Dimensions of Best Execution for Market Orders: Assessing Differences between the NYSE and the Nasdaq Third Market

Robert Battalio
Assistant Professor of Finance
Georgia State University

Brian Hatch
Assistant Professor of Finance
University of Cincinnati

and

Robert Jennings
Professor of Finance
Kelley School of Business
1309 E. 10th Street
Indiana University
Bloomington, IN 47405
(tel) 812-855-2696
(fax) 812-855-5875
jennings@indiana.edu

First Draft: November 5, 1999
This Draft: March, 2000
The authors thank Knight-Trimark Group, Inc. for providing data and Jeffrey Bacidore, Dean Furbush, Mark Ready, George Sofianos, workshop participants at the University of Notre Dame and Georgia State University, and participants at the New York Stock Exchange s U.S. Equity Markets in Transition Conference for comments. The views expressed in the paper are those of the authors and not Knight-Trimark or the New York Stock Exchange.

Dimensions of Best Execution for Market Orders: Assessing Differences between the NYSE and the Nasdaq Third Market

Abstract

To date, the debate regarding which trading venue offers retail equity traders best execution focuses on comparing trade prices to contemporaneous quoted prices. In practice, market-order traders also value execution speed and the ability to trade more than the quoted number of shares at the quoted price (liquidity enhancement). We document these facets of execution quality for trades in NYSE-listed stocks on the Exchange and through a third-market dealer aggressively paying for order flow. Consistently with extant studies, the NYSE generally provides better trade prices than the dealer. The dealer offers faster executions and more liquidity enhancement than the NYSE. We use the realized liquidity premium, with its lagged quote benchmark, to measure overall execution quality and find no significant difference between the NYSE and the dealer. Considering order-flow payments as an alternative to better prices provides the dealer with an edge over the NYSE.

1.0 Introduction

The Securities and Exchange Commission (SEC) emphasizes that a broker-dealer has a fiduciary responsibility to obtain the most favorable terms available under the circumstances for a customer s order (see SEC Release No. 34-37619, SEC [1994], and Macey and O Hara [1997]). Furthermore, the SEC indicates that this best-execution obligation requires a broker-dealers to regularly and rigorously assess the execution quality of alternative trading venues (see SEC [1997]). Despite this requirement s importance, the SEC offers no specific definition of best execution (see Investment Dealers Digest [1998]). Instead, it notes that best execution has several elements. According to the SEC, these elements include trade price, liquidity, the likelihood of filling an order, the speed with which an order executes, the order s display in the national market system, the technology available with which to access the market center, transaction costs, and the confidentiality of trading. By defining execution quality broadly, the SEC allows a broker-dealer the flexibility to emphasize features it believes customers value. For some

traders, execution price is the paramount consideration. Traders placing larger-than-average sized orders are concerned with liquidity. When order size exceeds quoted size, the market maker is not obligated to honor the quoted price. For these traders, the market center s willingness and ability to trade large orders at the quoted price matters. On-line traders may insist that their orders fill quickly at predictable prices. Thus, for many market participants, transaction price is but one aspect of best execution.

We use two order audit-trail data sets to examine these elements of execution quality. Trimark Securities, Inc., a National Association of Security Dealers (NASD) market-maker, provides data allowing us to examine executions of NYSE-listed stocks in the third market.[1] In addition, Trimark provides a detailed scheduled of order-flow payments during the sample period. The other order data set is from a NYSE member firm and permit us to measure the execution quality of orders routed to a primary exchange. Each firm processes substantial order flow. According to AutEx/Block Data, these firms were two of the top five listed-security firms in July, 1999, combining for more than 10% of total order flow during that month.

Academic execution-quality research concludes that the NYSE generally offers better prices than those available elsewhere (see, e.g., Blume and Goldstein [1992], Lee [1993], Angel [1994], Petersen and Fialkowski [1994], Easley, Kiefer, and O Hara [1996], Huang and Stoll [1996a], Ross, Shapiro and Smith [1996], Bessembinder and Kaufman [1997a] and [1997b], SEC [1997], Battalio, Greene, and Jennings [1998], and Bessembinder [1999]). In an experi-mental

[1] The term third market is commonly used to refer to trading exchange-listed securities in the NASD market. In this taxonomy, the listing exchange (e.g., the NYSE) is the primary market and trading on other exchanges (e.g., regional stock exchanges) represents trading in the secondary market. As our data are from only one (although a significant one) market maker, we provide a limited view of what occurs on the third market.

design similar to ours, Lee (1993) and Bessembinder and Kaufman (1997b) study trade quality on the NYSE and Nasdaq for a common set of securities. Lee finds that Nasdaq trades face higher liquidity costs than similar NYSE trades. Bessembinder and Kaufman conclude that Nasdaq extracts only slightly larger trading costs than the NYSE, but that orders executed on the NYSE are more likely to be from informed investors. Both studies rely on trade (not order) data, examine data prior to the recent changes in order-handling rules and minimum price variation, and focus on price-based measures of execution quality. Petersen and Fialkowski (1994) note the importance of order data in determining the benchmark quote for traditional execution-quality measures. Although Bessembinder (1999) employs recent trade data to examine price-based execution quality on the NYSE and Nasdaq (with a somewhat different experimental design), we are aware of no study examining multiple dimensions of execution quality.

Macey and O Hara (1997) note that brokers might consider execution speed, opportunity costs, commissions, and price impact in addition to transaction price when measuring execution quality. Despite the fact that multiple dimensions are used to evaluate institutional orders execution quality (see Keim and Madhavan [1997] and [1998]), extant studies of retail-order executions focus exclusively on trade price. Although on-line trading pressures trading venues to offer fast executions at predictable prices, we know little about relative execution speeds among venues. In addition, the literature is just beginning to document traders ability to execute orders for more than the quoted number of shares at the quoted prices.[2] We use order data to compare execution speed, trade prices, and the trader s ability to execute orders for more than the quoted

[2] See Battalio and Jennings (1999), Bacidore, Ross, and Sofianos (1999), and Bacidore, Battalio, and Jennings (2000).

number of shares on the NYSE and through Trimark. We see this research as a first attempt to examine multiple dimensions of execution quality. Our findings indicate that no one trading venue dominates all facets of best execution and can be thought of as providing a counter-example to the claim that every market order should be routed to a particular market center. We also find that, after netting out order flow payments, Trimark earns less providing liquidity than the NYSE s liquidity providers. This suggests that order-flow payments are not necessarily incompatible with high-quality trade executions.

