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The trades of NYSE floor brokers☆

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Abstract

This paper studies the contribution of NYSE floor brokers to the Exchange's agency auction market. Floor brokers represent 44%, specialists 11%, and system orders 45% of the value of all executed orders in our sample. We analyze how the cross-sectional distribution of floor broker trading depends on liquidity, block volume, on- and off-exchange competition, volatility, and order flow internalization. Floor brokers participate in large trades, primarily in liquid stocks, and they trade more when volatility is high. They provide two-sided liquidity to the market and often provide liquidity that would otherwise have been supplied by NYSE specialists.

JEL classification: G20; G29

Keywords: New York Stock Exchange; Floor brokers; Trading structure; Professional traders

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1. Introduction

In this paper, we use not-publicly-available data from the New York Stock Exchange's audit trail files to examine the contribution of floor brokers to the Exchange's floor-based auction market. The NYSE's trading structure is complex, with the Exchange's trading floor acting as a meeting place where floor brokers representing customer orders, the electronic limit order book and specialists interact and provide liquidity to the market. System volume, orders sent electronically through SuperDot to the floor of the Exchange, has increased steadily since SuperDot was introduced in 1976. The NYSE, however, maintains an active trading floor where brokers represent customer orders in person at the specialist posts. The decision to keep an active trading floor suggests that NYSE floor brokers are an integral part of the Exchange's trading process. Yet there is virtually no empirical evidence to illustrate how floor brokers contribute to NYSE liquidity and to identify what factors are important in determining the extent of floor broker trading for a particular stock. The purpose of this study is to fill this void.

Despite the accessibility and efficiency of SuperDot, floor brokers remain important contributors to NYSE liquidity. During our sample period, January 2–February 28, 1997, NYSE floor brokers executed trades corresponding to 44% of the value of all buys and sells. Almost half of twice trading volume, therefore, reaches the specialist's post not through SuperDot but through floor brokers. We call this 44% the floor broker *participation rate* and we use it to measure the floor brokers' contribution to liquidity.[1]

Floor brokers recieve public orders from off-exchange traders either at their broker booths or via hand-held electronic devices. The floor broker then walks the order to the specialist post and either attempts to execute the order as a member of the trading crowd (*active participation*) or leaves the order with the specialist (*passive participation*). In this study, we focus on the part of floor-broker-represented orders that are *actively* traded by floor brokers. Order instructions typically give the floor broker considerable discretion over execution strategies, and orders may be worked over substantial periods of time. For actively represented orders, the floor broker essentially acts like a smart limit order book, walking up to the specialist post, assessing the total liquidity available in the limit order book and in the trading crowd, and customizing execution strategies accordingly in order to minimize price impact.[2]

[1] Note that unlike the specialist participation rate which measures the specialist proprietary purchases and sales, the floor broker participation rate measures the percent of purchases and sales in which the floor broker acted as an agent: floor brokers are not allowed to trade on their own account. It is also important to recognize that while a specialist trading for his own account can be on only one side of a trade, floor brokers may represent orders on both sides of a trade.

[2] In a recent study, Handa et al. (1998) find that orders handled by AMEX floor brokers have a smaller temporary price impact and a larger permanent price impact compared to system orders.

We are first interested in the determinants of active floor broker participation across stocks and over time. Our starting point is the regression analysis of the trades of NYSE specialists in Madhavan and Sofianos (1998). Their evidence shows that specialists trade more in less liquid stocks and less when there is off-exchange competition, a result consistent with the specialist's role as a liquidity provider of last resort. How do variables like liquidity and off-exchange competition affect floor broker trading? Given the high opportunity cost of floor brokers' time, we expect that their activity should be focused in the most liquid stocks. However, the floor broker's ability to use his information advantage and trading expertise is likely to be particularly valuable when executing trades in less liquid stocks. Similarly, on- or off-exchange competition on say the bid side of the market might impair floor brokers' ability to execute buy orders, but it might actually facilitate the execution of floor broker represented sell orders. Our evidence shows that floor brokers trade more in liquid stocks and in stocks where there is plenty of volatility. However, holding volume and volatility constant, they trade more in stocks with a small market capitalization. This suggests that floor broker services are particularly valuable when attempting to execute difficult trades.

Second, what is the nature of the interaction between floor brokers and specialists? Since floor brokers represent public orders, their orders have priority over orders that the specialist may want to execute on his own account. At the same time, since floor brokers bring liquidity to the floor they may at times relieve the specialist of his fiduciary obligation as a liquidity provider of last resort. Both forces suggest that there will be a negative relationship between the participation rate of floor brokers and specialists. We analyze this relationship both in a regression framework based on total trading and by separately studying specialist participation in trades with and without active floor broker trading. Our results show that there is a negative relationship between specialist and floor broker participation. However, there is no evidence of a direct effect of floor broker participation on specialist participation (or vice versa) after we have controlled for other factors that determine their respective participation rates.

Third, what is the nature of trades when floor brokers step in and trade? NYSE's priority rules suggest that floor brokers should participate primarily in large trades. Our evidence is consistent with this. We find that trades with active floor broker participation (excluding upstairs-facilitated trades) are more than five times the size of trades without floor broker trading.

Finally, what effect do the trades of floor brokers have on public limit and market order submitters? One possibility is that floor brokers simply consume liquidity provided by public limit orders via SuperDot. If that were the case, we would on average find floor brokers (and the specialist) on one side of every trade with the order book as counterpart. A competing hypothesis is that floor brokers bring both buy and sell orders to the floor. As a result, we would on average see a floor broker participation rate exceeding 50% with the balance absorbed by the specialist and the order book. We find support for the second hypothesis – there are typically floor brokers on both sides of a trade with active floor broker participation.

Our findings have important implications for academics doing empirical work in market microstructure. Researchers using NYSE data typically ignore the contribution of floor brokers to the NYSE auction market. By highlighting the importance of floor brokers, we show how misleading this practice can be. For example, since the specialist quoted depth typically only partially reflects the total liquidity available on the floor of the Exchange, it is incorrect to make inferences about available liquidity based on quoted depth (as reported, for example, in trades-and-quotes databases like TAQ).[3] In addition, orders brought to the floor by NYSE floor brokers are not in the System Order Data (SOD) files, which only include SuperDot activity. The NYSE made available to academics a sample of the SOD file in the TORQ database. With the floor broker participation rate as high as 44%, it is misleading to make inferences concerning liquidity based solely on the limit order book as represented by the SOD file in TORQ.

The results of this paper are important not only for a better understanding of the current trading structure on the NYSE, but also for the design of future trading systems. This paper proceeds as follows. In Section 2, we provide an overview of floor brokers' role in the NYSE auction. Section 3 and the appendix describe the audit trail data we use for analyzing floor broker trades. In Section 4, we study the determinants of the cross-sectional distribution of floor broker and specialist participation rates. In Section 5, we analyze the nature of trades with active floor broker participation in greater detail. Section 6 concludes.

2. Overview of the floor brokers' role in the NYSE auction

Both floor brokers and specialists are members of the NYSE. Table 1 provides a breakdown of members into specialists and floor brokers over recent years. At the end of 1996, the NYSE had a total of 1427 members: 1366 owned or leased NYSE membership 'seats'; and 61 individuals were members through payment of an annual fee.[4] However, as Table 1 shows, all members do not necessarily participate actively in trading at all times. For example, at the end of March 1997, 1391 of NYSE's 1427 members were active on the floor.

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[3] The SOD file in the TORQ database has recently been used by academics for this purpose. Kavajecz (1999) makes inferences concerning the strategic choice of quoted prices and depths made by NYSE specialists based on comparing the specialist quotes to the limit order book as estimated from the SOD file.

[4] Source: NYSE Fact Book, 1996 Data. The number of NYSE membership 'seats' has been constant at 1366 since 1953.

Table 1
NYSE floor brokers and specialists[a]

	Floor brokers			Specialists	Missing	Total
	Commission house	Independent	Mixed business			
1997	332	527	67	458	7	1391
1996	333	530	67	450	4	1384
1995	299	444	69	438	118	1368
1994	301	446	74	446	91	1358
1992	343	514	15	419	52	1343

[a] Data from the NYSE's BADGE file which records floor brokers and specialists by their badge number, firm mnemonic, firm name, full name, floor location and other characteristics. The 1997 numbers are as of March 31. Historical numbers are for December 31 each year.

Floor brokers can in turn be divided into three groups: 'commission house' brokers; 'independent' brokers; and 'mixed business' brokers. Commission house brokers work exclusively for 'upstairs' securities firms (e.g., Merrill Lynch, Bear Stearns) that deal directly with the public. At the end of March 1997, there were 332 commission house brokers on the NYSE floor and 527 independent or so called 'two-dollar' brokers. Independent brokers receive orders from a variety of sources (directly from institutional investors, non-member firms, as well as from other member firms). Independent brokers range from sole proprietorships to partnerships of up to ten brokers. Another 67 floor brokers were 'mixed business' brokers taking orders both as independent brokers and as representatives of upstairs firms. Finally, at the end of March 1997, there were 458 registered specialists on the floor of the Exchange.[5] Over the past few years, the break down between floor brokers and specialists has been stable, with roughly a two-to-one ratio of floor brokers to specialists.

Why would off-floor traders use a floor broker as opposed to sending their orders electronically through SuperDot? To understand the benefits of using floor brokers for trade executions, some basic information on how orders are treated on the NYSE is useful. A more comprehensive account of NYSE trading procedures is provided in Hasbrouck et al. (1993) and the NYSE Constitution and Rules. Limit orders that reach the specialist post via SuperDot are sorted by price and time priority and are included in the specialist quotes and summarized in the Display Book. By contrast, floor broker represented orders are not

[5] Seven active floor participants did not have a type identifier in the data set and so could not be classified.

included in the quote or in the Display Book unless the floor broker explicitly requests that the specialist include the order in the quote.

SuperDot market orders arrive at the specialist's Display Book, but are not executed automatically against the order book. If there is floor interest, the specialist will expose these orders to the crowd before executing the trade. One or several floor brokers might choose to improve on the bid or offer thus stepping ahead of the book by virtue of price priority (and ahead of the specialist by public priority). This ability of floor brokers to step in and participate in the auction after the market order has arrived is valuable, particularly when the competition from the order book is strong.

