Tick Size, Bid-Ask Spreads and Market Structure

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Abstract

We propose a link between market structure and the resulting market characteristics – tick size, bid-ask spreads, quote clustering, and market depth. We analyze transactions data of stocks traded on the London Stock Exchange, a dealer market, and also traded as ADRs on the New York Stock Exchange, an auction market. We conclude that market characteristics are endogenous to the market structure. The London dealer market does not have a mandated tick size, and it exhibits higher spreads, higher quote clustering, and higher market depth than the NYSE auction market. Clustering of trade prices is similar in London and New York.

Tick Size, Bid-Ask Spreads and Market Structure

I. Introduction

In a financial market, the minimum tick size is the minimum allowable price variation. Minimum tick rules can apply to quotes, to trades and to trade reports. On the New York Stock Exchange (NYSE), the minimum tick for quotes, for trades and for trade reports is \$1/8 until June 24, 1997, when the tick size was reduced to \$1/16 (teenies). On the London Stock Exchange (LSE), there is no minimum tick size for quotes, trades or trade reports. On the Nasdaq Stock Market, there was a minimum tick size of \$1/8 for quotes until June 2, 1997. However trades could take place at any price increment. Trade reports were rounded to the next 1/8th. In the Chicago Mercantile Exchange's S&P 500 futures contract, the tick size is 0.10 index points or \$25 per contract. Formal tick size rules do not exist in the London Stock Market or in OTC bond markets and currency markets.

The literature on market microstructure is replete with studies of attributes that affect or reflect market liquidity such as tick size, bid-ask spreads, quote clustering, and market depth. While we begin with tick size, the objective of this paper is to tie these various characteristics of markets into a more general view that reflects the underlying market structure. We examine the source and the impact of a minimum tick rule by considering stocks traded in different market structures. Specifically, we examine a set of stocks traded in London, where there is no mandated tick size, and also traded on the NYSE, where there is a mandated tick size. We conclude that market structure is the exogenous factor responsible for the presence of tick size rules and other market microstructure attributes.

Related to the question of tick size is the empirical phenomenon of clustering. Clustering on even 1/8ths was used as evidence by Christie and Schultz (1994) of implicit collusion on Nasdaq. We propose a measure of clustering that is akin to the Herfindahl Index, and we analyze clustering of quotes and of trade prices and the relation of clustering to spreads, tick size and market structure. In particular, we examine the hypotheses that price clustering is due to (1) ease of negotiation, (2) implicit collusion, and (3) market structure. We conclude that market structure is responsible for the observed clustering. We also find evidence that suggests higher spreads in the LSE are partially offset by higher mandated depth behind the quotes. We trace the differential depth requirements to the differential market structures.

Our general approach differs from many recent studies that focus on the effect of particular market features. For example, a flurry of recent studies, some prompted by the planned decimalization of the U.S. market, examines the pre and post-effects of a reduction in tick size.[1] On July 18, 1994, the Stock Exchange of Singapore reduced the minimum tick size for stocks trading at or above $25 from $0.50 to $0.10. Lau and McInish (1995) examine the effects of the reduction on both bid-ask spreads and market depth. The American Stock Exchange (AMEX) has reduced its tick size in stages. Crack (1995) and Ahn, Cao, and Choe (1996) examine the 1992 switch from 1/8th to 1/16th for stocks below $5. Ronen and Weaver (2000) examine the extension of the rule to all stocks on the AMEX on May 7, 1997. The Toronto Stock Exchange (TSE) moved from a fractional to a decimal trading system on April 15, 1996. Bacidore (1997), Porter and Weaver (1997), and Ahn, Cao, and Choe (1998) study the impact of the TSE's switch on bid-ask spreads. The NYSE adopted the teenies on June 24, 1997. Bollen and Whaley (1998) and Goldstein and Kavajecz (1998) examine this change. The Nasdaq Stock Market changed the minimum quote increment from 1/8th to 1/16th for bid prices greater than $10 on June 2, 1997.[2] Smith (1998) examines the change that occurred in the midst of a series of changes to implement the Order Handling Rules (OHR).[3] All these studies conclude that the adoption of a smaller tick size lowers spreads. The evidence on the market depth is less uniform but, by and large, suggests that it may be adversely affected.

