between December 12th, 1972 and August 31st, 1984 the source was the Interactive Data Corporation (IDC). From November 1st, 1982 until the present, data comes from the National Association of Securities Dealers (NASD), with the exception of February 1986 when the source was the Interactive Data Services, Inc. (IDSI). Between November 1st, 1982 and August 31st, 1984 the primary source was the NASD and the secondary one was the IDC. Despite the overlap in sources, there are some gaps in the data that will be described later in this section.

The first group of firms traded on the NMS includes 49 of the most heavily traded firms. On August 9th, 1982 an additional 12 firms were included; and on November 8th, another additional 24 firms were included. These three groups of firms belong to the first tier and the firms in the second tier were added since February 8th, 1983, and in total, more than 4,000 firms became part of the NMS experiment throughout the 1980s. We collect the actual date when the stock of a firm was first included in the NMS trading from the NASD press releases and the Wall Street Journal articles.

We remove firms with more than 10 percent of observations missing before or after stocks are included in the NMS and more than ten trading days of volume information missing before or after NMS on a (-60, 60) trading days window. We also remove observations with a negative spread (i.e., the closing bid price greater than the ask price) and additional 23 firms due to missing data in CRSP in 1985. The final sample is 2,882 firms after removing two stocks that have a price of $500 before they began trading in the NMS. Finally, because stocks with different levels of information content are likely to be differentially affected by the NMS and often the trading volume reflects aspects of the information structure that traders pay addition to

(Blume, Easley and O'Hara 1994), we divide the sample into terciles according to their trading volume in the 60 trading days prior to the inclusion into the NMS.

From the price data and the inclusion dates we construct the variables of closing bid, closing ask, volume, and closing price and define the event window of 60 trading days before and 60 trading days after inclusion.[5] The quoted spread is computed as the closing ask price minus the closing bid price.[6] The spread is calculated as the mean quoted spread 60 days prior to NMS and the mean quoted spread 60 days after NMS. Due to the lack of availability of closing prices for stocks not on the NMS, price is calculated as the midpoint spread computed as (Closing Ask_{it} + Closing Bid_{it})/2. Before October 4th, 1982 CRSP reports the midpoint spread as price for the National Market System. We calculate price before NMS as the mean closing price of the 60 days before NMS. After that date, closing price is reported in CRSP and verified in the Wall Street Journal. After inclusion into the NMS, price is calculated as the mean closing price of the 60 days after NMS. For non-NMS firms, closing price is always the midpoint spread. The volatility of returns is the standard deviation of daily returns 60 days before and 60 days after NMS. Returns prior to NMS are calculated from the midpoint spread and after NMS; returns are obtained from the closing price. Because the trading volume is doubly recorded on the OTC market as documented by Atkins and Dyl (1997) we halve its value to obtain the mean daily volume, and compute the absolute value of the log of the mean daily volume. We also calculate the mean volume 60 days before NMS and 60 days after NMS.

To investigate whether the inclusion into the NMS matters for the market quality as measured by the spread and the volatility of stock returns, we take two complementary approaches. In the first set of tests, we compare the spread and volatility of stocks before and after being included into the NMS and with those of non-NMS stocks (i.e., matched firms that were not included to the NMS between 1982 and 1989). A non-NMS stock is considered an

[5] Three batches of firms were included to the NMS in June, August, and November 1982. Beginning in November 1st, 1982 CRSP makes available the volume for all firms. We hand collect from microfilm volume information from the Wall Street Journal for the firms that were included prior to November 1st, 1982 because it is not available on CRSP. Data is available for this group for the (-60, 60) period except for Phoenix Resources Corporation, which merged with Texas International soon after trading on NMS. The second date is August 8th. This group has 13 firms but on October 4th, Central Louisiana Electric Company switched to the NYSE. However, this batch is completely removed from the analysis because CRSP has no available information for these firms during the month of October. The last batch joined NMS on November 8th, 24 firms were incorporated but three firms are removed due to lack of CRSP data.

[6] A sample of 10% of CRSP closing ask and bid prices was verified with the Wall Street Journal to assure the validity of the source.

adequate match if its market value is within 10 percent of the NMS stock in question. This criterion reduces the sample size from 2,822 to 2,634 firms because there aren't enough matches that satisfy the 10 percent criterion. We also examine the effect of NMS on firms that trade prior to NMS at high spreads. Christie and Schultz (1994) show that dealers avoid spreads lower than $0.25 in order to increase their profits. Additionally, an eighth of a dollar pricing grid does not permit a spread lower than $0.125 for stocks trading above $1. Therefore, we would not expect stocks with a pre NMS spread width of $0.25 or less to experience any reduction in spread post NMS inclusion. Thus, we remove firms that have 80 percent of their spreads at $0.25 or less for the sixty day period prior to inclusion in the NMS. In the second set of tests, we use multivariate regression and difference-in-difference regression to study the changes in both spread and volatility after being included into the NMS.

6. Empirical Results

6.1. Descriptive statistics

Summary statistics are presented in Table 1 for stocks included into the NMS between 1982 and 1989. We examine the volume, price, spread, and volatility over the event window of 60 trading days before and 60 trading days after inclusion which is often used in the literature on transparency. The average daily trading volume and price level increased from 8,280 shares and $15.157 to 8,740 shares and $15.229 respectively during this eight-year period. The increases in both volume and price are the lowest in the 25 percentile (+0.011 shares and -$0.039) and highest in the 75 percentile (+0.125 shares and +$0.148). Compared to the distribution of the price, the volume is positively skewed and the almost 5,000 shares difference between the mean and the median number of daily trading volume. This observation is important to our study because less frequently traded stocks may not possess enough trading information, which may distort the estimates of cross-sectional regressions; therefore, we will divide the stocks into terciles based on their trading volume in the subsequent regression analysis.

The variable of interest, the average level of quoted spread, declined 5 percent, from $0.531 to $0.505, after firms were included into the NMS, and the decline is consistent across quartiles. Another important measure of market quality is the volatility of stock returns and during the same time period, it had a 41 percent decline, from 0.040 to 0.023. A close examination of the distribution of return volatility suggests that the changes in the median and other percentiles are not significant. Taking these results at face value, market quality as measured by trading costs (i.e., quoted spread) and return volatility generally improved after the implementation of the NMS. Before drawing conclusions we need to conduct more rigorous tests of mean differences in these variables, especially spread and volatility, in the next section.

[Insert Table 1 Here]

6.2. Univariate analysis

To assess the statistical significance of the difference in means before and after the NMS implementation, we first perform two-sample t-test and present the results in Table 2. Although on average there is an increase of 460 shares in daily trading volume and $0.057 in price level after inclusion into the NMS, the difference in mean is not significant (t-statistics are 1.21 and 0.69 respectively). The 2.5-cent decline in trading costs as shown in the third column is significant at the 1 percent level and it represents a reduction of almost 5 percent in the quoted spread. This finding provides evidence to support the first hypothesis that post-trade transparency reduces transaction costs. The volatility of stock returns is also reduced by 0.0167, and this 41% decline is significant at the 5 percent level. Without controlling for firm characteristics this evidence is consistent with the second hypothesis that an increase in post-trade transparency reduces volatility.