The crowd might also trade against a market order without offering price improvement even if they have not displayed their orders prior to the arrival of the market order. According to NYSE's Rule 72, floor broker represented orders may be able to gain precedence over pre-existing orders because of size.[6] The specialist may allow floor brokers to see parts or all of the limit order book. Indeed, provided that the submitters of the orders have authorized disclosure, specialists must on request disclose to floor brokers the contents of their limit order book: depth at different prices and the identity of the member firms representing the orders in the book (NYSE Rule 2115). In addition, by standing in the crowd, floor brokers may learn about additional broker-represented liquidity. Floor brokers exchange information on their trading intentions such as size and direction of unexposed orders when they believe that sharing this information is beneficial to their customers. Off-floor traders and researchers, on the other hand, can see only the specialist's quoted depth at the best bid and ask, and thus have a limited picture of available liquidity. Having the additional information combined with the ability to potentially 'size-out' the book helps floor brokers to obtain better prices for the orders they represent.

The floor brokers' informational advantage enables them to react quickly to changing market conditions, especially in fast-moving volatile markets. The floor brokers' better-informed judgement and ability to react instantly to changing conditions are perhaps the most valuable services floor brokers provide and the main reason for using a floor broker. These advantages of using a floor broker are especially valuable for large orders and orders in less liquid stocks. Consider a floor broker representing a large buy order. On receiving the order, the broker will walk up to the specialist post, evaluate the available liquidity and then decide what strategy to implement. Suppose the broker realizes there is not

[6] NYSE's Rule 72 (a) says that the first (in time) order at the bid (ask) always has priority. However, if the first order is filled and there is a remaining balance, any orders (book or floor) at that price whose size equals or exceeds the balance shall have priority over smaller orders, and shall be filled in the order of their time stamp (NYSE Rule 72 (c)). Moreover, if the incoming sell (buy) order exceeds the first order at the bid (ask) and all remaining orders (book and floor) at this price are smaller than the balance, the remaining orders shall be given precedence by size (NYSE Rule 72 (d)).

much competing buy interest. The broker will then 'work' the order, breaking it up in smaller orders so as to minimize market impact.[7] Suppose, on the other hand, the broker finds three other buyers in the crowd and realizes the market is starting to take off. Speed of execution is now very important: the broker will buy as much as possible as quickly as possible. In the execution of large orders, therefore, the floor broker acts like a smart, state-contingent limit order book reacting quickly to market conditions.

Floor brokers can also use their informational advantage to communicate information from the floor back to their customers. Floor brokers will often walk to a specialist post, talk to the specialist, find out what is in the electronic book, assess any trading crowd interest and then call their customers and describe the available liquidity. In reaction to the information, a customer might decide to change the timing, size, or direction of their own trades. Floor brokers thus enable customers to better fine-tune their trading strategies.

Finally, floor brokers play an important role in the execution of upstairs-facilitated trades (see Madhavan and Cheng, 1997). These trades are put together by upstairs brokers who find counterparts to block orders, and then use floor brokers to bring the matched orders to the specialist post for execution.

Floor brokers, therefore, provide a bundle of services to their customers: order routing, order execution, and information gathering.

3. Data

Our data on floor broker trades come from the NYSE's internal audit trail file (CAUD).[8] The audit trail file is described in Hasbrouck et al. (1993). The file contains detailed information on the parties involved in each trade. The data appendix discusses the main features of the data. The sample covers the two-month period January 2 through February 28, 1997 (41 trading days), and consists of all NYSE trades in 110 NYSE common stocks. We choose our sample stocks as follows. We first selected all NYSE listed common stocks trading in minimum price variations of one eighth of a dollar. We then ranked these stocks by their December 1996 trading volume and grouped them into deciles one (least active) through ten (most active). For deciles one through nine, we randomly selected ten stocks. For the most active decile, we randomly selected twenty stocks.[9]

It is important to understand the nature of NYSE's audit trail data for understanding the statistics that we report in this paper. Table 2 gives an

[7] The fact that the floor broker does not have to reveal a large order also reduces market impact.

[8] Publicly available data sources do not permit a detailed analysis of NYSE floor brokers' trades.

[9] Table 9 provides summary statistics on the sample stocks.

Table 2
Examples of Reports, Trades, and Orders

Symbol	Price	Size	TTime	Seqnum	BTime	BCQty	BBdge	BSource	STime	SCQty	SBdge	SSource
Report												
GE	105.375	9000	93850	3405960	93600	2500	$\boxed{\text{FB1}}$	CC	93500	2500	FB2	CC
Trade												
GE	105.375	9000	93850	3405960	93800	500	FB3	CC	93800	500	FB2	CC
					93600	2500	$\boxed{\text{FB1}}$	CC	93500	2500	FB2	CC
					93904	6000	SPEC	DS	93900	1100	FB2	CS
					0	0			93900	4900	FB2	CS
Potential order												
GE	105.375	8500	93458	3405690	93600	2000	$\boxed{\text{FB1}}$	CS	93626	2000	B13	LS
					0	0			93629	200	B21	LS
					93500	4000	FB4	CC	93500	4000	FB2	CC
GE	105.375	100	93629	3405830	93629	100	B11	DS	0	0	0	
GE	105.375	100	93634	3405850	93629	100	B4	DS	0	0	0	
GE	105.500	100	93519	3405710	93515	100	B19	DS	93515	100	B17	LS
GE	105.375	500	93523	3405720	93519	500	SPEC	CS	93519	500	B7	LS
GE	105.375	100	93600	3405760	93555	100	B14	DS	93555	100	B11	DS
GE	105.250	200	93601	3405770	93558	200	B6	LS	93558	200	B11	DS
GE	105.250	700	93608	3405780	93610	700	B6	LS	93610	100	B11	DS
					0	0			93610	600	B9	DS
GE	105.375	500	93613	3405800	93612	500	B8	LS	93612	500	B13	LS
GE	105.375	4500	93625	3405820	93502	700	B12	LS	93500	700	FB2	CS
				3405820	93502	3800	SPEC	DS	93500	3800	FB2	CS

GE	105.375	400	93708	3405870	93703	400	B14	DS	93703	400	B2	LS
GE	105.250	100	93719	3405880	93716	100	B6	LS	93716	100	B11	DS
GE	105.375	100	93725	3405890	93722	100	B18	DS	93722	100	B2	LS
GE	105.250	200	93726	3405900	93724	200	B6	LS	93724	200	B11	LS
GE	105.375	4900	93846	3405950	0	0			93853	1000	B16	LS
					0	0			93853	100	B11	DS
					93853	4900	B1	LS	93853	100	SPEC	CS
					0	0			93853	200	B20	LS
					0	0			93853	1000	B5	LS
					0	0			93853	500	B7	LS
					0	0			93853	500	B3	LS
					0	0			93853	500	B19	LS
					0	0			93853	500	B15	LS
					0	0			93853	500	B10	LS
GE	105.375	9000	93850	3405960	93800	500	FB3	CC	93800	500	FB2	CC
					93600	2500	FB1	CC	93500	2500	FB2	CC
					93904	6000	SPEC	DS	93900	1100	FB2	CS
					0	0			93900	4900	FB2	CS

example of the data we use in the empirical analyses. It reports trading for stock symbol GE (General Electric) on the morning of February 10, 1997.[10] The first panel shows a trade *report* indicating that floor broker with badge number FB1 bought 2500 GE shares at $105.375 per share from floor broker FB2. An algorithm developed by the NYSE matches the trades as reported to the audit trail by the trade participants to the corresponding *tape print* representing the real-time reporting of the trade by NYSE's systems.

Note also that while FB1's time stamp is 9:36:00 and FB2's is 9:35:00, NYSE's algorithm matched the reports to a tape print with time stamp 9:38:50 and sequence number 3405960. Floor brokers record the trade time based on the time reported on the panel above the specialist's post. Since this time is reported in minutes, all floor broker time stamps are rounded to the nearest minute. In this example, both the FB1 and the FB2 flag the *source* (Bsource and Ssource respectively) as CC, indicating that this is a 'crowd-to-crowd' trade.

This 2500-share report is actually part of a larger tape-reported trade (tape print) with total volume of 9000 shares. In the audit trail this single trade is made up of four reports summarizing the trade's seven components (three buys and four sells).[11] The second panel in Table 2 shows all four reports that make up the *trade*. NYSE's algorithm attaches 9000 shares to the trade with sequence number 3405960.[12] In addition to the 2500 shares traded between floor brokers FB1 and FB2, the trade includes 500 shares traded between floor brokers FB3 and FB2. The trade also includes a SuperDot market order (Bsource DS) to buy 6000 shares represented by the GE specialist (Bbadge SPEC) and matched to two different sell orders represented by floor broker FB2 (1100 and 4900 shares).

Floor brokers often 'work an order', that is they break up a large order into a sequence of smaller trades to minimize market impact. For example, in the NYSE floor broker survey described in Sofianos and Werner (2000) we find that floor brokers typically break up their average-sized order (10,000–49,000 shares) in an S&P500 stock into eight trades. The floor broker typically needs between 11 and 29 min to fill the entire order. By comparison, the median largest order was 250,000–1,000,000 shares and it typically took 11–20 trades to complete. Their largest order was worked until the end of the day. Several floor brokers in our survey sample indicated that they received orders in excess of 1,000,000 shares and that those orders were worked for more than one week (more than 20 trades). Unfortunately, we do not have access to data on the original *orders* received by floor brokers in our sample. Given that floor brokers typically

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[10] We have suppressed a number of fields for brevity and changed the badge mnemonics to respect the proprietary nature of the data.

[11] In NYSE's TAQ database this tape print will appear as a single record.

[12] There are occasionally discrepancies between the number of shares reported on the tape and the number of shares that the NYSE's algorithm attaches to a tape print. We make no attempts to redo the matching of reports to tape prints other than the ones described in the appendix.

handle multiple orders, and that they have considerable discretion as to price and time of execution, we found it impossible to reliably aggregate trade reports into proxies for original orders.

To understand the nature of the problem, first consider floor broker FB1 in Table 2. The third panel in the table lists all the NYSE reports between the open and the 9000-share trade just discussed. At 9:34:58, floor broker FB1 bought 2000 shares of GE from broker B13 for $105.375.[13] At 9:38:50, floor broker FB1 bought another 2500 GE shares, this time from floor broker FB2. After 9:38:50, floor broker FB1 did not trade GE for several hours. It is, therefore, likely that floor broker FB1 had received an order to buy a total of 4500 shares, which he then broke into two smaller trades of 2000 and 2500 shares each. Now consider floor broker FB2 in Table 2. Following his trades is a real challenge: during the first hour and 15 min after the open, FB2 bought a total of 12,800 shares (5 reports) and sold 138,400 shares (37 reports)![14] We found grouping of these reports into orders to be virtually impossible.

