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Order Flow Distribution, Bid–Ask Spreads, and Liquidity Costs: Merrill Lynch's Decision to Cease Routinely Routing Orders to Regional Stock Exchanges*

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Merrill Lynch's decision to redirect order flow in exchange-listed equity securities from regional exchanges to the New York Stock Exchange (NYSE) provides an opportunity to examine (1) whether order flow affects market makers' spread-setting behavior and (2) whether brokers can capture liquidity-cost differences between market centers for their customers. Merrill's market-order customers appear to obtain better prices on the NYSE than on the regionals. Consistently with market microstructure theory, the NYSE's quoted spread for stocks affected by Merrill's decision falls relative to a control sample and decreases absolutely for a subsample of stocks we believe most sensitive to order-flow distribution. *Journal of Economic Literature* Classification Numbers: D40, G10. © 1998 Academic Press

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1. INTRODUCTION

The *Wall Street Journal* of October 20, 1995 reported that Merrill Lynch would no longer routinely send small retail orders in securities listed on the New York and American Stock Exchanges to affiliated specialists on regional stock exchanges. According to the *Wall Street Journal*, the objective of the switch was ''to ensure that individual investor clients have an opportunity to receive the best possible price when they buy or sell securities.'' Instead of being routinely sent to regional exchanges, these orders now go to the market listing the security, unless a regional exchange posts a better quote. This move, consummated at the close of trading on October 31, 1995, required Merrill to sell Pacific Exchange (PCX) specialist operations and terminate relationships with Boston Stock Exchange (BSE) specialists.[1] Before this decision, Merrill effectively internalized (i.e., took the other side of) its retail customers' orders.

Extant empirical work suggests that Merrill might have had reason to suspect that traders receive more favorable prices on the NYSE than on regionals. Blume and Goldstein (1992), Lee (1993), Petersen and Fialkowski (1994), Bessembinder and Kaufman (1997), and Securities and Exchange Commission (1997) document that the NYSE generally provides better prices than the regionals. These studies' results suggest that brokers should consider rerouting some orders to the NYSE. Moreover, the Securities and Exchange Commission (SEC) indicates that a broker's fiduciary responsibility to obtain the best execution price for customers encompasses more than executing trades at the contemporaneous National Best Bid or Offer (NBBO). Specifically, the SEC indicates that brokers should evaluate execution prices across trading venues and direct orders to the venue with the best prices.[2] We analyze the results of what appears to be one such evaluation by a major broker to determine whether brokers can realize the apparent benefits of rerouting order flow to exchanges previously identified with high execution-quality statistics.[3]

In addition to allowing us to investigate whether their customers appear to benefit from the switch, Merrill's decision provides a natural experiment to examine whether order-flow distribution affects quoted bid–ask spreads. Specifically, we can study whether the order-flow volume and mix observed

[1] See *Wall Street Journal* (1995). Conversations with Merrill officials, including Robert McCann (the co-head of equity trading), verify this story's overall accuracy.

[2] See *Investment Dealer's Digest* (1998) for a more complete discussion of brokers' responsibilities and Macey and O'Hara (1997) for a discussion of the legal and economic concept of ''best price.''

[3] Correspondence and conversations with Merrill officials indicate that these specialist operations were quite profitable, suggesting that the decision to route order flow to the NYSE was carefully researched.

in a particular market center affects quoted bid–ask spreads in a manner consistent with economic theories of spread-setting behavior. Given the size of Merrill's brokerage operation, New York specialists "see" considerably more order flow after Merrill redirects trade than before.[4] In addition, because the rerouted trades are small, retail orders, New York specialists are more likely to trade with uninformed investors after the switch. Market microstructure theory (see O'Hara 1995 for a review) suggests that market makers set spreads to cover order-processing costs, inventory costs, and adverse-selection costs. Each cost may be affected by order flow. If order-processing costs have a fixed component (e.g., exchange seat prices or technology expenses), then additional order flow decreases per-share costs. Inventory costs also may decrease with increased order flow through the additional opportunities to correct inventory imbalances. Finally, if the proportion of "uninformed" orders increases when Merrill redirects trade to New York, then, as formalized by Battalio and Holden (1998), specialists face less adverse selection.[5] Thus, the New York specialist's per-share trading costs may fall. If costs fall and markets are competitive, then quoted spreads should immediately fall. Finally, Dutta and Madhavan (1997) argue that Merrill's pre-switch internalization led to wider spreads because it reduced incentives for price competition. Because Merrill indicates that orders are sent to New York *unless the regional exchange offers a better quoted price*, Dutta and Madhavan's work also suggests that we may find narrower quoted spreads when order flow is redirected and the regionals have an increased incentive to compete on quoted price.

In summary, we investigate two questions. First, is order-flow redistribution associated with changes in market makers' behavior as reflected in quoted bid–ask spreads? Microstructure theory predicts that additional uninformed order flow to a market maker should decrease that market's quoted spread. Second, can brokers capture liquidity-cost differences between market centers for their customers? That is, we examine whether Merrill's rerouting affects investors with Merrill as a broker. Existing work finds that the NYSE typically offers better prices than regionals, implying

[4] Merrill's 1995 annual report indicates that it accounts for 11.7% of NYSE trading volume (half that if one divides the shares Merrill buys and sells by total shares bought plus total shares sold). If that percentage is correct, then Merrill's volume in NYSE-listed stocks exceeds any regional's according to NYSE (1997). We use the term specialist advisedly throughout; the NYSE quote may represent the interests of other NYSE market participants.

