NYSE Execution Costs

Ingrid M. Werner*

Abstract

This paper uses unique audit trail data to evaluate execution costs and price impact for all NYSE order types: system orders as well as all types of floor orders. Almost 50 percent of market order volume and floor broker volume in the sample receives price improvement. Prices move significantly in the direction of the trade before the execution of ITS orders, marketable limit orders, and floor broker orders. Realized half-spreads are significantly positive for market orders and ITS orders, but they are significantly negative for all floor-order types. Floor broker orders are the most informative order type, followed by ITS orders, and marketable limit orders. By contrast, prices move in the opposite direction to the trade following regular limit orders, specialist orders, and percentage orders. Despite this, limit orders, specialist orders, and percentage orders are the only order types to outperform the volume-weighted average price (VWAP). The reason is that these order-types on average gain the spread (negative effective half-spreads) rather than paying it. Although floor broker orders are most informative, they under-perform the VWAP. The most likely reason is that floor orders are associated with substantial leakage, presumably because of order splitting. Taken together, our results emphasize how important the composition of order flow is for measures of execution costs and market quality.

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Comments welcome.

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I. Introduction

Measures of execution costs are widely used as measures of the quality of securities market. Hence, many researchers compare execution costs across exchanges to make inferences regarding their quality: a market with lower execution costs is deemed to be “better” than one where the execution costs are higher. Early work simply relied on quoted spreads to compare execution costs across markets. However, Petersen and Fialkowski (1994) showed that many transactions in U.S. equity market occur inside the quoted spread. Hence, new measures, e.g., the effective half-spread and the realized half-spread, were developed for comparison of execution costs across stocks and market structures. It was also acknowledged early on that it is appropriate to control for factors like volatility and liquidity (Ho and Stoll (1981)) as well as trade size (Easley and O’Hara (1987)) when making spread comparisons across markets. To our knowledge, no previous research attempts to link the composition of order flow to measures of execution costs in a systematic way.

In this paper, we examine execution costs and price impact in a broad cross section of NYSE-listed stocks during the period July 21 – August 22, and September 2 – October 3, 1997. The sample is unique in that it includes executions based on all types of orders: orders that are traded actively by NYSE floor brokers in the downstairs market; orders that are upstairs facilitated; not-held orders that are left by floor brokers with the NYSE specialist; NYSE specialist orders; system market and limit orders that reach the NYSE trading floor via SuperDot; and orders from third markets that reach the floor via the Intermarket Trading System (ITS). We calculate traditional measures of execution costs such as effective half-spreads, and realized-half spreads. In addition, we test whether submitters of certain order types are better informed as measured by the price impact of their trades. Our primary goal is to examine how important the composition of trades are for traditional measures of information content and execution costs.

Execution costs is one of the most intensively researched areas in market microstructure. The focus of recent studies ranges from: comparison of execution costs for trades of different size (e.g., Kraus and Stoll (1972), Holthausen, Leftwich, and Mayers (1987,1990), Jones, Kaul, and Lipson (1994), and Chan and Fong (1998));

comparison of execution costs for system market and limit orders (Harris and Hasbrouck (1996), and Lightfoot, Martin, Peterson, and Sirri (1999)); comparison of execution costs for upstairs versus downstairs trades (e.g., Keim and Madhavan (1996), and Madhavan and Cheng (1997)); and cross-exchange comparisons of execution costs (e.g., Huang and Stoll (1996), Bessembinder and Kaufman (1997), and Blume and Goldstein (1997)). To date, no study has been able to analyze both order executions for system (SuperDOT) and executions based on floor broker orders.[1] With the exception of Handa, Schwartz, and Tiwari's (1998) study of the Amex, there is no empirical work that analyzes the execution quality of floor broker orders. Hence, this paper provides a more comprehensive picture of NYSE execution costs than has ever before been available.

We use NYSE audit trail data for our analysis. The data has several advantages compared to for example TAQ and TORQ.[2] First, the data contains information on the composition of the buy-side as well as the sell-side for each trade. Obviously, both the buyers and the sellers care about execution quality. However, traditional methods for analyzing execution quality rely on a trade classification algorithm, e.g., Lee and Ready (1991), to determine whether to measure execution quality for a particular trade from the buyer's or the seller's perspective. Our data enables us to look at execution quality for all types of orders on both side of each transaction. This is an improvement over recent detailed studies of retail market orders (Lightfoot, Martin, Peterson, and Sirri (1999), Bacidore, Ross, and Sofianos (2000) and SEC (2001)).[3] Additionally, the widely used Lee and Ready (1991) algorithm only classifies a trade as buyer-initiated if the price exceeds or is equal to the mid-quote (tick-test). We show that more than 100,000 market orders representing nearly 30 percent of all market orders in our sample are not reflected

[1] Harris and Hasbrouck (1996) compare system market and limit orders, Keim and Madhavan (1996) and Madhavan and Cheng (1997) compare upstairs facilitated and downstairs block trades, Lightfoot, Martin, Peterson, and Sirri (1999) compare system market orders and marketable limit orders, and Bacidore, Ross, and Sofianos (1999) study system market orders.

[2] For example, Harris and Hasbrouck (1996) use TORQ data, Lightfoot, Martin, Peterson, and Sirri (1999) use audit trail data from NYSE and regional exchanges, and Bacidore, Ross, and Sofianos (1999) use system order data (SOD) from the NYSE. Both data sets includes complete information on submissions, (whole of partial) executions, and cancellations of all limit and market orders that reach the NYSE floor via SuperDOT, but they do not include detailed information on the trades executed by floor members.

[3] Lightfoot, Martin, Peterson, and Sirri (1999) study retail system market orders, marketable limit orders, and regular limit orders for NYSE-listed stocks traded on the NYSE and the regionals. Bacidore, Ross, and Sofianos (2000) study NYSE system market orders. SEC (2001) studies retail market orders, marketable limit orders, and limit orders from the NYSE and Nasdaq. All studies explicitly exclude floor broker orders, percentage orders (not-held orders), and specialist orders from their analyses.

in the standard execution quality measure calculations. The fraction of orders that are ignored in the standard measures is even larger for many other order types. Second, since we know the composition of trade executions, we can analyze for example the realized spreads for a market order trading against a limit order and compare that to market order trading with a floor broker or the specialist.

The major drawback with our data is that it does not reveal the original order submission times, nor does it reveal the original size of orders that receive multiple executions. Hence, unlike for example Bacidore, Ross, and Sofianos (2000), we cannot analyze multiple fills of market orders. Nor are we able to study the fill rates for limit orders as was done by for example Harris and Hasbrouck (1996), Lightfoot et al (1999) and SEC (2001). While it at least in theory would be possible to match audit-trail data with NYSE's system order data file (SOD) for system orders, no data similar to SOD existed at the time of our sample for floor broker orders and percentage orders.[4] In the interest of treating order executions across all order type the same way, we ignore multiple fills in our analysis.

We first characterize how different types of orders are executed compared to the NYSE specialist's quotes and the resulting effective spreads and price improvements. This approach to measuring execution quality is essentially the one taken by Bacidore, Ross and Sofianos (1999) in their extensive study of market order executions on the NYSE. We extend that analysis by comparing how all types of orders are executed compared to the NYSE specialist's quotes. Only for market orders do these measures reflect market quality strictly speaking. For other order types, e.g., those traded by floor brokers, these measures do not directly reflect the "quality" of NYSE executions but rather the ability of, e.g., floor brokers to gain the spread instead of paying it. We find that as much as 45.2 percent of market order volume but only 24.3 percent of ITS volume receives price improvement (buys below ask and sells above bid). System limit orders instead often offer price improvement: 20.1 percent of regular limit orders improve on the quotes (execute inside the quotes) and roughly 25 percent of all limit orders are marketable (execute at the opposite side). Floor orders also receive substantial price

[4] The NYSE has recently started collecting more systematic data on orders handled by NYSE floor brokers. This data is, however, not yet publicly available.

improvements: 47.7 percent of floor broker volume; 71.3 percent of percentage volume; and, not surprisingly, 90.9 percent of specialist volume receives price improvement. Finally, 58.2 percent of upstairs-facilitated volume receives price improvement.

Second, we characterize how prices move in the period surrounding executions based on different types of orders. This is one way of measuring how well trades based on different types of orders are timed. Alternatively, it captures the information content of trades based on different types of orders. Our measures include leakage (price movement prior to the trade), effective half-spreads, and realized half-spreads (half-spreads net of subsequent price movements in the direction of the trade). We define half spreads and realized half-spreads as recommended in the Securities and Exchange Commission's recent "Report on the Comparison of Order Executions Across Equity Market Structures," (2001). However, our scope is different from that taken by the SEC: We compare executions across order types within one market structure. We do this to test which order types have superior information and/or timing ability. We find that realized half-spreads are significantly positive for system orders (with the exception of small regular limit orders), but they are significantly negative for floor orders. Our first measure of information content is how much share-weighted average mid-quotes move in the direction of the trade. It turns out that marketable limit orders are by far the most informative orders, followed by ITS orders, and floor broker orders. By contrast, market orders have limited information content, and prices move in the opposite direction to the trade for limit orders, percentage orders, and specialist orders.

We use a regression framework to control for factors other than trade composition that might affect spreads in the cross-section and the time-series. We find that ITS orders pay the highest realized half-spreads, followed by market orders. Regular limit orders, floor broker orders, percentage orders, and specialist orders achieve significantly negative realized half-spreads. We also find that it is floor broker orders that are most informative, followed by ITS orders, and marketable limit orders. The information content of percentage orders is modest, while prices move in the opposite direction following regular limit orders, specialist orders, and even market orders. We expand the analysis to account for both counterparts in each trade. We find that spreads and information content of orders vary systematically with who is on the other side of the order. Another way of looking at this is that the composition of order types in a market significantly affects measures of execution quality.

Our final comparison of execution costs and information/timing for various order types uses a commonly used industry-benchmark: the volume-weighted average price (VWAP). How a particular order type fares compared to VWAP is a complement to measuring market timing based on leakage and price impact.[5] If the traders using a particular order type are systematically better informed, we would expect that they would on average buy at a lower price and sell at a higher price compared to traders favoring other order types. We find that limit orders, percentage orders, and the specialist order are the only order-types that significantly beat the VWAP. Market orders, marketable limits, ITS orders, and floor broker orders significantly under-perform the VWAP.

The paper proceeds as follows. Section II provides a data description. In Section III, we characterize trade executions compared to the NYSE specialist's quotes. We study various price impact and spread measures in Section IV. The analysis of volume-weighted average prices is in Section V. Section VI concludes.

II. Data Description

We use NYSE audit trail data very similar to the data described in Sofianos and Werner (2000). They first grouped all NYSE-listed stocks into deciles based on December, 1996, trading volume and then sampled 20 stocks randomly from the most liquid stocks (decile 10), and 10 stocks randomly from each of the other nine deciles. Our sample is the 101 stocks that were still traded during the periods: July 21 – August 22, and September 2 – October 3, 1997.[6] We report cross-sectional descriptive statistics for the sample in Table 1. The average market capitalization is \$3.1 billion, the average stock price \$31.22, the average daily share (\$) volume is 275 thousand (12 million), and the average trade size is 1,926 (57,002) shares (dollars). Note that the sample by design

[5] Chan and Lakonishok (1993) use this measure in their study of U.S. institutional trades. Choe, Kho, and Stulz (2000) use this approach in a recent study of whether or not foreign investors have better information than local investors in Korea.

[6] The attrition was due to mergers and/or de-listings of the following stocks (decile): ACO (1), ALW (7), ATP (6), DFI (5), DNA (6), MFO (2), PDP (8), RTZ (1), and V (8).

has a large cross-sectional dispersion for all variables in Table 1. Most measures are also highly skewed to the right in part because we over-sampled in the most liquid category.

Briefly, in addition to the usual information on the time stamp (in seconds), size, and the price of trades, our data includes information that permits us to classify the underlying order types for all components of both the buy and the sell side. For example, one trade of 12,000 shares at price $89 13/16 that took place on August 22, 1997, at 9:52:26 may have 10,000 shares executed actively by a floor broker and a 2,000-share market order on the buy side, and an 8,000-share limit order and 4,000 shares executed by the specialist market order on the sell side.

We focus on trade executions during regular trading, and we therefore exclude opening trades executed through OARS as well as the after hours crossing sessions. If there are several executions based on orders of a particular type on the same side in a trade, these are aggregated. For example, if there are two limit orders of 500 shares on the buy side and one 1,000-share market order on the sell side, we aggregate this into one 1,000-share limit order on the buy and one 1,000-share market order on the sell side. Finally, we exclude 260 trade executions that are more than $0.50 outside the quotes in effect 5 seconds prior to the trade. We end up with a sample of 613,644 trade executions.

Table 2 provides an overview of the trade data by order execution type. The data are separated into trades executed downstairs, Panel A, and trades that are upstairs-facilitated, Panel B. We use the algorithm developed by Madhavan and Cheng (1997) to identify upstairs-facilitated trades. In a nutshell, an upstairs-facilitated trade exceeds 9,999 shares and has the same floor broker represented on both the buy and the sell side. In each panel, we report the fraction of trading represented by: system market orders, system marketable limit orders, system limit orders, trades that arrive to the NYSE specialist from other exchanges (ITS orders), floor broker orders (active floor broker orders); percentage orders left by floor brokers with the specialist;[7] and specialist orders. The category "other" captures orders that cannot be classified. The first column is based on the number of trade reports, counting both buys and sells. System limit orders are the most commonly occurring orders represented in 29.7 percent of all trades, followed by

[7] NYSE rules dictate that percentage orders (also called not-held orders or CAP orders) left by floor brokers with the specialist be non-discretionary to reduce conflict of interest for NYSE specialists.

system market orders, 26.0 percent, and specialist orders, 14.8 percent. However, as seen in the lower part of Panel A, this is because trades based on system and specialist orders are smaller than trades based on active floor broker and percentage orders. Active floor broker orders are largest, 5,934 shares on average, followed by percentage orders at 2,857 shares. System orders are considerably smaller: the average execution size for marketable limit orders is 1,661 shares; for limit orders 1,379 shares; and for market orders 1,016 shares. Both ITS orders and specialist orders are less than 1,000 shares on average. As a result, the largest fraction of share volume comes from active floor broker orders – 25.4 percent. System limit orders is a close second at 24.4 percent followed by system market orders and percentage orders at 15.3 and 14.5 percent respectively. Specialist orders represent 8.0 percent and ITS orders 1.4 percent of share volume. We cannot classify 1.1 percent of twice share volume. The value-weighted distribution of volume reported is reported in the third column of Table 2.

Panel B of Table 2 characterizes the distribution of order executions for upstairs-facilitated trades. As expected, floor brokers represent the vast majority of the volume in these trades, ranging from 92.8 percent for trade-weighted averages to 94.0 percent for share-weighted averages. However, note that percentage orders, limit orders, and market orders, do occasionally participate as the block is broken up when brought to the floor for execution.[8] It is also not surprising that the average execution size for active floor broker orders in Panel B is considerably larger than in Panel A. For example, the average size of a floor broker execution in an upstairs-facilitated trade is 52,856 shares. When other order types participate in blocks, they are typically also much larger on average than in the downstairs sample.