In addition to the kind of order splitting we describe above, there are two other ways in which orders originating off the floor may be divided. First, the order submitter may release pieces of a larger order to the floor broker sequentially. Second, the order submitter may send orders to several brokers, either simultaneously or over a period of time.[15] The data does not allow us to track the originator of the order, nor its parameters and trades (tape prints).

4. The provision of liquidity by floor brokers and specialists

There is considerable interest in the role of professional traders. The trades of NYSE specialists have been examined in several recent studies (e.g., Madhavan and Smidt, 1991, 1993; Hasbrouck and Sofianos, 1993; Sofianos, 1995; Madhavan and Sofianos, 1998). Madhavan and Sofianos (1998) find that specialist trading varies widely across stocks and is inversely related to trading volume, that specialists participate more in smaller trades than in larger trades, and that specialists participate less in stocks where there is off-exchange competition. We

[13] Note that this trade is aggregated over multiple sequence numbers (tape prints). The appendix describes in detail how we treat these types of records.

[14] The floor broker sold 26,500 shares and bought 1500 shares at $105.125; sold 48,500 shares and bought 11,300 shares at 105.375; sold 22,500 shares at $105.500; sold 39,900 shares at $105.625; and sold 5000 shares at $105.750. The trading pattern could be either 'participation trading' where a floor broker is instructed to be a certain fraction of the trading volume or it could represent many different limit orders.

[15] Floor brokers believe order submitters often release orders to multiple brokers. However, given that the originator of the order is confidential, it is impossible for them to verify that the order was indeed split up in this way.

extend these findings by documenting factors that jointly influence the participation of floor brokers and specialists on the NYSE.

Floor broker representation of orders takes two forms: active and passive. A floor broker *actively* represents an order when the broker walks the order to the appropriate specialist post and stands by waiting for an opportunity to execute the order. Actively represented floor broker orders are reported to the Tape under the executing floor broker's badge number. A floor broker *passively* represents an order when the broker walks the order to the post and leaves it with the specialist for the specialist to execute. To minimize any conflict of interest, the NYSE rules allow floor brokers to leave only *non-discretionary* orders with the specialist.[16]

Specialists have limited discretion to execute orders for their own account. These appear in the audit trail as proprietary trades executed by the specialist. Orders executed by the specialist on behalf of a floor broker are reported to the audit trail as executed by the specialist acting as an agent. Unfortunately, because it was not initially clear how to identify trade reports associated with floor broker orders left with the specialist in the data, our data extraction procedure did not capture all such trade reports.

Based on NYSE's audit trail data, the overall value-weighted floor broker *active* participation rate in our sample of 110 stocks is 33.7%. In other words, 33.7% of buy plus sell volume was represented actively by floor brokers. In Fig. 1, we provide a rough estimate of the *passive* floor broker participation rate. It is estimated as a residual. We start with the value of all NYSE executed orders and subtract: (1) the value of system orders (44.9%); (2) the value of actively represented floor broker orders (33.7%); and (3) the value traded by NYSE specialists for their own accounts (10.8%).[17] We then divide the residual (orders executed by the specialist as an agent or equivalently floor broker orders left with the specialist) by the value of purchases plus sales. Based on this calculation, the estimated *passive* liquidity contribution of floor brokers in our sample is 10.6%. Thus, on average, the value of specialist-represented floor broker orders is roughly equal to the value of orders in which specialists participate for their own account. The estimated overall (active plus passive) value-weighted floor participation rate in our sample is, therefore, 44.3%.

The interaction of floor brokers and specialists is largely determined by the role of the specialist as a liquidity supplier of last resort: the specialist provides

[16] Floor brokers leave two types of orders with specialists: limit orders and percentage orders. Percentage orders are also called CAP orders, go-along orders or participation orders. Based on our conversations with specialists, floor brokers and exchange officials, most orders left by floor brokers with the specialist are percentage orders.

[17] System volume comes from an internal NYSE document 'System Statistics – the 1st Quarter of 1997'. The sample is all NYSE-listed stocks. The value of active trades by floor brokers and of specialist trades come from our sample, see Table 3.

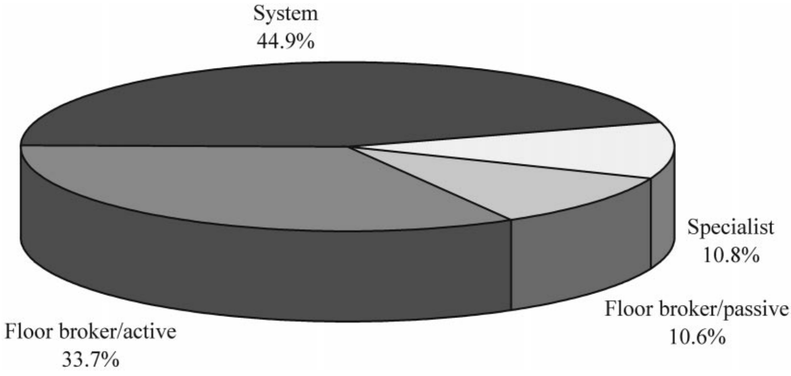

Fig. 1. Composition of purchases and sales by US dollar value 110 stocks, January and February 1997.

liquidity by trading as a dealer only after liquidity provided by the limit orders in the book and floor-broker represented orders is exhausted. When the limit order book is liquid and there is an active crowd, there is very limited need for the specialist to bridge gaps in natural liquidity. By contrast, when liquidity in the order book is sparse (or simply one-sided) and no active crowd is present, the specialist has a fiduciary responsibility to fill incoming market orders. The specialist may, however, seek floor broker assistance in exercising their fiduciary agency function.[18] The specialist may call floor brokers who previously represented trading interest in the stock to the post and inform them of an order imbalance. The floor brokers in turn will inform their clients and in this way may generate enough balancing orders to supply the additional liquidity, reducing the need for the specialist to participate.

Occasionally, the specialist may wish to participate in a trade to reduce an inventory imbalance or to take a position. Indeed, in fulfilling their Exchange obligation to maintain 'fair and orderly markets', specialists have some limited discretion over the timing and amount of their proprietary trades.[19] However, the ability of the specialist to participate is curtailed by the Exchange's priority rules: the specialist has to yield to all public orders, i.e., system orders and floor broker represented orders. This means that floor brokers may 'crowd out' the specialist either by improving on the bid (or offer) or by absorbing the entire balance of an order after the book has been satisfied at the bid (or offer). Werner (2000) models such active competition between floor brokers and the specialist.

[18] Specialist performance is assessed using a variety of criteria (including price continuity guidelines and stabilization rules), and failure to satisfy these criteria may result in various disciplinary measures, including re-allocation of stocks.

[19] NYSE Constitution and Rules, Rule 2104.10.

Finally, note that some of the floor broker trades in our sample are crosses of orders that reach the floor after going through the upstairs market. Both the 'affirmative obligation' of the specialist and the ability of the specialist to participate in these trades are limited. We therefore find it useful to break out upstairs-facilitated trades in some of the analyses below.

In sum, an active crowd reduces the need for the specialist to bridge gaps in natural liquidity, but also makes it more difficult for the specialist to execute proprietary trades. In the rest of this section, we examine factors that influence the participation rates of floor brokers and specialists.

4.1. Cross-sectional analysis of floor broker and specialist trading

To summarize the cross-sectional variation in active floor broker participation, we compute participation rates overall and for stocks grouped into deciles. We separate continuous trading from the opening call. Our reason for doing this is related to the way floor brokers' opening orders are reported in the data (see the appendix).

In Table 3 we focus on trades with *active* floor broker participation and show how the floor broker and specialist provision of liquidity varies across stock trading deciles. The total value of trading in our 110 sample stocks is \$47 billion and the overall value-weighted floor broker active participation rate is 33.7% compared to a specialist participation rate of 10.8%. Roughly four percent of the total value of trading occurs at the opening and the remaining 96% during continuous trading. Floor broker active participation rate during the open (other than through OARS) is 0.9% and during continuous trading it is 35.0%.

Table 3 also breaks down the data by trading volume decile. As emphasized by Madhavan and Sofianos (1998), one of the specialist's main functions is to help bridge the asynchronous arrival of buyers and sellers. This suggests that the overall specialist participation rate should be decreasing in liquidity, which is confirmed in Table 3. The specialist participation rate ranges from 18.1% for the least liquid stocks to 10.6% for the most liquid ones. These figures are comparable to those found by Madhavan and Sofianos (1998).[20] By contrast, we expect floor brokers to congregate where volume and activity make it worthwhile, avoiding inactive issues with long unproductive periods. The results in Table 3 also show that the floor broker active participation rate during continuous trading is increasing (albeit not monotonically) in liquidity, ranging from 26.3% for the least liquid stocks to 35.5% for the most liquid stocks. At the opening

[20] Madhavan and Sofianos (1998) define the specialist participation rate as specialist volume divided by total volume. Hence, their participation rates need to be divided by two for comparison with ours.

Table 3
Floor broker provision of liquidity, actively represented order[a]

	Overall			Opening call		Continuous trading	
	Trading value ($ million)	Value of trades executed by: Floor broker (active) (%)	Value of trades executed by: Specialist (proprietary) (%)	Trading value ($ million)	Value of active floor broker executed trades (excluding OARS) (%)	Trading value ($ million)	Value of active floor broker executed trades (%)
All stocks	46,924	33.7	10.8	1879	0.9	45,045	35.0
Decile 10	33,882	34.1	10.6	1428	0.4	32,454	35.5
Decile 9	5579	36.5	10.9	192	1.7	5387	37.8
Decile 8	3327	31.4	10.7	90	1.2	3237	32.3
Decile 7	2228	30.4	12.9	79	0.0	2149	31.5
Decile 6	643	29.3	13.0	21	8.0	622	30.0
Decile 5	394	20.7	13.5	21	5.5	373	21.5
Decile 4	415	27.9	13.1	17	1.4	398	29.1
Decile 3	230	22.0	14.5	11	1.5	219	23.1
Decile 2	163	30.0	13.1	12	16.9	151	31.1
Decile 1	62	26.4	18.1	7	26.8	55	26.3

[a] Data from the NYSE's audit trial file (CAUD) for January and February, 1997. The sample consists of 110 stocks. 10 stocks were drawn randomly from size-deciles 1–9. For the most liquid deicle 10, 20 stocks were drawn randomly following the same algorithm. Floor broker's (specialists') actual contribution to liquidity is calculated as the sum of the dollar value of floor broker (specialist) purchases and sales divided by the sum of the total dollar value of purchases and sales. The value traded by specialists during continuous trading can be found in Table 7.

call, the floor broker active participation rate other than through OARS is much higher in the least liquid stocks, i.e., deciles 1 and 2.