[Insert Table 2 Here]

While the two-sample difference in means tests provide preliminary evidence that market quality benefits from the NMS inclusion, these results do not take into account potential significant differences in firm characteristics between NMS-inclusion firms and non-NMS-inclusion stocks. It is likely that financially stressed, recently floated or simply small firms were not chosen for the experiment. To minimize the bias in the test resulting from heterogeneity between these two types of stocks we create a matched sample using observable firm characteristics. Specifically, for each stock that joins the NMS (i.e. the treated firm) we find a suitable match among those stocks that do not join NMS (i.e., the control firm). A suitable match is defined as a firm having a market value within 10 percent of the market value of each original sample firm. Unfortunately, not every (treated) firm has a matched (control) firm that conforms to the criteria and thus the sample size is reduced from 2,822 to 2,634 firms. In Table 3, we conduct paired difference-in-differences (DiD) test using this matched-firm sample. The underlying assumption of the DiD test is that if post-trade transparency reduces information asymmetry and transaction costs in the treated firms, one should not expect changes in spread and volatility in the control firms unless there are major changes in the market. However, Table 3 shows a significant decrease of spread by 0.008 which is a 2.3 percent change in trading costs, and it is similar to the findings in Bessembinder, Maxwell, and Venkatamaran (2006) that observe a decline in trading costs for bonds that are not part of TRACE but have similar characteristics to the transparent bonds. According to Amihud, Mendelson, and Lauterbach (1997), this liquidity externality comes from an increased knowledge of the market of pricing similar securities even if the matched firm does not experience an increase in transparency itself. Amihud et al. look at stocks from the Tel Aviv Stock Exchange that were transferred from a daily call auction mechanism to a call auction followed by continuous iterations. The new mechanism was expected to facilitate price discovery, improve trading efficiency, and increase liquidity. Given that spreads are not available at Tel Aviv, the authors look at alternate measure of market liquidity. They find an increase in volume and in the liquidity ratio (Amivest measure) after the new method was implemented and prices adjust faster to new information, and attribute this to the possibility that enhanced value discovery in one stock improves value discovery of a correlated stock, but with a smaller magnitude. In other words, to some extent in the context of the DiD test, the control firms are also treated by the NMS implementation; however, this will not affect the test results because the change of the treated firms is of a much larger magnitude (-0.024) compared to that of the control firms (-0.008). The net difference, or the difference-in-differences, of -0.015 is statistically significant at the 1 percent level.

[Insert Table 3 Here]

Interestingly there is no externality effect in the volatility of stock returns as the change in the volatility of control firms is insignificant (0.001) whereas the change in the volatility of the treated firms is -0.019 and statistical significant at the 5 percent level. The overall significant reduction in volatility confirms the findings using the un-matched sample in the previous section and hence supports the second hypothesis that an increase in post-trade transparency reduces volatility of stock returns. In terms of changes in trading volume and price level, the differences-in-differences are small and insignificant.

6.3. Multivariate analysis

Whereas the results of univariate tests suggest that trading costs (i.e., spread) benefit from NMS inclusion, these key characteristics (i.e., volume, price and volatility) can influence quoted spreads systematically. In this section we employ multivariate tests to better distinguish between the NMS inclusion effect and stock characteristics, as done in existing studies. For example, Gemmill (1996) controls for volatility to dismiss a spurious relationship between transparency and transaction costs. It is important to note that there are three components of spreads: order processing costs, inventory costs, and adverse selection costs (Stoll, 1978). Order processing costs are the direct costs that dealers incurred when processing an order. A higher dollar value per trade and volume can also help reduce the fixed costs of order processing. Dealers want to reduce their inventory risks and therefore it is necessary to control for volume given that transaction costs are inversely related to trading frequency. In addition, volatility and price affect inventory risks and therefore both variables need to be controlled for in the following regression model:

$$Spread_{it} = \beta_0 + \beta_1 Price_{it} + \beta 2 Volume_{it} + \beta_3 Volatility_{it} + \beta_4 PostNMS_{it} + \varepsilon_{it}$$

where spread is closing ask minus closing bid and price is the average midpoint spread. Volume is the absolute value of the log of the average daily trading volume and volatility is the standard deviation of returns based on the midpoint spread. To test the first hypothesis that an increase in post-trade transparency reduces information asymmetry and, consequently, the transaction cost (i.e., quoted spread), we construct an indicator variable to one if the firm is included in the NMS and zero otherwise (postNMS). This dummy variable captures the increase in post-trade transparency because after a stock begins trading in the NMS, traders must report the terms of a transaction within 90 seconds of execution. If the inclusion into the NMS does improve market quality, we expect a negative relation between this variable and spread.

As we discussed earlier, the presence of a large number of less frequently traded stocks may distort the estimates of cross-sectional regressions. Small firms, as proxied by thinly traded stocks, may not possess enough trading information and their volumes have an inverse relation to trading costs (Stoll and Whaley, 1983; Fortin, Grube, and Joy, 1990). Therefore, we divide the stocks into terciles based on their trading volume of 60 trading days before the inclusion.

[Insert Table 4 Here]

Table 4 reports coefficient estimates for the pooled OLS regressions. Consistent with the findings in previous research, quoted spread is positively related to price level and return volatility but negatively related to trading volume across all terciles of volume. Surprisingly, although the parameter estimate for our variable of interest, PostNMS, is of the expected sign, it is not a significant predictor of spread after controlling for trading volume, price level, and volatility of returns in the entire sample (Specification 1) and in fact, the quoted spread increases after a firm begins trading in the NMS in the subsample of thinly traded stocks (Specification 2). To some extent, this is consistent with the finding in Bloomfield and O'Hara (1999) that an increase in post-trade transparency leads to an increase in spreads and poorer execution and the authors attribute this phenomenon to the fact that an opaque market might give market makers incentives to quote narrow bid-ask. In the case of highly traded stocks, there is an expected and significant decrease of 0.009 in spread (Specification 4).

Table 5 incorporates the original firms and their match into a model that provides evidence that firms that increase transparency are responsible for a decrease in transaction costs. Specifically we estimate a regression model of the following form:

$$\text{Spread}_{it} = \beta_0 + \beta_1 \text{ Price}_{it} + \beta 2 \text{ Volume}_{it} + \beta_3 \text{ Volatility}_{it} + \beta_4 \text{ Original * PostNMS}_{it} + \varepsilon_{it}$$

where spread is closing ask minus closing bid; price is the average midpoint spread; volume is the absolute value of the log of the average volume; volatility is the standard deviation of returns based on the midpoint spread; original is a dummy variable which equals 1 if the firm becomes part of the NMS and zero otherwise; and postNMS is a dummy which equals 1 when the firm is trading in the NMS and zero otherwise.