[5] Easley and O'Hara (1987) suggest that large trades are more likely to be informed and Lin *et al.* (1995) find that the information content of trades in NYSE-listed securities increases with trade size. Easley *et al.* (1996) document that one regional's trades (those on the Cincinnati Stock Exchange) appear to have less information content than those on the NYSE. If we document a shift in small-trade executions toward the NYSE, then theory suggests that the event decreases the adverse selection cost faced by the New York specialist.

that Merrill's customers may benefit from the move to the NYSE even if spreads do not tighten after the rerouting.

Our results support the hypotheses that order-flow considerations affect spread-setting behavior and that the NYSE provides Merrill's market-order customers better prices than the involved regionals. Section 2 documents market-wide changes associated with Merrill's switch. Substantial shifts in the distribution of trade among competing venues occur around Merrill's rerouting. Although the change in the affected stocks' quoted NYSE spread is not statistically different from zero, it is significantly less than the spread change for a matched sample of stocks unaffected by Merrill's decision. The NYSE's quoted spread and the component due to adverse selection do decline significantly for stocks we believe should be most affected by the order-flow redistribution. The NBBO spread does not decrease, at least partially because regionals quote less aggressively after order flow is rerouted. In Section 3, we find that Merrill's customers seem to capture the previously documented difference in execution quality between the NYSE and the regionals. Proprietary data indicate that market-order prices are about \$0.02 per share better in \$0.25-spread markets and about \$0.0075 per share better in \$0.125-spread markets. If Merrill did not change commissions/services when moving order flow to New York, then the improved execution quality provides its customers lower trading costs. Section 4 concludes.

2. MARKET-WIDE CHANGES ASSOCIATED WITH MERRILL'S DECISION

In this section, we examine the distribution of where trade occurs and the width of the quoted bid–ask spread immediately before and after Merrill reroutes their trades. We use mean and signed-differences tests to compare these statistics.

2.1. *Data*

The regionals provide the names of NYSE-listed securities in which Merrill specialized or had joint ventures with regional specialists before redirecting orders. Because Merrill publicly announced its intent to redirect orders in mid-October, we compare statistics for September and November. Requiring complete Trades and Quotes (TAQ) data for September and November 1995 produces a sample of 417 securities (236 in Boston and 181 on the PCX).

TABLE I
Distribution of Trades for the Securities in Which Merrill Lynch Routinely Routed Orders to Regional Stock Exchanges Prior to October 1995[a]

	Small trades[c]		Large trades	
Trading venue[b]	September 1995	November 1995	September 1995	November 1995
Panel A—236 Boston Stock Exchange securities				
NYSE	**45.98%**	**50.15%**	**81.94%**	**84.14%**
BSE	**9.76**	**2.30**	**1.86**	**1.17**
PCX	8.49	9.95	2.25	2.30
CSE	6.04	6.84	1.24	1.26
Third Market	16.62	17.90	8.55	7.66
CHX	9.83	9.06	3.08	2.55
PHLX	3.28	3.75	1.08	0.92
Total trades	404,820	402,123	110,673	110,223
Shares ('000)	163,203.6	157,570.6	683,090.7	689,941.4
Panel B—181 Pacific Stock Exchange securities				
NYSE	**46.09%**	**55.58%**	**82.90%**	**85.82%**
BSE	3.48	3.46	1.47	1.36
PCX	**16.50**	**7.00**	**3.19**	**1.90**
CSE	5.12	4.70	1.25	1.04
Third Market	15.87	15.98	7.32	6.28
CHX	9.03	9.96	2.76	2.71
PHLX	3.91	3.30	1.11	0.89
Total trades	317,219	296,027	95,812	95,552
Shares ('000)	120,616.6	113,670.3	599,382.8	599,725.7

[a] The reported statistic is the percent of total trades across all trading venues (the row labeled Total Trades) executed at the given trading venue. Columns may not total 100.00 due to rounding. Percentages in bold denote significant changes in market share between September and November using a cross-sectional sign test.

[b] NYSE = New York Stock Exchange; BSE = Boston Stock Exchange; PCX = Pacific Exchange; CSE = Cincinnati Stock Exchange; CHX = Chicago Stock Exchange; Third Market = Nasdaq trades of exchange-listed securities; and PHLX = Philadelphia Stock Exchange.

[c] Small trades on the BSE are those for fewer than 1300 shares; on the PCX, for fewer than 1100 shares. Both figures represent the maximum-sized trade eligible for automatic execution on the respective exchange.

2.2. *Is Merrill's Decision Associated with an Order-Flow Shift?*

Using all uncancelled TAQ-recorded trades, we compute the distribution of trade among the NYSE, the regional exchanges, and the National Association of Security Dealers' over-the-counter market (i.e., the third market) in September and November for the 417 sample securities. Table I provides the results. Panel A reports the distribution of executed orders in securities

for which Merrill's Boston affiliates specialize. Panel B reports a similar distribution for the PCX securities. Small trades are those eligible for the exchanges' automatic execution systems. The stated limit is 1,299 shares on the BSE and 1,099 on the PCX.[6]

The BSE suffers a dramatic decline in its small-trade market share. When Merrill routes orders to BSE, it enjoys a 9.76% market share (39,514 trades, 13 million shares). That share falls to 2.3% (9,268 trades, 3 million shares) in November, a 76% decrease. For over 77% of the BSE stocks, the NYSE's small-trade market share increases between September and November. The 77% differs significantly (at the .01 level in a binomial test) from the 50% we would expect if order flow shifted randomly. Although the NYSE increases its large-trade market share for 65% of the stocks, Boston's large-trade market share is inconsequential even before Merrill's decision.

Panel B of Table I reports the PCX-sample results. In October, 16.5% of small trades in those 181 stocks execute on the PCX (52,337 trades, 17 million shares). In November, this drops to 7.0% (20,718 trades, 7 million shares), a market-share decrease of about 58% between the two months. The NYSE gains small-trade market share for 75% of the stocks, a figure statistically different from 50% at the .01 level. The PCX's large-trade share drops by 40% (from 3.2% to 1.8%) between September and November and the NYSE gains large-trade market share for nearly twice the number of stocks for which it loses market share.