The non-monotonic relationship between floor broker active participation and liquidity might seem puzzling. If the number of trading opportunities per day were all that mattered, we would not expect floor brokers to waste their time trying to trade less liquid stocks. However, off-floor traders' decision to engage a floor broker or first go through the upstairs market is also guided by a perception of how difficult the trade is likely to be. Since the market for less liquid stocks is thinner, and revealed buying and selling interest more asynchronous, the floor broker's ability to use his information advantage and judgement is likely to be particularly valuable when executing trades in less liquid stocks. We conjecture that this is why there is a less dramatic drop-off in floor broker participation rate than one might expect based simply on liquidity.

4.2. Regression analysis of floor broker and specialist trading

In this subsection, we extend the work on the determinants of dealer trades by Madhavan and Sofianos (1998), henceforth MS (1998). We use daily data for each stock in a pooled cross-section time-series to explore how the participation rates of both specialists and floor brokers depend on not only the liquidity of the stock, but also on measures of: block trading activity; on- and off-exchange competition; volatility; and order flow internalization. Since upstairs-facilitated trades by definition entail very limited interaction with the specialist and the crowd, we exclude all upstairs-facilitated trades when calculating the active floor broker participation rate.

As explained in MS (1998), we expect the specialist participation rate to be decreasing in liquidity because there is less need for the specialist to intervene in stocks with plenty of public orders. Moreover, since block trades may be facilitated upstairs, specialist participation is likely to be falling in block-volume. Another measure of liquidity we use is market capitalization. Information costs are likely to be lower for larger firms, and this suggests that the order book should be more active. As a result, there should be both limited need for specialist intervention and limited room for the specialist to execute his discretionary trades in larger cap stocks. On the other hand, all else equal specialists prefer to focus their discretionary trading in larger cap stocks where they can build and lay off positions relatively easily. We might thus find a negative or a positive relationship between specialist participation and market capitalization depending on which effect dominates.

More on-exchange competition should reduce the specialist participation rate. Since we expect more clustering of orders at the bid and offer if the stock price is low relative to the tick, one measure of on-exchange competition from the order book is the tick size divided by the stock price (Harris, 1991). However, the tick size divided by the stock price simultaneously captures the cost for professional traders of stepping ahead of the order book by providing price improvement. In this study, we therefore also measure on-exchange competition from the order book directly by using the average daily spread and depth. For securities with more internalized order flow, we expect less specialist participation as the need for specialist intervention is reduced when brokers match orders in house. Securities with a substantial amount of internalization include closed end funds and newly listed stocks where price-stabilization might be taking place (e.g., Aggarwal, 2000).

It is also conceivable that the specialist participation would be lower when there is more off-exchange competition. Measures of off-exchange competition include if the stock is ITS eligible (can be traded on third markets), and if the stock is exempt from Rule 390 according to Rule19(c)-3 (listed after April 26, 1979). Rule 390 prohibits NYSE member firms from effecting proprietary trades and in-house agency crosses in NYSE-listed securities off an organized exchange. Since it is not clear whether or not exempting securities from Rule 390 increases competition, we might not find a significant reduction in specialist participation for Rule 19(c)-3 stocks. Madhavan and Sofianos (1998) emphasize that NYSE's price-continuity rules suggest that the specialist participation should be increasing in intraday volatility. However, because volatility also increases inventory risk, the participation rate of specialists could decline in volatility. Finally, they argue that options trading could increase specialist participation if an active options market implies more induced volatility around contract expirations, but could also decrease specialist participation if an active options market increases competition from other liquidity providers.

How would the same set of factors affect the *downstairs* participation rate of floor brokers? The high opportunity cost of floor brokers' time suggests that floor broker participation should increase in liquidity. However, since the information advantage and judgement of a floor broker is particularly valuable when executing trades in less liquid stocks, floor broker participation might instead decrease in liquidity. Our first measure of liquidity is trading volume. Based on NYSE's priority rules, we predict that floor broker participation should increase in downstairs block volume. To the extent that floor brokers are reluctant to expose their orders, we expect floor broker participation to decrease in non-block volume. This follows since smaller market orders would primarily be executed against the book. Holding other measures of liquidity constant, we expect the benefits of using a floor broker to be larger for smaller capitalization stocks where the likelihood of informed trading is high.

We predict that floor brokers should participate less in stocks where the costs of stepping ahead of the book by providing price improvement are high. The effect of on- and off-exchange competition on floor broker participation is more complicated. It might seem more competition from the limit order book should make it more difficult for floor brokers to execute their trades. However, if floor brokers expose their orders and join the limit order book, their participation will not necessarily suffer from more on-exchange competition as measured by a tighter spread and higher depth. Moreover, since floor brokers benefit from a deep market when they initiate a trade (submit a market or marketable limit order), their participation might even increase in on- and off-exchange competition. By contrast, we expect order flow internalization to unambiguously reduce floor broker participation.

Because of the free-option nature of public limit orders, we expect floor broker participation to increase in volatility. Moreover, since floor brokers are often hired to do option layoffs, a stock with an active options market is likely to have a higher floor broker participation rate.[21] Finally, since there is limited retail trading in foreign stocks and closed end funds with a foreign focus, we expect that either the specialist or floor brokers have to act as the liquidity provider of last resort more often for these securities. It is an empirical question if this role is played by specialists or by floor brokers.

To capture how these factors influence the participation of professional traders in NYSE's auction market, we estimate the following two-equation system using GMM:

$$\begin{aligned}
Specialist_{i,t} = {} & \alpha_0 + \alpha_1\, NonBlkVol_{i,t} + \alpha_2\, BlkVol_{i,t} + \alpha_3\, LogCap_i \\
& + \alpha_4\, Volat_{i,t} + \alpha_5 (Tick/Price)_{i,t} + \alpha_6\, Spread_{i,t} \\
& + \alpha_7\, Depth_{i,t} + \alpha_8\, ITS_i + \alpha_9\, R19c3_i \\
& + \alpha_{10}\, NewList_{i,t} + \alpha_{11}\, ClsdEnd_i + \alpha_{12}\, Option_i \\
& + \alpha_{13}\, Foreign + \alpha_{14}\, Specialist_{i,t-1} + \alpha_{15}\, Floorbroker_{i,t} \\
& + \omega_{i,t} \\
Floorbroker_{i,t} = {} & \beta_0 + \beta_1\, NonBlkVol_{i,t} + \beta_2\, BlkVol_{i,t} + \beta_3\, LogCap_i \\
& + \beta_4\, Volat_{i,t} + \beta_5 (Tick/Price)_{i,t} + \beta_6\, Spread_{i,t} \\
& + \beta_7\, Depth_{i,t} + \beta_8\, ITS_i + \beta_9\, R19c3_i \\
& + \beta_{10}\, NewList_{i,t} + \beta_{11}\, ClsdEnd_i + \beta_{12}\, Option_i \\
& + \beta_{13}\, Foreign + \beta_{14}\, Floorbroker_{i,t-1} + \beta_{15}\, Specialist_{i,t} \\
& + \eta_{i,t}. \qquad (1)
\end{aligned}$$

[21] Seven percent of the orders received by floor brokers from another member firm were options layoffs according to the floor broker survey summarized in Sofianos and Werner (2000).

$Specialist_{i,t}$ and $Floorbroker_{i,t}$ are the endogenous specialist and downstairs floor broker participation rates for stock i and day t. $NonBlkVol_{i,t}$ is the square-root of non-block share volume, $BlkVol_{i,t}$ is the square-root of block share volume (excluding upstairs trades), $LogCap_i$ is the log of market capitalization of the stock based on the price and number of shares outstanding on December 31, 1996, $Volat_{i,t}$ is the standard deviation of mid-quote returns, $(Tick/Price_{i,t})$ is the tick size (1/8) divided by the average daily dollar price, $Spread_{i,t}$ is the cent spread, $Depth_{i,t}$ is the average of the bid and offer depth divided by 1000, ITS_i is a zero–one dummy that takes on the value of one if the stock is ITS-traded, $R19c3_i$ is a zero–one dummy variable that takes on the value of one if the stock is subject to Rule 19(c)-3, $ClsdEnd_i$ is a zero–one dummy that takes on a value of one if the security is a closed end fund, $NewList_i$ is a zero–one dummy that takes on the value of one if the stock was listed on the NYSE less than 60 days prior to January 1, 1997, $Option_i$ is a zero–one dummy variable that takes on the value of one if listed options trade on the stock, $Foreign_i$ is a zero–one dummy variable that takes on the value of one if the stock is issued by a non-U.S. corporation or the fund has a non-U.S. investment focus, and $\omega_{i,t}$ and $\eta_{i,t}$ are error terms. We include lagged participation rates as instruments.

We estimate pooled time-series cross-sectional GMM regressions for all except nine stocks in our sample.[22] We also estimate separate regressions for three groups of stocks: most liquid (deciles 9–10), medium liquidity (deciles 5–8), and least liquid (deciles 1–4). In these regressions, we exclude the dummy variables (*ITS, Rule19c3, ClsdEnd, NewList, Option,* and *Foreign*) since the number of firms in each sub-sample is limited. Table 4 reports the estimated coefficients for participation rates of specialists and floor brokers respectively.

We first focus on the regressions explaining the specialist participation rate reported in the first set of columns in Table 4. The results are overall similar to those found in MS (1998). The regression results for all stocks show that specialist participation is decreasing in block volume but not significantly affected by non-block volume. In contrast to MS (1998), we find that higher market capitalization holding volume constant is associated with more trading by specialists. In our sample, therefore, the fact that specialists' prefer to do their proprietary trading in large capitalization stocks dominates. Specialist participation is significantly increasing in intraday volatility, suggesting that NYSE's price-continuity rules are important for determining when specialists trade.