The most important difference in our study is its focus on the role of market structure in determining bid-ask spreads and tick size rules. In contrast, the earlier studies often hold market structure constant by examining a change in tick rule on the same exchange.[4] We examine whether both tick size rules and spreads are endogenous in a broader model of exchange structures. In addition we consider the extent to which other features of markets – the degree of quote and price clustering and the depth of market are associated with market structure. Previous studies, more narrowly focused on changes in existing tick size rules, may be affected by changes in market-wide and firm-specific information before and after the adoption of a new tick

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[1] See SEC (1994) Market 2000 report.

[2] For bid prices below $10, the tick size is 1/32nd.

[3] See Barclay et. al. (1997) for an analysis of the impact of OHR on the first 100 stocks to be phased into compliance with the rule.

[4] An exception is the study by Ahn, Cao, and Choe (1998) who examine TSE stocks that are cross-listed on the NYSE, AMEX, and Nasdaq.

size. Our study is robust with respect to these changes since we examine a given set of stocks traded at the same time in different markets.

The remainder of the paper is organized as follows. Section 2 develops the analytical framework. Section 3 describes our data set, which consists of U.K. stocks that are also traded on the NYSE as American Depository Receipts (ADRs). The next four sections present the empirical evidence on spreads (Section 4), clustering (Section 5), clustering and spreads (Section 6), and depth, tick size and spreads (Section 7). Section 8 contains the conclusion.

II. Analytic Framework

The premise underlying our analytical framework is that the distinction between auction and dealer markets is important. The key feature differentiating the two market structures is the treatment of public limit orders. In an auction market, limit orders are displayed and may trade against incoming market orders. In a pure dealer market, limit orders are held by each dealer, are not displayed, and can only be traded against the dealer's quote. The distinction has implications for the level of spreads, for the existence of a tick rule, for the degree of clustering, for the quoted depth and perhaps for other characteristics of markets.

A. Spreads

It is well established that the dollar spread varies cross-sectionally according to stock characteristics such the stock price, volume of trading, volatility, amount of informational trading, and the like. Under the null hypothesis that market structure has no effect on spreads, the relation between spread and stock characteristics would be the same in dealer and auction markets. But there is evidence for the alternative hypothesis that dealer market spreads are higher than auction market spreads even for the same stocks simply because of the effect of different market structures.[5] The principle reason for lower spreads in auction markets is that limit orders narrow spreads in comparison to dealer spreads. In a dealer market, dealers determine the spread. In an auction market, limit orders determine the spread.

B. Tick rules

The existence and importance of tick rules is also a function of market structure. A dealer market, like that in London, does not mandate time priority (across dealers). A tick rule, as Harris (1991) has pointed out, is essential if time priority is to have meaning. Time priority has

[5] See for example Huang and Stoll (1996).

little meaning if the person who is first to quote the best bid can lose that position to someone who quotes only a penny more. Conversely, if there is not time priority, a tick rule is not necessary. Consequently, it is not surprising that dealer markets, where there is not time priority, have evolved with little attention to a tick rule. Even on Nasdaq, the 1/8 tick was a convention for quoting bids and asks, not a rule, and the convention did not apply to transactions. Transactions could be negotiated at price increments of $1/256 or in decimal format with up to eight digits to the right of the decimal. In an auction market, where limit orders have standing, a tick rule is needed to make time priority meaningful. Without a tick rule, customers could easily step ahead of dealers or conversely dealers and floor brokers could easily step ahead of customers.[6] In summary, a tick rule is endogenous. It arises in auction markets to facilitate orderly trading and give time priority meaning.

A tick rule, while the outcome of an auction market, can have an independent effect on spreads, as demonstrated by Harris (1994). Tick size increases spreads for stocks with spreads that would otherwise be less than the tick size. For example, suppose an $8 stock would normally have an 8-cent spread. If the minimum tick is 12.5 cents, the spread can be no less than 12.5 cents. The tick size raises spreads in an auction market, particularly for low price stocks. Yet it remains possible that spreads in dealer market exceed those in an auction market.