Economically and statistically significant shifts in the venue of small trades follow Merrill's decision. Large-trade market shares also are affected, although less extremely. Of interest is whether quoted spreads also change in a manner consistent with economic theories of the relationship between spread width and order-flow mix.

2.3. *Does Rerouting Order Flow Affect Quoted Spreads?*

Microstructure theory suggests that the increased order flow associated with Merrill's decision may reduce NYSE specialists' costs and produce narrower quoted NYSE spreads. The expected effect on the NBBO spread is unclear. If regional exchanges only match the NYSE quote at all times, then the NBBO-spread change will be identical to the NYSE's. To the extent that the regionals compete with New York on even one side of the spread, the NBBO's spread change may differ from the NYSE's. If Merrill's order-flow redirection spurs competition, then the NBBO spread may fall more than the NYSE spread. It is possible, however, that regional specialists

[6] Merrill did send larger orders to the regionals. We choose to break on the exchanges' automatic-execution-system cutoffs to avoid differences in execution quality from automatic as opposed to manual execution. These order sizes are clearly eligible for SuperDOT, the NYSE's electronic order-delivery system.

are less aggressive after the order rerouting, suggesting that the NBBO spread may decrease less than the NYSE's. To address these issues, we compute the NYSE and NBBO time-weighted spreads (TWS) for each relevant security in September and November. The TWS is the weighted-average spread observed during the relevant month, with each observed spread width weighted by the fraction of the month during which that spread is in effect.[7] We weight the time-weighted spreads equally across securities in computing the reported mean TWS.

Because spreads are sensitive to trading activity (see Demsetz 1968), we examine total trading activity in the sample stocks across all venues in the two sample months. September has a daily average of 111.34 trades per stock; in November, 103.30 trades occur per stock per day. Trades average 1,878 shares in September and 1,784 in November. Neither figure indicates a statistically significant change in trading activity. Average share price declines slightly (about 4%) between September and November.

Although total trading activity and share prices remain relatively constant in the period, stocks may experience a systematic change in spread for other reasons. To determine whether spreads in stocks affected by Merrill's decision behave differently from those of stocks in general over this period, we construct two control samples (one for each regional) from the nonsample stocks with 2% or more of September's TAQ-recorded trades on either relevant regional. For each regional, we divide qualifying stocks into seven groups based on share price. Within each price group, we divide the stocks into six average spread-width subgroups based on September's NBBO TWS. We then select the control samples from these 42 subgroups by randomly assigning each Merrill stock a control stock from the appropriate price-spread subgroup.

Table II provides descriptive statistics of each sample's TWS and the results of parametric and non-parametric tests of null hypotheses regarding quoted-spread changes. Panel A indicates that the affected stocks' mean NYSE spread falls by \$0.0003. The change, however, is not statistically different from zero at traditional levels (even with a one-tailed test). Furthermore, less than 47% of Merrill-stock spreads decrease. Thus, although the average spread change is negative, we cannot confidently claim that Merrill-stock spreads fell between the two sample months. The control stocks' mean NYSE-TWS increases by \$0.0014 over the period, and 58% of the control

[7] About 1% of the time, the NBB is equal to or exceeds the NBO (i.e., the market is locked or crossed). We take three approaches to dealing with locked or crossed markets in computing the TWS: (1) ignoring the oldest quote resulting in the lock or cross under the assumption that it is stale, (2) arbitrarily assuming a minimum-variation spread, and (3) eliminating all quotes and trades occurring when the quote is locked or crossed. We report results using the third approach, but our conclusions are the same regardless of the approach. Results also are qualitatively similar when we eliminate the 28 stocks selling for less than \$5 per share.

TABLE II

Changes in Quoted Time-Weighted Spreads on the New York Stock Exchange and in the National Market System around the Time Merrill Lynch Ceased Routinely Routing Orders to Regional Stock Exchanges in October 1995

Sample	Percent with narrower TWS in November[a]	Binomial p-level[b]	Changes in mean TWS—September to November[c]	T-stat. p-level[d]
	Panel A—New York Stock Exchange quotes			
Merrill	46.52%	0.1702	−$0.0003	0.3456
Control	42.21%	0.0017	$0.0014	0.0550
Merrill-Control[e]	54.20%	0.0479	−$0.0017	0.0627
	Panel B—National best bid and offer quotes			
Merrill	44.84%	0.0396	$0.0003	0.3806
Control	42.45%	0.0027	$0.0012	0.0918
Merrill-Control	51.80%	0.2465	−$0.0009	0.2036

[a] TWS = time-weighted spread.

[b] The statistic results from testing whether the reported proportion of stocks with higher spreads in November than in September differs from 50%.

[c] Average (stock-weighted) November time-weighted spread less September time-weighted spread.

[d] The statistic results from testing whether the reported mean change is less than zero.

[e] For each Merrill stock another regionally traded stock matched on price and spread width is selected. The variable examined in these tests is the difference between the matched-stock's TWS and the Merrill-stock's TWS. Reported are the fraction of Merrill:Control pairs for which the Merrill stock's spread decreased by more than the Control stock's, the mean difference in the change in the quoted spread for the Merrill:Control pairs, and the appropriate test statistics.

stocks' spread changes are positive. Both parametric and nonparametric tests conclude that the control stocks' spreads rise. Comparing the Merrill stocks to the matched stocks, we conclude that the Merrill-stock spreads decrease relatively. On average, the Merrill-stocks' spread change is $0.0017 less than its control, and in over 54% of the Merrill:Control pairs, the Merrill-stock spread change is negative relative to its matched control stock.