[Insert Table 5 Here]

In this sample, the size increases to 10,536 but the terciles are based on the original sample of 2,882 stocks. The variable of interest on this regression is the interaction term Original * PostNMS. The most traded tercile shows that original firms after their inclusion to NMS have a decreasing effect on spreads and the result is significant at the 1 percent level. The second tercile has the opposite result but it is not significant. The least traded group of stocks shows similar results as Table 4 when the original group of firms increases spreads after they begin trading in the NMS. The impact is large enough to affect the entire sample where it can be observed that the interaction term increases spreads by .058, and results are significant at the 1 percent level. The effects from volume are similar, the decrease in trading costs derived from a higher volume is applicable to all terciles and the results are highly statistically significant. Volatility and price have similar results as Table 4 with a significant widening effect on spreads. In general, this table provides some evidence that firms that are incorporated to the NMS have a decreasing effect on the spreads for the highly traded stocks after they begin trading in the NMS.

Boehmer, Saar, and Yu (2005) provide a robustness test to confirm the time invariant effects on NYSE firms after increased transparency. We perform a similar test that measures the impact on spreads from volume, price and volatility of returns. Table 6 focuses on the original sample and the matching group, so the sample size is 5,268 stocks. The model is the following:

$$\Delta Spread_t = \beta_0 + \beta_1\ \Delta Price_t + \beta 2\ \Delta Volume_t + \beta_3\ \Delta Volatility_t + \beta_4\ Original_i + \varepsilon_t$$

where all the changes are after the stock begin in NMS minus before it begins trading in the NMS, spread is closing ask minus closing bid; price is the average midpoint spread; volume is the average daily trading volume in tens of thousands; volatility is the standard deviation of returns based on the midpoint spread; and original is a dummy variable which equals 1 if the firm becomes part of the NMS and zero otherwise.

[Insert Table 6 Here]

The change in volume does not a have a significant effect on the difference in the spreads. Volatility has a similar effect except for the first tercile where it has a positive effect but it is only significant at the 10 percent level. Price is highly significant and it shows across terciles and the overall sample that the increase in price has a widening effect on spreads. The dummy variable In this table, the original variable of the most traded group after NMS has a widening effect on spreads. These results are derived from Table 3, where it can be observed that the spreads of the original group after NMS are .526, whereas the spreads of the match are .391.

Jones, Karl, and Lipson (1994) show that the number of daily trades has a direct impact on volatility. They further show that volume impacts volatility because it is positively related to the number of transactions. Therefore, volume can be used as a proxy for number of trades. To test whether the observed reduction in volatility documented in Tables 2 and 3 is due to the increase in transparency or an exogenous change in volume, we propose the following model:

$$\text{Volatility}_{it} = \beta_0 + \beta_1 \text{ Volume}_{it} + \beta_2 \text{ PostNMS}_{it} + \varepsilon_{it}$$

where volatility is the standard deviation of returns based on the midpoint spread; volume is the absolute value of the log of the average volume; and PostNMS is a dummy which equals 1 when the firm is trading in the NMS and zero otherwise.

Table 7 contains the results of the above model for the three terciles as well as the overall sample. Examining the table reveals that the variable PostNMS is significant for the overall sample and for the first and second terciles. There is some evidence that an increase in post-trade transparency decreases volatility. The effect is significant at the 1 percent level for the second tercile and it is significant at the 5 percent level for the entire sample. The least traded tercile is also significant but only at the 10 percent level. Volume has a positive relation with volatility, which is significant at the 1 percent level for the entire sample and for the least and most traded terciles. The second hypothesis states that an increase in post-trade transparency should decrease volatility of returns. The results provide some evidence to support this hypothesis, which confirms the results obtained by Baker and Edelman (1992).

[Insert Table 7 Here]

The results from the previous tests show that an increase in transparency improves the market by reducing transaction costs and decreasing volatility. Furthermore, as presented in Table 3, the increased liquidity has spillover effects on the matched sample, which as predicted by Amihud, Mendelson, and Lauterbach (1997) will be of lesser magnitude.

6.4. Controlling for collusion between market makers and a discrete pricing grid

The next set of tests are based on Christie and Schultz (1994) who provide evidence that dealers avoid lower quotes to earn higher profits. In their paper, Christie and Schultz find that through collusion, market makers were generally able to maintain a minimum spread of .25. Therefore we expect spreads below $0.25 to be less common than other spreads. Table 8 provides a frequency table of quoted spreads before and after stocks are included in the NMS on a 60 day window. Examining the cumulative frequencies of spread widths before NMS we find that indeed only 44.06 percent of observed spreads are equal to or below $0.25. It can be observed that spreads equal to or less than $0.25 are more frequent after NMS, with 46.48 percent now equal to or below $0.25.

[Insert Table 8 Here]

Given the propensity of market makers to avoid spreads less than $0.25, we may want to look at firms that mainly have spreads that can go down further. That is, if a stock has a spread of $0.25 pre NMS, it most likely remain at or above $0.25 with or without transparency and thus the full effects of post-trade transparency are lost if we include these firms.

Accordingly, we replicate Table 4, but only for stocks with at least 80 percent of their spreads wider than $0.25 before they begin trading in the NMS. Table 9 contains the results of the subsample regressions. The parameter estimates for volume, price, and volatility are of the expected sign and significant across all terciles. Turning to the variable of interest, postNMS, and comparing them to those reported in Table 4, it can be observed that the parameter estimates are stronger for the two most traded terciles but the resulst are only statistically significant for the high-volume tercile. The magnitude increased by 133 percent from -.009 to -.021 and the statistical significance increased to a 5 percent level. Therefore, it can be seen that removing the impact of the coarse pricing grid for NASDAQ stocks results in results a bit more consistent with the stated hypotheses in this paper.

[Insert Table 9 Here]

6.5. Market returns at NMS inclusion

While the above tests are suggestive and point out the importance of post-transparency in the equity market, it will be equally important to validate the results by examining the market's response to the trading of the stocks in the NMS. Such responses in terms of short- and long-term abnormal stock returns around the period of the implementation reflects market participants' (i.e., traders, market makers, and investors) perceptions of the net benefits of the NMS inclusion. We define the inclusion date as the event date and collect the returns of the stocks that are included in the NMS during a period of 180 days before and 90 days after the implementation. We use the data of the previous 100 trading days to estimate the parameters of the various pricing models. The rolling-window returns are applied to calculate the abnormal returns of the overall stocks and the stocks in each of terciles. Table 10 presents the mean of the annualized stock returns over various 20-day periods around the inclusion of the NMS. Though overall the stock returns are high before being included in the NMS, this primarily is driven by the heavily traded stocks (Tercile 3). On the other hand, the thinly traded stocks (Tercile 1) tend to have higher return after being in the NMS.

[Insert Table 10 Here]

Figure 1 shows the dynamics of the market-adjusted returns, the excess return over the CRSP value-weighted market return. Being included in the NMS trading, overall, generates about a return of 12.1% higher return than the market in six months before the inclusion date. The excess returns do not change after inclusion, keeping the CAR between 11.7% and 13.3%. However, the size and pattern vary among the stocks of different trading volume. Specifically, the third tercile stocks generate a significant cumulative excess return (27.8%) before the inclusion of the NMS while the thinly traded stocks yield a low return (1.4%) in the same 180 days. The patterns of the cumulative returns changed after inclusion. Including in the NMS has a positive effect on the returns of the stocks of less liquidity but a negative effect on high-liquidity stock returns in 60 trading days after inclusion.