We measure execution-price quality with the net price improvement rate and the liquidity premium. Price improvement (disimprovement) occurs when an order receives a better (worse) price than the relevant National Best Bid or Offer price. For example, suppose the highest across-venues bid price is $20.00 and the lowest offer is $20.125. A buy order paying less (more) than $20.125 receives price improvement (disimprovement). Likewise, a sell order receiving more (less) than $20.00 is price improved (disimproved). Price (dis)improvement rates are computed by dividing the number of shares (dis)improved by the total shares executed. By netting the disimprovement rate from the improvement rate, we obtain the net price improvement rate. Although the net price improvement rate considers if traders receive better-than-quoted prices, it does not consider how much the trade price differs from that quoted. The liquidity premium addresses this deficiency. The liquidity premium measures the average amount by which a buy (sell) order s trade price exceeds (falls below) the mid-point of the contemporaneous bid-ask spread. If the spread s mid-point represents the security s value, then the liquidity premium represents how much more (less) than that value a security buyer pays to own (seller receives for selling) the security. In the example above, a trader may buy at the spread mid-point of $20.0625

on one market and at the bid of $20.00 at another. Although the trader receives price improvement in both markets, buying at $20.00 is preferred to buying at $20.0625.

Quotes contain both prices and sizes. Although extant execution-quality studies consider only the price dimension (some examine only orders for fewer than the quoted number of shares), it also is important to consider the size dimension when measuring execution quality. To do so, we document the frequency with which orders for more shares than being quoted in the National Best Bid or Offer (NBBO) receive the quoted price or better.[3] Continuing the previous example, assume that the $20.00 bid is associated with 2,000 shares. The market maker is not obligated to execute more than 2,000 shares for sell orders at the quoted (or higher) price. If customers can sell more than 2,000 shares at the quoted price, then they are better off than if the market maker allows the trade price to move to the next (lower) price in the order book. Following industry practice, we denote this aspect of execution quality as liquidity enhancement. A market s ability to enhance liquidity for large orders may be as valuable as the market s ability to provide price improvement for small orders (Bacidore, Battalio, and Jennings [2000] discuss the effect that considering quoted size has on traditional execution quality statistics) .

Considering multiple facets of execution quality allows brokers to focus on the dimension they believe their customers value. There are drawbacks, however, to assessing quality aspects individually. Some brokers may focus on a single quality dimension to justify self-serving routing decisions, e.g., they may stress fast executions while providing little price improvement. The multi-dimensional approach also does little to help regulators attempting an independent

[3] NBBO size is the largest size across all market centers having with the lowest ask and highest bid prices. If more than one market center has the best price, then we take the largest size, not the aggregate size, as the relevant size measure. We assume that it is difficult to reach across multiple market centers and obtain timely executions.

assessment of brokers execution quality. For these reasons, it is important to suggest an overall measure of execution quality. We focus on the cost of obtaining liquidity. Although cognizant of the fact that liquidity may be provided by liquidity demanders when market orders cross, we use an estimate of liquidity providers gross trading revenue on a particular trading venue as a proxy for the cost of a market-order trader obtaining liquidity on that venue. We proxy gross trading revenue with the realized liquidity premium, which compares trade prices with quoted prices a fixed amount of time after the trade. If one market s liquidity providers earn less providing liquidity to market-order traders than in another market, then the first market provides traders with better executions than the market where liquidity providers earn more revenue. As noted by Bessembinder (1999), Huang and Stoll (1996a), and others, the realized liquidity premium is sensitive to the informativeness of order flow across the two market centers.

We discuss our data in the following section. Section 3 contains an analysis of execution speed. We find that Trimark executes most orders in the same second they are received; faster than the NYSE. Given the differences in market structures, this is not surprising. The NYSE exposes each order to an auction, while Trimark immediately executes the order. In the fourth section, we analyze the price dimension of execution quality. Consistently with previous studies, we find that the NYSE typically offers better execution prices than Trimark. For orders arriving when the quoted spread exceeds the minimum price variation, however, the difference is not substantial. We introduce the concept of liquidity enhancement in the fifth section and find that Trimark provides liquidity enhancement more frequently than the NYSE. Finally, we discuss the realized liquidity premium as a measure of execution quality in Section 6. NYSE executions produce a statistically insignificantly lower average across-stock realized liquidity premium than

those from Trimark, suggesting that liquidity providers on the two trading venues earn similar gross trading revenues. Considering order-flow payments as an alternative to improved prices provides execution quality measures favoring Trimark, i.e., Trimark earns less *net* trading revenue providing liquidity than the NYSE. Finally, we summarize our findings and speculate how current trends in equity markets are likely to affect relative execution quality in the future.

2.0 Data

We obtain data from two prominent securities firms. One firm is a retail broker routing substantial order flow in exchange-listed stocks to several trading venues including the NYSE. The other data provider is Trimark Securities, Inc., a major third-market dealer. Both firms provide order audit-trail data including security name, order type, a buy-sell indicator, order quantity, execution price and quantity, the order s receipt/submission time to the second, order disposition (executed, canceled, or open), and to-the-second report/execution time during March 1999.[4] Consolidated quotes for March 1999 are obtained from the NYSE s Trades and Quotes (TAQ) database. It is worth repeating that order data allow us to precisely classify orders as either buyer or seller initiated. Much of the extant execution-quality research uses TAQ trade data, which requires inferences regarding the relationship between trades and orders and whether the observed trade results from a buy or sell order. In addition, our data contain orders for fewer than 100 shares, which are excluded from TAQ. Because these orders represent a large portion of retail order flow, our data allow us a more complete investigation of retail execution quality.

[4] The times associated with Trimark are the time it receives the order and the time it executes the order. For the retail broker, the recorded times are the time the order is sent to a market center for execution and the time the execution report is received from the market center. We generically refer to the first time as the order receipt time and the second time as the order execution time.

We begin with all regular market orders received during business hours after an opening quote is posted. Our analysis requires valid benchmark quotes when the order is received and up to 7.5 minutes after it executes. We also include screens for apparent data errors. Our data collection experience is summarized in Table 1.

[Insert Table 1.]

Because the Trimark data contain orders from many brokers, it is not surprising to find that its orders are a majority of the sample. Although both markets receive many pre-open orders, Trimark receives proportionally more than the anonymous broker sends to the NYSE. The broker s data exclude most non-regular market orders, which explains the difference in the frequency of these orders between the NYSE and Trimark samples. Finally, we note that the Trimark and NYSE samples contain approximately the same proportion of orders in the large-capitalization stocks included in the S&P500 (60% of qualifying orders for Trimark and 65% for the NYSE) and S&P100 (19% versus 22%) stock indexes. Our analysis focuses on stocks in the S&P100 Index to examine a common sample.[5] This results in 36 million shares in 95 stocks for Trimark and 13 million shares in 94 stocks for the NYSE. Most analyses employ a per stock mean of the variable of interest as the observation unit.