The distribution of trading volume is very similar to the one reported for an earlier sample in Sofianos and Werner (2000). The main difference is that the specialist share of volume is smaller while the share of percentage trades is larger in our sample. The main reason for these differences is that our more detailed data allows us to better classify orders executed by the specialist into proprietary trades and those trades that the

[8] NYSE Rule 76 describes the rules for "Crossing" Orders inside the spread. See also NYSE Rule 127 for crossing blocks outside the prevailing quotes. For a discussion of these and other NYSE rules, see Hasbrouck, Sofianos, Sosebee (1993).

specialist execute on behalf of floor brokers.[9] Another difference that might affect the distribution of trading volume is that our sample period is after the reduction of the minimum tick size to 1/16. Werner (2000) discussed the implications of the tick size reduction for the market shares of specialists and floor brokers.

A common misconception is that the typical NYSE trade is one where a market order (liquidity demander) trades either with a limit order or with the specialist (liquidity suppliers). Indeed, this assumption is the basis for trade-classification algorithms. Table 3 shows that the frequencies of market order to limit order and market order to specialist trades are relatively low -- 21.5 (8.1) and 11.7 (3.4) percent of trades (share-volume) respectively. From the table, we can also infer that 32.3 percent of all trades and 35.1 percent of share-volume consists *exclusively* of orders submitted by what we traditionally think of as liquidity suppliers (limit orders) and professional traders (floor brokers, percentage orders, and specialists). At least half of this consists of trades between counterparts for which we would not traditionally calculate a spread: limit orders and percentage orders (which have to have a price limit by NYSE rules). The table also shows that while the majority of *trades* have one particular order type on each side (77.0 percent), as much as 49.2 percent of downstairs *share-volume* involves more than one order type on one (or both) sides. Hence, larger trades are more likely to be complex. Finally, note that market orders are represented on both sides of 2.8 (4.8) percent of all trades (share-volume). For these trades, it is obviously not appropriate to calculate the spread from the viewpoint of one side of the transaction as is traditionally done.

Before proceeding with the analysis, it is important to note a few caveats. First, we only observe the time and size of trade executions based on different order types and not the time and size of the originally submitted orders. Our data treats system and floor orders equally in this regard, but we do have reason to believe that orders sent to NYSE floor brokers are systematically different from orders sent via SuperDot. Specifically, Sofianos and Werner (2000) show that active floor broker trades are roughly six to seven

[9] Percentage orders are not clearly marked in the NYSE audit-trail data. We developed an algorithm that identifies those orders as: (i) orders executed by the specialist (badge=SPEC), for the specialist's account (account=S), originating from system orders (source=D or L); (ii) orders executed by the specialist (badge=SPEC or for his own account (account=S), originating from OARS (source=O); and (iii) orders executed by the specialist (badge=SPEC) or for his own account (account=S) that are crowd orders (source=C,P , or Y).

times larger than trades where no floor broker traded actively. This does not in and of itself prove that the size distribution of the original orders were different, but such information can be gleaned from the survey of NYSE floor brokers summarized in Sofianos and Werner (1997). Hence, floor broker orders, both active and passive, are likely to be broken up in more pieces than system limit orders.

Second, we are not privy to the specific order instructions given to NYSE floor brokers by the investors. Our conjecture is that practically all orders entrusted floor brokers have a specified price limit. In other words, they are in effect limit orders. However, the fact that a floor broker executes a buy based on an order at, say, $89 13/16 does not mean that $89 13/16 was the price limit. A typical situation is that a customer asks a floor broker to buy, say, 20,000 shares at $90 or better. The floor broker is also typically given some time frame for executing the order (as soon as possible, before noon, before close, this week, etc.). It is the floor broker's job to deliver the best possible execution of the entire order given the order instructions. She may execute the entire buy order at once, or fill the order over time at potentially different prices. She may even choose to give it to the specialist for execution, what is called a percentage order.[10] The binding constraint is that she is asked to deliver an average execution price that is no worse than $90, and she has an incentive to deliver an average purchase price that is below $90 to attract future order flow. Thus, when interpreting the execution costs based on standard measures we should keep in mind that the floor broker trade is likely based on a limit order and that the execution price often entails a price improvement compared to the original order instructions.[11]

Third, percentage orders that are left by NYSE floor brokers with the specialist for execution all have explicit price limits. NYSE Rule 13 and 123A.30 defines a percentage order as: "A limited price order to buy (or sell) 50% of the volume of a

[10] NYSE rules dictate that percentage orders (also called not-held orders or CAP orders) left by floor brokers with the specialist be non-discretionary to reduce conflict of interest for NYSE specialists.
[11] It is of course possible that the broker in our example buys some of the shares at a price exceeding $90, but maintains an average execution price of $90 for the order by also buying some shares at a price below $90. Since all parts of the order are included in our volume-weighted measures of execution quality, it is still correct to interpret the average trade executions in our sample to take place at the limit price or better. We believe that it is extremely rare that the floor broker fails to deliver the price limit set by the customer.

specified stock after its entry."[12] The specific rules for percentage orders are complex and several different types exist. A simplified example might help convey their flavor. Consider a "straight limit" percentage order to buy 15,000 shares with a price limit of $45.00. An execution at $44 15/16 (the bid) for 5,000 shares will *either* trigger the "election" of a 5,000-share limit order to buy at $45 from the percentage order to be displayed in the specialist's book *or* be "converted" into a 5,000-share limit order to buy at $45 to make a bid (to be displayed) or to participate directly in a trade. If the percentage order were instead of the "last sale" type, the elected 5,000-share limit order would be entered into the book (or executed) at $44 15/16. Hence, when we observe an execution of a percentage orders, the price is always at least as good as the price limit stated on the original order. Since a floor broker typically makes the decision to leave a not-held order with the specialist, we also presume that the execution price respects the price limits given to the floor broker by his or her off-floor client.

Finally, by grouping floor participants into floor brokers and specialists, and by ignoring the broker identity for off-floor brokers routing orders through SuperDOT, we ignore the heterogeneity that undoubtedly exists across individual brokers and firms. What we seek to capture is the average execution quality for orders of a specific type. While an in-depth analysis of the cross-section of execution quality within each order type would certainly be very interesting, it is beyond the scope of this paper.

III. Trade Executions and Quotes

We first follow the lead of Bacidore, Ross, and Sofianos (1999) and characterize how different types of orders execute relative to the NYSE quotes. We provide the following characterization of order executions:

(a) How trades execute relative to the quotes posted by the NYSE specialist:

- i. Execution outside the quotes with price improvement (below bid for buys and above ask for sells).
- ii. Execution at the quotes on the same side (bid for buys and ask for sells).

[12] During this sample, there were three types of percentage orders: Straight Limit Percentage Orders; Last Sale Percentage Orders; and "Buy Minus" – "Sell Plus" Percentage Orders. Effective March 1, 1999, an additional type was added: "Immediate Execution or Cancel Election."

iii. Execution inside the quotes.

iv. Execution at the quotes on the other side (ask for buys and bid for sells).

v. Execution outside the quotes with inferior price (above ask for buys and below bid for sells).

(b) Percent of trades with depth improvement (an order exceeding the quoted size).

(c) Effective spreads (purchase price minus bid and ask minus sell price).

(d) Percent price improvement relative to the quote (ask minus purchase price and sell price minus bid).

We know from Table 2 that the size distribution of orders differs significantly across order types. Therefore, we break down our measures by order execution size. We do this by classifying order executions into five categories: orders less than or equal to 500 shares; orders between 500 and 2,000 shares; orders between 2,000 and 10,000 shares; orders between 10,000 and 20,000 shares; and orders exceeding 20,000 shares. Note that since a trade may have several types of orders represented on the buy and sell sides respectively, the order size may be smaller or equal to the actual trade size.

We also need to match the trades from NYSE audit trail with quotes from TAQ data in order to calculate the measures of execution listed above. NYSE audit trail data does not include information on the time an order arrived to the floor of the NYSE. The only information that we have is the time stamps (to the second) of the trades themselves. Our goal is to treat trades based on all orders the same way and to avoid biases that might arise from assigning arbitrary delays for different types of orders. Therefore, we use the same algorithm for matching trades and quotes regardless of whether part of the trade was a trade based on a floor broker order or a trade based on another type of order. We follow much of the literature on execution quality by using a 5 seconds delay as originally proposed by Lee and Ready (1991).[13] In other words, we match each trade with the NYSE quotes in effect 5 seconds before the time stamp of the trade.

We first characterize trade executions for system orders in Table 4. Numbers for the "all" category are share-weighted, while numbers when broken down by execution

[13] The results in this paper are qualitatively the same if we use 5, 15, 30, or 60 seconds delay of the quotes. The only major difference is that more executions occur outside the posted quotes the longer the delay.

size are execution-weighted.[14] We exclude executions that are part of upstairs-facilitated transactions in these numbers (see below). The table gives both aggregate statistics and divides the data by the number of shares in a trade that is based on a particular order type (execution size). Our discussion will focus mostly on the aggregate numbers.

Overall, there are 352,703 trade executions with market orders on the buy and/or the sell side. Roughly half of those market order executions (175,726) are less than 500 shares and the frequency of executions declines strongly in order size. The majority of market order volume (53.0 percent) pays the spread (e.g., buy at the ask), and 1.8 percent even gets worse execution than the best quotes. However, a full 19.7 percent of market order volume executes at the best quotes on the same side (e.g., buy at the bid) and 0.6 percent even execute at a better price than the best quotes on the same side (e.g., buy below the bid). Thus, 20.2 percent of market order volume does not pay any spread. An additional 25.0 percent of market order volume executes inside the best quotes, and thus pays less than the quoted spread. These market orders get price improvement, either by the specialist stepping in and improving the NYSE quotes or by being exposed to floor broker represented orders that are not reflected in the NYSE quotes. Market orders at the same side are not captured when researchers condition their measures on trade direction, and market orders executing inside are only reflected to the extent that the execution price exceeds the mid-quote. Interestingly, contrary to popular belief, the fraction of market orders that receives price improvement *increases* strongly in order size. The reason is that large orders are more likely to interact with the crowd at the specialist's post and hence benefit from the added non-displayed liquidity provided by floor brokers. Note that market orders in our sample get better execution than what is reported by Bacidore, Ross, and Sofianos (1999): 45.3 percent of market order volume receives price improvement in our 1997 sample compared to 35.5 percent in their 1999 sample. The difference is likely to be attributable to the fact that we are unable to account for multiple fills.[15] An average of 35.4 percent of market order volume gets depth improvement (e.g.,

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[14] We use execution-weighted statistics for the size-bins to avoid putting most of the weight at the upper end of each bin.

[15] If prices move in the direction of the trade, we will compare the execution to a more favorable benchmark than if we were able to pin-point the quotes at the time of order submission. Another difference is that we do not condition on whether or not the order received depth improvement. Note also that we exclude market orders that are part of an upstairs-facilitated trade.

buy more than the size at the offer). Finally, effective spreads (purchase price minus bid/ask price minus sell price) are on average 25.3 basis points and the average price improvement 12.1 basis points. Effective spreads are roughly constant across order sizes, while price improvements increase strongly in order size.

There are 141,957 marketable limit order executions in our sample. A marketable limit order is one where the purchase (sale) price is larger than (smaller than) or equal to the ask (bid) price. Hence, 99.1 percent of marketable limit order volume occurs at the other side, and 0.9 percent of the volume even receives price dis-improvement. When using a marketable limit order, the submitter obtains priority over existing orders in the specialist's Display Book by offering a better price. These orders technically do not pay a spread, but the price improvement they offer compared to existing orders in the book can be thought of as a transaction cost (see, e.g., Lightfoot, Martin, Peterson, and Sirri (1999)). Marketable limit order executions are typically small, 65 percent are for less than 500 shares, and by definition they do not get any price improvement. On average 30.8 percent of marketable limit order volume gets depth improvement. By comparing the quoted spread at the time of the trade, we can see that marketable limit orders occur at narrower spreads than market orders on average 27.2 basis points compared to 37.3 basis points). However, since they do not obtain any price improvement, the effective spread for marketable limit orders are even higher than that of market orders on average.

There are 414,220 trade executions with regular system limit orders on the buy and/or on the sell side. Roughly 40 percent of the limit order executions are 500 shares or less, and another 40 percent are between 500 and 2,000 shares. Larger limit orders are relatively rare. As expected, the majority of limit order volume executes at the quotes at the same side (78.8 percent) or better (1.2 percent). However, 20.1 percent of regular limit order volume executes inside the spread. This means that one-fifth of all limit order volume is executed before it is displayed (reflected in the specialist's quotes). While non-standard in the literature, these orders can be thought of as marketable limits since they pay the price of improving on the existing book to get filled. On average 39.9 percent of trades based on regular limit orders get depth improvement. Finally, effective spreads (paid) are on average 4.4 basis points and price improvements (spread gained) 29.5 basis points for limit orders. Effective spreads start at 5.2 basis points for small orders, increase reaching a peak of 5.8 basis points for limit orders between 500 and 2,000 shares, and then decrease back down to 2.5 basis points. Price improvements (spread gained) increases strongly with size.

There are 33,228 trade executions in our sample that have ITS orders on the buy and/or on the sell side. Almost 50 percent of these executions are in the 500-2,000-share range. Large ITS executions are rare. Roughly three-quarters of ITS volume pays the spread (74.9 percent) and 0.8 percent even gets worse execution than the best quotes. Only 5.3 percent of ITS volume executes at the same side or better, while 19.0 percent executes inside the NYSE quotes. The larger the ITS order, the worse is its execution. An average of 20.7 percent of ITS volume gets depth improvement. Effective spreads are on average 31.0 basis points and price improvements 6.9 basis points for ITS orders. Effective spreads increase with order size while price improvements decrease with order size. Thus, while the execution patterns resembles that of system market orders, ITS orders systematically get worse execution than comparably sized system market orders.

We summarize trade executions for floor orders in Table 5. There are 100,062 downstairs trades with executions of actively represented floor broker orders on the buy and/or on the sell side. Almost half of these executions are 2,000 to 10,000 shares and another roughly 30 percent are 500 to 2,000 shares. Executions by floor brokers are on average substantially larger than what we saw in Table 3 for system orders. 51.5 percent of active floor broker volume pays the spread or more, while 24.0 percent gains the spread or better. The remaining 23.8 percent executes inside the best quotes. Both the fraction of volume that gains the spread and the fraction occurring inside the spread are declining in order size. By contrast, the fraction of executions that pays the spread is increasing in order size. A full 64.4 percent of floor broker volume receives depth improvement. The average effective spread for floor volume is 23.6 basis points, and the average price improvement 12.7 percent. Effective spreads increase while price improvements decrease in order size.