[Insert Figure 1 Here]

We further compute abnormal returns by controlling the risk factors known to influence returns, including (1) the market model, (2) Fama and French (1993) three-factor model, (3) the Carhart (1997) four-factor model, and (4) the Fama and French (2015) five factor model. The variables in the analysis include firm i's return (r_{it}), risk-free rate (r_{ft}), market portfolio return (r_{mt}), the size premium (SMB_t), the value/growth premium (HML_t), the momentum factor (MOM_t), the robust minus weak profitability factor (RMW_t), and the conservative minus aggressive

Figure 2 shows the cumulative abnormal return (CAR) that measured by the marketmodel. Overall the stocks generate abnormal profit during the 180 trading dates before the inclusion of the NMS and then decline to -2% in 90 days after. The patterns of the three terciles of stocks, however, differ significantly from each other and their market adjusted return. Among them, the first tercile stocks generate higher CAR than the second tercile stocks before the inclusion of the NMS. After the event, the thinly traded stocks, unlike the other two groups, demonstrate a lasting excess profit in 90 days after being included in the NMS. After considering systematic risk, the first tercile stocks outperform the stocks of higher trading frequencies.

[Insert Figure 2 Here]

We further investigate the abnormal returns with controlling the loading factors other than market risk. The CARs generated by the Fama-French (1993) three-factor model, Carhart (1997) four-factor model, and Fama-French (2015) five-factor model are presented in Figures 3, 4, and 5. The patterns of the three models are similar and the overall excess return before the inclusion is small, which is mostly contributed by the first tercile stocks during day -60 to 0. Interestingly, after being included in the NMS, the heavily traded stocks underperform the thinly traded stocks. These results provide some evidence that transparency reduces the mispricing of liquid stocks and therefore abnormal returns decrease after inclusion to the NMS. In the case of illiquid stocks where information asymmetry is high, the opposite result is observed, suggesting that requiring post-trade reporting alone is not enough to eliminate mispricing.

[Insert Figure 3, 4, and 5 Here]

7. Conclusion

Transparency does not necessarily mean market improvement because informed traders may decide to withdraw from participation and consequently dry the liquidity out of the markets. This situation becomes even more worrisome if liquidity traders cannot benefit from increased transparency and hence avoid trading altogether. As the literature review in this article suggests, there are several scenarios under which transparency might harm trading and some degree of opaqueness might be desirable for certain types of investors. However, the evidence from our study shows that the trading costs and return volatility of publicly traded firms that became part of the NMS between 1982 and 1989 had been declining over time. The robustness checks using matched stocks and omitting low-spread stocks prior to the NMS confirm the significance of post-trade transparency for the market. The fact that we have a larger sample size, control for exogenous variable, and apply matched sample analysis provides more confidence in the results compared to findings mainly based on univariate tests in Baker and Edelman (1992).

The main finding of our study–that the improvement of post-trade transparency as a result of the stock being included in the NMS reduces the trading cost as measured by the quoted spreads–will help to answer the question whether having different gradations of transparency across exchanges that cater to investors with a diversity of needs is desirable. Furthermore, our results can serve as a guide in the creation of comprehensive policies that can effectively maintain a fair and orderly equity market.

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Figure 1
Cumulative Abnormal Return: Market Adjusted Return.
We collect the excess return over the CRSP value-weighted market return of the stocks that are included in the NMS during a period of 180 days before the inclusion and 90 days after.

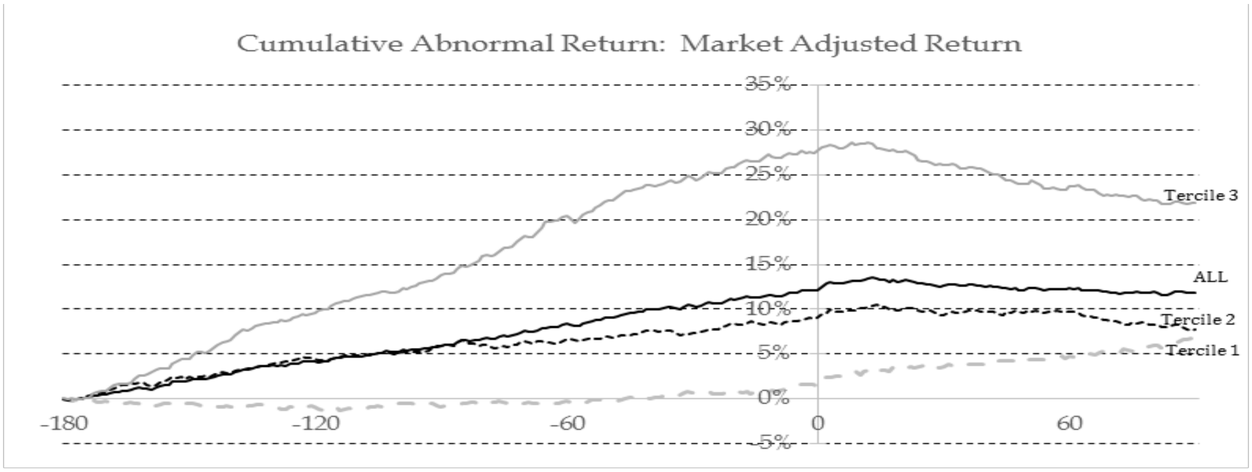

Figure 2

Cumulative Abnormal Return: Market Model.

We collect the excess return over the expected return estimated by the market model for the stocks that are included in the NMS during a period of 180 days before the inclusion and 90 days after. Specifically, $AR_{i,t} = r_{i,t} - [\alpha_{i,t} + \beta_{i,t}(r_m - r_f)]$. The data of the previous 100 trading days are used to estimate the parameters. The rolling-window returns are applied to calculate the abnormal returns of the overall stocks and the stocks in each of terciles

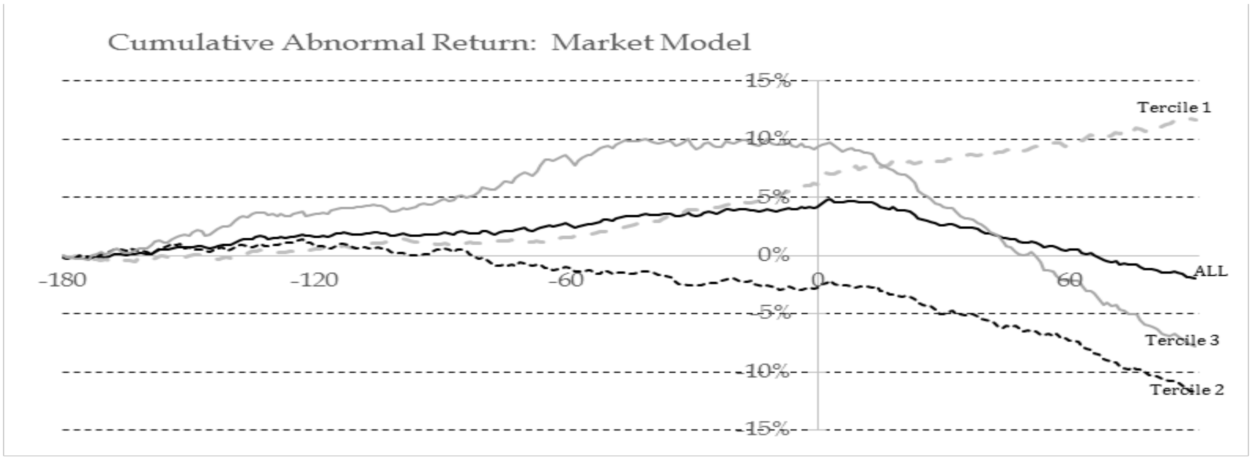

Figure 3

Cumulative Abnormal Return: Fama-French Three Factor Model.