3.0 Execution Speed

Ideally, we measure execution speed from when the customer places the order until the customer receives the trade s confirmation. Unfortunately, our data do not contain these times. In addition, the time stamps for our two data sets are not directly comparable. Time stamps in the

[5] Since obtaining data, Trimark has changed its price improvement algorithm on S&P500 stocks to match that used for S&P100 stocks. Thus, NYSE-Trimark comparisons on S&P500 stocks with our data are misleading relative to current practice. Trimark now provides similar execution quality in S&P500 and S&P100 stocks.

broker s data represent the time the broker receives the order and the time the confirmed trade returns to the broker. For Trimark, order receipt time is the time the order arrives at Trimark and execution time is the time the confirmation is sent to the broker. Thus, the Trimark data ignore the time required for its computer system to communicate with the broker s system.

With this issue in mind, Table 2 reports the cumulative frequency distributions of elapsed time between order receipt and trade execution for trades at the two market centers. Columns 2 and 3 report execution speeds for orders with sufficient receipt-time quoted size on the relevant side of the quote (bid for sell orders and ask for buys) to execute the trade. In Columns 4 and 5, we report execution wait-times for those orders with size exceeding the relevant quoted size. We refer to the former as small orders and the latter as large orders.

[Insert Table 2.]

As expected, small orders execute more quickly than large orders. The difference in speed between the auction market (NYSE) and dealer market (Trimark) is substantial. The median execution time for Trimark is less than one second. For small orders, Trimark executes 89% of the orders in the *same second* in which the order arrives. Even when order size exceeds quoted size, 78% of the orders execute during the second in which they arrive at Trimark. Although execution speeds for the NYSE and Trimark are not directly comparable, it is unlikely that the time required for inter-computer communication accounts for such large time differences. For customers placing a high value on execution speed, Table 2 indicates that the dealer market structure offers an advantage over the auction market.

As indicated, Trimark s execution times do not include the time required for the brokers computer systems to communicate with Trimark s. Although this is likely to be only fractions of

a second in many cases, it may be longer in times of market stress. The retail broker data provide a mechanism by which we can check, albeit on a limited basis, whether the execution-speed difference between the NYSE and Trimark samples appears to be due to the difference in time stamping procedures. The retail broker routes orders in 12 S&P100 stocks to a major third-market dealer (not Trimark). The execution speeds for these trades include the time required for the broker s and dealer s computer systems to communicate. Over 80% of these orders (both small and large) execute within one second, suggesting that computer delays are not likely to account for the substantial differences in execution times noted in Table 2.[6]

Execution speed may depend on order traits and market conditions. Table 3 reports order size, quoted spread, and changes in the spread s mid-point in the five minutes after order receipt conditional on execution speed. The quoted spread and the change in that spread s mid-point are intended to proxy for market conditions at the time of and immediately following order receipt.

[Insert Table 3.]

Short execution times are associated with small orders. For both NYSE and Trimark trades, the order size for orders executing in ten seconds or less is significantly smaller (at the .01 level) than the order size in each of the other execution-speed categories using either a t-test or a sign-test. The relationship between order size and execution speed is not monotonic, however, for longer execution times on the NYSE. Likewise, fast executions are associated with narrow quoted spreads, although the differences in spreads between execution speed categories for the NYSE are statistically insignificant at traditional levels. Overall, this suggests that the fastest executions are

[6] Note also that our median NYSE execution-time (between 10 and 20 seconds) is less than that reported in Bacidore, Ross, and Sofianos (1999) using internal NYSE data (22 seconds).

associated with small orders in liquid stocks. Table 3's final column reports the change in the quoted spread s mid-point in the five minutes after order-receipt time, a statistic we call Slip. If the spread s mid-point represents the security s value, then Slip represents the security s change in value over this time interval. The change is signed based on whether the initiating order is a buy or sell so that the reported figure is positive if the change in value favors the market maker and negative if it favors the initiating trader. That is, for seller-initiated orders, we subtract the order-receipt-time spread s mid-point from the mid-point of the quoted spread five minutes later. For buy orders, we subtract the quoted spread s mid-point five minutes after receipt-time from the mid-point of the receipt-time spread. Although the reported numbers are consistently negative, indicating that quoted prices typically move against the market maker immediately after a trade, only the greater-than-60-second execution-speed category and overall numbers for Trimark are reliably negative at traditional significance levels.

4.0 Quality of Execution Price for Market Orders

We measure execution-price quality with price improvement rates and the liquidity premium. Price improvement occurs when traders transact at prices more favorable than the receipt-time quoted price. Because traders may receive prices worse than those quoted (due to orders arriving ahead of their s or the order size exceeding quoted size), subtracting the price disimprovement rate from the price improvement rate to produce a net price improvement rate is important. Although the resulting net price improvement rate measures the frequency of better-than-quoted prices, it does not address the issue of how much better trade prices are than quoted prices. The liquidity premium does. The liquidity premium is the distance between the trade price and the mid-point of the receipt-time quoted spread. If the spread s mid-point represents the

security s value, then the liquidity premium represents how much more than fair value a trader pays to buy a security or how much less than fair value a trader receives when selling.

The net price improvement rate (NPIR) and liquidity premium (LP) are defined below.

$$NPIR = (N_b - N_w)/N, \quad (1)$$

where N_b represents the number of shares receiving a price better than the relevant quoted price, N_w represents the number of shares receiving a price worse than the relevant quoted price, and N is the total number of shares executed.

$$LP = (\text{transaction price} - \text{spread mid-point at order receipt time}) \times I, \quad (2)$$

where I is +1 if the trader wishes to buy and -1 if the trader wishes to sell. A venue offering high-quality executions for market orders has a high NPIR and a low LP.

Table 4 reports NPIR and LP. Although the distribution of quoted spreads and the mean quoted spread (reported in parenthesis in the All row) are quite similar in the two samples, we report conditional values of LP in addition to the overall figures because potential LP values depend on the order-receipt-time spread. There are few orders in S&P100 securities with spreads exceeding $0.1875 (less than 5% of the sample), so we do not report them separately.

[Insert Table 4.]

Average order size, volume-weighted average price (VWAP), order receipt-time spread, and that spread s change immediately after order arrives (Slip) are similar for two samples. This suggests that these venues receive similar orders in comparable stocks under similar market conditions for our sample. Consistently with extant work, we find that the NYSE generally offers better trade prices, i.e., higher NPIR and lower LP, than Trimark. Of the 94 stocks for which the sample contains both NYSE and Trimark executions, 63 have lower LP in the NYSE market. This

fraction differs significantly from one-half at the .01 level. The overall NPIR across the two venues are not statistically different at conventional significance levels using either a sign-test or a t-test. This suggests that, although Trimark and the NYSE provide better-than-quoted prices at about the same frequency, the NYSE improves prices more than Trimark. The mean NPIR for Trimark is negative (i.e., price disimprovement is more frequent than price improvement) in markets where the bid-ask spread is $0.0625, but nearly identical to the NYSE otherwise.[7]

Execution price quality varies considerably by order size. Table 5 presents descriptive statistics on the quality of trade prices in three order-size categories.