For completeness, we also report results for the 4,517 upstairs-facilitated trades included in our sample. Since the bulk (99.2 percent) of these trades consist of floor broker orders, we only report results for the floor broker component. By definition, these are much larger than the regular actively represented floor broker executions. It is slightly more likely that (40.2 percent) that the upstairs-facilitated volume executes at the other side than at the same side (36.0 percent). However, note that when we break down the data by execution sizes, the distribution of executions is more symmetric. Hence, there are a few large upstairs-facilitated trades that skew the share-weighted averages. Trades inside the quoted spread represent 20.7 percent of all upstairs-facilitated volume. Not surprisingly, 97.3 percent of upstairs-facilitated volume receives depth improvement. Finally, note that upstairs-facilitated trades tend to take place when the spread is wider. It is also evident from the effective spread (29.0 basis points) and the price improvement (26.2 basis points) that the upstairs facilitated trades on average execute roughly at the mid-quote.

Non-discretionary orders left by floor brokers with the NYSE specialist, or percentage orders, represent 118,571 order executions in the sample. In our sample, these orders are on average smaller than the orders that floor brokers trade actively, and the biggest size-class is orders between 500 and 2,000 shares. 44.3 percent of percentage volume gains the spread or more, while 28.7 percent pays the spread on average. 26.9 percent of executions occur inside the quoted spread. The fraction of executions that gain the spread is pretty constant across order sizes, while the fraction that pays the spread increases. Executions inside the spread decline as order sizes get larger. Depth improvement is offered to 59.7 percent of percentage volume. Effective spreads are 15.6 basis points on average for percentage orders, and the average price improvement is 20.9 basis points. Effective spreads increase slightly in order size, while price improvements are roughly constant.

Finally, we characterize trade executions for the 224,720 trades that include specialists' proprietary orders. These orders are predominantly small – the specialist takes less than 500 shares in almost half the trades where he participates. The specialist gains the spread or more on 41.7 percent of executions, and pays the spread or more on 19.1 percent of his trades. Inside executions amount to 39.2 percent of specialist volume. The larger is the order, the more likely it is that the specialist actually pays the spread. Executions inside and executions gaining the spread both decrease in order size. On average, 25.2 percent of specialist volume gets depth improvement. The effective spread for specialist orders is 12.8 basis points on average, and the average price improvement is

26.6 basis points. Effective spreads increase in orders size, while price improvements decrease in order size.

Since detailed information on NYSE floor orders has not previously been available, it is interesting to compare these orders with system orders. The execution quality statistics for active floor broker orders are similar to system market orders. Note that this is *not* evidence of poor execution quality for floor broker represented orders. Recall that is quite likely that the execution price is equal to or better than the price limit stipulated by the off-floor trader that originated the order. Percentage orders resemble system limit orders, but they have a larger fraction of trades executing inside the quotes than do regular limit orders. This is natural since any converted percentage orders that execute immediately after conversion will by definition improve on the quotes. Executions for specialist orders also resemble that of limit orders, except that the specialist is almost twice as likely to execute an order inside the spread instead of at the other side (pay the spread). Effective spreads are about 7.3 basis points higher and price improvements are the same as for limit orders – in other words, quoted spreads are on average wider when specialists participate. Trade executions inside the quotes arise as a result of the specialist offering price improvement of one or more ticks when the spread is wider than one tick.

IV. Price Impact and Spread Measures

In this section we study how prices move around order executions based on different order types. Studying the price movements prior to (leakage) as well as after (price impact) a particular trade type is standard practice in the literature on price impact of block trades and institutional trades in the literature.[16] Leakage might occur as information about the impending block trade is revealed to other traders, or because the block trade is split up into a sequence of executions. If a particular type of order execution is based on superior information about the true value of an asset, we expect that prices will increase following buys and fall following sells based on that particular order

[16] See, e.g., Holthausen, Leftwich, and Mayers (1987, 1990), Chan and Lakonishok (1993), Keim and Madhavan (1996), and Madhavan and Cheng (1997).

type. In studies where the focus is to evaluate execution quality, researchers instead primarily examine how the execution price compares to the mid-quote at the time of the trade (effective half-spread) and to the mid-quote at some point after the trade (realized half-spread).   The mid-quotes serve as estimates of the true value of the asset in these calculations. By allowing for time to pass between order execution and when the true value is estimated, the realized half-spread incorporates the information that might have been included in the trade itself. Since we are interested in the information content of orders as well as how well they are timed relative to price movements, we report measures compared to several past, present, and future benchmarks in our analysis.

We first calculate three measures: leakage; realized half-spreads; and total price impact. Leakage is defined as the logarithm of the purchase price minus the logarithm of the past mid-quote for buy orders and the logarithm of the past mid-quote minus the logarithm of the sale price for sell orders. A positive leakage effect means that prices are moving in the direction of the order, up for buys and down for sells. The realized half-spread is defined as the logarithm of the purchase price minus the logarithm of the future mid-point for buy orders and the logarithm of the future mid-point minus the logarithm of the sale price for sell orders. As a result, a positive realized half-spread means that the spread is paid while a negative realized half-spread means that the spread is gained. Finally, total price impact is defined as the logarithm of the mid-quote after the trade minus the mid-quote before the trade for buys, and the reverse for sells. Hence, a positive total price impact means that the price is moving in the direction of the order. It is unclear what the relevant time-horizon should be for evaluating these measures.[17] To ensure that our results are robust to the choice of horizon, we use three different windows: plus/minus 5 minutes around the trade; plus/minus 30 minutes around the trade; and the beginning of the day (BOD) and the end of the day (EOD).   Note that the BOD and EOD benchmarks imply a window of variable length from the trade execution itself. To economize on tables, we combine buy and sell orders for the purpose of this analysis.

[17] For example, Huang and Stoll (1994) use 5-minute and 30-minute windows, Bessembinder and Kaufman (1996,1997) use 30-minute and 24-hour windows, Madhavan and Cheng (1997) use a 20-trade window, Handa, Schwartz, and Tiwari (1998) use a 15-trade window, and the recent SEC Report (2001) uses a 5 minute window.

Table 6 summarizes leakage, realized half-spread, and total price impact for system orders broken down by window and order execution size. Our discussion will focus on the 5-minute windows. Prices clearly move significantly in the direction of market orders (10.0 basis points), marketable limit orders (14.0 basis points), and ITS orders (10.5 basis points) prior to the execution. By contrast, limit orders tend to execute after the price trends in the opposite direction to the trade (-16.7 basis points). I.e., limit order purchases occur after prices fall and limit order sales after prices have risen. For market orders and regular limit orders, extending the window amplifies the effect. By contrast, marketable limits and ITS orders seem to be triggered by shorter-term trends in prices. Perhaps with the exception of market orders, the leakage effect is also monotonically increasing in order size.

Realized half-spreads are significantly positive for market orders (3.0 basis points), limit orders (1.5 basis points) and ITS orders (3.8 basis points), but they are insignificant for marketable limit orders (0.0 basis points). When we break down the sample by order size, we find that realized half-spreads decrease in size for market orders and increase in size for limit orders, but the pattern is less consistent for marketable limits and ITS orders. Small market orders have a significantly positive realized half-spread (5.2 basis points) while small limit orders have a significantly negative realized half-spread (-4.5 basis points).

The total price impact is defined as leakage minus the realized half-spread. Marketable limit orders have the largest price impact in the direction of the trade (14.9 basis points), followed by market orders (8.0 basis points), and ITS orders (7.1 basis points). Prices continue to move in the opposite direction of limit orders after the trade, and the total price impact is negative as a result (-18.0 basis points). Hence, the negative leakage for limit orders does not constitute evidence of market timing. Instead, prices continue their trend also after the trade. The magnitude of the total price impact tends to increase both with the length of the window, and with the size of the trade, for market orders and regular limit orders. For marketable limit and ITS orders, the picture is more complicated.

Table 7 reports the same price impact measures for orders executed by floor members broken down by window and order size. Actively represented floor broker orders execute after prices have moved in the direction of the trade by 8.3 basis points on average (positive leakage), and the effect is increasing in trade size and window. By contrast, percentage orders and specialist orders execute after prices have moved in the opposite direction to the trade by 2.3 and 13.1 basis points respectively (negative leakage). The negative leakage, particularly for percentage orders, but also for specialist orders, is a short-term phenomenon and is strongest for smaller orders. This is consistent with the nature of percentage orders, and with the price-stabilizing duties of the NYSE specialist. Upstairs-facilitated trades are not associated with significant leakage, which makes sense since we are counting both the buy and the sell side of the trade.

In contrast to the results for system orders, realized half-spreads for floor orders are negative for all order types except upstairs-facilitated orders. Realized half-spreads are –1.6 basis points for active floor broker orders, -0.6 basis points for percentage orders, –4.6 basis points for specialist orders, and 0.2 basis points for upstairs-facilitated orders. In other words, floor members on average gain the spread instead of paying the spread. Moreover, realized half-spreads decrease as we extend the window but increase in order size for all types but specialist orders. Hence, it is easier for floor brokers and percentage orders to gain the spread in smaller orders. The realized spread-gain is larger than for system limit orders for all floor orders (except upstairs-facilitated ones) on average and it remains larger after controlling for order size in the case of floor broker orders and percentage orders. For specialists, realized half-spreads decrease in order size. This is consistent with the specialist's fiduciary obligation to help bridge gaps in liquidity for smaller orders. At the same time, the data suggests that the specialists are skilled in timing their (larger) discretionary trades.

The total price impact surrounding floor orders is positive and significant for floor broker orders (9.9 basis points), and the impact increases as we extend the window. In the short-horizon, price impact increases in trades size, but this pattern is reversed as we extend the window. As expected, the total price impact for upstairs-facilitated trades is not significantly different from zero. For percentage orders, the short-term impact is slightly negative (-1.7 basis points), but for the 60-minute window prices move in the direction of the trade (2.5 basis points). Total price impact falls in execution size for percentage orders. Specialist orders occur during price declines, regardless of the window. However, the effect is more pronounced for small executions than for large ones.

How can the realized spread-gain be larger for floor orders than for limit orders when effective spreads are if anything wider when floor orders execute (Tables 4 and 5)? To answer this question, we decompose realized spreads into the effective half-spread and changes in mid-quotes in Tables 8 and 9. The effective half-spread is defined as the logarithm of the execution price (mid-quote) minus the logarithm of the mid-quote (execution price) for buy (sell) orders, and the change in the mid-quote is defined as the logarithm of the mid-quote 5-minutes or 30-minutes after the trade, or at the end of the day, minus the logarithm of the mid-quote at the time of the trade. Note that realized half-spreads are the effective half-spread *minus* the change in the mid-quote. Recall that the change in the mid-quote is a measure of the information content of the trade.

Most theories (see, e.g., Seppi (1997)) assume that informed traders submit market orders. Yet, Table 8 shows that these orders have lower information content than either marketable limit orders or ITS orders. The effective half-spreads for market orders are 6.6 basis points and the change in the mid-quote 3.7 basis points. The effective spread declines in order size and the magnitude of the change in the mid-quote increases in order size for small and medium sized orders and then becomes insignificantly different from zero for large orders. As suggested by Barclay and Warner (1993), it is the medium sized (2,000-10,000 shares) system market orders that seem to carry the most information. Marketable limit orders are the most informative system order type: While they have the highest effective half-spreads (14.3 basis points), they are followed by an equally large change in the mid-quote (14.3 basis points). Hence, while the effective spread is large for marketable limit orders, the change in the mid-quote perfectly offsets it on average. By contrast, prices move in the opposite direction of a limit order execution (-14.1 basis points) to the point that it more than eats up more than the spread-gain of 12.6 basis points. System limit orders are thus poorly timed relative to subsequent quote moves. Market prices fall substantially (rise) after limit orders to buy (sell) are executed. This is consistent with limit orders getting “picked-off” by traders with better information. The change in the mid-quote increases in order size for all system order types except limit orders.

Table 9 repeats the decomposition exercise for floor orders. Among floor orders, active floor broker orders are the most informative order type. The change in the mid-quote is 7.1 basis points and this more than offsets the average effective spread of 5.4 basis points. The larger is the order execution, the larger is both the effective half-spread and the change in the mid-quote. An execution based on a floor broker represented order is followed by almost twice as large a price change (information content) as a system market order holding order size fixed. The information content for floor orders is similar to that for ITS orders, but represents only half the price change following marketable limit orders. Upstairs-facilitated orders have a small short-term information effect, but no significant long-term effect. Percentage orders suffer from the same problem as limit orders do -- they tend to get picked off. Hence, mid-quotes move in the opposite direction to the trade on average by 2.2 basis points. The information content is decreasing in order size for percentage orders. Since percentage orders are passive "participation" or "go-along" orders, this is not surprising. Specialist orders are followed by price moves in the opposite direction of the trade of on average 2.3 basis points, which eats up one-third of the negative effective spread (-6.9 basis point). This pattern is consistent with specialists stepping in to slow down price changes in periods of order-imbalances.

Most empirical work attempting to measure realized half-spreads and total price impact classifies trades as either buyer- or seller-initiated using for example the Lee and Ready (1991) algorithm. As mentioned in the introduction, this means that the researcher ignores the execution quality for orders on the opposite side of the trade. Employing such a classification method would have a substantial effect on measures of execution quality in our data.[18] We provide a comparison of the two methods in Appendix Tables 2 and 3 but high-light some findings here. Effective half-spreads for market orders would be 15.9 basis points on average, compared to 6.6 basis points when all orders are counted. Realized half-spreads for market orders would be 5.2 basis points on average (5-minute window) compared to 3.0 basis points when all orders are counted. Effective half-spreads for floor broker orders would be 16.8 basis points compared to 5.4 basis points

[18] For completeness, we include Appendix Tables 2-3 that compares results conditioned on trade direction (Lee and Ready (1991)) to our calculations. Similar observations are made by Lightfoot, Peterson, and Sirri (1999), and by Peterson and Sirri (1999).

when all orders are counted. Realized half-spreads for floor broker orders would be –0.7 basis points (5-minute window) compared to –1.6 basis points. Perhaps most telling is the spreads for upstairs-facilitated trades: If we classify trades using the Lee and Ready (1991) algorithm, effective (realized) half-spreads would be 25.2 (8.4) basis points compared to 1.4 (0.2) basis points when counting all orders.

Regression Analysis

The measures of price impact that we have provided so far aggregate across stocks and time. This would be fine if order types are equally represented for all stocks, and in all time periods within days and across days. It is highly unlikely that this is the case. We know for example from Sofianos and Werner (2000) that the floor broker participation rate is highest for the most liquid stocks. To control for other variables that are likely to influence spreads, we run pooled time-series cross-section regressions for each of four spread variables: leakage, realized half-spreads, effective half-spreads, and mid-quote changes. We want to sample each trade only once. Therefore, we define all spreads as for a buy order, e.g., the realized half-spread is the execution price minus the logarithm of the mid-quote 5-minutes after the trade. Spreads are defined using a 5-minute window, and are multiplied by 10,000.