We collect the excess return over the expected return estimated by the Fama-French (1993) model for the stocks that are included in the NMS during a period of 180 days before the inclusion and 90 days after. Specifically, $AR_{i,t} = r_{i,t} - [\alpha_{i,t} + \beta_{1,i,t}(r_{m,t} - r_{f,t}) + \beta_{2,i,t}HML_t + \beta_{3,i,t}SMB_t]$. The data of the previous 100 trading days are used to estimate the parameters. The rolling-window returns are applied to calculate the abnormal returns of the overall stocks and the stocks in each of terciles

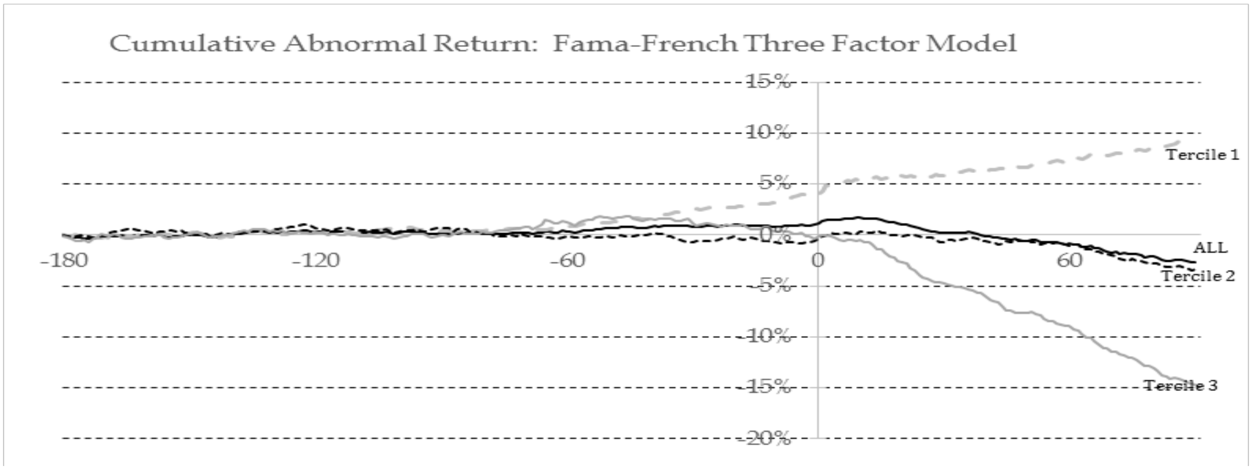

Figure 4

Cumulative Abnormal Return: Fama-French-Carhart Four Factor Model.

We collect the excess return over the expected return estimated by the Carhart (1997) model for the stocks that are included in the NMS during a period of 180 days before the inclusion and 90 days after. Specifically, $AR_{i,t} = r_{i,t} - [\alpha_{i,t} + \beta_{1,i,t}(r_{m,t} - r_{f,t}) + \beta_{2,i,t}HML_t + \beta_{3,i,t}SMB_t + \beta_{4,i,t}MOM_t]$. The data of the previous 100 trading days are used to estimate the parameters. The rolling-window returns are applied to calculate the abnormal returns of the overall stocks and the stocks in each of terciles

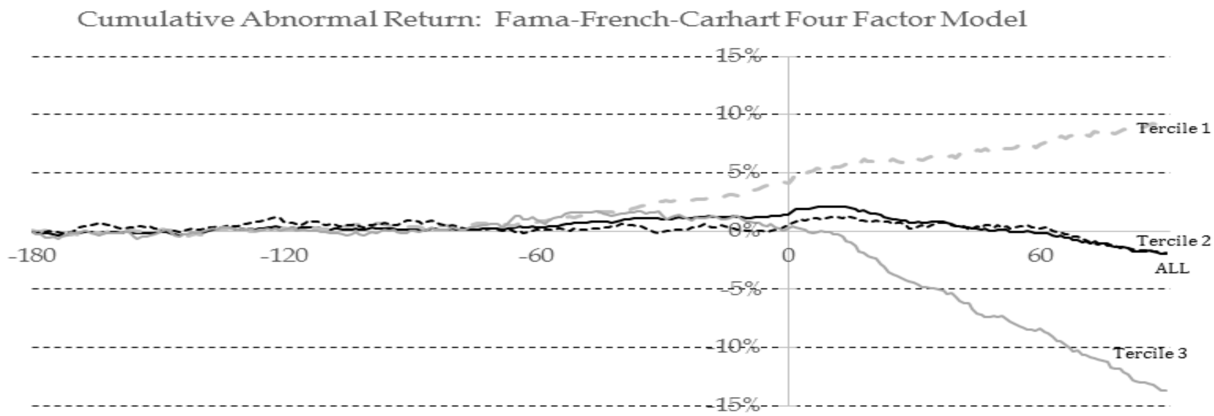

Figure 5

Cumulative Abnormal Return: Fama-French Five Factor Model.

We collect the excess return over the expected return estimated by the Fama-French (2015) model for the stocks that are included in the NMS during a period of 180 days before the inclusion and 90 days after. Specifically, $AR_{i,t} = r_{i,t} - [\alpha_{i,t} + \beta_{1,i,t}(r_{m,t} - r_{f,t}) + \beta_{2,i,t}HML_t + \beta_{3,i,t}SMB_t + \beta_{4,i,t}RMW_t + \beta_{5,i,t}CMA_t]$. The data of the previous 100 trading days are used to estimate the parameters. The rolling-window returns are applied to calculate the abnormal returns of the overall stocks and the stocks in each of terciles