There is no evidence of a decrease in the Merrill sample's NBBO spread (see panel B), either absolutely or relative to their control.[8] This finding is consistent with the hypothesis that regional specialists quote less aggressively after the order-flow shift. Supporting this conclusion, we find that the fraction of time that the PCX is at either side of the TAQ-recorded NBBO falls from 53.2% before the switch to 51.1% afterwards. For the BSE stocks, these fractions are 5.2% before and 4.3% afterwards. There

[8] Results are unchanged using the percentage spread (the quoted spread divided by the spread midpoint).

are several explanations for this decrease. The most basic is that Merrill limit orders equaling or improving the NBBO are NYSE quotes instead of regional quotes after the switch. In addition, regional specialists frequently tighten the quotes for a short period of time after a market order is submitted if the spread exceeds the minimum variation ($0.125) in an attempt to provide the order a better price. Following the decrease in market-order order flow, regional specialists are less likely to submit these ''fishing'' quotes. Finally, with fewer orders, there may be less need for regional specialists to quote aggressively in an effort to manage inventory risk.

Although Merrill-stock spreads do not fall (in a statistically reliable sense) between September and November, we might be able to identify a subsample of affected stocks for which we expect order-flow rerouting to be most important to the NYSE specialist. To try to do so, we divide the sample on the basis of two stock attributes measured in September (ex ante). The first attribute is the relative importance of the spread's adverse selection component. NYSE specialists trading stocks for which a significant proportion of the spread is associated with adverse selection are more likely to benefit from Merrill's rerouting than those trading stocks with little adverse selection. Using all market centers' TAQ-recorded September trades and quotes and the Madhavan *et al.* (1997) spread-decomposition methodology, we classify our sample stocks as having a ''high'' or ''low'' adverse-selection proportion of the spread relative to the median. The second stock attribute we employ is trading frequency. Stocks trading infrequently may impose higher inventory-adjustment costs on the specialists trading them. We measure the number of TAQ-reported transactions in September as our proxy for the ease with which specialists rebalance inventory and, independently of the adverse-selection distinction, divide the sample into ''low'' and ''high'' categories relative to the median.

Table III displays our results for the NYSE-TWS, using the 413 stocks (of 417) for which we have sufficient data to estimate spread components reliably. Results are consistent with our conjecture: the mean TWS falls for the stocks we believe most likely to be affected by the rerouting. Stocks with a large September adverse-selection spread component have a mean NYSE TWS decrease of $0.0030, which is statistically significant at traditional levels. Those with few trades have a statistically significant mean spread decrease of $0.0025. If we look at the 124 stocks characterized by both low trading and high adverse selection, then the results are even stronger in favor of our conjecture. For those stocks, the mean TWS falls by $0.0047. Furthermore, over 58% of those stocks experience spread decreases between September and November. Consistently with the claim that the additional uninformed order flow reduces adverse-selection costs for the NYSE specialists, the adverse-selection component of the NYSE spread for the 123 of these stocks for which we can reliably compute spread components in November falls from $0.1022 (65.3% of the spread) to $0.0956

TABLE III

NYSE Spread by Subsample Based on the Number of Transactions and the Fraction of the Spread Due to Adverse Selection in September 1995 for the Stocks in Which Merrill Lynch Routinely Routed Orders to Regional Stock Exchanges Prior to October 1995[a]

	Low number of transactions (mean = 443.9)[b]	High number of transactions (mean = 3,032.6)	All
Low adverse selection	\$0.0010 (0.2799)	\$0.0032 (0.0006)	\$0.0023 (0.0042)
(mean = 20.43%)[c]	0.4321 (0.2664)	0.3571 (0.0017)	0.3865 (0.0013)
	81	126	207
High adverse selection	−\$0.0047 (0.0128)	−\$0.0004 (0.4260)	−\$0.0030 (0.0263)
(mean = 62.92%)	0.5806 (0.0876)	0.4878 (0.9122)	0.5437 (0.2362)
	124	82	206
All	−\$0.0025 (.0425)	\$0.0017 (0.0492)	−\$0.0003 (0.3489)
	0.5220 (0.5764)	0.4087 (.0101)	0.4649 (0.1682)
	205	208	413

[a] Each cell reports the mean change in the quoted time-weighted spread between September 1995 and November 1995, the frequency of stocks for which this mean decreased between the two sample months, and the number of sample stocks falling in the indicated subsample. The numbers in parentheses are the *p*-levels associated with a *t*-test of whether the mean is less than zero and a chi-squared test of whether the reported proportion differs from .50.

[b] The number of transactions in the sample stock in September 1995.

[c] The proportion of the quoted spread associated with adverse selection costs using the approach of Madhavan *et al.* (1997). Data requirements eliminate four stocks with inadequate data to accurately conduct the estimation procedure.

(62.4% of the spread) after order flow is redirected. The \$0.0066 (2.91 percentage point) mean decrease in the adverse-selection component of the spread is significantly less than zero at the .04 (.06) level and approximately 60% of the 123 stocks experience a decrease. Table III also reports the TWS change for the subsample we classify as having relatively little ex ante benefit to rerouting (i.e., stocks with little adverse selection in their spreads and frequent trading opportunities). For those stocks, the mean TWS increases by a statistically significant \$0.0032.

In summary, although the affected stocks' mean spread does not fall a statistically reliable amount, it does decrease relative to a control sample's spread. Furthermore, in a subsample for which we expect that the rerouting is likely to be most important, the NYSE-quoted spread falls by nearly one-half cent per share between September and November. This drop is consistent with market microstructure models of spread-setting behavior.[9]

[9] Battalio *et al.* (1997a) find that NYSE spreads do not increase when order flow is directed away from the NYSE. They attribute this to competition. The amount of order flow redirected in their study is less than that redirected in this study, and this may partially explain why they detect no significant effects of redirection. They do find, however, that regional specialists become *more* aggressive with the increased order flow.