[22] We also estimated each equation separately with double-truncated TOBIT regressions (limited dependent variable). The results are qualitatively similar to the GMM results in Table 4. Further, we estimated the system of equations with 3SLS. The point estimates for the parameters are identical, but the standard errors of the GMM are larger. To be conservative, we report the results of the GMM estimation here. The nine stocks were excluded for comparability with Werner (2000).

Table 4
Regression analysis of floor broker and specialist trading[a]

Dependent variable	Specialist participation rate				Floor broker participation rate			
	All stocks	Most liquid	Medium liquid	Least liquid	All stocks	Most liquid	Medium liquid	Least liquid
Sqr. root non-block volume	2.67	**8.98**	7.72	**−16.83**	**−8.23**	**−8.60**	**−13.83**	**23.51**
	1.99	1.21	4.87	5.97	2.59	4.21	4.94	5.21
Sqr. root block volume	**−5.40**	**−1.41**	− 15.93	**−47.54**	**15.19**	**10.37**	**30.13**	**78.13**
	2.02	0.67	8.63	12.90	1.32	1.17	4.86	8.42
Log market capitalization	**0.47**	**−0.33**	0.44	**1.65**	**−0.58**	− 0.13	− 0.63	**−1.88**
	0.20	0.15	0.31	0.49	0.28	0.41	0.58	0.68
Std. Dev. returns	**0.38**	**−0.28**	0.17	**0.80**	**0.37**	0.49	0.22	− 0.07
	0.16	0.13	0.20	0.23	0.17	0.31	0.27	0.25
Tick/price	0.28	0.46	− 0.17	**1.54**	**−3.83**	**−3.53**	− 0.52	**−2.17**
	0.66	0.46	0.89	0.63	0.54	1.85	1.46	0.55
Spread	**0.33**	**0.92**	**0.57**	**0.21**	− 0.07	0.29	− 0.18	0.00
	0.06	0.08	0.09	0.06	0.07	0.31	0.22	0.06
Depth	**−0.11**	**−0.05**	**−0.13**	**−0.31**	**0.12**	0.09	0.05	− 0.00
	0.02	0.01	0.02	0.04	0.03	0.05	0.06	0.06
ITS dummy	**−1.83**				− 0.76			
	1.17				1.39			
Rule 19(c)-3 dummy	0.51				− 0.27			
	0.35				0.45			
Closed end fund dummy	**−2.54**				**−9.02**			
	1.28				0.85			

New listing	**3.68**				− 1.86			
	1.07				1.38			
Option dummy	− 0.58				0.51			
	0.44				0.61			
Foreign dummy	− 0.42				**4.71**			
	0.80				0.75			
Specialist participation rate					− 0.08	− 0.34	0.48	0.17
					0.09	0.20	0.28	0.10
Floor broker participation rate	0.04	0.00	0.24	0.17				
	0.12	0.05	0.33	0.15				
Lag(specialist participation)	**0.31**	**0.38**	**0.17**	**0.32**				
	0.03	0.03	0.04	0.03				
Lag(floor broker participation)					**0.12**	**0.23**	0.05	**0.17**
					0.02	0.04	0.03	0.05
Adj. R^2	0.4512	0.6425	0.3128	0.3740	0.3067	0.2883	0.0885	0.1391

[a] For comparability with Werner (2000), the sample excludes 9 firms that were delisted (or changed name in 1997. For each stock, the dependent variable is the daily fraction (times 100) of total trading volume (buys and sells) that was executed by the specialist and by the floor brokers (excluding upstairs facilitated trades) respectively. We analyze participation rates in a two equation system using GMM for the overall sample as well as for three subsamples: most liquid (deciles 9–10); medium liquidity (deciles 5–8); and least-liquid stocks (deciles 1–4). Explanatory variables were drawn from TAQ and NYSE's archives. Total volume is the daily share volume for a stock. Block (non-block) volume is the daily share volume in trades in excess of 9999 shares (below 10,000 shares) for a stock Market capitalization is calculated based on shares outstanding as of December 31, 1996, and was drawn from NYSE's archives. Std. Dev. returns is the standard deviation of time-weighted mid-quotes calculated daily for each stock from TAQ. The tick size for all our stocks is 1/8, and for price we use the average daily trade price from TAQ. ITS dymmy takes on the value of one if the stock is ITS eligible. Rule 19(c)-3 dummy takes on a value of one if a firm was listed after 1979 and thus is exempt from rule 390. Closed end fund dummy, foreign dummy, and option dummy take on the value of one if the security is a closed-end fund, issued by a foreign firm, foreign fund, or has traded options respectively. The dummy variables were coded based on NYSE's archives for December 31, 1996. Unlike Madhavan and Sofianos (1998), we have no preferred stock in our sample.

More competition from the limit order book, captured by a narrower spread or higher depth, significantly decreases specialist participation as predicted.[23] By contrast, the variable (*Tick/Price*) does not significantly affect specialist trading after we have controlled for the order book liquidity. Hence, more on-exchange competition decreases specialist participation but the cost of stepping ahead of the order book does not seem to significantly affect specialist participation in our sample.

Two measures of off-exchange competition and internalization are significantly negatively related to specialist participation (*ITS* and *ClsdEnd*). The new listing dummy is significantly positive and thus has the opposite sign to the one found by MS (1998). However, this result should be interpreted with caution since we only have four stocks that are newly listed in the sample. The Rule 19(c)-3 dummy is insignificant while it was significantly negative in MS (1998). Thus, there is no evidence in our sample that the market for securities exempt from Rule 390 is more competitive. The difference may either result from the fact that we use a more recent time period or from the fact that our cross section of stocks is much smaller. Neither options trading nor whether or not a stock (or fund) is foreign significantly affects specialist participation. The extent of floor broker participation does not affect specialist participation when we control for other factors. Finally, specialist participation for a particular stock is significantly positively autocorrelated.

The next three columns report the estimated coefficients for three sub-samples based on liquidity. Higher block volume is associated with lower specialist participation rate for all sub-samples, although the magnitude of the effect is larger for least liquid stocks. By contrast, higher non-block volume is associated with significantly *higher* specialist participation for the most liquid stocks but significantly *lower* specialist participation for the least liquid stocks. One possible explanation for these results is that specialists trade more actively for their own accounts (by participating in non-block trades) in more liquid stocks. The market capitalization of the firm and volatility of its stock price are positively related to specialist participation in the full sample, but from the sub-sample regressions we see that the effect comes entirely from the group of least liquid stocks. In fact both market capitalization and volatility are associated with significantly *lower* specialist participation for the most liquid category. Thus, the negative effect on specialist participation of a more liquid limit order book dominates for stocks in the most liquid category while the positive effect of a more liquid market for proprietary trading dominates for stocks in the least liquid category. The volatility results are consistent with a reduced need for

[23] We also estimate a four-equation system where Spread and Depth are endogenous variables. The results are qualitatively the same as those reported in Table 4.

specialist intervention in order to provide price continuity for more liquid stocks.

While the cost of stepping ahead of the order book was insignificant in the full sample, it actually significantly *increases* specialist participation for the least liquid category. This suggests that a higher cost of price improvement is a more important deterrent for floor brokers and limit order submitters than for the specialist (see below). Specialist participation significantly decreases in on-exchange competition for all sub-samples. Finally, floor broker participation does not affect specialist participation for any subgroup after controlling for other factors.

We now turn to the regressions that explain the active floor broker participation rate reported in the second set of columns in Table 4. The fifth column reports the results for the full sample. Floor broker participation is significantly increasing in block volume and significantly decreasing in non-block volume. This suggests that the opportunity cost of floor brokers' time (commissions) is an important factor when off-floor traders decide to direct order flow to floor brokers. On the other hand, a lower market capitalization is associated with significantly higher floor broker trading after we have controlled for volume. This reflects the need for discretion when trading small stocks where the likelihood of informed trading is high. It is the combination of these two factors that generates the non-monotonic relationship between floor broker participation and liquidity in Table 3. Higher volatility increases the option value of public limit orders, and is associated with significantly higher floor broker participation.

The variable capturing the cost facing floor brokers when stepping ahead of the order book, (*Tick*/*Pri*), is significantly negatively related to floor broker participation as predicted. More liquidity as measured by greater depth at the quotes significantly increases floor broker participation, while a narrower spread does not significantly affect floor broker participation after we control for other variables. Recall that a weak link between on-exchange competition and floor broker participation was what we expect. An active order book may make it difficult for floor brokers to trade, but it is equally likely that floor brokers benefit from being able to trade against a deep and tight order book.

As is to be expected, the results for variables capturing off-exchange competition and internalization are mixed. If the stock is a closed end fund, the floor broker participation is significantly lower which is consistent with the retail focus for these funds. By contrast, whether or not the stock is traded on ITS, Rule 19(c)-3 eligible, is a new listing, or has traded options does not significantly affect the floor broker participation rate. Thus, floor broker participation is not significantly affected by off-floor competition in our sample. However, a non-U.S. stock or a closed end fund with foreign focus has significantly higher floor broker participation rate. The latter result suggests that floor brokers play an important role in helping the specialist fulfill his fiduciary duty by filling gaps in natural liquidity in the limit order book for foreign securities. Specialist participation does not significantly affect floor broker participation after we have controlled for other variables. Finally, floor broker participation for a particular stock is significantly autocorrelated.

The last three columns in Table 4 report the results from the three sub-samples. Higher block volume is universally associated with higher floor broker participation. However, higher non-block volume significantly decreases floor broker participation for most liquid and medium liquidity stocks but it significantly *increases* floor broker participation for the least liquid stocks. These results are consistent with a more competitive order book (or specialist) for more liquid stocks compared to the least liquid stocks. Market capitalization entered significantly with a negative sign in the overall regression, but this effect clearly comes from the least liquid stocks. Thus, it is primarily for less liquid stocks that the need for discretion in trading smaller firms significantly influences floor broker participation. While higher volatility is associated with more floor broker trading in the overall sample, this effect is not statistically significant in either of the sub-samples.