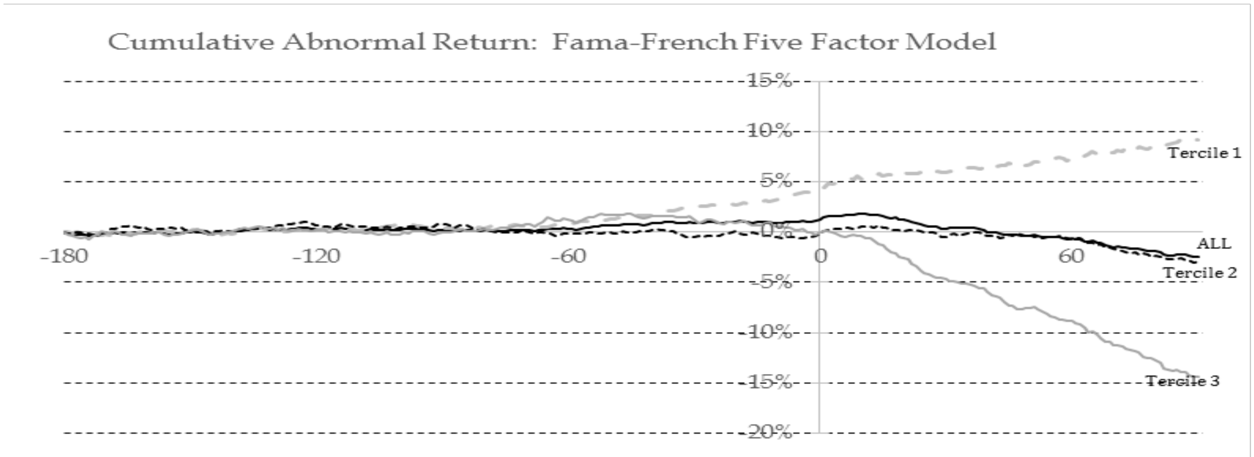

Table 1
Summary statistics.
This table shows descriptive statistics of NASDAQ stocks before and after they were incorporated to the National Market System NMS between 1982 and 1989. The price is calculated as the mean closing price of the 60 trading days before and after inclusion into NMS. Spreads are calculated as the mean quoted spread per firm. Quoted spreads are calculated as closing ask - closing bid. Volatility is the standard deviation of daily returns per firm. The returns are based on the midpoint spread, which is calculated as (closing ask + closing bid)/2. The returns are then calculated as (midpoint spread$_{i,t}$ - midpoint spread$_{i,t-1}$) / midpoint spread$_{i,t-1}$. Price before NMS is the log of the mean daily midpoint spread after NMS it is the log of the mean daily closing prices per firm. Volume is mean volume per firm in tens of thousands.

		25%	Median	Mean	75%	Standard Deviation
Volume	Pre-NMS	0.141	0.355	0.828	0.839	2.427
	Post-NMS	0.158	0.396	0.874	0.964	2.063
Price	Pre-NMS	7.097	12.294	15.157	19.829	11.804
	Post-NMS	7.058	12.254	15.214	19.977	11.860
Spread	Pre-NMS	0.250	0.402	0.531	0.588	0.541
	Post-NMS	0.242	0.383	0.505	0.563	0.501
Volatility	Pre-NMS	0.014	0.022	0.039	0.032	0.427
	Post-NMS	0.013	0.020	0.023	0.029	0.031
N		2,882	2,882	2,882	2,882	2,882

Table 2

Difference in means before and after NMS.

This table shows the t-test of difference in means before and after firms are incorporated to the NMS between 1982 and 1989. The price is calculated as the mean closing price of the 60 trading days before and after inclusion into NMS. Spreads are calculated as the mean quoted spread per firm. Quoted spreads are calculated as closing ask - closing bid. Volatility is the standard deviation of daily returns per firm. The returns are based on the midpoint spread, which is calculated as (closing ask + closing bid)/2. The returns are then calculated as (midpoint spread$_{i,t}$ - midpoint spread$_{i,t-1}$) / midpoint spread$_{i,t-1}$. Price before NMS is the log of the mean daily midpoint spread, after NMS it is the log of the mean daily closing prices per firm. Volume is mean volume per firm in tens of thousands. T-statistics are shown in the parentheses with ***, ** and * indicating its statistical significant level of 1%, 5% and 10% respectively.

	Volume	Price	Spread	Volatility
Post-NMS Mean	0.874	15.214	0.505	0.023
Pre-NMS Mean	0.828	15.157	0.531	0.039
Difference	0.0463	0.0568	-0.025***	-0.01667**
t-test	(1.206)	(0.693)	(-6.068)	(-2.09)
Standard Deviation	2.063	4.407	0.226	0.427
N	2,882	2,882	2,882	2,882

Table 3
Difference in means before and after NMS that have a matching sample.
This table shows the paired t-test of difference in means before and after firms are incorporated to the NMS between 1982 and 1989 using a firm-matched sample. This is a subsample of firms that have a matching sample of NASDAQ firms within a 10% distance of their market value that were not incorporated to the NMS on the same time frame. The price is calculated 60 trading days before and after NMS. Spreads are calculated as the mean quoted spread per firm. Quoted spreads are calculated as closing ask - closing bid. Volatility is the standard deviation of daily returns per firm. The returns are based on the midpoint spread, which is calculated as (closing ask + closing bid)/2. The returns are then calculated as (midpoint spread$_{i,t}$ - midpoint spread$_{i,t-1}$) / midpoint spread$_{i,t-1}$. Price is the mean daily midpoint spread. Volume is mean volume per firm in tens of thousands. T-statistics are shown in the parentheses with ***, ** and * indicating its statistical significant level of 1%, 5% and 10% respectively.

		Volume	Price	Spread	Volatility
	Post-NMS Mean	0.8986	15.235	0.501	0.023
NMS	Pre-NMS Mean	0.8548	15.193	0.526	0.041
Listing	Difference	0.0438	0.041	-0.024***	-0.018**
	t-test	(1.046)	(0.47)	(-5.522)	(-2.07)
	Post-NMS Mean	0.989	13.588	0.382	0.03
Matched	Pre-NMS Mean	1.027	13.392	0.391	0.029
Firms	Difference	-0.369	0.196***	-0.008***	0.001
	t-test	(-1.195)	(3.23)	(-2.56)	(0.448)
Difference-in-Difference = NMS - Matched		0.081	-0.154	-0.015***	-0.019**
		(1.56)	(-1.52)	(-2.81)	(-2.11)
N		2,634	2,634	2,634	2,634

Table 4
Regression results on quoted spreads.
This table shows regression results for the model:
$Spread_{it} = \beta_0 + \beta_1\, Price_{it} + \beta_2\, Volume_{it} + \beta_3\, Volatility_{it} + \beta_4\, PostNMS_{it} + \varepsilon_{it}$
The firms are NASDAQ stocks before and after they were incorporated to the National Market System NMS between 1982 and 1989. The period is 60 trading days before and after NMS. Firms are categorized by the mean daily volume 60 trading days prior to NMS. The least traded firms are in group 1 and the most traded firms are in group 3. Spreads are calculated as the mean quoted spread per firm. Quoted spreads are calculated as closing ask - closing bid. Volatility is the standard deviation of daily returns per firm. The returns are based on the midpoint spread, which is calculated as (closing ask + closing bid)/2. The returns are then calculated as (midpoint $spread_{i,t}$ - midpoint $spread_{i,t-1}$) / midpoint $spread_{i,t-1}$. Price is the mean daily midpoint spread. Volume is the absolute value of the log of the mean volume per firm. PostNMS is a dummy variable, which equals 1 if the firm is trading on the NMS. T-statistics are shown in the parentheses with ***, ** and * indicating its statistical significant level of 1%, 5% and 10% respectively.