3. CHANGES IN INVESTORS' EXECUTION QUALITY

Quoted prices may not provide a very accurate measure of execution prices. Trades may occur at prices better than the relevant quote (''price improvement'' in the profession's vernacular), which reduces trading costs. To measure execution quality, we compute liquidity premiums and price improvement rates. Liquidity premiums measure the trade price's average distance from the midpoint of the quoted spread. If the spread's midpoint measures the security's value, then the liquidity premium provides a per share estimate of execution costs.[10] The price-improvement rate measures how frequently trade prices are better than the relevant quote.

Many studies (e.g., Blume and Goldstein 1992, Lee 1993, and Bessembinder and Kaufman 1997) compute liquidity premiums with commercially available data and find that the NYSE's liquidity costs are less than the regional exchanges'. If Merrill extrapolated these findings to their trading, then they had reason to believe that NYSE routing might produce better prices for their customers.[11] We are interested, however, in whether Merrill can capture this apparent advantage for its customers. Because TAQ does not identify a trade's parties, we cannot focus on Merrill's trades or effectively analyze trade quality when the quoted spread is equal to the minimum variation. Nor does TAQ allow us to separate a market-order from a limit-order execution. Therefore, we obtain proprietary Merrill data.

3.1. *Proprietary Data Description*

The proprietary data include system order data for Merrill before and after the routing change. Merrill's October and November SuperDOT NYSE trades are available to us electronically. Unfortunately, Merrill's regional trades (about 2,500 daily market orders) are not available electronically, so we must gather those data by hand from hard copy reports. This limits our investigation to five days in each month (October 2–6 and November 17, 27–30).

The regional-exchange proprietary data include (1) order submission and execution date(s) and to-the-*minute* time(s), (2) stock symbol, (3) a buy or sell indicator, (4) a market or limit order indicator, (5) order and trade size (number of shares), (6) execution price, and (7) trading venue. To establish a contemporaneous to-the-*second* NBBO, we match executed proprietary database market orders for at least 100 shares submitted after the market opens with a TAQ-reported trade (where the time stamp includes seconds). We base the match on the stock, trade size, execution

[10] See Lee (1993) for a more complete discussion of liquidity premium. Petersen and Fialkowski (1994) illustrate computing liquidity premia with detailed proprietary data.

[11] We reach a similar conclusion (results not reported) using TAQ data to estimate the overall liquidity costs associated with our sample securities during September 1995.

TABLE IV
Sample Selection Process for Merrill Lynch Proprietary Market Order Data[a]

	October 2–6, 1995		November 17 and 27–30, 1995	
	BSE sample[b]	PCX sample[c]	BSE sample	PCX sample
Total trades	7,951	8,312	11,031	9,714
Invalid trades[d]	489	494	844	684
Valid trades[e]	7,462	7,818	10,187	9,030
No valid trade match[f]	1,394	1,248	2,586	2,625
No valid quote match[g]	132	72	274	37
Sample size—trades[h]	5,936	6,498	7,327	6,368
Number of shares ('000s)	2,279	2,519	2,580	2,187

[a] Because Merrill's data time-stamp trades only to the minute, we match these trades to trades recorded on the NYSE's Trades and Quotes database to obtain a to-the-second time stamp, which is needed to match trades with quotes more accurately.

[b] BSE = Boston Stock Exchange.

[c] PCX = Pacific Exchange.

[d] Odd lots, orders received prior to opening, and trades executed before the New York Stock Exchange opens.

[e] Row 1 less row 2.

[f] No quote match within 5 min of reported trade time, a nonunique match, or trades reported late or out of sequence.

[g] The quote is for zero depth or is not in integer increments of the stock's minimum variation or the transaction price differs from the mid-point of the contemporaneous quote by more than (1) \$8, (2) 24 times the quote width, or (3) 10% of the quote mid-point.

[h] Row 3 less rows 5 and 6.

price, and report time. Assuming that we correctly identify Merrill trades, the TAQ-matched trade provides a to-the-second execution time. We ignore trades matched to a TAQ trade flagged as reported late or out of sequence. We then calculate liquidity premiums and price improvement rates.[12] To include a trade in our analysis, we require a unique match within five minutes of the time reported in our proprietary database.

Table IV outlines our experience matching the proprietary data to TAQ trades and quotes. In October, 7,462 valid BSE-sample securities' trades execute on either the BSE or the NYSE. We find a unique TAQ match within 5 min for 6,068 (81%) of them. Analogous PCX numbers are 7,818 qualifying trades and 6,570 matches for an 84% matching success rate. Valid quotes exist for nearly all qualifying trades.[13] The resulting 12,434 trades

[12] Because Merrill's order submission times are time-stamped only to the nearest minute, we continue to use TAQ-matched quotes as the benchmark for our computations. Typically, liquidity premiums and price improvement are defined relative to order submission-time quotes.

[13] A valid quote is one for at least 200 shares on the relevant side, denominated in even increments of the stock's minimum price variation, and not differing from the transaction price significantly. Specifically, when a transaction price differs from the spread midpoint by more than (1) \$8, (2) 24 times the contemporaneous spread, or (3) 10% of the spread midpoint, we exclude that trade assuming a recording error.

(4.8 million shares) form the sample for analyzing Merrill's trade quality before the rerouting. Extrapolated to a monthly basis, these trades represent 15% of the total trades and 11.5% of the total shares traded in Table I. Most of our preswitch trades occur on the regional exchanges, but large trades and some that appear eligible (on a size basis) for regional routing occur on the NYSE.