C. Clustering

Another feature of markets that may be affected by market structure is the degree to which prices cluster. Clustering is the tendency for prices to fall on a subset of available prices. Clustering is defined with respect to a price grid. For example if prices are quoted in eighths, clustering exists if all eight price positions are not used equally. Clustering can be measured by the fraction of prices at even eighths as in Christie and Schultz (1994). We define a measure of clustering for stock i, C_i , that is similar to the Herfindahl Index:

$$C_i = \sum_k (F_{ik} - F_{ik}^*)^2 ,$$

where F_{ik} is the observed frequency of price k and F_{ik}^* is the theoretical frequency under the assumption of a uniform distribution. For example if the available prices are eighths, the theoretical frequency with which a price falls on each eighth is 1/8. If the actual frequency is also

[6] The NYSE does not follow a strict time priority rule. To minimize the breaking up of large orders, the time priority rule applies only to the first limit order. The remaining limit orders follow a size priority rule; namely limit orders that match

1/8, $C = 0.0$. If only even eighths are used, $C = 1/8$. A feature of this measure is that a doubling of available prices accompanied by a doubling of used prices will result in a smaller clustering measure. For example if a decline in the tick size from 1/8 to 1/16 results in the use only of even sixteenths, the clustering measure is $C = 1/16$. The clustering measure is half as large, which is appropriate given that twice as many prices are used, as was the case when only even eighths were used.

Price clustering may arise for at least three reasons. First, prices cluster to simplify negotiation. Traders cannot use an infinite set of numbers. If there is no tick size or if the tick size is small, clustering would occur simply as a matter of trading convenience. Under this view, we expect clustering within a market to increase with stock price and with the spread, and we do not expect it to differ between auction and dealer markets. Independent of market structure, the higher the stock price and/or the greater the spread, the less the importance of a small price increment and the larger the price increment traders are likely to choose. For example, in negotiating for a house, the price increment will not be $0.25.

Second, clustering is a function of market structure because it is related to the number of traders with standing. In a dealer market, only recognized dealers have standing and display quotes. Dealers are often required to trade in size, and they must cover a variety of costs. These obligations and costs can lead to wider quoted spreads and greater clustering. In an auction market, limit orders have standing. Public investors do not incur some of the costs of a dealer, and they have an incentive to place limit orders that beat dealer quotes. The presence of many limit orders tends to narrow spreads and reduce clustering because more prices are likely to be used. In a dealer market, clustering will be most evident in quotes and will tend to be negotiated away in trades. In an auction market, limit orders allow the public to pre-negotiate prices inside dealer quotes by placing limit orders. Consequently we expect less quote clustering in an auction market (where every price is more likely to be used) than in a dealer market (where fewer participants reduce the chance that every price is used).

Third, Christie and Schultz (1994) and Dutta and Madhavan (1997) argue that clustering of prices on even eighths reflects coordination by dealers in Nasdaq to raise spreads above competitive levels. Christie and Schultz find nearly total avoidance of odd eighths for some but not all Nasdaq stocks, and they conclude that coordination among dealers raises spreads. Both

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the size of the market order at the best price are given priority over other limit orders that might have been placed earlier the market structure and implicit collusion imply greater clustering in dealer than in auction market. We distinguish the two by examining the nature and degree of clustering in quotes in comparison to trade prices. The coordination view implies substantial clustering in both quotes and trade prices. If dealers are to profit from wide spreads associated with quote clustering, they must trade at the quoted prices; hence, trade prices must also cluster.

In summary, we investigate three hypotheses in regard to clustering. The ease of negotiation hypothesis implies increased clustering with increased price, but does not imply that clustering should be different in different market structures. The market structure hypothesis of clustering implies that quote clustering in a dealer market exceeds quote clustering in an auction market for the same reason that spreads in a dealer market exceeds spreads in an auction market. However, the minimum tick size is a complicating factor. Whereas clustering could go to zero, the minimum $1/8^{th}$ tick in an auction market puts a lower bound of $1/8^{th}$ on the spread in an auction market. To distinguish implicit collusion and market structure, we look at the amount and pattern of quote clustering in comparison to the amount of trade price clustering. Completely effective dealer coordination implies quote clustering and trade price clustering of the same level, for it is the transactions that yield any profits. If trade prices cluster significantly less than quotes, we would reject the hypothesis of systematic implicit collusion.[7]

D. Depth

Define depth to be the quantity bid or offered at the inside quote. Depth will be related to other features of market such as spreads, tick size and degree of clustering. In particular, we expect depth to be less in an auction market because limit orders narrow the spread. Depth is reduced because spread narrowing limit orders are small. They are small because large limit orders do not want to take the risk of being "picked off" by informed traders, and because many limit orders may be placed by individual investors seeking to better the quote. Depth will tend to be larger in pure dealer markets because dealers implicitly operate at larger spreads and larger tick size.

but are not first in time at the best price.

[7] Of course we cannot rule out that there are some traders or times in which dealers are able to extract monopoly rents.