Dependent variable: Spread	(1) All firms	(2) Low-volume	(3) Mid-volume	(4) High-volume
Intercept	1.852***	2.480***	0.959***	0.856***
	(60.64)	(29.83)	(11.41)	(23.14)
Volume	-0.198***	-0.347***	-0.084***	-0.071***
	(-56.21)	(-28.28)	(-8.24)	(-18.63)
Price	0.019***	0.029***	0.011***	0.007***
	(46.16)	(35.93)	(22.76)	(27.10)
Volatility	0.077***	10.153***	0.379***	0.023***
	(4.81)	(11.89)	(3.46)	(4.24)
PostNMS	-0.006	0.052**	-0.007	-0.009*
	(-0.65)	(2.29)	(-0.74)	(-1.73)
N	5,764	1,920	1,922	1,922
R-squared	0.497	0.553	0.227	0.364

Table 5

Regression results on quoted spreads with a matching sample.

This table shows regression results for the model:

$Spread_{it} = \beta_0 + \beta_1\ Price_{it} + \beta_2\ Volume_{it} + \beta_3\ Volatility_{it} + \beta_4\ Original*PostNMS_{it} + \varepsilon_{it}$

The firms are NASDAQ stocks before and after they were incorporated to the National Market System NMS between 1982 and 1989. The period is 60 trading days before and after NMS. Firms are categorized by the mean daily volume 60 trading days prior to NMS. The least traded firms are in group 1 and the most traded firms are in group 3. Spreads are calculated as the mean quoted spread per firm. Quoted spreads are calculated as closing ask - closing bid. Volatility is the standard deviation of daily returns per firm. The returns are based on the midpoint spread, which is calculated as (closing ask + closing bid)/2. The returns are then calculated as (midpoint $spread_{i,t}$ - midpoint $spread_{i,t-1}$) / midpoint $spread_{i,t-1}$. Price is the mean daily midpoint spread. Volume is the absolute value of the log of the mean volume per firm. Original is a dummy variable, which equals 1 if the firms becomes part of NMS. PostNMS is a dummy variable, which equals 1 if the firm is trading on the NMS. The matching sample is based on market value witihn a 10% distance of the firm. T-statistics are shown in the parentheses with ***, ** and * indicating its statistical significant level of 1%, 5% and 10% respectively.

Dependent variable: Spread	(1) All firms	(2) Low-volume	(3) Mid-volume	(4) High-volume
Intercept	1.092***	1.420***	0.460***	0.778***
	(45.83)	(30.55)	(8.91)	(21.92)
Volume	-0.012***	-0.165***	-0.060***	-0.067***
	(-43.71)	(-27.82)	(-9.74)	(-17.70)
Price	0.235***	0.026***	0.029***	0.012***
	(90.45)	(40.85)	(82.93)	(35.44)
Volatility	0.076***	0.215***	0.602***	0.026**
	(6.13)	(3.04)	(5.28)	(2.12)
Original*PostNMS	0.058***	0.095***	0.014	-0.039***
	(6.32)	(5.07)	(0.93)	(-3.50)
N	10,536	3,468	3,488	3,580
R-squared	0.514	0.490	0.680	0.352

Table 6
Regression results on difference of quoted spreads with a matching sample.
This table shows regression results for the model:
$\Delta Spread_i = \beta_0 + \beta_1\, \Delta Price_i + \beta_2\, \Delta Volume_i + \beta_3\, \Delta Volatility_i + \beta_4\, Original_i + \varepsilon_i$
The firms are NASDAQ stocks before and after they were incorporated to the National Market System NMS between 1982 and 1989. The variables are measured as Post minus Pre NMS. The period is 60 trading days before and after NMS. Firms are categorized by the mean daily volume 60 trading days prior to NMS. The least traded firms are in group 1 and the most traded firms are in group 3. Spreads are calculated as the mean quoted spread per firm. Quoted spreads are calculated as closing ask - closing bid. Volatility is the standard deviation of daily returns per firm. The returns are based on the midpoint spread, which is calculated as (closing ask + closing bid)/2. The returns are then calculated as (midpoint $spread_{i,t}$ - midpoint $spread_{i,t-1}$) / midpoint $spread_{i,t-1}$. Price is the mean daily midpoint spread. Volume is the absolute value of the log of the mean volume per firm. Original is a dummy variable, which equals 1 if the firms becomes part of NMS. The matching sample is based on market value witihn a 10% distance of the firm. T-statistics are shown in the parentheses with ***, ** and * indicating its statistical significant level of 1%, 5% and 10% respectively.

Dependent variable: ΔSpread	(1) All firms	(2) Low-volume	(3) Mid-volume	(4) High-volume
Intercept	-0.013***	-0.011	-0.007	-0.019***
	(-3.69)	(-1.56)	(-1.40)	(-4.23)
ΔVolume	-0.002	-0.001	0.001	0.000
	(-1.18)	(-0.28)	(0.44)	(-0.57)
ΔPrice	0.022***	0.037***	0.009***	0.009***
	(33.68)	(32.14)	(7.64)	(11.78)
ΔVolatility	0.011	0.057*	-0.057	0.001
	(1.1)	(1.70)	(-1.25)	(-0.11)
Original	-0.012**	-0.047***	-0.010	0.012**
	(-2.39)	(-4.52)	(-1.31)	(2.01)
N	5,268	960	1,744	1,790
R-squared	0.178	0.380	0.034	0.074

Table 7

Regression results on volatility of returns.

This table shows regression results for the model:

$Volatility_{it} = \beta_0 + \beta_1\ Volume_{it} + \beta_2\ PostNMS_{it} + \varepsilon_{it}$

The firms are NASDAQ stocks before and after they were incorporated to the National Market System NMS between 1982 and 1989. The period is 60 trading days before and after NMS. Firms are categorized by the mean daily volume 60 trading days prior to NMS. The least traded firms are in group 1 and the most traded firms are in group 3. Volatility is the standard deviation of daily returns per firm. The returns are based on the midpoint spread, which is calculated as (closing ask + closing bid)/2. The returns are then calculated as (midpoint $spread_{i,t}$ - midpoint $spread_{i,t-1}$) / midpoint $spread_{i,t-1}$. Volume is the absolute value of the log of the mean volume per firm. PostNMS is a dummy variable, which equals 1 if the firm is trading on the NMS. T-statistics are shown in the parentheses with ***, ** and * indicating its statistical significant level of 1%, 5% and 10% respectively.

Dependent variable: Volatility	(1) All firms	(2) Low-volume	(3) Mid-volume	(4) High-volume
Intercept	-0.125***	-0.003*	0.013	-1.015***
	(-5.26)	(-1.67)	(-0.75)	(-6.71)
Volume	0.020***	0.003***	0.005**	0.113***
	(7.12)	(10.66)	(2.35)	(7.24)
PostNMS	-0.018**	-0.003*	-0.006***	-0.034
	(-2.35)	(-1.67)	(-2.77)	(-1.48)
N	5764	1920	1922	1922
R-squared	0.009	0.062	0.006	0.028

Table 8

Frequency of spreads.