[Insert Table 5.]

Orders for fewer than 100 shares are ignored in most extant work because odd-lot trades are not reported on TAQ. These orders represent about 30% of the NYSE orders and one-third of Trimark orders. Odd-lot orders receive different executions than round-lots and partial-round-lots regardless of venue. The negative NPIR are interesting because these orders should execute immediately at the quoted price (barring stock ahead).[8] Trimark s overall odd-lot NPIR is statistically significantly greater than the NYSE s. The difference in overall odd-lot LP, although also in favor of Trimark, is not significant at traditional confidence levels. The second order-size category, 100-499 shares, represents 56% of the sample NYSE orders and 50% of those routed to Trimark. For these orders, the NYSE provides a significantly lower NPIR and higher LP. For

[7] Trimark provides no price improvement when the quoted spread equals the minimum price variation. With stock ahead and large order sizes, however, trade prices can be worse than order-receipt-time quoted prices.

[8] The NYSE automatically executes odd-lot orders against the Best Price Quote (BPQ), not the NBBO. The BPQ excludes quotes for which either the bid or ask depth is zero, quotes $0.25 or more away from the NYSE quote, and quotes occurring when the NYSE s Message Delivery System is closed from the NBBO.

orders submitted when the spread is $0.0625, the NYSE transaction prices better Trimark s. It is a different story, however, for markets where the order-receipt-time spread exceeds the minimum price variation. In those markets, Trimark consistently offers significantly higher NPIR than the NYSE. When the spread is $0.1250, Trimark offers a LP close to zero, i.e., almost all trades execute at the quoted spread s mid-point. When the spread is $0.1875, three ticks, the LP for Trimark is (insignificantly) larger than the NYSE s LP even though Trimark has a substantially greater NPIR. Trimark s LP is approximately equal to one-half of the minimum price variation when the spread is $0.1875. This suggests that Trimark regularly gives traders one tick price improvement, but seldom provides more. Conversely, the NYSE gives price improvement less frequently, but appears more likely to give more than one tick of improvement. By the time we reach the third order-size category, 500-999 shares, the NYSE establishes its execution-price quality dominance. Not coincidentally, Trimark s price improvement algorithm treats orders for fewer than 500 shares differently than orders for 500 shares or more.

It also is interesting to examine trade prices conditional on order size relative to the order-receipt-time quoted size. Although orders with sufficient quoted size should not experience price disimprovement (except due to stock ahead), relatively large orders are not guaranteed the quoted price. Table 6 reports execution-quality statistics for trades conditional on whether or not the order size does or does not exceed the relevant quoted size.

[Insert Table 6.]

For small orders, the NYSE has a higher NPIR and a significantly lower LP. This advantage is driven by orders arriving when the quoted spread is $0.0625. In a preview to the paper s next section, Trimark provides better executions (significantly higher NPIR) than the NYSE for all but

the widest reported spread market when the receipt-time quoted size is less than order size.[9]

5.0 Liquidity Enhancement

Liquidity enhancement refers to the market s ability to execute orders with more shares than the quoted size at the quoted price (or better). Table 7 documents the frequency of liquidity enhancement at each market center.

[Insert Table 7.]

We report shares received in orders of the indicated size, the fraction of these shares eligible for liquidity enhancement, and the fraction of eligible shares enhanced. To compute the fraction of eligible shares, we subtract the relevant quoted size from the order size, add the positive numbers from this calculation, and divide the sum by the total number of shares received. Trimark is asked to enhance a larger portion of shares than the NYSE; 14% versus 8.5%. Further, Trimark offers higher liquidity enhancement rates than does the NYSE for all order sizes. For order sizes of fewer than 5,000 shares, the third-market firm executes over 95% of the excess shares at the quoted price or better. This compares to the NYSE s 60-70% enhancement rates.

The NYSE provides a lower LP than Trimark despite Trimark s higher rate of liquidity enhancement. This suggests that the NYSE gives better prices, on average, than Trimark even after considering the dealer s higher enhancement rate. In other words, although Trimark provides more liquidity enhancement, orders with more-than-quoted size are submitted so infrequently that Trimark s better liquidity enhancement is insufficient to compensate for the better prices offered on smaller-than-quoted-size orders by the NYSE.

[9] Differences in security characteristics or market conditions do not seem to explain the differences in execution quality. The mean order size, VWAP, order-receipt-time spread, and SLIP do not differ across venues for any of the subsamples examined.

6.0 An Overall Measure of Execution Quality

Markets present choices regarding execution quality. Trimark executes orders quickly with substantial liquidity enhancement, but the NYSE generally provides better prices. Because properly weighing each quality dimension when evaluating best execution is difficult, regulators, markets, brokers, and traders may find a comprehensive measure of execution quality useful.[10] We suggest the realized liquidity premium (RLP). The RLP measures the distance between the trade price and the quoted bid-ask spread s mid-point five minutes *after* the trade. Assuming that the spread s mid-point is a good proxy for the stock s value and that the liquidity provider values incremental inventory positions acquired from trading five minutes after taking the position, the RLP represents the liquidity provider s gross trading revenue. Markets generating large trading revenues for liquidity providers impose large costs on liquidity demanders.[11] RLP also facilitates comparisons between market centers with different types of order flow.[12]

6.1 Realized Liquidity Premium

The formal definition of the realized liquidity premium (RLP) is,

$$RLP = I \times (\text{transaction price} - \text{the bid-ask spread s mid-point five minutes after the trade}), \quad (3)$$

[10] An aggregate measure of execution quality would not be needed if one is willing to report LP with a sufficient level of conditioning. This, however, makes it difficult to justify routing decisions. What if Venue A is best on one set of orders and Venue B another? A properly constructed aggregate measure would be more useful.

[11] We are not the first to use the RLP as a proxy for trading revenue. Huang and Stoll (1996b), for example, use the realized half-spread as a measure of dealer profit. The RLP allows us to assess the gross cost of liquidity. In an auction market, where traders interact with each other more frequently than in a dealer market, liquidity may be supplied by a liquidity demander, which serves to reduce the net cost of liquidity.

[12] Consider, for example, index-arbitrage orders versus orders from independent, liquidity traders. If the market maker can distinguish between them (see Battalio, Jennings, and Selway [1999] and Ready [1999]), then it may be reasonable to expect different LP but similar RLP. An index-arbitrage trade may get an execution with a high LP but, because other trades of the same type are likely to arrive in the immediate future, a low RLP. The liquidity trader may receive a low LP and a similar sized RLP.

where I equals +1 if the trade is initiated by a trader s buy order and -1 if initiated by a sell order. In Table 8, we report RLP conditional on order-receipt-time bid-ask spread.