One might be tempted to compare same-stock, across-exchange execution quality using Merrill's October data. During this period, however, Merrill typically routed small retail orders to the regionals and larger orders to New York. Thus, it is difficult to conclude that an order routed to one venue would have been better served had Merrill rerouted it to the other venue. For example, suppose that the average October liquidity premium associated with regional executions is lower (more favorable to the customer) than the average liquidity premium associated with NYSE trades. Can we conclude that traders are better off with regional executions? Only if we do not believe the NYSE would offer better prices on the regionally routed orders. Because smaller orders received regional routing in October, this conclusion is difficult to justify without additional analysis. To provide this analysis, we also examine November execution quality.

On the NYSE during the November period, we use the procedure described above to match 7,601 (6,405) trades from a universe of 10,187 (9,030) valid trades using BSE-sample (PCX-sample) securities for a 74.6% (71.9%) matching success. We find valid quotes for about 98% of these matched trades.[14] These 13,695 trades (4.77 million shares) form our post-change sample. We find no Merrill trades executing on the regionals in the November period.

Table V provides descriptive statistics for the Merrill market orders included in our sample during the October and November test periods separated into Boston and PCX samples. More market orders execute in November than in October. However, this difference is not statistically significant at traditional levels. Mean trade size decreases from 386 shares per trade in October to 347 in November. Treating each stock's mean trade size as a data point to conduct a *t*-test for a difference in means suggests that the BSE-sample's mean trade-size change is not significant at traditional levels, but that the PCX-sample's change is significant at the .04 level. The PCX stock's mean trade size decrease is due to an increased frequency of 100-share trades (from 31% to 36.8% of trades). Most of this increase results from fewer 200–500 share trades, although all larger trade-size frequencies decrease slightly.

[14] Conversations with NYSE officials suggest that the lower match rate for NYSE executions is due to the practice of bunching several individual orders into one execution. Our conclusions are unaffected if we use all November Merrill NYSE trades (i.e., do not match the NYSE trades to TAQ).

TABLE V

Descriptive Statistics for Merrill Lynch Market Orders before and after the Rerouting of Trade from the Regional Stock Exchanges to the New York Stock Exchange on October 31, 1995[a]

	October 2–6, 1995		November 17 and 27–30, 1995	
Statistic	BSE sample	PCX sample	BSE sample	PCX sample
Transactions	5,936	6,498	7,327	6,368
Average shares per trade	384.0	387.7	350.3	343.4
Number of shares ('000)	2,279.4	2,519.3	2,566.6	2,186.8
Frequency Distribution of Trade Size (% in each category)[b]				
100 Shares	36.02	31.13	38.00	36.81
200–500 Shares	47.61	53.09	48.89	49.76
600–1000 Shares	11.25	10.93	9.28	9.74
>1000 Shares	5.12	4.85	3.83	3.69

[a] These statistics are computed from the trades surviving our data screens.

[b] The data report only the round lot portion of trade size. Actual order sizes are truncated.

3.2. *Does Merrill Capture Better Prices?*

3.2.1. *Liquidity premiums.* We calculate the liquidity premium as

$$\text{LP} = \text{I} \times (\text{transaction price} - \text{spread mid-point}),$$

where I is $(+1)$ for buyer-initiated orders and (-1) for seller-initiated ones.[15] LP are positive if buyers pay more (sellers receive less) than the spread midpoint. Table VI reports share-weighted liquidity premiums for Merrill's small-order trades in the sample periods.[16] When the contemporaneous spread is \$0.125, the BSE- (PCX-) sample securities' mean LP falls by \$0.0104 (\$0.0058) per share between October and November. At a .05 significance level, neither a mean-change t-test nor a paired-sign test rejects the null hypothesis that the LP are equal across the two months for either

[15] For the results reported in this paper, we use the spread in effect 15 s before execution time as the reference spread. Conclusions do not change if we use the spread 30 s before or 5 minutes after execution.

[16] Ross *et al.* (1996) show that regionals' average trade size is smaller than the NYSE's. By using small trades for all venues, we reduce one potential source of difference among venues' execution statistics.

TABLE VI

Share-Weighted Liquidity Premiums for Merrill Lynch's Small-Order Trading for the Stocks in Which Merrill Lynch Routinely Routed Orders to Regional Stock Exchanges Prior to October 1995[a]

Sample[b]	Spread width[c]	Mean October liquidity premium[d]	Mean November liquidity premium[e]	Difference in liquidity premium[f] t-test (p-level)
BSE	\$0.125	\$0.0538	\$0.0424	−0.9746 (.3305)
	\$0.25	\$0.0676	\$0.0524	−3.2988 (.0011)
PCX	\$0.125	\$0.0578	\$0.0520	−1.7269 (.0854)
	\$0.25	\$0.0805	\$0.0513	−5.2785 (.0001)

[a] The liquidity premium is the share-weighted average signed (buy orders +1 and sell orders −1) difference between transaction price and the mid-point of the contemporaneous bid-ask spread. Small orders are those that can be executed on the regional exchange's automatic execution system, i.e., fewer than 1100 shares on the Pacific Exchange and fewer than 1300 on the Boston Stock Exchange.

[b] BSE = Boston Stock Exchange; PCX = the Pacific Exchange.

[c] Spread width is the national best offer price less the national best bid price at order execution time.

[d] October 2–6, 1995 is the preperiod.

[e] November 17, 27–30, 1995 is the postperiod.