III. Data

We begin with a sample of 31 FTSE 100 firms that are traded in the U.S. in 1995. Five firms are deleted from the list for trading less than 200 times during January or December of 1995. One additional firm was lost for switching exchanges and another one for merging during the year. Of the remaining 27, there are 19 listed on the NYSE, 4 on the AMEX, and 1 on Nasdaq. Our final sample is the set of 19 British stocks traded as ADRs on the NYSE.[8]

By examining the same stocks under different market structures, we hold constant stock characteristics and are able to investigate the role of market structure. NYSE quote and transaction data are from TAQ. We restrict the data set to quote and trade prices on the NYSE and exclude quotes and prices from the regional exchanges and Nasdaq. The Transaction Data Service of the LSE supplied the U.K. transactions data. The data is error-checked with the typical filters.[9] Days when either the NYSE or LSE is closed are excluded.

The sample list and some descriptive statistics are provided in Table 1. It shows the ADRs' number of market makers on the LSE along with their ADR ratios. The ADR ratio is the number of ADRs that correspond to one UK share. For example an ADR ratio of 1/4 indicates one ADR is collateralized by 4 U.K. shares. The ADR ratio ranges from 1/2 to 1/10, reflecting the lower price of shares in the U.K. as compared with the U.S. Under the law of one price, a U.K. share adjusted for the ADR ratio has the same value as the ADR. For example, British Airways U.K. price of 4.27 would be 42.70 after adjusting for the 1/10 ADR ratio. This pound price is equivalent to the dollar price of $67.35 at an exchange rate of 1.58 dollars per pound, the approximate exchange rate during the period of our study. British Airways daily UK share volume of 4,485,295, adjusted for the ADR ratio of 1/10 would be 448,530, which is significantly higher than U.S volume of 38,426. For all stocks in our sample, the daily average volume is about three times as large in London even after deflating the average share volume in London by 10, the biggest ADR ratio.

[8] It would also be of interest to examine U.S. firms that are traded on the LSE. We exclude this sample for structural and data reasons. The system for U.S. stocks on the LSE is the SEAQ-International (SEAQ-I). However, unlike SEAQ, SEAQ-I is more a brokerage system than a dealership market and quotes posted on the SEAQ-I are not firm and are primarily for advertising. There are data reasons for not looking at this sample as well. Of the 100 most actively traded foreign stocks in London, only four are U.S. firms in 1995. The available data on SEAQ-I for U.S. firms are also of poor quality.

[9] The error checks look for large changes in trade prices or quotes that would indicate an error. The error checks also search for negative trade prices, quotes, spreads, and depths.

IV. Spreads in London and New York

If differences in spread were a matter of tick size alone, one would expect smaller spreads in London, where there is no minimum tick, than in New York, where there is a minimum tick. We measure the percentage quoted spreads as

$$\%\, quotedspread = 100\left[\frac{(ask - bid)}{m}\right],$$

where m is the quote midpoint defined as $m=(ask+bid)/2$. Table 2A compares the percentage quoted spreads of the same stocks in London and New York, based on all quotes in each stock in calendar year 1995. The percentage quoted spreads are significantly lower in New York for every stock except three: BCS, RTZ, and UL.[10] Table 1 shows that these three exceptions have sizable daily U.K. share volume but have the three lowest daily U.S. share volume. Therefore, the higher quoted spreads in U.S. are due to the lack of liquidity on the New York market. Table 2B shows that when the comparison is restricted to the period in which both markets are open during the first two hours of trading on the NYSE, spreads remain significantly lower in New York than in London with the exception of the same three stocks.[11] London spreads are the same in the total and the overlap periods, but New York spreads are higher in the overlap period, something that reflects the well-known tendency for spreads to be higher at the open than during the rest of the day.

One cannot ascribe the lower New York quoted spreads to differences in stock characteristics – these are the same stocks. The underlying risk of each stock is a given. Furthermore, volume in London exceeds volume in New York after adjusting for the ADR ratio, which would imply higher spreads in New York, not in London.

Quoted Spreads could be higher in dealer markets than in auction markets because of structural factors, such as the treatment of limit orders and commissions, or because of implicit collusion (Christie and Schultz (1994) and Huang and Stoll (1996)), but the difference cannot be ascribed to a tick rule. Evidence on effective spreads can help distinguish these possibilities. The effective spread is defined as

[10] NYSE spreads are lower than London spreads despite the fact that ADRs on the NYSE have larger spreads than U.S. stocks. See Bacidore and Sofianos (2000) for a comparison of ADRs and U.S. stocks on the NYSE.