[Insert Table 8.]

The second and third columns report the total number of trades and the RLP for those trades. Note that the reported number is consistently less than the LP reported in Table 4. Using a t-test across stock means, the differences between the LP and RLP are significant at the .01 level for both NYSE and Trimark trades. This implies that, on average, the security s value moves in the trader s favor (increases when the trader buys and decreases when the trader sells) and against the liquidity provider in the five minutes after the trade executes.[13]

Overall, NYSE liquidity providers reap less revenue than Trimark, suggesting that the NYSE provides liquidity more cheaply than the third-market firm. The difference between the NYSE s RLP and Trimark s ($0.0044 per share) is not statistically significant at traditional levels using either a t-test or a sign test. If we divide orders into those with sufficient quoted size to execute the order and those with insufficient quoted size to execute the order, then the NYSE s advantage is magnified for the small orders ($0.0054/share) and reduced for the large orders ($0.0014/share). Neither the small- or large-order RLP differences are significant. The fact that the RLP differences between the NYSE and Trimark are statistically insignificant suggests that we cannot convincingly argue that one venue or the other provides higher quality executions.

6.2 Direct Trading Costs

RLP, LP, and effective spreads measure the indirect cost imposed on liquidity demanders.

[13] Sensitivity analysis, using times between 2.5 and 7.5 minutes, suggests that the RLP is not particularly sensitive to the amount of time we allow to elapse after the trade before collecting the benchmark quote.

In addition, there are direct costs charged by market centers. These include membership costs, transaction-based fees, order-flow payments (a negative cost), and other cash flows between the market center and the broker. Both the NASD and the NYSE charge membership fees. This is typically a fixed fee suggesting that its effect on the incremental routing decision is minor (especially if one examines the difference). Marginal transaction fees are nearly zero for both NYSE and third-market trades. During the sample period, the NYSE did not charge fees for post-opening orders of fewer than 2,100 shares (most of our sample) and places a maximum on annual total transaction fees (that most large brokers pay). The third-market does not charge transaction fees for market orders. The major difference in fees between the NYSE and Trimark is that Trimark pays the broker for order flow. During the sample period, Trimark made order-flow payments averaging $0.013 per share for the sample stocks. The NYSE does not directly pay for order flow. With a difference in overall RLP of $0.0044, subtracting the average order-flow payment from Trimark's mean RLP reported on Table 8 provides a *net* trading revenue estimate for Trimark that is statistically significantly less than the NYSE s mean RLP.[14] Thus, Trimark earns less reward for providing liquidity than do the liquidity providers on the NYSE after netting payments for order flow from our estimates of trading revenue.[15]

---

[14] To the extent payment for order flow is passed on to customers in the form of lower commissions, this suggests that payment for order flow might be thought of as certainty equivalent price improvement. That is, a venue can provide high, stochastic price improvement without payment for order flow or low, stochastic price improvement with payment for order flow to provide the broker with roughly identical execution quality. The SEC has been reluctant to consider payments for order flow as a positive factor in best execution studies because it is difficult to determine how (if) these payments are passed on to traders.

[15] We focus on the execution quality venues provide brokers and, therefore, the costs imposed on brokers. A similar analysis could be performed examining the execution quality received by traders. In this case, the major direct cost is the broker s commission. Although the conclusions are identical regardless of approach, considering commissions requires us to assume that all other brokerage services are equal. When attempting comparisons across the full-service brokers using the NYSE and the discount brokers using the third-market dealers, this is problematic.

7.0 Conclusions

Extant academic literature is unanimous (to our knowledge) in concluding that the NYSE provides better execution quality than other trading venues. This conclusion is reached by comparing trade prices to quoted prices and may not be robust to changing order type or to considering other quality dimensions. As an example of the former, Battalio, Greene, Hatch, and Jennings (1999) concludes that, with short queues and primary market print-protection programs, regional stock exchanges may provide better limit order executions than the NYSE. In this paper, we assess market-order execution quality as a multi-dimensional concept; comparing the NYSE and at a third-market dealer by evaluating execution speed, trade price, and the ability to trade more than the quoted size at the quoted price. We find that each trading venue provides high-quality executions on different dimensions of quality. On average, the NYSE betters the third-market firm in the traditional measures of trade-price quality, producing higher price improvement rates and lower liquidity premia. The third-market dealer, however, provides more timely executions and produces more liquidity enhancement than the NYSE. These results suggest that no single venue may provide best execution for all retail market orders, implying that the broker s routing decision is complex. With an overall execution-quality measure for market orders, we find that the two trading venues offer very similar execution quality. If one considers payment for order flow, then it appears that the third-market firm earns less revenue providing liquidity to market-order traders than the NYSE. This suggests that payment for order flow and high-quality trade executions are not necessarily mutually exclusive.

We believe that there are changes occurring in the securities market that are likely to affect the conclusions we draw from comparative execution quality studies such as this one. As

documented in Goldstein and Kavajecz (1999), the apparently forthcoming reduction in the minimum price variation for quoting and trading securities is likely to reduce quoted spreads and size. They find that quoted spread, quoted size at the best quoted price, and cumulative quoted size at any quoted price fell significantly when tick size was halved to $0.0625. If the tick size is reduced further and stocks trade with narrow spreads, then we expect little quoted size associated with quoted prices. Unless traders alter their order submission strategies, this suggests that a greater proportion of order sizes will exceed quoted size, making liquidity enhancement a more important aspect of execution quality. In addition, narrower spreads suggest that the dollar amount of price improvement market makers can offer is less.

Our analysis is a partial equilibrium approach, so we cannot make statements about which market structure (auction or dealer) is better. Because we examine only retail market orders, we can say nothing about the execution quality of limit orders or institutional orders. Furthermore, the paper takes the fragmentation of order flow and payment for order flow as given. We cannot determine what execution quality would be if order flow were concentrated on a single venue. In addition, we realize that many third-market dealers (including the one in our sample) select their customers/orders while the NYSE executes orders for all. This selective execution may impose costs on traders/orders that we do not measure. Finally, we do not analyze the costs and benefits of the dealer market. Traders interact with themselves in an auction market, so gains or losses in execution quality are primarily wealth transfers and have little effect on overall investor welfare. This is not true in a dealer market. Clearly, the dealer is compensated by the traders. If the dealer provides benefits, then whether investors are better or worse off with a dealer is not clear.

References

Angel, J., 1994, Who Gets Price Improvement on the NYSE?, unpublished paper, Georgetown University.

Bacidore, J., K. Ross, and G. Sofianos, 1999, Quantifying Best Execution at the NYSE, unpublished paper, New York Stock Exchange.

Bacidore, J., R. Battalio, and R. Jennings, 2000, Depth Improvement and Adjusted Price Improvement on the NYSE, unpublished paper, New York Stock Exchange.