Our control variables include variables that have been found by previous studies to explain the cross-section and time-series of spreads: trade size (thousand shares), inverse of dollar price (defined as the mid-quote 5 seconds prior to the trade), depth imbalance (defined as the depth at the offer in effect 5 seconds prior to the trade divided by the sum of the depths at the bid and offer), logarithm of market capitalization as of December 31, 1996, volatility (defined as 10,000 times the daily average logarithm of (high/low), and logarithm of average daily dollar volume. We also calculate variables that captures the activity during the trading day: Time of Day (takes on a value of 1 for trades between 9:30 and 11:30, takes on a value of 2 for trades between 11:30-2:00, and a value of 3 for trades between 2:00 and 4:00); Cumulative Buy Volume based on the widely used Lee and Ready (1991) classification, and Cumulative Volume. We divide the last two volume variables by average daily volume to control for heteroskedasticity. Execution costs should decrease with trading volume due to economies of scale and with market capitalization because of higher liquidity and lower information asymmetry. Costs should increase in volatility because liquidity suppliers are risk averse. To the extent that discreteness is important, spreads should increase in the inverse of price.[19] We know from studies of NYSE intraday patterns (e.g., Foster and Viswanathan (1993) and Werner and Kleidon (1996)) that spreads should decrease in the time of day and in cumulative volume as information asymmetry is reduced. Depth imbalance and cumulative buy volume are both measures of order imbalances.[20] More depth at the offer should hold spreads down, while more buyer-initiated trades should increase spreads all else equal. Trade size is traditionally expected to increase spreads, both because of inventory effects and the likelihood of large trades being information-based. However, in a market like the NYSE where the market maker rarely is the sole counterpart to a trade, it is less clear that larger trades should encounter wider spreads. Table 10 summarizes the distribution of the control variables. To make it easier to interpret the estimates for the effect of trade composition on spreads, we de-mean the control variables other than trade size.

We first use dummy variables to test if spreads, $S \in$ {Leakage, Realized Half-Spreads, Effective Half-Spreads, and Mid-quote Changes} depend significantly on the composition of orders on the buy and the sell side of the trade after controlling for other variables that might affect spreads:

$$S = \alpha + \beta_1 \text{Depth.Imb} + \beta_2 (1/\text{Price}) + \beta_3 \text{Time.of.Day} + \beta_4 \text{Cum.Buy.Vol} + \beta_5 \text{Cum.Vol} + \beta_6 \text{Mkt.Cap} + \beta_7 \text{Volatility} + \beta_8 \text{\$Volume} + \beta_9 \text{Trade.Size} + \sum_{j=1}^{8} \gamma_j^B D_j^B + \sum_{j=1}^{8} \gamma_j^S D_j^S + \varepsilon,$$

where $D_j^{B(S)}$ takes on the value of one if a buy (sell) order of type j is present in the trade, $j \in$ {Market Order, Marketable Limit order, Limit Order, ITs order, Floor Broker order, PerCentage order, SPecialist order, OtheR order} and zero otherwise. We use GMM to obtain robust standard errors. It is important to note that a trade has both buyers and sellers. Hence, the fitted spread for a 2,000 share trade with say a market buy order

[19] Harris (1994) makes this point.

[20] Handa, Schwartz and Tiwari (1998a) were the first to suggest that this variable is an important determinant of bid-ask spreads in order driven markets. See also Handa, Schwartz, and Tiwari (1998b).

trading with a regular limit order, in the middle of an average stock-day can be computed as: a+2.0xb_9+γ_{MO}^{B} +g_{LO}^{S}.

We then augment the regressions by adding interaction terms between the composition of orders and trade size:

$$S = j + f_1\text{Depth.Imb} + f_2(1/\text{Price}) + f_3\text{Time.of.Day} + f_4\text{Cum.Buy.Vol} +$$
$$f_5\text{Cum.Vol} + f_6\text{Mkt.Cap} + f_7\text{Volatility} + f_8\text{\$Volume} + f_9\text{Trade.Size} +$$
$$\sum_{j=1}^{8} l_j^B D_j^B + \sum_{j=1}^{8} n_j^B D_j^B \cdot \text{Trade.Size} + \sum_{j=1}^{8} l_j^S D_j^S + \sum_{j=1}^{8} n_j^S D_j^S \cdot \text{Trade.Size} + h$$

A positive estimated coefficient n_j^B means that the spread is increasing more in trade size when an order of type $j \in$ {Market Order, Marketable Limit order, Limit Order, ITs order, Floor Broker order, PerCentage order, SPecialist order, OtheR order} is present on the buy side than if the order was not present in the trade. The fitted spread for a 2,000 share trade with say a market buy order trading with a regular limit order, in the middle of an average stock-day can be computed as: j +2.0x(b_9+n_{MO}^{B}+n_{LO}^{S})+ l_{MO}^{B} + l_{LO}^{S}.

The first two sets of columns in Table 11 report the estimated coefficients and t-statistics for in the two specifications. Leakage is significantly decreasing in depth imbalance, market capitalization, and in the time of day dummy, and is significantly increasing in cumulative buy-volume, and volatility. After controlling for these factors, leakage depends significantly on the composition of trade. With a few exceptions, the order type dummies are highly significant. The leakage effect is largest for ITS orders, followed by floor broker orders, and market orders. By contrast, specialist orders, regular limit orders, and percentage orders are associated with significantly lower than average leakage. The results are robust with respect to including interaction terms between order-type dummies and trade size as can be seen from the second two columns in Table 11. Interestingly, the effect of trade size on leakage differs significantly across order types. A larger ITS buy order or floor broker buy order is associated with higher leakage. By contrast, leakage declines significantly in trade size for regular limit buy orders. The pattern is generally symmetric, with the exceptions that larger specialist sell orders are associated with significantly positive leakage and that larger percentage sell orders are associated with significantly negative leakage.

Realized half-spreads are significantly increasing in depth imbalance, but neither the other economic factors nor the intraday factors are statistically significant. Trade size significantly reduces realized half-spreads (see discussion below). The effect on realized half-spreads is highest for ITS orders, followed by market orders. By contrast, floor broker orders, percentage orders, regular limit orders, and specialist orders are associated with significantly lower than average realized half-spreads. The results are robust to including interaction terms between order-type dummies and trade size. As was the case for leakage, we find that trade size affects realized half-spreads differently depending on the trade composition. For market orders, marketable limit orders, ITS orders, and specialist orders, trade size significantly decreases realized half-spreads (reduces execution costs). By contrast, for floor broker orders and regular limit orders, trade size significantly increases half-spreads (increases execution costs).

Table 12 reports the results of both regression specifications for effective half-spreads and mid-quote changes. Effective half-spreads are significantly declining in depth imbalance and market capitalization, and are significantly increasing in cumulative buy-volume. Neither trade size, nor the other economic factors significantly affect effective half-spreads. After controlling for these factors, the composition of trades is highly significant. ITS orders face the highest effective half-spreads, followed marketable limit orders, market orders and floor broker orders. Regular limit orders and specialists have significantly lower than average effective half-spreads. Again, the results are robust to including interactions between order-type dummies and trade size (second two columns). Moreover, the impact of trade size depends significantly on the composition of the trade. Specifically, larger trade size implies a lower effective half-spread for market orders, marketable limits, limit orders, and specialist orders. By contrast, a larger trade size is associated with a higher effective half-spread for floor broker orders and percentage orders.

The last four columns of Table 12 report the results for mid-quote changes. Mid-quote changes are significantly decreasing in depth imbalance and time of day, and are significantly increasing in cumulative buy-volume. As expected, mid-quote changes or information content is significantly increasing in trade size. Even after controlling for these factors, trade composition matters significantly for mid-quote changes. A benchmark floor broker order is associated with the largest movements in the direction of the trade, followed by an ITS order, and a marketable limit order. Price impacts associated with market orders, specialist orders and regular limits are significantly lower than average. The results are robust to the inclusion of interaction terms between order-type dummies and trade size (last two columns). Moreover, the effect of trade size depends significantly on the composition of the trade. The presence of market orders, marketable limit orders, ITS orders, and specialist orders increases the impact of trade size. If a limit order is present in the trade, it significantly reduces the impact of trade size.

The regressions in Tables 11 and 12 do not allow for a potentially different effect of a having, say, a market order trading with a limit order as opposed to a floor broker. Our last regression specification allows for such differences. In an attempt to remain somewhat parsimonious, we only control for cases when a particular order type represents the entire buy or sell side of a trade, and when several order types are represented. The specification is as follows:

$$S = i + r_1\text{Depth.Imb} + r_2(1/\text{Price}) + r_3\text{Time.of.Day} + r_4\text{Cum.Buy.Vol} +$$
$$r_5\text{Cum.Vol} + r_6\text{Mkt.Cap} + r_7\text{Volatility} + r_8\text{\$Volume} + r_9\text{Trade.Size} +$$
$$\sum_{j=1}^{8}\sum_{k=1}^{8} w_{jk}A_j^B A_k^S + y$$

where $A_{j(k)}^{B(S)}$ takes on a value of one if a buy (sell) order of type $j(k) \in$ {Market Order, Marketable Limit order, Limit Order, ITs order, Floor Broker order, PerCentage, SPecialist, MIxed} represents the entire side of the trade. If for example $w_{MO,LO}$ is significantly higher than $w_{MO,FB}$, the spreads are higher when a market order trades with a limit order than when a market order trades with a floor broker, controlling for other factors that might affect the spread including size.

Table 13 reports the abbreviated results from these regressions. In the interest of space, we only report the fitted values for a 2,000-share trade of each type. They estimated coefficients for economic and intraday variables do not differ in any major way from what is presented in Tables 11 and 12.[21] To conserve space, we further collapse marketable limit orders and regular limit orders into one category – limit orders. For

[21] The results are available from the author on request.

frequencies of each order-type match in the sample, refer to Table 3. Table 13 reveals that there are significant differences in spreads for all order types depending on what order type is on the other side of the trade. For example, realized half-spreads for a market buy order are insignificantly different from zero if the counterpart is another market order. However, if the counterpart is an ITS order, the realized half-spread is significantly negative. If the counterpart is any other order type, the market buy order pays a significantly positive realized half-spread.

Effective half-spreads for a market buy-order trading with a market order is not significantly different from zero, but if a limit orders is on the other side, the effective half-spread is as high as 13.04 basis points. If the specialist is on the other side, the effective half-spread is 8.22 basis points. By contrast, if a floor broker order is on the other side, effective half-spreads are relatively low, 2.32 basis points, and if a percentage order is the counterpart, it is 5.60 basis points. This shows how effective the NYSE auction process is at lowering execution costs. Interestingly, if an ITS order is on the other side, the market buy order achieves a significantly negative effective half-spread of –11.56 basis points.

A market buy order trading with a limit order or a specialist has substantial information content (6.20 and 3.86 basis points respectively), but if the counterpart is instead a floor broker or ITS order, the prices move in the opposite direction of the trade by 3.02 and 6.99 basis points on average. This is consistent with the higher information content of floor broker and ITS orders that we detected previously. Regardless who a floor broker buys from, the mid-quote changes are significantly positive ranging from 16.28 basis points when the counterpart is a limit order to 0.64 basis points when it is another floor broker. ITS orders pick off market orders and the specialist, but prices move in the opposite direction to the order when they are trading with floor brokers.

Tables 11-13 reveal that the mix of orders on the NYSE significantly influences estimated spreads. Clearly, the order flow mix is different for different exchanges. For example, floor broker orders and percentage orders are not present in the mix of orders on Nasdaq. It follows that it is difficult, probably even impossible, to accurately compare execution cost measures across exchanges.

V. Value-weighted Average Spreads

Our final comparison of execution costs and information/timing for various order types uses a commonly used industry-benchmark: the volume-weighted average price (VWAP). How a particular order type fares compared to VWAP is a complement to measuring market timing based on leakage and price impact. If the traders using a particular order type are systematically better informed, we would expect that they would on average buy at a lower price and sell at a higher price compared to traders favoring other order types.

We first calculate the daily, *d*, volume-weighted average execution price, A_{dj}, for all stocks, *j*, based on all trades, *i* :

$$A_{dj} = \sum_{i=1}^{T} \frac{P_i \cdot V_i}{\sum_{i=1}^{T} V_i}$$

where P_i is the execution price and V_i is the number of shares. For each order type, *k*, and each stock, *j*, we then calculate the daily volume-weighted average buy (sell) price, $B^{B(S)}{}_{dkj}$, as:

$$B_{dkj}^{B(S)} = \sum_{i=1}^{T} \frac{P_{ik}^{B(S)} \cdot V_{ik}}{\sum_{i=1}^{T} V_{ik}}$$

where $P^{B(S)}{}_{ik}$ is the execution price of a buy (sell) order of type *k*, and V_{ik} is the number of shares in the trade of order type *k*. Our normalized measure of volume-weighted average execution price for buy (sell) orders of type *k* is:

$$VWAP_k^B = 10{,}000 \cdot (1 - (\sum_{d=1}^{D} \sum_{j=1}^{N} B_{dkj}^B / A_{dj}))$$

$$VWAP_k^S = 10{,}000 \cdot ((\sum_{d=1}^{D} \sum_{j=1}^{N} B_{dkj}^S / A_{dj}) - 1)$$

We present the results in Table 14. Panel A reports VWAP for buy orders and Panel B reports VWAP for sell orders. Days and stocks are equally weighted in the calculations.[22] We find that limit orders, percentage orders, and the specialist order are the only order-types that significantly beat the VWAP. That is, they have normalized

[22] We also weight the means by dollar volume, and by volatility, with very similar results. Finally, we control for economic variables in a similar way to the previous section but few of the economic variables are statistically significant. These are available from the author on request.

VWAPs that are significantly positive for both buys and sells. Market orders, marketable limits, ITS orders, and floor broker orders significantly under-perform the VWAP based on all trades. In the case of floor broker orders, the difference is small in economic terms. Panel C reports the results for sell minus buys, $VWAP^S + VWAP^B$. This measure is another comprehensive measure of execution costs or profits as the case may be. We only include stock-days when there are both buy orders and sell orders by the same order type for this calculation. Profits are highest for specialists, 26.2 basis points, followed by regular limit orders, 25.9 basis points. Percentage orders gain on average 5.2 basis points while floor broker execution costs are 5.0 basis points on average. More substantial execution costs are faced by ITS orders, 7.7 basis points, marketable limit orders, 17.5 basis points, and particularly market orders, 27.4 basis points.

We also break down the results by order execution size. Note that the benchmark value-weighted execution price for these calculations is based only on trades of the same size as the specific order execution size. Market orders and marketable limit orders under-perform the benchmark, and limit orders significantly out-perform the benchmark, for all order execution sizes. ITS orders significantly under-perform for small orders only, while percentage orders and specialist orders significantly out-perform for all sizes except the very largest. Floor-broker executions below 2,000 shares are not significantly different from the benchmark. Hence, it is the larger executions that create the significantly negative average VWAP for floor broker orders. This is probably related to the fact that floor brokers tend to trade very large orders (see Sofianos and Werner (1997)) and face substantial price impact – leakage -- as an order is filled in multiple trades.