[11] The overlap trading time is two hours for most of the year but is one hour (9:30-10:30 U.S. ET) from March 26 to April 1.

$$\%\,effectivespread = 200\left[\frac{|p-m|}{m}\right]$$

where p is the transaction price. Table 3 shows that the effective spread is less than the quoted spread in both markets.[12] Traders can often improve their trade prices relative to the quoted prices. On average, price improvement is greater in London (a 45.26% improvement) than in New York (a 20.18% improvement). This evidence suggests that implicit collusion is not the reason for higher spreads in London. If dealers were able to co-ordinate to make abnormal profits, they would do so with respect to trade prices as well as quotes. However the effective spread data indicates there is more negotiation of prices within the spread in London than in New York. Despite the greater price improvement in London, effective spreads continue to be greater in London than in New York (0.6023% versus 0.4679%). This could reflect some remaining coordination among dealers, but it could also arise because auction markets charge a commission, whereas dealer markets frequently do not. The difference between an effective spread of 0.6023% and 0.4679% is 5.3 cents on a $40 stock, which is of the magnitude of an institutional commission on the NYSE at the time of the study. Thus commissions could explain the difference in effective spreads between London and New York.

In Table 4 we compare LSE and NYSE effective spreads by trade size category. Trade sizes in London are grouped by normal market size (NMS). NMS is the amount London dealers must be willing to trade at their quotes. This number is publicly available. Share volumes are grouped into those less than half the NMS, those greater than half NMS and less than 1 NMS, and those greater than 1 NMS. Corresponding trade size categories are constructed for New York by using the ADR ratio to adjust the NMS. The table shows that effective spreads in London exceed effective spreads in New York in all size categories. In a dealer market one might expect little decline in the effective spread for small orders, which are not able to negotiate. However, the effective spread for small orders in London is about the same as the effective spread for medium orders, where negotiation might be more common.

We hasten to add that we do not want to put too much reliance on the effective spread results because the calculation of effective spreads is subject to error. To calculate an effective spread a trade price must be compared to the quote existing when the trade took place. Because

[12] The careful reader will note that the number of observations in Table 3 is different from the number in Table 2. This is because the item being observed in Table 3 is the trade. Given a trade the preceding quote is associated with it. It is possible that a given quote is followed by more than one trade, or that quotes change without trades.

trades and quotes are reported by different systems and with potentially different delays, the trades and quotes that correspond can be difficult to identify. Our procedure was to associate each trade with the immediately preceding reported quote. If trades are reported less quickly than quotes – which we believe is the case – the effective spread may be misstated. We believe trade delays are more likely in a dealer market with self-reporting by dealers than in an auction market where a floor clerk reports trades. Consequently the misstatement is likely to be greater for London than for New York. Without additional data, we cannot assess the accuracy of our results. Studies that examine the accuracy of trade classification into buyer and seller initiated trades give estimates of the fraction of trades incorrectly classified, but do not always provide evidence on relative reporting lags and the resultant impact on effective spreads.[13] Even if the trade is correctly signed, to calculate an effective spread the correct quote is required. Schultz (2000) finds that there are significant delays in the recording of Nasdaq trades in 1995 and that this resulted in wide effective spreads. The wider spreads would result if stock prices are volatile. In a volatile market a delayed trade price, dating back 5 minutes, for example, might very well be outside the current bid-ask spread because the current spread reflects the current information, not the information of 5 minutes ago. If this reasoning also applies to our data, effective spreads would be biased upward. This does not appear to be the case, for London effective spreads (where the reporting delays are feared to be large) decline more in relation to quoted spreads than they do in New York (where reporting delays are assumed to be less).

V. Clustering in London and New York

A difficulty in measuring clustering for the U.K. is that in the absence of a minimum tick size, the set of available prices is not readily defined. We assume that the available prices can fall on pennies, which is a fine price grid. However, relative to the average stock price in London, it is only slightly finer than in New York. In London the price increment of one penny is 0.17% of the average stock price of £6, and in New York, the price increment of $1/8 is 0.27% of the average stock price of $46. Thus the price grids are of approximately the same magnitude relative to stock prices in each market. The somewhat finer London price grid biases our cluster

[13] For studies on the accuracy of trade classification see Lee and Balkrishna (2000), Odders-White (2000), Finucane (2000), Ellis, Michaely and O'Hara (2000) and Bessembinder (2000). Finucane, using the TORQ data base finds that about 83% of trades are correctly classified by either the Lee and Ready (1991) or the tick rule such as that used in Kraus and Stoll (1971).

measure in the direction of higher clustering in LSE relative to NYSE because the likelihood that all prices are used is reduced when there are more price positions.