A higher cost of stepping ahead of the order book discourages floor broker trading for all sub-samples, and the effect is significant for the most liquid and the least liquid stocks. Measures of on-exchange competition do not significantly affect floor broker participation in any of the sub-samples, which is to be expected. Specialist participation does not significantly affect floor broker participation in any of the sub-samples after we have controlled for other factors. Finally, floor broker participation is significantly positively correlated for the most liquid and the least liquid stocks.

To sum up, we find that specialists participate more in less liquid stocks, particularly those with little block volume, thus primarily fulfilling their fiduciary function as liquidity providers of last resort. By contrast, floor brokers participate more in liquid stocks, particularly stocks with plenty of block volume, which is natural given NYSE's priority rules and the value of floor brokers time. Floor brokers also trade more in smaller capitalization stocks holding volume constant. This suggests that their services are particularly valuable in situations where there is relatively more information trading. Specialists, on the other hand, trade more in large capitalization stocks holding volume constant. This reflects their desire to focus their discretionary trading in stocks with less adverse selection. Higher cost of stepping ahead of the order book significantly reduces floor broker but not specialist trading. Further, the evidence suggests that while specialist participation declines in measures of on- and off-exchange competition, this is not the case for floor broker participation. In fact, the evidence suggests that floor brokers actually benefit from added liquidity, whatever its source. Finally, there is no evidence that more floor broker participation implies less specialist participation or vice versa after we control for the underlying economic factors that explain floor broker and specialist participation.

5. Trades with active floor broker participation

In this section, we examine the characteristics of *trades* where the floor brokers chose to step in and execute (all or parts of) customer orders. Do floor brokers, for example, participate uniformly in all trades or do they concentrate in a subset of trades? Do floor brokers mostly trade with each other or do they trade with the specialist and system order? Are upstairs-facilitated trades systematically different from other trades with floor broker participation?

5.1. The size of trades

There are several reasons for why we expect floor brokers to primarily participate in large trades. First, to hire a floor broker is likely to be more expensive than sending the order through SuperDot. It is therefore reasonable that floor brokers tend to handle larger and more complicated *orders*. In executing those orders, we expect that floor brokers try to minimize the number of trades necessary to complete the order, resulting in on average larger *trades*. Second, the priority rules described in Section 2 imply that floor brokers can always participate by offering price improvement, but may only participate by time precedence if they have already asked the specialist to expose their orders. If a floor broker represented order has not been exposed, the floor broker can participate at the bid (or offer) only when the incoming order is sufficiently large, i.e., the order exceeds the first order at the bid (or offer). Finally, floor brokers bring upstairs-facilitated trades (which are typically large) to the floor for execution.

In Table 5, we analyze the size of trades with and without active floor broker participation during continuous trading. Trades without active floor participation are made up of system orders, floor broker orders left with the specialist, and specialists' proprietary orders.

The overall value of trades in which floor brokers actively participate is \$25 billion and the value of trades without active floor broker participation is \$20 billion. In our sample, therefore, the value of trades with some degree of active floor broker participation represents 56% of the dollar value traded.[24] The

[24] Note that this figure differs from the 33.7% active floor broker participation rate discussed earlier. In calculating the participation rate we look only at the value of shares bought and sold by the floor broker; here we are calculating the *total* value of the trades in which the floor broker participates and not just the floor broker component.

Table 5
The size of trades[a]

	Trades with active floor broker participation				Trades without active floor broker participation			
	Volume in $ million	Number of trades	Average trade size in thousands		Volume in $ million	Number of trades	Average trade size in thousands	
			U.S.$	Shares			U.S.$	Shares
All stocks	25,240	69,632	362.5	10,124	19,979	366,084	54.6	1508
Decile 10	18,750	48,432	387.2	10,252	13,854	213,103	65.0	1526
Decile 9	3060	8598	355.8	12,057	2346	47,248	49.7	1482
Decile 8	1650	4895	337.0	8778	1592	31,838	50.0	1540
Decile 7	1011	2769	365.0	9335	1139	23,751	48.0	1614
Decile 6	283	1731	163.3	9332	339	15,926	21.3	1259
Decile 5	134	1020	131.7	6276	238	9834	24.2	1242
Decile 4	178	978	181.7	6395	221	10,653	20.7	1016
Decile 3	77	538	143.7	6158	141	7782	18.1	976
Decile 2	74	467	159.3	5990	76	4154	18.3	1465
Decile 1	23	204	114.4	4776	31	1795	17.3	1111

[a] Data from the NYSE's audit trail file (CAUD) for January and February, 1997. The sample consists of 110 stocks. 10 stocks were drawn randomly from size-deciles 1–9. For the most liquid decile, decile 10, 20 stocks were drawn randomly following the same algorithm. The definition of dollar volume is the average of total buys and total sells. Opening trades are excluded.

number of trades with active floor broker participation, however, is 70 thousand compared with 366 thousand trades without: floor brokers participate in only 16% of the trades (excluding the open) in our sample. Hence, as predicted, floor brokers tend to actively participate in the larger trades. The average value of a trade with active floor broker participation is $363 thousand (10,124 shares) compared with $55 thousand (1508 shares) for other trades: on average, trades with active floor broker participation are more than six times the size of other trades.

Table 5 also breaks down the results by volume decile. The fraction of the total value of trades that is represented by trades with active floor broker participation increases in liquidity from 43% for decile 1 to 58% for decile 10. Not surprisingly, the average size of trades with and without floor broker participation falls as we move from liquid to less liquid stocks. The average dollar value of trades with active floor broker participation is roughly six to seven times larger than other trades and this ratio does not vary systematically with liquidity.

Trades with floor broker participation include three categories of trades: upstairs-facilitated block trades (in excess of 9999 shares), downstairs (regular) block trades (in excess of 9999 shares), and non-block trades (less than 9999 shares). Upstairs-facilitated trades tend to be very large and thus strongly influence the statistics for average trade size. To complete the picture, we therefore also separately report the average size of trades with floor broker participation for each category. The NYSE audit trail does not distinguish between upstairs-facilitated and regular trades. We therefore identify upstairs-facilitated block trades using an algorithm similar to the one in Madhavan and Cheng (1997). They define upstairs-facilitated block trades as trades exceeding 9999 shares with the same floor broker badge appearing on both the buy and sell side of the transaction.

Table 6 reports dollar volume, number of trades, and average trade size in U.S. dollars and shares for non-block trades, downstairs block trades, and upstairs-facilitated block trades respectively. Downstairs non-block trades with floor broker participation correspond to $6.7 billion or 26% of the value of trades with floor broker participation (Panel A). There are roughly 50 thousand such trades in our sample, with an average trade size of $134 thousand or 3065 shares. Downstairs block trades represent $12.9 billion or 51% of trades with floor broker participation (Panel B). There are almost 17 thousand downstairs block trades with an average trade size of $766 thousand or 22,567 shares. By weighting the average trade sizes in Panels A and B we find the average size of a *downstairs* trade with floor broker participation is $294 thousand or 8000 shares. In other words, we find that downstairs (regular) trades with floor broker participation on average are more than five times larger than trades where no floor broker traded actively (Table 5). Upstairs-facilitated block trades represent the remaining $5.6 billion or 22% (Panel C). Given that trades with floor broker

Table 6
The size of trades with active floor broker participation by category[a]

	Volume in $ million	Number of trades	Average trade size in thousands	
			U.S.$	Shares
Panel A: Non-block trades				
All stocks	6668	49,845	134	3065
Decile 10	5048	34,436	147	3092
Decile 9	669	5877	114	3155
Decile 8	424	3556	119	3084
Decile 7	257	2046	126	2814
Decile 6	83	1336	62	2944
Decile 5	54	822	66	2839
Decile 4	63	795	79	2662
Decile 3	30	432	70	2639
Decile 2	27	369	74	2888
Decile 1	12	176	69	2627
Panel B: Downstairs block trades				
All stocks	12,926	16,886	766	22,567
Decile 10	10,022	12,288	816	22,978
Decile 9	1482	2239	662	23,550
Decile 8	731	1058	690	17,927
Decile 7	407	544	748	20,505
Decile 6	35	91	379	26,641
Decile 5	54	157	341	17,383
Decile 4	54	127	425	16,920
Decile 3	25	77	320	18,723
Decile 2	32	74	435	15,828
Decile 1	5	18	276	15,311
Panel C: Upstairs-facilitated block trades				
All stocks	5646	2901	1946	58,973
Decile 10	3680	1708	2155	63,074
Decile 9	909	482	1886	67,215
Decile 8	495	281	1761	46,398
Decile 7	347	179	1938	49,914
Decile 6	84	91	924	45,301
Decile 5	27	41	648	32,668
Decile 4	61	56	1087	35,525
Decile 3	22	29	768	25,210
Decile 2	15	24	624	23,350
Decile 1	6	10	618	23,650

[a]The definition of trade volume is the average of total buys and total sells. Opening trades are excluded. Non-block trades are trades less than 10,000 shares, downstairs block trades are larger than 9999 shares, and upstairs-facilitated block trades are larger than 9999 shares and have the same floor broker on both the buy and the sell side.

participation correspond to 56% of the total dollar value traded (Table 5), upstairs-facilitated trades in our sample correspond to 12% of total dollar volume – very close to the numbers found by Hasbrouck et al. (1993). The average size of an upstairs-facilitated trade is $1946 thousand or 58,973 shares.

The results are also broken down by volume decile in Table 6. The average trade size increases in liquidity for all trade categories, but this pattern is most apparent for upstairs-facilitated block trades. When we compare dollar value of trades with floor broker participation in Table 5 to the corresponding numbers for each category in Table 6, some patterns emerge. The fraction of dollar value in the non-block category *decreases* almost monotonically in liquidity: from 52% for decile 1 to 27% for decile 10. This is offset by an increase in the fraction of dollar value in the downstairs block category, which ranges from 22% for decile 1 to 53% for decile 10. Thus, either floor brokers split their orders into smaller components to limit price impact, or they receive on average smaller orders from off-floor clients for less liquid stocks. By contrast, the fraction of dollar volume represented by upstairs-facilitated trades does not vary systematically with liquidity. Finally, we compare trade sizes after adjusting for upstairs-facilitated trades for the deciles as we did with the overall sample. The average size of downstairs trades with floor broker participation relative to that of trades where no floor broker traded is u-shaped in liquidity, ranging from 4:1 to 7:1. Thus downstairs trades with floor broker participation are considerably larger than trades where no floor broker participated for stocks in all deciles.