VI. Conclusions

We have provided a comprehensive analysis of NYSE execution costs, including all order types on the NYSE. While several authors previously have studied market orders, marketable limit orders, and specialist trading, no one has previously studied ITS orders, floor broker orders and percentage orders in detail. It is important to remember that our analysis is based on order executions, not the originally submitted orders.

We find that the frequency of orders that obtain price improvements compared to the NYSE specialist's quotes is substantial. For example, almost half the market orders and floor broker orders receive price improvement. Price improvements can be offered by the specialist, or can be obtained when an order is exposed to the liquidity on the floor represented by floor brokers. Indeed, this is probably the main advantage of NYSE's agency-auction trading protocol. The high frequency of price improvements for market orders also imply that traditional methods for evaluating execution quality based on classifying trades into buyer- and seller-initiated trades significantly overestimate execution costs.

We also find that prices move significantly in the direction of the trade prior to execution for ITS orders, marketable limit orders, and floor broker orders. Realized half-spreads are significantly positive for market orders and ITS orders, but they are significantly negative for all floor-order types. Total price impact is largest for marketable limit orders, followed by floor broker orders, market orders, and ITS orders. By contrast, limit orders and specialists on average buy when prices are declining and sell when prices are increasing.

Interestingly, floor broker represented orders are the most informative order type, followed by ITS orders, and marketable limit orders. The evidence thus supports the notion that floor brokers, or their off-floor clients, have superior information and/or better timing ability than traders using SuperDOT. While market orders are often assumed to be the order type that is favored by informed investors, this prediction is not borne out in the data. Prices move in the opposite direction to the trade following regular limit orders, specialist orders, and percentage orders. Hence, the data suggests that these orders do get "picked off" on average as suggested by theory. However, note that these order types do not systematically lose money since they gain the spread on average. Indeed, they are the only order types that significantly outperform the VWAP.

This study shows how important the composition of order flow is for measures of NYSE execution costs. We examine the average execution costs for trades with different order flow composition on the NYSE after controlling for economic factors, intraday variation, and trade size. An important caveat is that this analysis assumes that the order flow composition is exogenous. In future work, we will examine execution costs incorporating the endogeneity of order flow in a spirit similar to Madhavan and Cheng (1997).

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Table 1. Descriptive Cross-Sectional Sample Statistics

The original sample of 110 stocks comes from Sofianos and Werner (2000). They formed deciles of all NYSE listed stocks with a minimum price variation of 1/8 based on December, 1996, consolidated dollar trading volume. A random sample of 10 stocks were drawn from deciles 1 through 9 and a random sample of 20 stocks were drawn from decile 10 (the most liquid stocks). This paper covers the periods: July 21 - August 22, September 2 - October 3, 1997 (September 12 is missing). Attrition between December, 1996, and the later sample period reduced the sample to 104 stocks. The descriptive statistics are based on the daily summary files from TAQ. Volatility is calculated as1,000 times the sum across days of ln(close/open)^2 [ln(high/low)^2] divided by the number of days with trades for a particular stock.

	Mean	Min	Q1	Median	Q3	Max
Market Capitalization ($Million)	3,063.5	4.1	141.2	561.0	3,049.9	58,751.9
Price ($)	31.22	4.37	13.89	25.99	39.01	112.46
Volatility (Close/Open)	0.301	0.003	0.133	0.219	0.352	2.424
Volatility (High/Low)	0.616	0.010	0.277	0.503	0.821	4.819
Daily Share Volume	274,923	390	23,571	80,908	333,061	2,267,892
Daily Dollar Volume ($Thousand)	12,152	7	408	1,805	12,187	152,023
Number of Days	47	8	49	49	49	49
Trade Size (Shares)	1,926	195	1,241	1,755	2,356	6,656
Trade Size (Dollars)	57,002	3,505	20,647	49,867	76,964	199,571
Number of Trades	5,972	20	775	2,028	8,313	45,417

Table 2. Distribution of Order Execution Types

Panel A describes the breakdown of trading volume and the execution size distribution for different types of orders for 611,383 downstairs trades in the sample. The Appendix describes more in detail how orders are classified. A marketable limit order to buy (sell) is a limit order that executes above the bid (below the ask) quote posted by the specialist 5 seconds before the trade. Percentage orders are orders that floor brokers leave with the specialist for execution as not-held orders. The "Other" category captures orders for which the audit trail does not include information on the order type. Panel B describes the breakdown of trading volume and the execution size distribution for 2,261 upstairs facilitated trades. Upstairs facilitated trades are defined as in Madhavan and Cheng (1997).

A. Downstairs Trades

	Fraction of Total Buys and Sells		
	Trade-weighted	**Share-weighted**	**Value-weighted**
Market Orders	26.0	15.3	16.1
Marketable Limit Orders	11.2	10.1	9.8
Limit Orders	29.7	24.4	24.2
ITS Orders	2.6	1.4	1.2
Floor Broker Orders (active)	7.2	25.4	24.4
Percentage Orders (passive)	7.9	14.5	14.5
Specialist Orders	14.8	8.0	8.7
Other	0.5	1.1	1.1

	Execution Size Distribution			
	Mean	**Q1**	**Q2**	**Q3**
Market Orders	1,016	200	500	1,000
Marketable Limit Orders	1,661	400	1,000	2,000
Limit Orders	1,379	200	500	1,300
ITS Orders	961	300	500	1,000
Floor Broker Orders (active)	5,934	1,000	3,000	6,100
Percentage Orders (passive)	2,857	500	1,000	3,000
Specialist Orders	828	200	500	1,000

B. Upstairs Facilitated Trades

	Fraction of Total Buys and Sells		
	Trade-weighted	**Share-weighted**	**Value-weighted**
Market Orders	1.1	0.8	0.9
Marketable Limit Orders	0.0	0.0	0.0
Limit Orders	2.6	2.2	2.2
ITS Orders	0.0	0.0	0.0
Floor Broker Orders (active)	92.8	94.0	93.7
Percentage Orders (passive)	3.2	2.7	2.9
Specialist Orders	0.0	0.0	0.0
Other	0.2	0.2	0.2

	Execution Size Distribution			
	Mean	**Q1**	**Q2**	**Q3**
Market Orders	5,522	1,000	3,000	7,000
Marketable Limit Orders	2,286	700	1,550	3,300
Limit Orders	9,119	1,900	5,000	11,000
ITS Orders	2,225	400	850	2,500
Floor Broker Orders (active)	52,856	15,000	25,000	50,000
Percentage Orders (passive)	12,761	3,900	8,550	17,600
Specialist Orders	1,849	200	800	2,000

Table 3. Composition of NYSE Trades

This table reports the frequency of trade compositions in our sample. We report frequencies where the order type represents the entire buy side or the entire sell side (bold), or one order type represents one side of the trade and the other order type represents the entire other side. Share-weighted frequencies use the entire trade size as weights.

	Order type alone on each side	
	Trade-weighted (%)	Share-weigthed (%)
Market Order - Mixed	6.70	7.90
Market Order - Market Order	0.92	0.26
Market Order - Limit Order	21.54	8.07
Market Order - ITS Order	2.65	1.10
Market Order - Floor Broker Order	1.53	1.78
Market Order - Percentage Order	2.83	1.65
Market Order - Specialist Order	11.67	3.44
Limit Order - Mixed	8.56	12.10
Limit Order - Limit Order	12.93	8.93
Limit Order - ITS Order	0.00	0.00
Limit Order - Floor Broker Order	3.28	6.84
Limit Order - Percentage Order	3.16	2.79
Limit Order - Specialist Order	10.44	5.56
ITS Order - Mixed	0.46	0.53
ITS Order - ITS Order	0.00	0.00
ITS Order - Floor Broker Order	0.30	0.14
ITS Order - Percentage Order	0.35	0.12
ITS Order - Specialist Order	1.38	0.20
Floor Broker Order - Mixed	3.19	15.83
Floor Broker Order - Floor Broker Order	1.05	4.35
Floor Broker Order - Percentage Order	1.34	3.65
Floor Broker Order - Specialist Order	0.06	0.02
Percentage Order - Mixed	1.28	3.98
Percentage Order - Percentage Order	1.46	1.91
Percentage Order - Specialist Order	0.11	0.02
Specialist Order - Mixed	0.57	0.49
Mixed - Mixed	2.24	8.33
Total	**100.00**	**99.99**

Table 4. Trade Executions for System Orders by Execution Size

This table summarizes how different order types are executed relative to the quotes in effect 5 seconds before the order execution. For example, a 3,000 share market buy order execution at $12.0625 when the quoted prices (depths) are $12.000 (2,000) -$12.125 (2,000) will be tabulated as "Inside" with a depth improvement (DI). Similarly, a 3,000 share market buy order execution at $12.000 when the quoted prices (depths) are $12.0000 (2,000) -$12.1250 (2,000) will be tabulated as "At Same Side." with a depth improvement (DI). Buy and sell orders are lumped together. If more than one buy (sell) order execution of a particular type occurs in one trade, these buy (sell) order executions are aggregated. Effective Spread is defined as 10,000 times the difference between the price and the midquote (difference between the midquote and the price), divided by the midquote, for a buy (sell) order. Price improvement (PI) is defined as 10,000 times the difference between the ask and the price (difference between the price and the bid), divided by the midquote, for a buy (sell) order. Statistics for all are share-weighted. Statistics are execution-weighted by size. Figures in italics are not significantly different from zero.

				Distribution of Price Relative To Quotes						Relative Spreads (Basis Points)		
	Execution Size	**Number**	**Cum. Pct.**	**Outside PI**	**At Same Side**	**Inside**	**At Other Side**	**Outside PD**	**DI**	**Quoted**	**Effective**	**PI**
Market Orders	**All**	**352,703**		**0.6**	**19.7**	**25.0**	**53.0**	**1.8**	**35.4**	**37.3**	**25.3**	**12.1**
	x<500	175,726	50	0.1	13.1	32.9	53.3	0.6	1.5	33.4	23.5	9.8
	500<x<2000	129,716	87	0.2	16.1	27.0	55.3	1.4	14.1	35.1	25.2	9.9
	2000<x<10000	44,058	99	0.3	19.2	23.4	55.1	1.9	39.0	38.9	25.7	11.2
	10000<x<20000	2,584	100	1.4	25.7	25.0	46.2	1.7	67.5	43.1	26.3	16.8
	x>20000	619	100	1.1	30.5	20.8	44.6	2.9	81.9	46.4	26.2	20.1
Marketable Limits	**All**	**141,957**		***0.0***	***0.0***	**0.0**	**99.1**	**0.9**	**30.8**	**27.2**	**28.4**	**-0.2**
	x<500	92,667	65	*0.0*	*0.0*	0.0	99.2	0.8	14.2	25.4	25.6	-0.1
	500<x<2000	32,163	88	*0.0*	*0.0*	0.0	99.3	0.7	15.0	25.3	25.5	-0.1
	2000<x<10000	15,667	99	*0.0*	*0.0*	0.0	99.2	0.8	32.4	28.0	28.2	-0.2
	10000<x<20000	1,207	100	*0.0*	*0.0*	0.0	99.1	0.9	47.2	33.0	33.2	-0.2
	x>20000	253	100	*0.0*	*0.0*	0.0	100.0	*0.0*	53.4	35.1	35.1	0.0
Limit Orders	**All**	**414,220**		**1.2**	**78.8**	**20.1**	***0.0***	***0.0***	**39.9**	**33.9**	**4.4**	**29.5**
	x<500	167,635	40	0.7	73.6	25.7	*0.0*	*0.0*	1.5	30.8	5.2	25.7
	500<x<2000	168,948	81	0.9	71.4	27.7	*0.0*	*0.0*	12.9	32.1	5.8	26.3
	2000<x<10000	70,055	98	1.1	78.4	20.5	*0.0*	*0.0*	38.3	33.4	4.6	28.8
	10000<x<20000	5,871	100	1.5	83.8	14.7	*0.0*	*0.0*	67.3	36.3	3.3	33.0
	x>20000	1,711	100	1.5	88.9	9.6	*0.0*	*0.0*	83.3	39.3	2.5	36.9
ITS Orders	**All**	**33,228**		**0.6**	**4.8**	**19.0**	**74.9**	**0.8**	**20.7**	**37.9**	**31.0**	**6.9**
	x<500	12,333	37	0.4	4.2	30.1	64.3	1.0	2.3	35.6	27.3	8.3
	500<x<2000	16,858	88	0.9	6.4	24.6	67.3	0.9	10.0	38.3	29.3	9.0
	2000<x<10000	3,847	99	0.5	4.3	15.8	78.8	0.5	26.5	37.7	31.8	5.9
	10000<x<20000	134	100	*0.0*	3.0	11.2	85.1	*0.7*	41.8	36.3	32.7	3.5
	x>20000	56	100	*0.0*	*1.8*	12.5	83.9	*1.8*	50.0	37.8	34.2	3.6

Table 5. Trade Executions for Floor Orders by Execution Size

This table summarizes how different order types are executed relative to the quotes in effect 5 seconds before the order execution. For example, a 3,000 share floor broker buy order execution at $12.0625 when the quoted prices (depths) are $12.000 (2,000) -$12.125 (2,000) will be tabulated as "Inside" with a depth improvement (DI). Similarly, a 3,000 share floor broker buy order execution at $12.000 when the quoted prices (depths) are $12.0000 (2,000) -$12.1250 (2,000) will be tabulated as "At the Same Side." with a depth improvement (DI). Buy and sell orders are lumped together. If more than one buy (sell) order execution of a particular type occurs in one trade, these buy (sell) order executions are aggregated. Effective Spread is defined as 10,000 times the difference between the price and the midquote (difference between the midquote and the price), divided by the midquote, for a buy (sell) order. Price improvement (PI) is defined as 10,000 times the difference between the ask and the price (difference between the price and the bid), divided by the midquote, for a buy (sell) order. Statistics for all are share weighted. Statistics are execution-weighted by size. Figures in italics are not significantly different from zero.