[f] The t-test is reported for the difference between October's mean LP and November's.

sample. When the contemporaneous spread is \$0.25, the BSE (PCX) stocks' mean LP falls by a statistically significant \$0.0152 (\$0.0292) per share.[17]

3.2.2. *Price-improvement rates.* Another approach to measuring execution quality is computing the fraction of price-improved shares. For our purposes, price improvement occurs when a transaction price is better than

[17] Recall that the average trade size for the PCX sample stocks decreased between October and November, with the frequency of 100-share trades increasing about 5 percentage points, the frequency of trades of 200–500 shares decreasing by about 3 percentage points, the frequency of trades of 600–1000 shares decreasing by about 1 percentage point, and the frequency of trades greater than 1000 shares decreasing by about 1 percentage point. Extant research suggests that liquidity premiums increase in trade size. Should we expect the differences in trade sizes to explain completely the difference in mean liquidity premium? Table V-6B in SEC (1997) suggests not. From that table, we expect 100-share trades to be associated with 4.4-cent liquidity premiums on the NYSE; 200–500 share trades to be associated with 5.5-cent liquidity premiums; 600–1000 share trades to be associated with 7-cent liquidity premiums; and trades greater than 1000 shares to be associated with 10-cent liquidity premiums. Assuming the most extreme changes in order sizes consistent with the distribution of Merrill trade sizes documented in our Table V suggests that trade-size difference accounts for a mean liquidity premiums change of only about \$0.0012. This is well short of the \$0.0292 difference we document in Table VI.

TABLE VII

The Share-Weighted Price Improvement Rate for Merrill Lynch's Small Trades for the Securities in Which Merrill Lynch Routinely Routed Orders to Regional Stock Exchanges Prior to October 1995[a]

Sample[b]	Spread width[c]	October 2–6, 1995	November 17, 27–30, 1995	Difference in price improvement rates *t*-test (*p*-level)[d]
BSE	$0.125	8.02%	17.12%	2.0125 (.0450)
BSE	0.25	44.61	56.25	3.6810 (.0003)
PCX	0.125	4.08	9.29	2.9522 (.0035)
PCX	0.25	34.85	57.85	5.8511 (.0001)

[a] Price improvement occurs when the trader buys at a price less than the contemporaneous ask or sells at a price greater than the contemporaneous bid. The reported number is shares receiving price improvement divided by total shares traded. Small trades are trades eligible for automatic execution on the indicated regional exchange (i.e., fewer than 1300 shares on the Boston Stock Exchange and fewer than 1100 shares on the Pacific Exchange).

[b] BSE = Boston Stock Exchange; PCX = Pacific Exchange.

[c] Spread width is the national best offer price less the national best bid price at the time of order execution.

[d] A *t*-test of the difference between November's mean price improvement rate and October's mean price improvement rate.

the relevant quote at order-execution time.[18] A buy (sell) order receives price improvement if the trade executes at a price less (greater) than the offer (bid) price.

Table VII reports average price improvement rates for the sample stocks' trades eligible for electronic execution. Our findings support the LP results suggesting Merrill's customers benefit from the better execution quality available on the NYSE. In $0.125-spread markets, Merrill's BSE-stocks' price-improvement rate increases from 8% in October to 17% in November. Over the same time, the PCX-stocks' rate more than doubles to greater than 9%. Further, for $0.25-spread markets, the BSE- (PCX-) sample's 44.6% (35%) October rate increases to over 56% (58%) when trades move to the NYSE. Finally, *t*-tests of mean differences suggest that all price improvement rates are statistically greater (at the .05 significance level) after the move to New York and sign tests indicate that significantly more than 50% of the stocks in the PCX $0.125- and $0.25- and BSE $0.25-spread samples increase price improvement rates at the .01 level.

[18] Battalio *et al.* (1997b) indicate that execution-time price improvement rates are likely to be greater than submission-time execution rates. Thus, our rates are not directly comparable with those in studies such as Ross *et al.* (1996) and SEC (1997).

3.3. *Summary*

Merrill's market-order execution quality increases between early October 1995, when trades execute through affiliated BSE and PCX specialists, and November 1995, when executions occur only on the NYSE. Liquidity premiums in \$0.125-spread markets drop about \$0.0075. In \$0.25-spread markets, the LP drops by about \$0.0152 for the BSE stocks and \$0.0292 for the PCX stocks. Consistently with these findings, the NYSE offers higher price improvement rates than the regional exchanges.[19]

4. CONCLUSIONS

We associate significant changes in trading venues' small-trade market share with Merrill Lynch's October 1995 decision to stop routinely sending customer orders to Merrill-affiliated specialists on regional stock exchanges. In the month following the decision, both the BSE and the PCX lose significant market share in the relevant trades small enough for the exchanges' automatic execution systems. Merrill's order flow shift seems complete; we find no Merrill orders executing on regionals in our post-switch proprietary data.

Our interpretation of market microstructure theory suggests that this redistribution of order flow should decrease NYSE specialists' trading costs. The increased order flow should reduce the (per share) order processing and inventory costs, and the more frequent interaction with uninformed investors should decrease the adverse-selection cost. If markets are competitive, then the savings should be passed on to investors through tighter quoted spreads. We find that the mean overall NYSE-quoted spread falls by a statistically insignificant \$0.0003 between September and November 1995 for the stocks affected by Merrill's decision. Furthermore, less than 47% of the sample stocks have tighter spreads in November than in September. Relative to a matched sample of stocks, however, spreads fall in the stocks affected by Merrill's rerouting. In addition, a subsample of stocks

[19] The results in Tables VI and VII suggest that Merrill-affiliated specialists provided price improvement in nontrivial amounts on regional exchanges. Unlike the NYSE, where most price improvement occurs when two public orders interact to the benefit of both, the specialist is the counterparty to most regional trades. In some cases, price improvement results from a deliberate decision by the specialist; in other cases, it results from the regionals' reluctance to establish new intraday high or low prices for the stock or to transact at a price that would continue an upward or downward stock-price trend (to avoid a double-up tick or a double-down tick). In any case, regional price improvement suggests that regional specialists did not simply pocket the quoted spread on all trades. Merrill-affiliated specialists' liquidity premia and price improvement rates are similar to those in Battalio *et al.* (1997b) for overall BSE and PCX trading.

we believe most likely to be affected by the order-flow rerouting experience a statistically significant decrease in their quoted NYSE spreads. In neither the overall sample nor the subsample does the NBBO spread decrease significantly, suggesting that regional specialists quote less aggressive after Merrill's shift. Consistent with that claim, the frequency with which the affected regional specialists' quotes are on at least one side of the NBBO decreases slightly after order flow moves to New York.