Battalio, R., and R. Jennings, 1999, Technical Document to Accompany Battalio and Jennings Presentation at the Knight-Trimark Securities, Inc. Best Execution Forum, unpublished paper, Indiana University.

Battalio, R., J. Greene, B. Hatch, and R. Jennings, 1999, Does the Limit Order Routing Decision Matter?, unpublished paper, Indiana University.

Battalio, R., J. Greene, and R. Jennings, 1998, Order Flow Distribution, Bid-Ask Spreads, and Liquidity Costs: Merrill Lynch s Decision to Cease Routinely Routing Orders to Regional Stock Exchanges, *Journal of Financial Intermediation* 7, 338-358.

Bessembinder, H., 1999, Trade Execution Costs on NASDAQ and the NYSE: A Post-Reform Comparison, *Journal of Financial and Quantitative Analysis* 34, 387-407.

Bessembinder, H., and H. Kaufman, 1997a, A Comparison of Trade Execution Costs for NYSE and NASDAQ-Listed Stocks, *Journal of Financial and Quantitative Analysis* 32, 287-310.

Bessembinder, H., and H. Kaufman, 1997b, A Cross-Exchange Comparison of Execution Costs and Information Flows for NYSE-listed Stocks, *Journal of Financial Economics* 46, 293-319.

Blume, M., and M. Goldstein, 1992, Differences in Execution Prices among the NYSE, the Regionals, and the NASD, Working Paper 4-92, Rodney White Center for Financial Research, Wharton, University of Pennsylvania.

Easley, D., N. Kiefer, and M. O Hara, 1996, Cream-skimming or Profit-sharing? The Curious Role of Purchased Order Flow, *Journal of Finance* 51, 811-834.

Goldstein, M., and K. Kavajecz, 1999, Eights, sixteenths, and Market Depth: Changes in Tick Size and Liquidity Provision, *Journal of Financial Economics*, forthcoming.

Huang, R. and H. Stoll, 1996a, Dealer versus Auction Markets: A Paired Comparison of Execution Costs on NASDAQ and the NYSE, *Journal of Financial Economics* 41, 313-357.

Huang, R., and H. Stoll, 1996b, Revenues of Immediacy Suppliers versus Execution Costs of Investors: Evidence from the NYSE, unpublished paper, Vanderbilt University.

Keim, D., and A. Madhavan, 1998, The Cost of Institutional Equity Trades, *Financial Analysts Journal* 54, 50-69.

Keim, D. and A. Madhavan, 1997, Transaction Costs and Investment Style: An inter-exchange Analysis of Institutional Equity Trades, *Journal of Financial Economics* 46, 265-292.

Investment Dealers Digest, 1998, What s Best Execution ? Regulators Raise the Bar, March 16, page 12.

Lee, C., 1993, Market Integration and Price Execution for NYSE-listed Securities, *Journal of Finance* 48, 1009-1038.

Macey, J., and M. O Hara, 1997, The Law and Economics of Best Execution, *Journal of Financial Intermediation* 6, 188-223.

Petersen, M., and D. Fialkowski, 1994, Posted versus Effective Spreads: Good Prices or Bad Quotes?, *Journal of Financial Economics* 35, 269-292.

Ready, M., 1999, The Specialist s Discretion: Stopped Orders and Price Improvement, *Review of Financial Studies* 12, 1075-1112.

Ross, K., J. Shapiro, and K. Smith, 1996, Price Improvement of SuperDOT Market Orders on the NYSE, NYSE working Paper 96-02.

U. S. Securities and Exchange Commission, 1994, Market 2000 Report.

U.S. Securities and Exchange Commission, 1997, Report on the Practice of Preferencing.

Table 1

Market Order Sample from a Retail Brokerage Firm Routing to the NYSE and from Trimark Securities, Inc. during March 1999

	NYSE Orders[1]		Trimark Orders	
Regular Market Orders	275,962	100%	845,891	100%
ORT before opening quote[2]	15,382	5.57%	139,874	16.54%
Special market orders[3]	104	0.04%	25,526	3.02%
Canceled market orders	424	0.15%	1,545	0.18%
Orders not filled completely	781	0.28%	325	0.04%
Invalid benchmark quotes[4]	7,900	2.86%	19,561	2.31%
Apparent data error[5]	1,129	0.41%	163	0.02%
Order executes after 15:52:30[6]	6,041	2.19%	21,244	2.51%
Remaining orders	244,201	88.49%	637,653	75.38%
Orders in NYSE-listed S&P500 Stocks	158,929	57.59%	380,148	44.94%
Orders in NYSE-listed S&P100 Stocks	53,016	19.21%	123,011	14.54%
Shares in NYSE-listed S&P100 Stocks	13,761,793	n.a.[7]	36,141,053	n.a.
Number of S&P100 Stocks	94	n.a.	95	n.a.

[1] NYSE = New York Stock Exchange.

[2] ORT = order receipt time. Note that we exclude orders received within 10 seconds of the opening quote being posted to allow for any clock synchronization problems. This affects very few orders (170 across the two market venues).

[3] Special market orders include all-or-none, good-til-canceled, fill-or-kill, do not increase (reduce), not held, and market-on-close orders.

[4] Valid quotes have positive bid and offer prices, have an offer price that exceeds the bid price, and have non-zero sizes associated with both the bid and the offer prices.

[5] We presume a data error if the order receipt time is after the execution time or if the execution price differs from the mid-point of the quoted spread by more than $5.00.

[6] We require 7.5 minutes after execution for post-execution benchmark quotes used in sensitivity analyses.

[7] n.a. = not applicable

Table 2

Cumulative Frequency Distribution of Execution Speed for a Sample of Executed Market Orders in NYSE-listed Securities Included in the S&P100 Stock during March 1999

Execution Time[1] (in seconds)	Small Orders Order Size ≤ Quoted Size		Large Orders Order Size > Quoted Size	
	NYSE[2]	Trimark[3]	NYSE	Trimark
0	0.00%	88.99%	0.00%	78.10%
1	0.00%	89.61%	0.00%	78.78%
2	0.01%	90.17%	0.00%	79.20%
3	0.41%	90.66%	0.00%	79.69%
4	3.40%	91.08%	0.00%	80.17%
5	10.38%	91.44%	0.00%	80.50%
6	18.26%	91.81%	0.16%	80.92%
7	24.80%	92.15%	0.64%	81.21%
8	29.97%	92.47%	2.13%	81.58%
9	34.63%	92.83%	5.00%	82.05%
10	39.76%	93.11%	9.04%	82.34%
20	74.29%	95.17%	55.18%	85.45%
30	85.06%	98.74%	74.00%	89.60%
40	90.24%	98.91%	83.04%	90.93%
50	93.26%	99.05%	88.78%	91.90%
60	95.18%	99.19%	92.45%	92.80%
Orders	51,135	117,540	1,881	5,471
Av. order size	230 shares	240 shares	1,076 shares	1,465 shares

[1] Execution time is the difference between the order s receipt and execution time. For the NYSE columns, this time includes the time required to send the order from the broker to the market center and receive the report back from the market center. For the Trimark columns, the reported time is the time between the market maker s receipt time and execution time.