This table shows the frequency of spreads for 120 trading days, 60 trading days before and after NMS. The firms are NASDAQ stocks before and after they were incorporated to the National Market System NMS between 1982 and 1989. Quoted spreads are calculated as closing ask - closing bid.

	Pre-NMS			Post-NMS		
Spread	Frequency	Percent	Cumulative	Frequency	Percent	Cumulative
0	29	0.02	0.02	30	0.02	0.02
0.03125	754	0.44	0.45	497	0.29	0.3
0.0625	3011	1.74	2.2	2784	1.61	1.92
0.09375	101	0.06	2.25	82	0.05	1.96
0.125	21862	12.65	14.9	24219	14.01	15.97
0.15625	9	0.01	14.91	16	0.01	15.98
0.1875	936	0.54	15.45	676	0.39	16.37
0.21875	12	0.01	15.46	5	0	16.37
0.25	49433	28.6	44.06	52053	30.11	46.48
0.28125	1	0	44.06	1	0	46.48
0.3125	97	0.06	44.11	63	0.04	46.52
0.34375	7	0	44.12	3	0	46.52
0.375	12423	7.19	51.31	12310	7.12	53.64
0.40625	2	0	51.31	2	0	53.64
0.4375	5	0	51.31	19	0.01	53.66
0.46875	8	0	51.31	1	0	53.66
0.5	42190	24.41	75.73	42026	24.31	77.97
0.5625	1	0	75.73	NA	NA	NA
0.625	781	0.45	76.18	784	0.45	78.42
0.75	19684	11.39	87.57	18046	10.44	88.86
0.875	226	0.13	87.7	157	0.09	88.95
1	8873	5.13	92.83	7887	4.56	93.51
1.125	43	0.02	92.86	16	0.01	93.52
1.25	1502	0.87	93.73	1512	0.87	94.39
1.375	24	0.01	93.74	28	0.02	94.41
1.5	4308	2.49	96.23	3691	2.14	96.55
1.625	9	0.01	96.24	7	0	96.55
1.75	612	0.35	96.59	598	0.35	96.9
1.875	3	0	96.59	8	0	96.9
2	2499	1.45	98.04	2223	1.29	98.19
2.125	1	0	98.04	72	0.04	98.23
2.25	114	0.07	98.11	1	0	98.23
2.5	1012	0.59	98.69	984	0.57	98.8
2.625	3	0	98.69	NA	NA	NA
2.75	56	0.03	98.72	38	0.02	98.82
3	1150	0.67	99.39	1122	0.65	99.47
3.25	3	0	99.39	14	0.01	99.48
3.5	246	0.14	99.53	222	0.13	99.6
3.75	7	0	99.54	3	0	99.61
4	198	0.11	99.65	10	0.01	99.61
4.5	31	0.02	99.67	355	0.21	99.82
4.75	18	0.01	99.68	35	0.02	99.84
5	228	0.13	99.81	108	0.06	99.9
5.5	NA	NA	NA	11	0.01	99.91
6	195	0.11	99.93	80	0.05	99.95
6.5	NA	NA	NA	1	0	99.95
7	56	0.03	99.96	31	0.02	99.97
7.5	NA	NA	NA	2	0	99.97
8	30	0.02	99.98	27	0.02	99.99
9	27	0.02	99.99	4	0	99.99
10	15	0.01	100	16	0.01	100
Total	172,830	100			172,699	100

Table 9
Regression results on quoted spreads greater than 0.25.
This table shows regression results for the model:
$Spread_{it} = \beta_0 + \beta_1 Price_{it} + \beta_2 Volume_{it} + \beta_3 Volatility_{it} + \beta_4 PostNMS_{it} + \varepsilon_{it}$
The firms are NASDAQ stocks before and after they were incorporated to the National Market System NMS between 1982 and 1989. The period is 60 trading days before and after NMS. Firms are categorized by the mean daily volume 60 trading days prior to NMS. The least traded firms are in group 1 and the most traded firms are in group 3. Spreads are calculated as the mean quoted spread per firm. Firms that have more than 80% of their spreads at equal or less than .125 are removed. Quoted spreads are calculated as closing ask - closing bid. Volatility is the standard deviation of daily returns per firm. The returns are based on the midpoint spread, which is calculated as (closing ask + closing bid)/2. The returns are then calculated as (midpoint $spread_{i,t}$ - midpoint $spread_{i,t-1}$) / midpoint $spread_{i,t-1}$. Price is the mean daily midpoint spread. Volume is the absolute value of the log of the mean volume per firm. PostNMS is a dummy variable, which equals 1 if the firm is trading on the NMS. T-statistics are shown in the parentheses with ***, ** and * indicating its statistical significant level of 1%, 5% and 10% respectively.

Dependent variable: Spread	(1) All firms	(2) Low-volume	(3) Mid-volume	(4) High-volume
Intercept	2.070***	2.480***	1.028***	0.083***
	(51.57)	(28.84)	(10.56)	(11.12)
Volume	-0.229***	-3.450***	-0.085***	-0.053***
	(-45.94)	(-27.06)	(-7.12)	(-6.56)
Price	0.020***	0.029***	0.009***	0.004***
	(40.03)	(34.55)	(16.95)	(9.30)
Volatility	0.076***	10.140***	0.287***	0.012***
	(4.08)	(11.53)	(2.49)	(2.04)
PostNMS	-0.022	0.050**	-0.011	-0.021**
	(-0.16)	(2.1)	(-0.93)	(-2.27)
N	4200	1824	1534	842
R-squared	0.462	0.542	0.175	0.124

Table 10

Average Stock Returns.

The means of the annualized returns for all stocks and each tercile are reported. The firms are NASDAQ stocks before and after they were incorporated to the National Market System NMS between 1982 and 1989. The period is 60 trading days before and after NMS. Firms are categorized by the mean daily volume 60 trading days prior to NMS. The least traded firms are in group 1 and the most traded firms are in group 3.

Period (Day)	(1) All firms	(2) Low-volume	(3) Mid-volume	(4) High-volume
-180 ~ -161	35.62%	11.80%	45.42%	52.63%
-160 ~ -141	46.30%	16.20%	38.51%	85.85%
-140 ~ -121	38.46%	22.92%	40.13%	55.58%
-120 ~ -101	34.17%	24.23%	25.81%	54.27%
-100 ~ -81	37.62%	10.86%	29.54%	79.72%
-80 ~ -61	41.10%	20.38%	23.87%	83.34%
-60 ~ -41	41.38%	30.54%	26.22%	69.76%
-40 ~ -21	38.06%	35.71%	25.53%	51.22%
-20 ~ -1	31.50%	38.40%	21.68%	33.38%
1 ~ 20	23.65%	36.97%	18.79%	12.31%
21 ~ 40	-0.39%	20.09%	1.94%	-25.74%
41 ~ 60	13.41%	28.30%	9.80%	-1.19%
61 ~ 80	11.45%	35.04%	-2.98%	-2.24%
81 ~ 90	8.37%	26.34%	-7.19%	4.61%