5.2. *The composition of trades*

From the preceding subsection, we learned that trades with floor broker participation are considerably larger than those without. In this subsection, we explore whether the composition of trades with floor broker participation also differs substantially from those where no floor broker traded. Specifically, we are interested in learning the extent to which floor brokers aid specialist in providing liquidity. We are also interested in finding out whether floor brokers mostly demand liquidity by trading against the public limit order book, or if they effectively supply additional liquidity by trading against each other and against public market orders.

In Table 7, we compare the composition of trades with and without floor broker participation. As before, the participation rate is defined as the sum of the dollar value of buys and sells for a particular type divided by the sum of the total dollar value of buys and sells.

The first four columns of Table 7 show the percent of dollar volume of trades with active floor broker participation that was traded: actively by floor brokers; passively by floor brokers; by specialists; and through SuperDot respectively. The last two columns of the table reports the percent of dollar volume without active floor broker participation that was traded by specialists for their own

Table 7
The composition of trades[a]

	Trades with active floor broker participation				Trades without active floor broker participation	
	Percent of dollar volume represented by				Percent of dollar volume represented by	
	Floor broker		Specialist	System	Specialist	System
	Active	Passive				
All stocks	62.7	8.1	7.6	21.6	14.7	85.3
Decile 10	61.7	6.6	7.9	23.9	14.0	86.0
Decile 9	66.5	10.6	6.5	16.4	16.3	83.7
Decile 8	63.5	14.3	6.9	15.3	14.4	85.6
Decile 7	67.0	15.1	7.1	10.8	17.8	82.2
Decile 6	66.0	11.9	7.9	14.2	17.1	82.9
Decile 5	59.9	14.3	7.9	17.9	16.7	83.3
Decile 4	65.2	13.9	6.9	14.0	17.8	82.2
Decile 3	65.7	11.8	6.2	16.4	18.8	81.3
Decile 2	63.2	15.5	7.4	14.0	18.5	81.5
Decile 1	62.2	11.5	9.1	17.2	24.0	76.0

[a]Data from the NYSE's audit trail file (CAUD) for January and February, 1997. The sample consists of 110 stocks. 10 stocks were drawn randomly from size-deciles 1–9. For the most liquid decile, decile 10, 20 stocks were drawn randomly following the same algorithm. The definition of dollar volume is the average of total buys and total sells. Opening trades are excluded. In the case of trades without active floor broker participation, system volume may include (passive orders left by floor brokers with the specialist.

account and through SuperDot. These trades have zero *active* floor broker participation by definition, but note that *passive* floor broker participation may be included in the system category. The average active floor broker participation rate in trades with floor broker trading is 62.7%, and the passive participation rate is 8.1%. The specialist participation rate in these trades is 7.6% compared to a specialist participation rate almost twice as high, 14.7%, in trades where no floor brokers traded actively.

Table 7 also illustrates how the composition of trades varies with stock liquidity. The fraction of dollar value of trades with floor broker participation that was actually executed by floor brokers is roughly constant across volume deciles. Interestingly, for trades with active floor broker participation, the specialist participation rate is also roughly constant across deciles. For trades without active floor participation, however, the specialist participation rate increases sharply as we move from the most liquid stocks (14.0%) to the least liquid stocks (24.0%). Thus, it is when no floor brokers are present that there is a stronger need for specialist intervention to bridge gaps in natural liquidity for less liquid stocks.

To complete the picture, we next examine the composition of trades with floor broker participation in more detail. We again focus on the trades with active floor broker participation grouped into non-block trades (less than 10,000 shares), downstairs (regular) block trades (more than 9999 shares), and upstairs-facilitated block trades. We examine how trades with floor broker participation are broken down among floor brokers, specialists and system orders. From whom do floor brokers buy and to whom do they sell? Do floor brokers typically trade with SuperDot limit orders so that they primarily consume liquidity? Or, do floor brokers trade mainly with each other creating additional two-sided liquidity on the floor?

Table 8 shows what fraction of trades with floor broker participation that was executed by floor brokers (active and passive), specialists, and system orders. System orders include SuperDot market and limit orders, ITS orders and opening orders routed through OARS. To clarify how participation rates are calculated, suppose that a floor broker buys 1000 shares out of a 50,000-share SuperDot sell order, with the limit order book buying 40,000 shares and the specialist the remaining 9000. In this case the floor broker active participation rate is 1%, the specialist participation rate is 9% and the system (SuperDot) participation rate is 90%.

We first compare non-block and downstairs block trades in Panels A and B. Floor brokers on average actively represented 49.5% of total buys and sells in non-block trades and 57.1% of total buys and sells in downstairs block trades. Floor broker participation thus increases with trade size even when upstairs-facilitated trades are excluded. Adding active and passive floor broker participation together, the average total participation is 56.5% and 68.5% for non-block and block trades respectively. To understand how this maps into counterparts of trades, consider non-block trades. The 56.5% participation rate could for example be the result of floor brokers representing the entire buy-side (50% of buys and sells) and 13% of the sell-side (6.5% of buys and sells). Alternatively, it could be the result of floor brokers representing roughly a third of the buy-side (31.5% of buys and sells) and half the sell-side (25% of buys and sells). In other words, on average there are floor brokers on both sides of a downstairs trade with floor broker participation. These numbers thus show that NYSE floor brokers bring two-sided liquidity to the NYSE floor.

Note also that while there is no systematic variation in *active* floor broker participation across volume deciles, the *passive* participation rate is generally inversely related to liquidity. Some of the greater need for discretion when trading less liquid stocks is thus satisfied by passive floor broker trading rather than through more active trading by floor brokers. This is consistent with the

Table 8
The composition of trades with active floor broker participation by category[a]

	Percent of dollar volume represented by					
	Floor broker		Specialist	System		
	Active	Passive		Market	Limit	Other
Panel A: Non-block trades						
All stocks	49.5	7.0	10.2	6.1	26.2	1.0
Decile 10	49.3	5.4	10.1	6.8	27.2	1.1
Decile 9	50.5	9.8	10.4	4.8	23.8	0.8
Decile 8	49.2	12.1	9.9	3.7	24.2	1.0
Decile 7	49.0	15.6	12.1	3.6	19.0	0.6
Decile 6	49.9	11.3	11.0	2.8	24.6	0.5
Decile 5	51.4	11.9	11.2	1.9	23.2	0.4
Decile 4	50.9	12.7	10.5	3.4	21.6	0.9
Decile 3	49.6	14.3	8.8	1.5	25.6	0.2
Decile 2	53.8	11.2	11.1	2.6	20.4	0.9
Decile 1	48.0	14.4	14.0	1.8	21.9	0.1
Panel B: Downstairs block trades						
All stocks	57.1	11.4	8.6	1.6	20.0	1.3
Decile 10	57.3	9.0	8.8	1.9	21.7	1.4
Decile 9	58.2	16.1	7.5	0.9	15.8	1.5
Decile 8	53.3	23.5	8.4	0.6	13.4	0.9
Decile 7	56.1	24.4	8.6	0.3	9.9	0.0
Decile 6	58.4	19.3	9.6	0.2	12.5	0.0
Decile 5	51.5	23.5	7.5	0.1	17.0	0.4
Decile 4	51.2	25.6	8.6	0.2	14.4	0.0
Decile 3	61.2	14.5	7.9	0.1	15.7	0.6
Decile 2	59.0	24.0	6.3	0.6	10.1	0.0
Decile 1	52.0	18.9	8.2	0.1	20.8	0.0
Panel C: Upstairs-facilitated block trades						
All stocks	91.0	2.1	2.2	0.2	3.2	1.2
Decile 10	90.5	1.7	2.4	0.3	3.7	1.4
Decile 9	92.0	2.3	2.0	0.2	2.7	0.9
Decile 8	90.8	2.2	2.6	0.1	2.2	2.2
Decile 7	93.0	3.9	1.7	0.1	1.2	0.2
Decile 6	92.3	2.3	2.6	0.0	1.9	0.9
Decile 5	94.1	0.9	1.9	0.1	2.8	0.3
Decile 4	92.5	4.7	1.6	0.0	1.1	0.1
Decile 3	92.5	5.2	0.7	0.0	1.6	0.0
Decile 2	89.1	5.0	2.8	0.0	3.0	0.0
Decile 1	98.6	0.0	0.1	0.0	1.3	0.0

[a]The definition of trade volume is the average of total buys and total sells. Opening trades are excluded. Trades represented actively by floor brokers are traded by the floor broker in the auction. Passively represented orders are left by floor brokers with the specialist. The Other category for system orders include mainly ITS orders. The participation rates are calculated as the sum of buys and sells of that type over the total sum of buys and sells for each trade. Non-block trades are trades less than 10,000 shares, downstairs block trades are larger than 9999 shares, and upstairs-facilitated block trades are larger than 9999 shares and have the same floor broker on both the buy and the sell side. (see Madhavan and Cheng, 1997).

notion that floor brokers' time is extremely valuable. At the same time, the fact that off-floor traders still use floor brokers in less liquid stocks suggests that there is considerable value added in the types of orders that a floor broker may leave with the specialist (percentage orders) compared to the types of orders that an off-floor broker may submit through SuperDot.

What are the residual components of trades with floor broker participation? Panels A and B show that specialists represent on average 10.2% of total volume (buys plus sells) in non-block trades and 8.6% in downstairs block trades. There is no evidence for this subset of trades of a systematic relationship between specialist participation and volume deciles. Overall, system orders represent a smaller fraction of downstairs block trades than they do of non-block trades. System limit (market) orders account for 26.2% (6.1%) of non-block trades and 20.0% (1.6%) of downstairs block trades. This is natural given the priority rules that we discussed above. Finally, the fraction of trades represented by market orders is increasing in liquidity but there is no systematic variation in the fraction of trades represented by limit orders across volume deciles.

As a benchmark for system orders, consider the evidence from the TORQ data presented in Harris and Hasbrouck (1996). They find that system limit orders represent 16% and system market orders represent 12% of executed share volume. While their sample and time periods are different from ours, the samples do represent similar cross-sections of stocks. Compared to the overall population of trades, there is a different mix of SuperDot market and limit orders when floor brokers trade actively. Specifically, limit orders are over-represented while publicly provided market orders are under-represented. A possible explanation for this pattern is that floor brokers sometimes initiate trades, thus effectively submitting market orders.