We first measure clustering of quotes and trade prices in London and New York by calculating the distribution of trades by tick category and reporting our cluster index. These data are provided for each stock in Tables 5 and 6.

Consider first clustering in quoted prices. Data for each stock for London and New York are in Tables 5A and 6A respectively. Only the cluster indices for bid quotes are shown but the conclusions are the same for ask quotes. First, clustering of quotes in London is less than we anticipated. There is evidence of some clustering at the “0” and “5” digits, but the average fraction of quotes at these digits is 13.8% and 13.5% of the quotes as compared with 10% under a uniform distribution. The average cluster measure for the LSE is 0.01331. Recall that the measure would be 0.10 if half the available digits were used. The clustering in London does not appear to be of the same magnitude as that found in Nasdaq by Christie and Schultz (1994). Second, quote clustering is higher in London than in New York. The quote cluster index averages .0133 in London and .0067 in New York. We expect the cluster index to be somewhat higher in London because the price grid is relatively finer in London than in New York and because ten possible price digits (0 to 9) rather than just eight (0 to 7) in New York. Even taking account of these factors, clustering appears higher in London than New York. We suspect that limit orders, which are responsible for many of the NYSE quotes, are the source of lesser quote clustering in New York than London.

Now consider clustering in trade prices in Tables 5B and 6B. First a comparison of Tables 5A and 5B shows that trade price clustering in London is substantially less than quote clustering in London. The trade cluster index averages .00243 in London in comparison to the quote cluster index of 0.01331. If the relatively small amount of quote clustering is the result of dealer coordination, the coordination is not effective as measured by trade clustering. Indeed trade clustering in London is less than on the NYSE, where the trade cluster index averages 0.00551. On the NYSE, quote and trade clustering are similar. This is because quotes change as frequently as prices on the NYSE, whereas in a dealer market quotes change much less frequently than trade prices. The substantial difference between quote and trade clustering in London suggests that trade prices are negotiated inside the quotes. This finding is independent of and consistent with the effective spread results discussed above.

We conclude that an auction market structure tends to result in less quote clustering than does a dealer market structure but that differences in market structure do not result in differences in trade clustering. In a dealer market like London, quotes may cluster, but trade prices are often negotiated inside the quotes, reducing the clustering of trade prices relative to quotes. In an auction market like New York, quotes don't cluster because the placement of limit orders inside dealer quotes reduces clustering. In an auction market, limit orders effectively pre-negotiate the terms at which they trade as part of the trading system, by placing limit orders. In a dealer market, incoming orders negotiate better prices outside the market structure via telephone or other means. In an auction market, limit orders cause the clustering in transaction prices to be like the clustering in quotes, whereas in a dealer market, the clustering in transaction prices is less than the clustering in quotes.

VI. Clustering and Spreads

How are clustering and spreads related? In our analytical framework we propose that, within a market, quote clustering and spreads are related to firm characteristics in the same way. In other words, the larger a stock's bid-ask spread the larger its clustering index. Table 7 shows that quote clustering and spreads are indeed very highly correlated within each market. In the NYSE, the correlation between quote clustering and bid-ask spread is 0.97, and in London, this correlation is 0.93. Although quoted spreads and clustering are highly correlated in both markets, the level of spreads and of clustering is greater in the London dealer market, as shown in the preceding sections.

The correlations of trade clustering and spreads are different in the two markets. Trade clustering is highly correlated with spreads in New York, with a correlation of 0.940, but, in London, the correlation of trade clustering and spreads is 0.588, which is much less than that for quotes. This difference reflects the role of limit orders. On the NYSE, quotes change as limit orders are traded, with the result that quote changes and price changes are more closely aligned. Consequently clustering of quotes and trade prices are highly correlated on the NYSE. In dealer markets, quotes are not directly influenced by limit orders and change less frequently, while transactions may take place at several price locations at or inside the spread. Consequently quote clustering and trade price clustering are not as highly correlated. In the London dealer market there is more room for negotiation of the final price relative to the quote than in the NYSE auction market.