[2] NYSE = New York Stock Exchange.

[3] Trimark = Trimark Securities, Inc.

Table 3

Order Characteristics and Market Conditions Conditional on Execution Speed for a Sample of Market Orders in NYSE-listed Securities Included in the S&P100 Stock Index during March 1999

Panel A: Orders routed to the New York Stock Exchange

Execution Speed (seconds)[1]	Number of Stocks	Total Orders Executed	Total Shares Executed	Av. Order Size (shares)	SW-ORT Spread[2]	Slip[3]
0 to 10	90	20,499	2,027,195	98.89	$0.0962	-$0.0355
11 to 30	92	24,386	8,526,392	349.64	$0.1026	-$0.0145
31 to 60	84	5,525	2,203,793	398.88	$0.1061	-$0.0270
> 60	87	2,606	1,004,413	385.42	$0.1070	-$0.0265
All	94	53,016	13,761,793	259.58	$0.1025	-$0.0205

Panel B: Orders routed to Trimark Securities, Inc.

Execution Speed (seconds)	Number of Stocks	Total Orders Executed	Total Shares Executed	Av. Order Size (shares)	SW-ORT Spread	Slip
0 to 10	95	113,950	27,791,228	243.89	$0.0990	-$0.0101
11 to 30	94	7,013	5,342,821	761.85	$0.1410	-$0.0157
31 to 60	86	703	831,127	1,182.26	$0.1155	-$0.0019
> 60	92	1,345	2,175,877	1,617.75	$0.1187	-$0.1538
All	95	123,011	36,141,053	293.80	$0.1068	-$0.0194

[1] Execution time is the difference between the order s receipt and execution time. For the NYSE columns, this time includes the time required to send the order from the broker to the market center and receive the report back from the market center. For the Trimark figures, the reported time is the time between the market maker s receipt time and execution time.

[2] SW-ORT = Share-Weighted Order Receipt Time. SW-ORT Spread is the share-weighted average order-receipt-time quoted offer price less the order-receipt-time quoted bid price.

[3] Slip = the change in the quoted spread s mid-point in the five minutes after order receipt. The change in the spread s mid-point is computed using the spread at order-receipt-time and the spread existing five minutes after order receipt-time. For seller-initiated orders, we subtract the mid-point of the receipt-time quoted spread from the mid-point of the quoted spread five minutes after receipt-time. For buy orders, we subtract the mid-point of the quoted spread five minutes after receipt-time from the mid-point of the quoted receipt-time spread.

Table 4

Execution Price Quality for a Sample of Market Orders in NYSE-listed Securities Included in the S&P100 Stock Index during March 1999

Panel A: Orders sent to the New York Stock Exchange

ORT Spread[1]	Number of Stocks	Orders	Shares	Av. Order Size (shrs.)	VWAP[2]	Slip[3]	NPIR[4]
$0.0625	94	27,298	7,338,595	268.83	$54.94	-$0.0066	5.60%
$0.1250	93	19,000	4,789,266	252.07	$62.68	-$0.0529	42.5%
$0.1875	89	4,584	1,099,049	239.76	$70.84	-$0.0041	50.8%
All ($0.1025)	94	53,016	13,761,793	259.58	$59.92	-$0.0205	23.9%

Panel B: Orders to Trimark Securities, Inc.

ORT Spread	Number of Stocks	Orders	Shares	Av. Order Size (shrs.)	VWAP	Slip	NPIR
$0.0625	95	61,123	18,340,238	300.01	$57.68	-$0.0193	-1.92%
$0.1250	95	43,056	12,453,191	289.23	$68.99	-$0.0182	43.2%
$0.1875	94	12,579	3,606,889	286.74	$80.47	-$0.0029	49.8%
All ($0.1068)	95	123,011	36,141,053	293.80	$65.43	-$0.0194	21.2%

[1] ORT = order receipt time. The ORT Spread is the order-receipt-time quoted offer price less the order-receipt-time quoted bid price. The number in parenthesis in the All row is the share-weighted mean ORT spread.

[2] VWAP = Volume-Weighted Average Price. The dollar value of each trade (number of shares traded times trade price) divided by the total number of shares traded.

[3] Slip = the change in quoted spread s mid-point between order-receipt time and five minutes later.

[4] NPIR = Net Price Improvement Rate. NPIR = (number of shares receiving price improvement - the number of shares receiving price disimprovement)/total shares. Price improvement is buying (selling) at less (more) than the offer (bid) price. Price disimprovement is buying (selling) at more (less) than the offer (bid) price.

[5] LP = Liquidity Premium. LP = I×(trade price - spread mid-point), where I = +1 for buy orders and -1 for sell orders.

Table 5

Execution Price Quality for a Sample of Market Orders in NYSE-listed Securities Included in the S&P100 Stock Index during March 1999 Conditional on Order Size

Panel A: Orders routed to the New York Stock Exchange (94 S&P100 stocks)

ORT Spread[1]	Order size < 100 shares			Order size: 100-499 shrs.			Order size: 500-999 shrs.		
	Orders	NPIR[2]	LP[3]	Orders	NPIR	LP	Orders	NPIR	LP
$0.0625	7,843	-5.17%	$0.0350	15,338	10.91%	$0.0240	2,528	10.45%	$0.0240
$0.1250	5,928	-1.97%	$0.0644	10,517	52.27%	$0.0243	1,536	52.43%	$0.0257
$0.1875	1,466	-0.96%	$0.0948	2,569	64.73%	$0.0300	318	55.05%	$0.0432
All	15,841	-3.43%	$0.0551	29,681	32.38%	$0.0251	4,536	29.74%	$0.0265

Panel B: Orders routed to Trimark Securities, Inc. (95 S&P100 stocks)

ORT Spread	Order size < 100 shares			Order size: 100-499 shrs.			Order size: 500-999 shrs.		
	Orders	NPIR	LP	Orders	NPIR	LP	Orders	NPIR	LP
$0.0625	19,356	-0.30%	$0.0316	31,331	1.08%	$0.0306	5,255	0.51%	$0.0312
$0.1250	14,484	1.25%	$0.0617	21,592	87.28%	$0.0078	3,506	36.15%	$0.0395
$0.1875	4,340	3.84%	$0.0905	6,250	90.98%	$0.0338	1,022	48.60%	$0.0605
All	40,377	1.09%	$0.0541	62,212	44.24%	$0.0224	10,299	20.05%	$0.0402

[1] ORT = order receipt time. The ORT spread is the order-receipt-time quoted offer price less the order-receipt-time quoted bid price.