We now turn to the composition of upstairs-facilitated block trades reported in Panel C. One average, floor brokers represent 91.0% of total volume of buys and sells in upstairs-facilitated block trades. The participation rate is roughly constant across volume deciles. When floor brokers bring upstairs-facilitated trades to the floor for execution, they always run the risk of the cross being broken by other floor brokers or the specialist. That is why there is some limited participation by specialists and system orders in upstairs-facilitated trades.

6. Conclusions

Beyond the conjecture that 'Floor brokers tend to represent larger, more difficult to execute orders',[25] little is known about NYSE floor broker trades. In

[25] Hasbrouck et al. (1993, p. 5).

this paper, we remedy this by providing a comprehensive analysis of the trades of NYSE floor brokers. Our sample consists of NYSE audit trail data on 110 NYSE stocks over the two-month period January 1 through February 28, 1997.

We estimate that in our sample, floor brokers represent roughly 44.3% of the total value of orders executed on the NYSE. Floor brokers *actively* represent 33.7% of the total value of orders executed. They *passively* represent the remaining 10.6%, leaving these orders with the specialist as limit or percentage orders.

We study the factors that influence the participation rates of specialists and floor brokers in a regression framework. Some variables that are associated with an increase in specialist participation tend to reduce floor broker participation. For example, we find that floor broker participation significantly increases in block volume while specialist participation significantly decreases in block volume. Higher market capitalization increases specialist participation, while it reduces floor broker participation holding other factors constant. The regression results also point to other differences across trader groups. Floor broker participation is not strongly influenced by measures of on-exchange competition, but higher on-exchange competition significantly reduces specialist participation. We also find that floor brokers trade significantly less when the cost of stepping ahead of the order book is high, but this factor does not affect specialist trading. Floor brokers are not significantly affected by off-exchange competition, while such competition reduces specialist trading. Finally, both specialists and floor brokers trade more when intraday volatility is high, but presumably for different reasons. NYSE's price continuity rules force the specialist to participate more in volatile markets. The fact that there is more floor broker trading on volatile days is more likely to be related to the increased value of a floor broker's services in fast and volatile markets.

Our evidence suggests that while floor broker and specialist trading on average are negatively correlated, there is no evidence of a direct effect of floor broker trading on specialist trading or vice versa after we control for the underlying determinants of trading. We also find that the evidence that specialist participation is higher for less liquid stocks derives entirely from periods when there is no active trading crowd. We find that the specialist average participation rate is 7.6% in trades with active floor broker participation compared to 14.7% when no floor brokers are trading actively. Moreover, specialist participation in trades with active floor broker participation does not depend on liquidity. By contrast, specialist participation is strongly inversely related to liquidity for trades without floor broker participation. Thus, the evidence is consistent with floor brokers helping the specialist bridge gaps in natural liquidity.

We also take a closer look at trades with active floor broker participation. These trades are substantially larger than other NYSE trades: downstairs trades with active floor broker participation are more than five times the size of trades without active floor broker participation. On average 56% of the value of non-block trades and 68% of the value of downstairs block trades where there is some floor broker participation are actually executed by floor brokers. Thus, on average there are floor brokers on both sides of a trade involving the crowd. This suggests that floor brokers, rather than use up liquidity (execute against system limit orders), create a substantial amount of additional liquidity on the floor.

The evidence presented in this paper shows that floor brokers are extremely important components of the NYSE auction market. In pursuing empirical research based on NYSE data, researchers must, therefore, take account of the presence of floor brokers. Failing to do so may lead to erroneous inferences. For example, measuring liquidity by looking at just the quotes and depth reported in the TAQ database grossly underestimates the liquidity available on the floor of the exchange because it only partially reflects the liquidity provided by floor brokers.

Appendix A. Data

Our audit trail data sample consists of 110 stocks listed on the NYSE during the period 1/2/97–2/28/97, a total of 41 trading days. We sampled 10 stocks randomly from size deciles 1–9 based on December 1996 trading volume. For the most liquid stocks, decile 10, we sampled 20 stocks randomly using the same methodology. The average daily NYSE market share in the sample stocks is 86.8%. Table 9 gives additional summary information on the sample stocks.

The audit trail represents a reconstruction of the market. See Hasbrouck et al. (1993) for details. The audit trail matches each trade (tape print) with comparison data reported by buyers and sellers. For trades exclusively involving system orders, this is a reasonably straightforward exercise. When a trade involves the crowd, the task of matching reports with tape prints becomes considerably more complicated. The NYSE has developed a sophisticated algorithm that assembles the components (buyer and seller reports) of each such trade and matches it up to a tape print. Since the spirit of the audit trail file is to provide a starting point for investigation when a complaint is raised, the matching algorithm is left incomplete in that buyer and seller reports that do not match up with trade prints remain in the file. For our sample, approximately 8% of the trading volume have reports that are not matched to tape prints.

There are several explanations for the existence of unmatched reports. The most common reason is that a floor broker submitted one buy report that matches against multiple sell tape prints. In this case the sell side will be matched, but there will be no information about the buy side for the print, causing an unbalanced trade. Another explanation is that submitted reports may be missing vital matching information such as the trade time or the broker

Table 9
Characteristics for NYSE Trading for Sample Stocks[a]

Panel A

	Average daily closing price				Average daily dollar volume			
	Mean $	Min $	Median $	Max $	Mean $1000	Min $1000	Median $1000	Max $1000
All stocks	27.92	4.16	24.88	123.79	10,007	0.5	1518	132,255
Decile 10	40.68	9.18	33.36	123.79	39,610	1550.0	29,299	132,255
Decile 9	35.01	13.38	31.91	60.54	13,143	4017.2	11,448	32,611
Decile 8	34.21	11.77	32.60	52.81	7,849	514.2	5852	16,043
Decile 7	31.53	5.51	30.71	64.11	5,311	312.9	3918	13,342
Decile 6	21.13	5.88	19.66	41.75	1,529	177.9	1300	2885
Decile 5	20.20	8.50	18.99	37.41	943	173.5	735	2332
Decile 4	23.43	4.85	24.64	52.68	996	117.3	634	3888
Decile 3	19.68	4.16	16.17	44.36	542	101.0	287	1843
Decile 2	17.12	7.45	17.35	33.89	386	77.4	204	1771
Decile 1	23.42	8.15	16.00	61.44	151	0.5	75	531

Panel B

	Average number of trades per day				Number of days with trades			
	Mean	Min	Median	Max	Mean	Min	Median	Max
All stocks	98	0	35	733	40.7	6	41	41
Decile 10	325	51	318	733	41.0	41	41	41
Decile 9	138	40	141	195	40.9	40	41	41
Decile 8	91	20	89	176	40.9	40	41	41
Decile 7	66	11	67	114	41.0	41	41	41
Decile 6	43	10	32	154	40.8	40	41	41
Decile 5	27	11	22	66	41.0	41	41	41
Decile 4	29	13	24	67	41.0	41	41	41
Decile 3	21	9	17	41	40.7	40	41	41
Decile 2	12	4	12	21	40.2	36	41	41
Decile 1	6	0	6	14	35.4	6	39	40

[a]The sample period is January and February 1997. The sample consists of 110 stocks. 10 stocks were drawn randomly from size-deciles 1–9. For the most liquid decile, decile 10, 20 stocks were drawn randomly following the same algorithm. There were a total of 41 trading days. statistics reported in the table are based on the summary file from the TAQ database. The numbers refer to primary market (NYSE) trading. The table reports the cross-sectional distribution of the statistics. All daily averages are based on the entire 41 trading days, whether the stock actually traded all of those days or not.

identifier(s). When this happens, the reports matched to the tape print will have unbalanced buy and sell volumes. The incomplete report is kept intact at the end of the file. Finally, a small number of reports where both buyer and seller agree that they have traded do not hit the tape.

In our sample, 84.5% of trade reports are matched to tape prints and have compared buy and sell volumes that balance. Of the remaining 15.5%, roughly 8% are reports not matched to tape prints at all and 7.5% are reports matched to tape prints but have buy and sell volumes that do not balance. By comparison, 87.5% of floor broker reports are matched to tape prints and have compared buy and sell volumes that balance. Of the missing 12.5%, roughly 8% are reports not matched to tape prints at all and 4.5% are reports matched to prints where the compared buy and sell volumes do not balance.

We develop an algorithm to reassemble into 'trades' the reports that are components of unbalanced trades matched to tape prints and the reports that are unmatched. These reports, sorted by price and time stamp for each stock and trading day, are assembled sequentially into trades. The following three requirements are made for reports to be included in a trade:

(a) All components of a trade have the same price.
(b) Any two sequential reports in a trade have time stamps less than or equal to 3 min apart.
(c) At most 6 min have passed between the time stamp of the first report and the time stamp of the last report.

When a trade has matching aggregate buy and sell volumes, it is completed and a new trade is started. A violation of any of these three requirements will cause the assembly to stop and the trade to be left with unbalanced volume. After running our algorithm, on average 93.4% (95.2%) of daily volume (floor broker volume) have compared buy and sell volume that aggregate properly into trades, while the remaining 6.6% (4.8%) of volume represents unbalanced trades.

We save the audit trail information for all reports that form trades with floor broker participation. Summary information is gathered from the audit trail file about trades that do not involve floor brokers. The detailed floor broker file is then merged with TAQ data for information about quotes and system trades. We also use a file that permits us to group floor brokers into Independent and Commission House brokers.

Floor brokers who want to participate in the opening call will usually hand their pre-opening orders to the specialist. The specialist will then enter the orders into OARS, the NYSE's Opening Automated Report System. During the pre-opening period, floor brokers standing by the post may instruct the specialist to adjust their OARS orders to reflect the amount of volume that is 'paired' (matched). Floor brokers may also participate in the opening call without entering their orders into OARS. Floor broker participation outside of OARS is typically motivated by a large order imbalance announced by the specialist immediately preceding the open.[26] Unfortunately, NYSE's audit trail does not distinguish the crowd-entered OARS orders from the orders that reach OARS through SuperDot. We cannot therefore quantify the floor brokers' participation in the opening call through OARS. As a consequence, we can only measure the floor brokers' participation in the opening call other than through OARS.

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[26] Preceding the opening bell, floor brokers typically visit specialist posts to obtain updates on opening order imbalances. Floor brokers report this information back to their off-floor clients. This information-dissemination role is particularly important when order imbalances at the opening force the specialist to delay opening the stock.