VII. Depth, Tick Size and Spreads

Given a choice, why would investors trade on a dealer market like London rather than an auction market? Many investors, of course do not have the choice, but others, such as large institutions, do. An offsetting benefit to a higher spread is the ability to carry out larger trades. Tick rules are usually related to depth rules. On the NYSE, there is no minimum depth for quotes. For example, a limit order can be entered for as little as 100 shares. In an auction market, limit orders not only narrow the spread, as we noted earlier, but also tend to lower the quoted depth. On the other hand, in an institutionally oriented dealer market such as London, dealers tend to offer substantial depth. London requires dealers to trade a normal market size (NMS) that is substantial.

Table 8 shows that for all stocks in our sample, the minimum depth established by the NMS averages 16,513 ADR shares in comparison to an average quoted depth of about 12,000 shares in New York.[14] The NMS is substantially larger than the average quoted depth in New York for all stocks except GLX, HAN, ICI, and VOD. These results for quoted depth are consistent with the other differences between the NYSE auction market and London dealer market: Limit orders narrow spread, require tick rules, lower depth, and lessen clustering.

Trade sizes, tabulated in Table 9 relative to the NMS, reflect the greater depth in London. Similar to Table 4, trade sizes are grouped into those less than half the NMS, those greater than half NMS and less than one NMS, and those greater than one NMS. A larger fraction of London trades exceed the NMS – 6% -- than is the case in New York– 2%. These trades are likely to be negotiated outside the normal trading process – in London with the dealer, in New York as a block trade. For trades greater than ½NMS and less than NMS, trade sizes are larger in London (13564) than New York (12094). In addition, trades in this middle size category occur somewhat more frequently in London than in New York. For trades less than ½NMS, the average trade size on the LSE (834) is only slightly larger than on the NYSE (678), and for 10 stocks the trade size is larger in New York than in London. The difference in trade sizes confirms the greater depth in London, although the difference is not as great as the difference in quoted depth.

[14] In our sample, the quoted depth exceeds the NMS 9% of the time.

Dealers in London also face the risk of not seeing the entire order flow and not knowing what other dealers are doing. As Ho and Stoll (1983) have shown, if dealers are not quick to adjust quotes an investor can execute several trades with different dealers at the current quote. Each dealer knowing of this possibility must set spreads to reflect the anticipated difficulty of reversing his position in a market where other dealers are trying to reverse their positions. Consequently spreads are higher in London not only because depths are higher but also because of the additional risk. Because quoted spreads are relatively higher than differences in depth might imply, effective spreads fall by 45% from the quoted spreads in London but by only 20% in New York as shown earlier in Table 3. The differences in these declines are not due to differences in trade sizes. Table 9 shows that London trade sizes exceed those on New York albeit not by as much as the difference in depths might imply.

In summary, the higher quoted spreads on the LSE relative to those on the NYSE are associated with higher depth requirements on the LSE. However, spreads and quote sizes are also related to other characteristics of dealer markets such as the absence of time priority rules and tick sizes. These characteristics are a result of the dealer market structure, in particular the role of limit orders on the LSE. Thus, depth, tick size and spreads are all interrelated and reflect the underlying market design.

VIII. Conclusion: Market Structure, Spreads, Tick Size, Clustering, and Depth

The basic proposition of this paper is that microstructure characteristics are not independent of market structure. Spreads, tick size, clustering, depth and market structure are linked. Our conclusion may be summarized as follows:

Dealer markets tend to have higher spreads than auction markets. London spreads are higher than New York spreads in those same stocks. This conclusion is similar to that in Huang and Stoll (1996) were we find that Nasdaq spreads exceed NYSE spreads in comparable stocks. However in the Nasdaq/NYSE comparison the difference in spreads appeared too large to be explained by market structure alone. In the London/NYSE comparison we conclude market structure alone, not implicit collusion of dealers, explains the difference.

A minimum tick is required in an auction market to encourage liquidity provision by limit orders and by dealers. Without a minimum tick (or a minimum trade size), a limit order can cheaply step ahead of another limit order or a dealer quote. If there is no minimum tick, it is easy to avoid time priority. Dealer markets do not require time priority across dealers and they have less need for a minimum tick. However, each dealer quotes in depth even in the absence of a tick rule because he wishes to maintain a reputation for liquidity or because dealer markets set standards as to depth.

Quote clustering is highly correlated with spreads and with the stock characteristics that determine spreads. If a market has higher spreads it has greater clustering. While this result is true for London/NYSE, we show that the degree of clustering in London is less than was found by Christie and Schultz in their analysis of the Nasdaq dealer market.