				Distribution of Price Relative To Quotes						**Relative Spreads (Basis Points)**		
	Execution Size	**Number**	**Cum. Pct.**	**Outside PI**	**At Same Side**	**Inside**	**At Other Side**	**Outside PD**	**DI**	**Quoted**	**Effective**	**PI**
FB Orders	**All**	**100,062**		**1.3**	**22.7**	**23.8**	**50.5**	**1.8**	**64.4**	**36.6**	**23.6**	**12.7**
	x<500	6,629	7	0.6	37.8	40.6	20.4	0.7	2.2	33.1	14.2	18.9
	500<x<2000	28,657	35	0.6	38.3	32.2	28.3	0.6	15.3	31.1	14.9	16.2
	2000<x<10000	46,628	82	0.7	27.2	27.2	44.0	0.9	42.6	32.4	19.4	13.0
	10000<x<20000	11,904	94	0.8	19.0	24.4	54.2	1.5	64.9	35.6	24.3	11.4
	x> 20000	6,244	100	1.4	19.2	21.2	55.9	2.2	80.3	38.6	26.7	11.9
FB Orders	**All**	**4,517**		**1.4**	**36.0**	**20.7**	**40.2**	**1.6**	**97.3**	**55.2**	**29.0**	**26.2**
Upstairs Facilitated	500<x<2000	7	0	*0.0*	71.4	*14.3*	*14.3*	*0.0*	*14.3*	34.2	*7.1*	27.2
	2000<x<10000	151	3	*0.7*	76.8	13.2	9.3	*0.0*	62.9	40.5	6.0	34.5
	10000<x<20000	1,324	33	1.0	34.9	30.5	32.9	0.8	81.8	41.1	20.0	21.1
	x> 20000	3,035	100	1.2	34.4	24.2	38.8	1.3	96.6	16.4	24.2	22.2
Percentage Orders	**All**	**118,571**		**1.5**	**42.8**	**26.9**	**27.2**	**1.5**	**59.7**	**36.6**	**15.6**	**20.9**
	x<500	26,324	22	0.6	42.6	44.2	12.2	0.5	2.6	36.4	13.1	23.3
	500<x<2000	48,336	63	0.8	41.7	36.6	20.3	0.6	17.5	34.7	14.0	20.7
	2000<x<10000	35,752	93	1.1	43.4	29.0	25.7	0.8	46.8	34.7	14.3	20.4
	10000<x<20000	6,020	98	1.3	40.0	25.0	32.7	1.2	73.2	36.4	16.6	19.8
	x> 20000	2,139	100	1.5	43.1	22.5	31.1	1.7	88.3	40.2	17.7	22.5
Specialist Orders	**All**	**224,720**		**2.0**	**39.7**	**39.2**	**18.8**	**0.3**	**25.2**	**39.4**	**12.8**	**26.6**
	x<500	111,802	50	0.9	36.6	56.4	5.9	0.2	1.8	38.8	13.2	25.6
	500<x<2000	91,066	90	1.6	43.3	46.2	8.6	0.3	14.8	39.5	11.7	27.7
	2000<x<10000	20,992	100	2.3	40.6	34.2	22.6	0.3	27.0	39.7	12.5	27.2
	10000<x<20000	723	100	2.4	22.3	22.0	52.8	0.6	39.6	41.9	18.6	23.3
	x> 20000	137	100	4.4	11.7	10.9	72.3	*0.7*	31.4	36.3	22.0	14.3

Table 6. Price Impact for System Orders by Execution Size (Basis Points)

This table summarizes the price impact for order executions of different types both overall and by order execution size. Buy and sell orders are lumped together to condense the tables. Leakage for a buy [sell] order execution is defined as 10,000 times ln(price(t)/midquote(t-T)) [ln(midquote(t-T)/price(t))], where t is the time of the trade and T is either 5 minutes, 30 minutes, or the beginning of the day (BOD). Realized spread for a buy [sell] order is defined as 10,000 times ln(price(t)/midquote(t+T)) [ln(midquote(t+T)/price(t))], where t is the time of the trade and T is either 5 minutes, 30 minutes, or the end of the day (EOD). Total price impact for a buy [sell] order is defined as 10,000 times ln(midquote(t+T)/midquote(t-T)) [ln(midquote(t-T)/midquote(t+T))], where t is the time of the trade and T is either 5 minutes, 30 minutes, or from the beginning to the end of the day. Hence, total price impact is leakage minus realized spread. Statistics for all trades are share-weighted. Statistics by order size are order execution weighted. Figures in italics are not significantly different from zero.

			Leakage			Realized Spread			Total Price Impact		
	Execution Size		-5 min	-30 min	BOD	5 min	30 min	EOD	-5,+5 min	-30,+30 min	BOD,EOD
Market Orders	**All**	**352,703**	**11.0**	**11.8**	**14.2**	**3.0**	**3.3**	**2.8**	**8.0**	**6.9**	**11.4**
	x<500	175,726	8.4	10.0	9.4	5.2	5.5	5.6	3.2	4.5	3.8
	500<x<2000	129,716	11.3	12.7	13.3	3.8	3.8	3.6	7.5	8.7	9.7
	2000<x<10000	44,058	12.0	12.8	15.9	3.3	3.2	2.4	8.8	9.1	13.4
	10000<x<20000	2,584	9.3	8.3	13.0	*0.7*	3.9	*5.2*	7.9	*-0.5*	*7.8*
	x> 20000	619	11.7	12.2	22.9	*-3.1*	*-5.6*	*-3.0*	13.3	*-6.4*	25.9
Marketable Limits	**All**	**141,957**	**15.0**	**15.1**	**12.1**	**0.0**	**-0.1**	**0.0**	**14.9**	**15.0**	**12.1**
	x<500	92,667	13.1	13.8	18.5	0.7	-0.1	-2.3	12.2	14.4	20.8
	500<x<2000	32,163	11.5	7.8	-15.3	0.7	1.8	4.5	10.9	5.3	-19.8
	2000<x<10000	15,667	13.2	10.1	-15.9	0.7	2.2	7.6	12.5	6.7	-23.4
	10000<x<20000	1,207	15.2	14.1	-15.2	*1.2*	*1.0*	*6.8*	13.7	8.4	-21.9
	x> 20000	253	17.4	24.7	*9.9*	*2.5*	*5.9*	*14.8*	15.4	13.9	*-4.9*
Limit Orders	**All**	**414,220**	**-16.7**	**-24.0**	**-43.8**	**1.5**	**2.9**	**3.9**	**-18.0**	**-26.2**	**-47.7**
	x<500	167,635	-9.5	-10.6	-13.7	-4.5	-4.2	-4.1	-4.9	-6.3	-9.5
	500<x<2000	168,948	-10.8	-12.9	-19.0	-1.4	-0.7	-0.8	-9.3	-11.8	-18.1
	2000<x<10000	70,055	-15.8	-22.4	-38.8	1.8	3.3	4.5	-17.5	-24.9	-43.3
	10000<x<20000	5,873	-21.7	-35.3	-67.7	3.6	4.6	5.5	-24.8	-39.0	-73.2
	x> 20000	1,711	-29.9	-46.7	-104.7	5.8	10.3	14.4	-35.6	-56.3	-119.1
ITS Orders	**All**	**33,228**	**10.5**	**6.5**	**-0.6**	**3.8**	**2.6**	**2.8**	**7.1**	**4.8**	**-5.9**
	x<500	12,333	8.6	4.5	*2.6*	3.6	2.3	2.1	4.8	2.3	*0.6*
	500<x<2000	16,858	6.0	-0.6	-10.4	4.2	4.6	7.5	1.8	-4.7	-18.0
	2000<x<10000	3,847	12.7	7.4	*-4.9*	3.9	*1.7*	6.0	8.9	7.1	-10.9
	10000<x<20000	134	14.1	15.8	*10.5*	*3.8*	*0.1*	*3.5*	10.3	20.3	*7.0*
	x> 20000	56	15.5	37.1	64.1	*-5.8*	*3.1*	*-12.5*	21.6	39.4	76.6

Table 7. Price Impact for Floor Orders by Execution Size (Basis Points)

This table summarizes the price impact for order executions of different types both overall and by order execution size. Buy and sell orders are lumped together to condese the tables. Leakage for a buy [sell] order execution is defined as 10,000 times ln(price(t)/midquote(t-T)) [ln(midquote(t-T)/price(t))], where t is the time of the trade and T is either 5 minutes, 30 minutes, or the beginning of the day (BOD). Realized spread for a buy [sell] order is defined as 10,000 times ln(price(t)/midquote(t+T)) [ln(midquote(t+T)/price(t))], where t is the time of the trade and T is either 5 minutes, 30 minutes, or the end of the day (EOD). Total price impact for a buy [sell] order is defined as 10,000 times ln(midquote(t+T)/midquote(t-T)) [ln(midquote(t-T)/midquote(t+T))], where t is the time of the trade and T is either 5 minutes, 30 minutes, or from the beginning to the end of the day. Hence, total price impact is leakage minus realized spread. Statistics for all trades are share-weighted. Statistics by order size are order execution weighted. Figures in italics are not significantly different from zero.

			Leakage			Realized Spread			Total Price Impact		
	Execution Size		-5 min	-30 min	BOD	5 min	30 min	EOD	-5,+5 min	-30,+30 min	BOD,EOD
FB Orders	**All**	**100,062**	**8.3**	**12.2**	**20.6**	**-1.6**	**-2.5**	**-3.7**	**9.9**	**14.9**	**24.3**
	x<500	6,629	0.3	6.0	25.0	-7.3	-9.9	-14.3	7.7	16.0	39.3
	500<x<2000	28,657	1.5	6.1	23.6	-7.0	-9.0	-10.9	8.5	14.7	34.6
	2000<x<10000	46,628	5.7	9.5	19.7	-3.0	-4.2	-6.7	8.6	13.5	26.4
	10000<x<20000	11,904	9.6	13.0	19.6	*-0.8*	-1.5	*-1.3*	10.3	14.3	20.8
	x> 20000	6,244	10.6	14.1	22.5	*-0.5*	*-1.6*	*-2.8*	11.1	16.6	25.3
FB Orders	**All**	**4,517**	**1.9**	***2.1***	***2.6***	***0.2***	***-0.1***	***-0.6***	***1.7***	***2.0***	***3.2***
Upstairs Facilitated	10000<x<20000	1,324	*-0.7*	*0.0*	*-0.6*	*0.0*	*-0.5*	*2.1*	*-0.8*	*1.0*	*-2.7*
	x> 20000	3,035	*1.3*	*1.2*	*1.6*	*0.2*	*0.1*	*-0.1*	*1.1*	*0.6*	*1.7*
Percentage Orders	**All**	**118,571**	**-2.3**	**1.2**	**12.6**	**0.7**	**-1.0**	**-1.0**	**-1.7**	**2.5**	**13.6**
	x<500	26,324	-4.8	*-0.6*	13.7	-4.1	-6.4	-10.3	-0.7	6.0	24.0
	500<x<2000	48,336	-2.6	2.7	16.5	-3.1	-4.6	-5.3	0.7	7.6	21.8
	2000<x<10000	35,752	-2.7	0.9	11.9	-1.9	-2.3	-2.1	-0.6	3.7	14.0
	10000<x<20000	6,020	-1.3	2.2	14.5	*0.0*	*0.6*	*-0.6*	-1.3	2.7	15.2
	x> 20000	2,139	-2.3	*0.7*	11.2	1.6	*0.2*	*3.1*	-4.0	*0.7*	*8.1*
Specialist Orders	**All**	**224,720**	**-13.1**	**-10.1**	**1.2**	**-4.6**	**-5.5**	**-5.0**	**-11.0**	**-12.2**	**-7.2**
	x<500	111,802	-11.7	-13.2	-8.3	-1.1	-1.2	-0.9	-10.5	-11.9	-7.4
	500<x<2000	91,066	-14.8	-14.1	-5.2	-2.4	-2.8	-2.7	-12.4	-11.2	-2.4
	2000<x<10000	20,992	-14.5	-9.7	3.7	-6.2	-7.2	-6.4	-8.2	-2.6	10.1
	10000<x<20000	723	*-1.2*	10.0	26.2	-10.9	-13.6	-12.9	11.1	21.0	39.1
	x> 20000	137	13.2	31.2	79.0	-8.4	-22.2	-32.8	20.8	48.5	111.8

Table 8. Decomposition of Realized Spreads for System Orders by Execution Size

This table summarizes the decomposition of realized spreads into effective (half) spreads, defined as 10,000 times ln(price(t)/midquote(t)) [ln(midquote(t)/price(t))] for a buy [sell] order, and the change in the midquote, defined as 10,000 times ln(midquote(t+T)/midquote(t)) [ln(midquote(t)/midquote(t+T))] for a buy [sell] order, where T is either 5 minutes, 30 minutes, or until the end of the day (EOD). Realized spread are effective spreads minus the change in the midquote. Statistics for all trades are share-weighted. Statistics by order size are order execution weighted. Figures in italics are not significantly different from zero.

		Relative (Basis Points)			
		Effective	Change in Midquote		
	Execution Size		5 min	30 min	EOD
Market Orders	**All**	**6.6**	**3.7**	**3.4**	**3.8**
	x<500	6.9	1.7	1.5	1.3
	500<x<2000	7.6	3.9	3.9	4.0
	2000<x<10000	7.3	4.1	4.2	4.8
	10000<x<20000	4.8	3.5	*-0.2*	*0.5*
	x> 20000	3.0	*2.4*	*4.0*	*6.0*
Marketable Limit	**All**	**14.3**	**14.3**	**14.3**	**14.3**
	x<500	12.8	12.1	13.0	15.1
	500<x<2000	12.8	12.1	11.1	8.3
	2000<x<10000	14.2	13.5	12.0	6.7
	10000<x<20000	16.7	15.5	15.6	9.9
	x> 20000	17.6	15.1	11.2	*2.8*
Limit Orders	**All**	**-12.6**	**-14.1**	**-15.4**	**-16.5**
	x<500	-10.2	-5.8	-6.0	-6.1
	500<x<2000	-10.3	-8.8	-9.5	-9.4
	2000<x<10000	-12.1	-13.9	-15.3	-16.6
	10000<x<20000	-14.8	-18.2	-19.3	-20.4
	x> 20000	-17.2	-22.9	-27.4	-31.7
ITS Orders	**All**	**12.1**	**8.7**	**9.2**	**6.8**
	x<500	9.5	5.9	7.2	7.5
	500<x<2000	10.1	6.0	5.5	2.6
	2000<x<10000	12.9	9.1	11.2	6.9
	10000<x<20000	14.6	10.8	14.9	*11.1*
	x> 20000	15.3	21.0	*12.1*	*27.8*

Table 9. Decomposition of Realized Spreads for Floor Orders by Execution Size

This table summarizes the decomposition of realized spreads into effective (half) spreads, defined as 10,000 times ln(price(t)/midquote(t)) [ln(midquote(t)/price(t))] for a buy [sell] order, and the change in the midquote, defined as 10,000 times ln(midquote(t+T)/midquote(t)) [ln(midquote(t)/midquote(t+T))] for a buy [sell] order, where T is either 5 minutes, 30 minutes, or until the end of the day (EOD). Realized spread are effective spreads minus the change in the midquote. Statistics for all trades are share-weighted. Statistics by order size are order execution weighted. Figures in italics are not significantly different from zero.