The motives for Merrill's routing decisions may affect the interpretation of our results. Merrill may have made both the initial decision to send orders to the regionals and the decision to reroute trade to the primary exchange based on what it deemed best for its customers at the time. Historically, regional exchanges offer low fees, product and technological innovation, and a flexible operating environment for their members.[20] Thus, it is possible that regional exchanges' advantages created a low-cost environment for investors offsetting the regionals' higher liquidity costs during the time Merrill routed orders to the BSE and the PCX. In this scenario, Merrill rerouted orders when the regionals' cost advantages no longer exceeded the higher cost of liquidity. If Merrill originally decided to route trade to its regional specialists to reduce costs and not because it could use its better-informed position to execute uninformed trades selectively, then rerouting trade to the NYSE should not significantly reduce the NYSE specialist's trading costs due to adverse-selection considerations. If that is true, then the only benefits of additional order flow are reduced order processing and inventory costs. Such minimal benefits suggest a muted decrease in the stocks' NYSE spreads.

Alternatively, regional routing may have provided Merrill private benefits by selectively executing orders. Harris (1995) and Macey and O'Hara (1997) note the potential agency problem inherent in practices such as internalization and payment for order flow. Internalization allowed Merrill to receive dealer revenue on trades Merrill deemed uninformed. In this scenario, Merrill routed trades to the NYSE only when external forces (e.g., legal and political costs) made regional routing expensive to Merrill. If Merrill actively used its ability to execute orders selectively, then we anticipate more substantial spread reductions when orders are rerouted. We believe that our results support the conjecture that Merrill benefitted from the ability to execute orders selectively for some stocks. Specifically, stocks with a large adverse-selection component in their quoted spread experience

[20] Domowitz (1993) and SEC (1994) provide a more complete discussion of these issues. The latter notes that while regional exchanges "do not compete for order flow consistently on the basis of quotes, they have provided vigorous competition to the NYSE through lower transactions fees and new services and products." A recent discussion of industry consolidation, *Wall Street Journal* (1998), notes that "... the regionals have often been first to cut fees or introduce new technology."

a statistically significant reduction in the NYSE spread and the adverse-selection component of that spread when orders are redirected.

Although the NBBO spread does not decrease, Merrill's customers may still benefit from the rerouting. Specifically, Merrill's market-order customers may receive better prices on the NYSE than on the regionals. Extant work finds that the NYSE's execution quality is typically better than the regionals'. At issue, however, is whether a broker can capture these better prices for its customers by switching trading venues. Merrill's decision provides an opportunity to examine this issue. Furthermore, because the broker remains the same in our experiment, we hold order mix, nominal trading commissions, and other services (e.g., research) constant.[21] We find that Merrill's move improves its execution-quality statistics, suggesting that the NYSE offers better prices and Merrill captures those prices for its customers. Liquidity premiums obtained on the NYSE are lower (more favorable for the trader) for both the BSE- and the PCX-sample securities after the rerouting than the preswitch regional liquidity premiums. We also find higher price improvement rates for Merrill's trades after the switch than before. If other trading costs do not change, then our results indicate that Merrill's rerouting of orders to the NYSE provided its customers, on average, with lower-cost executions. Our findings may have implications for other brokerage firms considering rerouting orders.[22] The results also suggest that it is important to consider transactions within the quoted spread when measuring transactions costs. With price improvement, the NBBO may not be a useful measure of market price.

We note limitations in what we measure and how we measure it. A discrete price grid may limit our ability to detect quoted-spread changes. Although only one stock traded at the minimum-variation spread in October (making a quoted-spread decrease impossible), price discreteness may restrict specialists' ability to transmit trading cost savings to market participants by quoting better prices. Data restrictions require we measure liquidity premiums and price improvement rates relative to order-execution-time quotes. Although impossible here, it is more common to measure these statistics relative to submission-time spreads. If spreads behave differently across venues between order submission and execution, say, because one market exerts more influence on the NBBO, then our market-quality statistics are measured with error. In addition, nondisplayed trading interests may vary among exchanges, making our market-quality statistics incompatible.

[21] Because commissions are negotiable, we do not necessarily hold actual commissions constant.

[22] See "Smith Barney and A. G. Edwards Study Merrill's NYSE Program," *Investment Dealers' Digest*, November 6, 1995. Personal communication with the Cincinnati Stock Exchange and Smith Barney officials indicates that Smith Barney recently directed order flow from the Cincinnati Stock Exchange to the NYSE.

Finally, we measure only one aspect of market quality—the price market orders receive. We ignore other dimensions of market-order execution quality (e.g., speed, convenience, opportunity costs) and limit orders.

Caution should be used in extrapolating our results either to securities excluded from the sample or to other broker-dealers. Because we focus on securities Merrill-affiliated specialists traded, we cannot make general inferences about regional-exchange execution quality. Likewise, we cannot conclude that NYSE executions better serve all order flow in these securities. Other brokers' order-flow redirection may induce behavior different from that which we document. For example, Merrill officials indicate that they did not change commissions or services after redirecting order flow. This suggests that the better transaction prices directly benefit Merrill's customers. Discount brokers, however, who rely on market-making income to keep commissions low, might be forced to increase commissions if they cease acting as dealers.

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