[2] NPIR = Net Price Improvement Rate. NPIR = (number of shares receiving price improvement - the number of shares receiving price disimprovement)/total shares. Price improvement is buying (selling) at less (more) than the contemporaneous offer (bid) price. Price disimprovement is buying (selling) at more (less) than the offer (bid) price.

[3] LP = Liquidity Premium. LP = I×(trade price - spread mid-point), where I = +1 for buy orders and -1 for sell orders.

Table 6

Execution Price Quality for a Sample of Market Orders in NYSE-listed Securities Included in the S&P100 Stock Index during March 1999 Conditional on Order Size Relative to Order-Receipt-Time Quoted Depth

Panel A: Orders routed to the New York Stock Exchange (94 S&P100 stocks).

ORT Spread[1]	Order size ≤ ORT quoted size			Order size > ORT quoted size		
	Orders	NPIR[2]	LP[3]	Orders	NPIR	LP
$0.0625	26,261	12.01%	$0.0231	1,037	-32.23%	$0.0554
$0.1250	18,444	50.40%	$0.0260	556	-9.24%	$0.0752
$0.1875	4,388	59.78%	$0.0349	196	13.47%	$0.0832
All	51,135	31.18%	$0.0257	1,881	-18.16%	$0.0692

Panel B: Orders routed to Trimark Securities, Inc. (95 S&P100 stocks).

ORT Spread	Order size ≤ ORT quoted size			Order size > ORT quoted size		
	Orders	NPIR	LP	Orders	NPIR	LP
$0.0625	58,412	1.04%	$0.0308	2,720	-13.27%	$0.0503
$0.1250	41,341	54.97%	$0.0280	1,715	-0.42%	$0.0671
$0.1875	11,922	65.25%	$0.0501	657	11.40%	$0.0925
All	117,540	28.68%	$0.0330	5,471	-5.05%	$0.0689

[1] ORT = order receipt time. The ORT Spread is the order-receipt-time quoted offer price less the order-receipt-time quoted bid price.

[2] NPIR = Net Price Improvement Rate. NPIR = (number of shares receiving price improvement - the number of shares receiving price disimprovement)/total shares. Price improvement is buying (selling) at less (more) than the contemporaneous offer (bid) price. Price disimprovement is buying (selling) at more (less) than the offer (bid) price.

[3] LP = Liquidity Premium. LP = I×(trade price - spread mid-point), where I = +1 for buy orders and -1 for sell orders.

Table 7

Liquidity Enhancement Rates for a Sample of Market Orders in Stocks Included in the S&P100 Stock Index Conditional on Order Size during March 1999[1]

Panel A: Orders routed to the New York Stock Exchange

Order Size (shrs)	Shares	Average Order Size	Percent Eligible[2]	Average Order Size Eligible Order	Percent Enhanced[3]
100 - 499	5,769,227	194.4	1.86%	253.8	66.02%
500 - 999	2,580,906	569.0	5.20%	597.7	70.18%
1000-1999	2,495,253	1,104.6	10.22%	1,170.7	66.06%
2000-4999	1,391,703	2,458.8	21.70%	2,506.0	61.24%
> 5,000	890,057	6,692.2	48.00%	6,963.6	42.44%
All	13,761,793	259.6	8.48%	1,075.6	57.19%

Panel B: Orders routed to Trimark Securities, Inc.

Order Size (shrs)	Shares	Average Order Size	% Eligible	Average Order Size Eligible Order	Percent Enhanced
100 - 499	10,959,717	176.2	1.99%	258.2	97.38%
500 - 999	5,909,400	573.8	6.35%	612.7	94.10%
1000-1999	7,853,421	1,096.5	11.66%	1,159.4	95.44%
2000-4999	6,118,388	2,540.9	26.31%	2,613.5	94.18%
> 5,000	3,774,304	6,925.3	50.75%	7,263.9	55.79%
All	36,141,053	293.8	13.82%	1,464.8	79.90%

[1] Liquidity enhancement is defined as executing orders for more than the NBBO quoted size at the NBBO quoted price (or better). If more than one market center is at the relevant NBBO quote, the largest size (not the sum of the sizes) is used to determine whether or not an order is eligible for liquidity enhancement.

[2] The percent of shares eligible for enhancement is the sum of the expression max{0, order size - quoted size} across all orders divided by the total number of shares.

[3] The percent of shares enhanced is the number of shares receiving enhancement divided by the total number of shares eligible for enhancement.

Table 8

Realized Liquidity Premia (RLP) for a Sample of Market Orders in Stocks Included in the S&P100 Stock Index Conditional on Order Size during March 1999[1]

Panel A: Orders routed to the New York Stock Exchange (94 S&P100 stocks)

ORT Spread[2]	All Orders		Small Orders[3]		Large Orders[4]	
	Orders	RLP	Orders	RLP	Orders	RLP
$0.0625	27,298	$0.0213	26,261	$0.0219	1,037	$0.0220
$0.1250	19,000	$0.0212	18,444	$0.0225	556	$0.0125
$0.1875	4,584	$0.0267	4,388	$0.0308	196	$0.0098
All	53,016	$0.0229	51,135	$0.0231	1,881	$0.0218

Panel B: Orders routed to Trimark Securities, Inc. (95 S&P100 stocks)

ORT Spread	All Orders		Small Orders		Large Orders	
	Orders	RLP	Orders	RLP	Orders	RLP
$0.0625	61,132	$0.0232	58,412	$0.0279	2,720	$0.0054
$0.1250	43,056	$0.0224	41,341	$0.0225	1,715	$0.0210
$0.1875	12,579	$0.0505	11,922	$0.0426	657	$0.0698
All	123,011	$0.0273	117,540	$0.0285	5,471	$0.0232

[1] The realized liquidity premium (RLP) is the difference between the trade price and the mid-point of the bid-ask spread in existence five minutes after the trade multiplied by +1 if the trade is initiated by the trader s wish to sell and -1 if initiated by the trader s wish to buy. We interpret RLP as the revenue earned by liquidity providers on the indicated trading venue. In making this interpretation, we are ignoring fees charged by and order-flow payments made by the market center.

[2] ORT = order receipt time. The ORT spread is the order-receipt-time quoted offer price less the order-receipt-time quoted bid price.

[3] A small order is one in which the order size is less than or equal to the quoted size at the relevant NBBO quote. If more than one market center is at the relevant NBBO quote, the largest size (not the sum of the sizes) is used as the quoted size at the relevant quote.

[4] A large order is one in which the order size exceeds the quoted size at the relevant NBBO quote. If more than one market center is at the relevant NBBO quote, the largest size (not the sum of the sizes) is used as the quoted size at the relevant quote.