		Relative (Basis Points)			
		Effective	**Change in Midquote**		
	Execution Size		**5 min**	**30 min**	**EOD**
FB Orders	**All**	**5.4**	**7.1**	**7.9**	**9.1**
	x<500	-2.4	4.9	7.7	11.9
	500<x<2000	-0.7	6.4	8.4	10.3
	2000<x<10000	3.2	6.2	7.4	9.9
	10000<x<20000	6.5	7.3	7.9	7.7
	x> 20000	7.4	8.0	9.1	10.2
FB Orders	**All**	**1.4**	**1.2**	***1.5***	***2.0***
Upstairs Facilitate	10000<x<20000	*-0.5*	*-0.5*	*-0.1*	*-2.6*
	x> 20000	1.0	*0.9*	*0.8*	*1.1*
Percentage Orders	**All**	**-2.7**	**-2.2**	**-1.8**	**-1.6**
	x<500	-5.1	-0.9	1.4	5.2
	500<x<2000	-3.4	*-0.2*	1.3	1.9
	2000<x<10000	-3.1	-1.1	*-0.6*	-1.0
	10000<x<20000	-1.6	-1.7	-2.3	-1.0
	x> 20000	-2.4	-4.2	-3.0	-5.4
Specialist Orders	**All**	**-6.9**	**-2.3**	**-1.4**	**-1.9**
	x<500	-6.2	-5.0	-5.0	-5.2
	500<x<2000	-8.0	-5.7	-5.3	-5.3
	2000<x<10000	-7.3	-1.2	*-0.1*	*-1.0*
	10000<x<20000	-2.3	8.7	11.3	*10.6*
	x> 20000	*3.8*	12.1	25.7	36.6

Table 10. Distribution of Regressors

This table summarizes the distribution of the regressors in Table 14. Trade Size is measured in thousands of shares, depth imbalance is defined as the depth at the offer (depth at the bid) in effect 5 seconds prior to the trade divided by the sum of the depths at the bid and the offer for a buyer (seller) initated trade. Market Capitalization as of December 31, 1996. Volatility is measured as 10,000 times the daily average ln(high/low) during the sample period for the stock. Dollar Volume is average daily consolidated dollar volume over the sample period. The inverse of the price is defined as the inverse of the midquote 5 minutes prior to the trade. Time of day takes on the value of 1 if the trade occurs between 9:30 and 11:30, the value of 2 if the trade occurs between 11:30 and 2:00, and the value of 3 if the trade occurs between 2:00 and 4:00pm. Cumulative Signed Volume is the share volume in the direction of the trade that has taken place prior to the trade execution, divided by average daily share volume. Cumulative Volume is unsigned share volume during the day prior to the trade execution, divided by average daily share volume.

A. Means etc.	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Trade Size (Thousand Shares)	2.1146	9.0769	0.0510	2458.0000
Inverse Price	0.0295	0.0235	0.0080	0.2602
Depth Imbalance	0.5148	0.2684	0.0010	0.9990
Time of Day	1.9960	0.8326	1.0000	3.0000
Cumulative Buy Volume	0.0038	0.0341	-1.0271	1.1506
Cumulative Volume	0.0590	0.0706	0.0000	1.4933
Log(Market Capitalization)	22.2348	1.5078	15.2299	24.7966
Volatility (High/Low)	9.1594	6.1628	0.6573	48.1919
Log(Dollar Volume)	16.9201	1.5090	8.8550	18.8396

B. Correlations

	Inv. Price	Depth Imb.	Time of Day	Cum Buy Vol	Cum Vol	Log(MktCap)	Volatility	Log($Vol)
Trade Size	0.0222	0.0034	-0.0063	0.0111	0.0361	0.0058	0.0233	0.0219
Inverse Price		-0.0178	-0.0065	-0.0020	0.0495	-0.6388	0.2394	-0.6409
Depth Imbalance			0.0051	0.0307	-0.0110	0.0232	0.0160	0.0237
Time of Day				0.0586	0.4113	0.0106	-0.0315	-0.0096
Cumulative Buy Volume					0.0776	-0.0032	0.0748	0.0334
Cumulative Volume						-0.0711	0.0779	-0.0275
Log(Market Capitalization)							-0.1725	0.0861
Volatility (High/Low)								0.1943
Log(Dollar Volume)								

Table 11. Leakage and Realized Spreads and Trade Composition

The table summarizes GMM regressions of spreads defined as: Leakage ln[price(t)/midquote(t-5)] and Realized spreads ln[price(t)/midquote(t+5)], on a set of control variables, trade size, and dummy variables for the presence of order-types on the buy and the sell side of the trade. Note that all spreads are defined as for a buy order, and are multiplied by 10,000. Depth imbalance is defined as the depth at the offer in effect 5 seconds prior to the trade divided by the sum of the depths at the bid and the offer. The inverse of the price is defined as the inverse of the midquote 5 minutes prior to the trade. Time of day takes on the value of 1 if the trade occurs between 9:30 and 11:30, the value of 2 if the trade occurs between 11:30 and 2:00, and the value of 3 if the trade occurs between 2:00 and 4:00pm. Cumulative Buy Volume is the net buy volume executed prior to the trade execution during the trading day, divided by average daily share volume. Cumulative Volume is unsigned share volume prior to the trade execution during the trading day, divided by average daily share volume. Market Capitalization is measured in as of December 31, 1996. Volatility is measured as 10,000 times the daily average ln(high/low) during the sample period for the stock. Dollar Volume is average daily consolidated dollar volume over the sample period. Trade Size is measured in thousands of shares. To facilitate the interpretation of the estimates, all control variables except trade size are de-meaned.

	Leakage				Realized Spreads			
	Estimate	t-statistic	Estimate	t-statistic	Estimate	t-statistic	Estimate	t-statistic
Intercept	1.588	7.15	1.545	5.99	-0.859	-4.31	-1.100	-4.80
Depth Imbalance	-3.202	-10.79	-3.881	-12.93	11.503	40.41	11.747	41.04
Inv. Price	*-5.874*	*-0.64*	*-6.338*	*-0.69*	*-15.092*	*-1.86*	-14.782	-1.82
Time of Day	-0.384	-2.57	-0.372	-2.51	*0.250*	*1.81*	0.250	1.81
Cum. Buy Vol.	64.232	13.30	62.371	13.17	*2.350*	*0.78*	3.130	1.05
Cum. Vol.	*2.349*	*0.98*	*2.345*	*0.99*	*-0.987*	*-0.52*	-1.080	-0.57
Log(Mkt. Cap.)	-0.630	-3.23	-0.615	-3.16	*-0.006*	*-0.03*	*-0.003*	*-0.02*
Volatility(High/Low)	0.089	2.35	0.086	2.28	*-0.036*	*-1.08*	-0.034	-1.02
Log($ Volume)	*0.427*	*1.84*	*0.413*	*1.79*	*0.259*	*1.23*	0.259	1.23
Trade Size	*0.019*	*1.55*			-0.054	-4.61		
Buy Orders								
MO	2.324	13.97	3.400	17.29	3.511	23.77	4.225	24.12
ML	*0.144*	*0.73*	1.053	4.54	*0.255*	*1.38*	1.164	4.86
LO	-10.259	-59.25	-8.849	-41.64	-2.270	-15.17	-2.222	-12.83
IT	6.514	17.67	6.846	16.17	6.252	18.83	7.093	19.26
FB	5.329	20.03	4.883	16.15	-5.091	-21.76	-5.502	-20.82
PC	-1.025	-5.03	*-0.292*	*-1.07*	-3.323	-17.20	-3.347	-15.01
SP	-11.965	-69.02	-11.320	-55.31	-1.018	-6.55	*-0.011*	*-0.05*
OR	*0.489*	*0.69*	3.655	4.12	1.789	2.87	1.630	2.51
Sell Orders								
MO	-4.088	-23.72	-4.728	-22.13	-2.817	-17.85	-3.466	-17.88
ML	-2.043	-9.75	-2.757	-10.69	1.291	6.33	0.627	2.57
LO	10.723	64.39	8.915	42.79	2.073	13.43	2.171	12.06
IT	-4.634	-13.77	-4.812	-12.89	-4.819	-15.58	-5.691	-16.68
FB	-3.906	-14.13	-3.489	-10.72	5.367	22.08	5.871	20.16
PC	*0.381*	*1.79*	*0.257*	*0.91*	3.357	16.04	3.765	14.99
SP	12.426	74.58	11.486	59.69	0.894	5.68	0.443	2.44
OR	-1.587	-2.27	-3.690	-4.23	*-0.438*	*-0.67*	*-0.105*	*-0.16*
Buy Orders* Trade Size								
MO			*0.005*	*0.11*			-0.377	-10.42
ML			*-0.069*	*-1.23*			-0.334	-4.45
LO			-0.391	-8.36			0.200	6.32
IT			0.392	2.55			-0.417	-3.42
FB			0.161	5.02			0.110	3.83
PC			*0.057*	*1.30*			*0.042*	*1.30*
SP			*0.053*	*0.86*			-0.565	-7.96
OR			-0.522	-4.55			*0.070*	*1.66*
Sell Orders*Trade Size								
MO			-0.219	-4.32			0.419	10.27
ML			*0.012*	*0.16*			0.253	3.47
LO			0.620	14.50			-0.164	-5.58
IT			-0.541	-3.87			0.641	5.08
FB			*-0.140*	*-1.46*			-0.139	-4.55
PC			-0.216	-4.73			-0.132	-4.16
SP			0.119	2.32			0.290	5.61
OR			0.349	3.14			-0.102	-2.57
Adj. R-square		0.152		0.156		0.030		0.032
Observations		600,721		600,721		591,428		591,428

Table 12. Effective Spreads and Midquote Changes and Trade Composition

The table summarizes GMM regressions of spreads defined as: Effective Spreads, ln[price(t)/midquote(t)]; and Miquote Changes, ln[midquote(t+5)/midquote(t)], on a set of control variables, trade size, and dummy variables for the presence of order-types on the buy and the sell side of the trade. Note that all spreads are defined as for a buy order, and are multiplied by 10,000. Depth imbalance is defined as the depth at the offer in effect 5 seconds prior to the trade divided by the sum of the depths at the bid and the offer. The inverse of the price is defined as the inverse of the midquote 5 minutes prior to the trade. Time of day takes on the value of 1 if the trade occurs between 9:30 and 11:30, the value of 2 if the trade occurs between 11:30 and 2:00, and the value of 3 if the trade occurs between 2:00 and 4:00pm. Cumulative Buy Volume is the net buy volume executed prior to the trade execution during the trading day, divided by average daily share volume. Cumulative Volume is unsigned share volume prior to the trade execution during the trading day, divided by average daily share volume. Market Capitalization is measured in as of December 31, 1996. Volatility is measured as 10,000 times the daily average ln(high/low) during the sample period for the stock. Dollar Volume is average daily consolidated dollar volume over the sample period. Trade Size is measured in thousands of shares. To facilitate the interpretation of the estimates, all control variables except trade size are de-meaned.

	Effective Spreads				Midquote Changes			
	Estimate	t-statistic	Estimate	t-statistic	Estimate	t-statistic	Estimate	t-statistic
Intercept	0.324	3.70	*0.137*	*1.35*	1.235	5.91	1.429	5.86
Depth Imbalance	-3.584	-33.82	-3.915	-36.66	-15.098	-50.72	-15.695	-52.48
Inv. Price	*-10.172*	*-1.88*	*-10.016*	*-1.85*	*5.771*	*0.72*	*5.322*	*0.67*
Time of Day	-0.032	-0.82	*-0.030*	*-0.77*	-0.288	-2.02	-0.288	-2.02
Cum. Buy Vol.	21.797	13.01	20.987	12.84	19.685	5.99	18.103	5.57
Cum. Vol.	*1.087*	*1.50*	*1.124*	*1.58*	*2.186*	*1.08*	*2.268*	*1.13*
Log(Mkt. Cap.)	-0.259	-3.60	-0.256	-3.56	*-0.258*	*-1.36*	*-0.258*	*-1.36*
Volatility(High/Low)	*0.013*	*0.85*	*0.012*	*0.77*	*0.048*	*1.34*	*0.045*	*1.26*
Log($ Volume)	*0.176*	*1.89*	0.178	1.91	*-0.066*	*0.30*	*-0.068*	*-0.30*
Trade Size	*0.002*	*0.30*			0.05	4.36		
Buy Orders								
MO	2.434	35.29	3.383	35.79	-1.055	-6.95	-0.895	-5.15
MLO	3.729	43.22	4.403	42.12	3.545	18.28	3.311	13.43
LO	-9.320	-121.88	-8.458	-87.61	-6.989	-44.76	-6.166	-33.83
IT	10.221	51.33	10.871	49.85	4.058	12.46	3.864	10.60
FB	1.432	14.77	1.080	8.41	6.681	26.75	6.574	23.08
PC	-2.366	-25.00	-2.036	-17.07	1.035	5.19	1.252	5.41
SP	-5.037	-67.43	-4.426	-46.47	-4.001	-24.88	-4.387	-20.47
OR	-0.083	-2.83	*0.338*	*0.83*	-2.658	-4.11	-1.815	-2.53
Sell Orders								
MO	-3.174	-43.21	-3.779	-39.28	-0.466	-2.89	-0.561	-2.92
MLO	-4.276	-46.97	-4.596	-40.12	-5.678	-26.83	-5.440	-21.38
LO	8.959	121.81	8.075	88.99	6.794	42.63	5.703	31.10
IT	-9.022	-49.29	-9.440	-46.88	-4.291	-13.28	-3.895	-11.01
FB	-1.452	-13.78	-0.908	-6.73	-6.912	-26.98	-6.983	-23.08
PC	2.558	27.59	2.474	20.56	-0.909	-4.19	-1.586	-6.17
SP	4.879	68.46	4.455	51.38	3.956	24.51	3.908	20.91
OR	*0.518*	*1.77*	*-0.034*	*-0.08*	*0.672*	*1.04*	*-0.309*	*-0.43*
Buy Orders*Trade Size								
MO			-0.193	-8.45			0.216	5.69
MLO			*-0.032*	*-1.57*			0.281	3.51
LO			-0.163	-7.97			-0.395	-10.81
IT			*-0.045*	*-0.81*			0.349	2.66
FB			0.125	7.84			*0.015*	*0.52*
PC			0.070	3.90			*0.058*	*1.64*
SP			*-0.058*	*-1.90*			0.484	5.61
OR			-0.157	-2.78			-0.152	2.22
Sell Orders*Trade Size								
MO			0.087	4.54			-0.307	-7.54
MLO			*-0.052*	*-1.72*			-0.300	-4.00
LO			0.261	16.60			0.438	14.02
IT			*-0.004*	*-0.07*			-0.670	-4.57
FB			-0.120	-6.91			*0.016*	*0.52*
PC			-0.094	-5.23			*0.056*	*1.64*
SP			*-0.002*	*-0.10*			-0.292	-5.18
OR			*0.080*	*1.44*			0.198	2.74
Adj. R-square		0.344		0.348		0.089		0.093
Observations		600,721		600,721		591,428		591,428

Table 13. Spreads and Trade Composition

The table summarizes OLS regressions of Realized Half-Spreads, Effective Half-Spreads, and Mid-quote changes, on a set of control variables, trade size, and dummy variables for the presence of order-types on the buy and the sell side of the trade. Note that all spreads are defined as for a buy order, and are multiplied by 10,000. Depth imbalance is defined as the depth at the offer in effect 5 seconds prior to the trade divided by the sum of the depths at the bid and the offer. The inverse of the price is defined as the inverse of the midquote 5 minutes prior to the trade. Time of day takes on the value of 1 if the trade occurs between 9:30 and 11:30, the value of 2 if the trade occurs between 11:30 and 2:00, and the value of 3 if the trade occurs between 2:00 and 4:00pm. Cumulative Buy Volume is the net buy volume executed prior to the trade execution during the trading day, divided by average daily share volume. Cumulative Volume is unsigned share volume prior to the trade execution during the trading day, divided by average daily share volume. Market Capitalization is measured in as of December 31, 1996. Volatility is measured as 10,000 times the daily average ln(high/low) during the sample period for the stock. Dollar Volume is average daily consolidated dollar volume over the sample period. Trade Size is measured in thousands of shares. The table only reports the fitted effects for a 2000 share trade in the middle of the average stock-day in the sample. Insignificant coefficients are in italics.

Realized Half-Spreads	**Sell Order Type**						
Buy Order Type							
	Market Order	Limit Order	ITS Order	FB Order	Percentage Order	Specialist Order	Mixed
Market Order	0.04	6.09	-5.34	4.63	5.40	3.67	-6.81
Limit Order	-7.33	*-0.90*	n.a.	5.20	0.77	-1.44	2.70
ITS Order	5.13	n.a.	n.a.	9.30	6.99	2.24	-9.12
FB Order	-3.73	-6.53	-7.83	*-0.81*	-2.39	-4.23	5.96
Percentage Order	-5.89	-2.43	-5.98	*0.02*	*-0.74*	-4.24	3.76
Specialist Order	-3.52	*-0.32*	-3.28	-6.06	*-1.80*	n.a.	0.80
Mixed	4.22	-3.78	4.31	-6.91	-5.35	-2.76	2.25

Effective Half-Spreads	**Sell Order Type**						
Buy Order Type							
	Market Order	Limit Order	ITS Order	FB Order	Percentage Order	Specialist Order	Mixed
Market Order	-0.17	13.04	-11.56	2.32	5.60	8.22	-5.53
Limit Order	-13.10	0.34	n.a.	-9.80	-5.96	-2.91	6.50
ITS Order	12.21	n.a.	n.a.	3.82	7.22	7.43	-8.21
FB Order	-0.73	10.52	-2.59	0.58	3.99	-0.17	1.26
Percentage Order	-4.37	7.39	-6.08	-3.77	0.64	-3.21	4.82
Specialist Order	-7.00	3.04	-5.43	-1.70	*1.18*	n.a.	3.76
Mixed	5.82	-7.25	4.25	-1.17	-5.68	-2.85	3.13

Mid-Quote Changes	**Sell Order Type**						
Buy Order Type							
	Market Order	Limit Order	ITS Order	FB Order	Percentage Order	Specialist Order	Mixed
Market Order	-1.13	6.20	-6.99	-3.02	-0.72	3.86	0.32
Limit Order	-6.55	0.50	n.a.	-15.74	-7.38	-2.22	3.01
ITS Order	6.34	n.a.	n.a.	-6.23	-0.50	4.48	-0.05
FB Order	2.29	16.28	4.54	0.64	5.66	3.25	-5.50
Percentage Order	0.85	9.03	-0.84	-4.56	0.64	*0.33*	*0.10*
Specialist Order	-4.28	2.62	-2.97	3.71	*2.12*	n.a.	2.28
Mixed	1.14	-4.27	*-0.79*	4.92	-1.01	*-0.79*	*0.15*

Table 14. Value-weighted Average Buy and Sell Prices by Order Execution Type

Value-weighted average buy and sell prices are calculated for each order type for each stock and day (B). We also calculate the value-weighted average trade price based on all trades for each stock and day (A). For buy orders, the statistics reported in the table represent an equally-weighted average across stock-days of 10,000 times one minus the ratio of the value-weighted average price for an order type, e.g., MO, divided by the value-weighted average trade price based on all trades (B/A). The sign is reversed for sell orders. Hence, a positive number means better than average execution. We also break down the statistics by order size. Finally, we report value-weighted sells minus buys. T-statistics are reported in parentheses.

	Order Execution Type						
	MO	**MLO**	**LO**	**ITS**	**FB**	**PC**	**SP**
A. Buy Orders							
All Trades	**-14.51**	**-9.73**	**11.52**	**-6.29**	**-2.73**	**3.17**	**12.81**
(t-stat: H_0=0)	(-24.85)	(-14.09)	(21.91)	(-5.91)	(-3.68)	(4.13)	(20.08)
Number of stock-days	4,476	3,934	4,543	2,867	3,034	3,203	4,241
Orders < 500 shares	-11.94	-6.23	10.65	-3.32	2.44	4.85	9.24
(t-stat: H0=0)	(-24.14)	(-7.45)	(19.58)	(-2.54)	(1.38)	(4.50)	(16.05)
Number of stock-days	4,102	2,963	4,148	1,994	1,198	2,457	3,913
Orders 500-2000 shares	-12.16	-7.34	9.84	-1.09	1.58	3.38	12.82
(t-stat: H0=0)	(-22.03)	(-10.73)	(18.22)	(-0.89)	(1.30)	(3.66)	(19.43)
Number of stock-days	3,997	3,417	4,132	2,180	2,138	2,752	3,722
Orders 2000-10000 shares	-10.76	-6.21	8.93	-2.43	-2.59	2.40	10.30
(t-stat: H0=0)	(-11.81)	(-6.99)	(11.99)	(-1.11)	(-2.99)	(2.70)	(8.23)
Number of stock-days	2,807	2,571	2,976	899	2,543	2,576	2,109
Orders > 10000 shares	-10.73	-6.29	15.60	-12.25	-2.86	-1.75	-3.91
(t-stat: H0=0)	(-4.41)	(-2.88)	(8.72)	(-1.50)	(-3.46)	(-1.51)	(-0.76)
Number of stock-days	765	735	970	85	1,732	1,539	303
	MO	**MLO**	**LO**	**ITS**	**FB**	**PC**	**SP**
B. Sell Orders							
All Trades	**-13.13**	**-9.63**	**13.80**	**-4.23**	**-3.93**	**3.25**	**12.79**
(t-stat: H_0=0)	(-23.30)	(-13.31)	(26.75)	(-4.08)	(-4.91)	(3.97)	(19.44)
Number of stock-days	4,656	3,870	4,495	3,045	2,890	3,078	4,293
Orders < 500 shares	-11.52	-5.30	12.06	-1.26	0.66	2.09	10.21
(t-stat: H0=0)	(-22.50)	(-5.86)	(22.41)	(-1.01)	(0.35)	(1.71)	(17.83)
Number of stock-days	4,221	2,807	4,076	2,172	1,103	2,227	3,956
Orders 500-2000 shares	-11.78	-7.59	10.46	-2.81	2.64	1.82	11.27
(t-stat: H0=0)	(-22.53)	(-10.11)	(19.38)	(-2.51)	(1.90)	(1.82)	(16.32)
Number of stock-days	4,194	3,299	4,068	2,398	1,979	2,611	3,715
Orders 2000-10000 shares	-7.39	-8.83	9.91	-6.09	-2.55	1.34	10.61
(t-stat: H0=0)	(-8.52)	(-9.71)	(14.60)	(-2.63)	(-2.86)	(1.45)	(8.54)
Number of stock-days	2,811	2,488	3,099	895	2,451	2,484	2,090
Orders > 10000 shares	-4.63	-13.47	14.58	-2.76	-4.25	0.45	-3.29
(t-stat: H0=0)	(-1.73)	(-5.28)	(10.30)	(-0.31)	(-4.77)	(0.34)	(-0.55)
Number of stock-days	729	686	1,153	70	1,670	1,449	215
	MO	**MLO**	**LO**	**ITS**	**FB**	**PC**	**SP**
C. Sell minus Buy Orders							
All Trades	**-27.43**	**-17.51**	**25.92**	**-7.66**	**-5.01**	**5.25**	**26.24**
(t-stat: H_0=0)	(-33.19)	(-17.06)	(32.51)	(-4.84)	(-4.53)	(5.09)	(28.78)
Number of stock-days	4,248	3,456	4,341	2,258	2,475	2,761	3,981
Orders < 500 shares	-24.11	-9.29	22.86	-1.73	-0.16	4.78	19.41
(t-stat: H0=0)	(-30.82)	(-6.65)	(26.37)	(-0.72)	(-0.04)	(2.65)	(21.78)
Number of stock-days	3,850	2,282	3,782	1,291	572	1,756	3,547
Orders 500-2000 shares	-24.81	-13.43	21.29	-2.53	4.87	3.34	24.31
(t-stat: H0=0)	(-27.79)	(-11.32)	(24.13)	(-1.23)	(2.29)	(2.43)	(22.37)
Number of stock-days	3,704	2,791	3,718	1,529	1,414	2,190	3,246
Orders 2000-10000 shares	-18.11	-14.02	21.81	-4.51	-3.20	2.62	18.97
(t-stat: H0=0)	(-12.52)	(-9.79)	(18.19)	(-0.87)	(-2.29)	(2.17)	(9.30)
Number of stock-days	2,249	1,959	2,422	389	1,970	2,123	1,513
Orders > 10000 shares	-6.90	-16.69	41.31	6.27	-7.91	-0.66	-6.63
(t-stat: H0=0)	(-1.45)	(-3.35)	(12.13)	(0.14)	(-5.63)	(-0.34)	(-0.50)
Number of stock-days	385	367	595	8	1,299	1,095	93

Appendix Table 1. Comparing Price Impact when Conditioning on Trade Direction

This table summarizes the price impact for order executions of different types both overall and by order execution size. Trades in the first row for each order type are classified as buyer and seller initiated following the Lee and Ready (1991) algorithm. Only order executions in the same direction as the trade are considered in this analysis. Buy and sell orders are lumped together to condese the table. The second row includes all trades as in Tables 6 and 7. Leakage for a buy [sell] order execution is defined as 10,000 times ln(price(t)/midquote(t-T)) [ln(midquote(t-T)/price(t))], where t is the time of the trade and T is either 5 minutes, 30 minutes, or the beginning of the day (BOD). Realized spread for a buy [sell] order is defined as 10,000 times ln(price(t)/midquote(t+T)) [ln(midquote(t+T)/price(t))], where t is the time of the trade and T is either 5 minutes, 30 minutes, or the end of the day (EOD). Total price impact for a buy [sell] order is defined as 10,000 times ln(midquote(t+T)/midquote(t-T)) [ln(midquote(t-T)/midquote(t+T))], where t is the time of the trade and T is either 5 minutes, 30 minutes, or from the beginning to the end of the day. Hence, total price impact is leakage minus realized spread. Statistics are share-weighted. Figures in italics are

			Leakage			Realized Spread			Total Price Impact		
	Execution Size		-5 min	-30 min	BOD	5 min	30 min	EOD	-5,+5 min	-30,+30 min	BOD,EOD
Market Orders	Lee & Ready	247,994	22.41	25.00	29.83	5.21	5.51	5.51	16.96	16.96	24.32
	All	352,703	10.98	11.78	14.22	3.00	3.26	2.78	7.98	6.93	11.44
Marketable Limits	Lee & Ready	141,957	14.98	15.08	12.09	*0.01*	*-0.07*	*-0.03*	14.92	14.95	12.12
	All	141,957	14.98	15.08	12.09	*0.01*	*-0.07*	*-0.03*	14.92	14.95	12.12
Limit Orders	Lee & Ready	38,029	11.34	8.15	-10.39	1.85	2.58	6.20	9.57	4.47	-16.59
	All	414,220	-16.71	-23.98	-43.83	1.53	2.95	3.92	-17.99	-26.16	-47.75
ITS Orders	Lee & Ready	26,261	15.43	13.06	11.00	3.56	2.14	4.16	11.87	12.34	6.87
	All	33,228	10.46	6.46	-0.57	3.83	2.62	2.78	7.09	4.79	-5.89
FB Orders	Lee & Ready	49,497	21.53	27.65	43.47	*-0.66*	-2.36	-2.80	21.92	29.44	46.27
	All	100,062	8.32	12.17	20.61	-1.58	-2.46	-3.66	9.90	14.92	24.27
FB Orders	Lee & Ready	2,060	32.56	37.07	47.83	8.37	4.68	10.13	24.08	32.43	37.69
Upstairs Facilitated	All	4,517	1.94	2.08	2.55	0.18	-0.13	-0.60	1.72	2.02	3.15
Percentage Orders	Lee & Ready	36,232	19.79	28.09	44.60	*2.73*	1.65	3.68	16.24	25.08	40.92
	All	118,571	-2.30	1.24	12.60	0.65	-0.99	-1.02	-1.73	2.55	13.62
Specialist Orders	Lee & Rady	37,882	9.01	13.45	37.21	-4.09	-4.62	-6.57	12.92	17.39	43.77
	All	224,720	-13.13	-10.12	1.16	-4.65	-5.54	-5.03	-11.00	-12.16	-7.18

Appendix Table 2. Comparing Decomposition of Realized Spreads when Conditioning on Trade Direction

This table summarizes the decomposition of realized spreads into effective (half) spreads, defined as 10,000 times ln(price(t)/midquote(t)) [ln(midquote(t)/price(t))] for a buy [sell] order, and the change in the midquote, defined as 10,000 times ln(midquote(t+T)/midquote(t)) [ln(midquote(t)/midquote(t+T))] for a buy [sell] order, where T is either 5 minutes, 30 minutes, or until the end of the day (EOD). Realized spread are effective spreads minus the change in the midquote. Trade directions are classified using the Lee and Ready (1991) algorithm. Only order executions in the direction of the trade are used in the calculations labeled Lee & Ready. The rows labeled All are from Tables 8 and 9. Statistics are share-weighted. Figures in italics are not significantly different from zero.

		Relative (Basis Points)			
		Effective	Change in Midquote		
	Execution Size		5 min	30 min	EOD
Market Orders	Lee & Ready	15.9	10.7	10.4	10.4
	All	6.6	3.7	3.4	3.8
Marketable Limits	Lee & Ready	14.3	14.3	14.3	14.3
	All	14.3	14.3	14.3	14.3
Limit Orders	Lee & Ready	12.2	10.3	9.6	6.0
	All	-12.6	-14.1	-15.4	-16.5
ITS Orders	Lee & Ready	16.2	12.7	14.1	12.1
	All	12.1	8.7	9.2	6.8
FB Orders	Lee & Ready	16.8	17.5	19.2	19.6
	All	5.4	7.1	7.9	9.1
FB Orders	Lee & Ready	25.2	16.8	20.5	15.1
Upstairs Facilitated	All	1.4	1.2	1.5	2.0
Percentage Orders	Lee & Ready	16.1	12.6	13.6	12.4
	All	-2.7	-2.2	-1.8	-1.6
Specialist Orders	Lee & Ready	12.2	16.3	16.8	18.7
	All	-6.9	-2.3	-1.4	-1.9