Trade clustering is less than quote clustering in London and about the same in New York. We ascribe this difference to differences in market structure – the role of limit orders in particular. In New York, limit orders break up quote clustering as they seek to gain priority. In London fewer traders have standing – only the dealers. Negotiation for better prices by customers takes place off the screen whereas negotiation in an auction market takes place on the screen via limit order placement. In London negotiation is successful as measured by the decline in trade price clustering relative to quote clustering. In New York, trade prices cluster about the same amount as quotes.

Higher spreads in the London dealer market are accompanied by greater depth. Trade sizes are larger in London consistent with the large depth, but the difference in trade size is not as great as the difference in depths. In the NYSE auction market limit orders tend to pre-negotiate by placing orders inside the specialist's quote that tend to narrow the spread and lessen the depth. In the London dealer market, dealers set wider quotes and larger depths but negotiate trades for smaller quantities and smaller spreads.

Viewing the evolution of exchanges as Darwin viewed the evolution of species, we conclude that the various features of markets reflect adaptation to their surroundings. Tick size, spread, clustering, depth, trade size, and effective spread are all endogenous to basic market structure, namely, dealer versus auction market.

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Table 1
Descriptive Statistics

The table presents the list of U.K. securities that are listed on the NYSE and their characteristics. The "# Market Makers" refers to the number of market makers in the securities on the London Stock Exchange. The "ADR Ratio" is the number of ADRs issued for every U.K. share. There are 1,509,670 U.K. trades and 444,723 U.S. trades. Trade prices are prices per trade and share volumes are total shares traded per day. The sample period is January 1, 1995 to December 31, 1995.

Ticker	Name	# Market Makers	ADR Ratio	U.K. Mean Trade Price (£)	U.S. Mean Trade Price ($)	U.K. Mean Daily Share Volume	U.S. Mean Daily Share Volume
BAB	BRITISH AIRWAYS	20	1:10	4.27	67.35	4,485,295	38,426
BAS	BASS	17	1:2	6.10	19.27	2,342,389	12,302
BCS	BARCLAYS	17	1:4	6.92	43.00	4,474,614	10,364
BP	BRITISH PETROLEUM CO	20	1:12	4.61	87.18	9,171,165	283,229
BRG	BRITISH GAS	19	1:10	2.82	42.39	10,624,140	22,159
BST	BRITISH STEEL	18	1:10	1.68	26.52	10,220,893	137,026
BTY	BRITISH TELECOM	19	1:10	3.92	60.35	10,421,320	49,644
CWP	CABLE & WIRELESS	20	1:3	4.15	19.68	5,688,347	135,943
GLX	GLAXO WELLCOME	20	1:2	7.51	23.72	7,033,755	852,960
GRM	GRAND METROPOLITAN	19	1:4	4.04	25.73	5,668,276	65,400
HAN	HANSON	19	1:5	2.18	16.64	13,199,847	1,093,738
ICI	IMPERIAL CHEM. IND.	20	1:4	7.66	47.95	2,374,264	111,884
NW	NAT'L WESTMINSTER BANK	17	1:6	5.78	54.85	4,949,742	16,698
RTZ	RTZ CORP	17	1:4	8.46	53.60	2,352,254	4,982
SBH	SMITHKLINE BEECHAM	20	1:5	5.61	45.21	4,860,820	39,329
SC	SHELL TRANSPORT. & TRAD.	19	1:6	7.48	72.34	6,091,650	45,233
UL	UNILEVER	18	1:4	12.30	78.08	1,748,243	4,862
VOD	VODAFONE GROUP	20	1:10	2.23	35.66	9,847,368	678,163
ZEN	ZENECA GROUP	20	1:3	10.47	50.61	2,153,001	22,105

Table 2A
Quoted Spread

The table presents quoted spreads as a percent of mid points for U.K. securities and their corresponding U.S. ADRs based on data for the entire trading day in each country. The sample period is January 1, 1995 to December 31, 1995. Heteroskedastic-consistent t-statistics are reported for test of the null hypothesis of equal U.S. and U.K. spreads. The # of observations is the sum of New York and London observations.

Ticker	# of Observations	LSE % Spread	NYSE % Spread	T-Statistic for H_0: Equal Spreads
BAB	44719	0.9572	0.4039	249
BAS	30662	1.1621	1.1204	4
BCS	61842	0.7339	1.2829	-50
BP	52771	1.0883	0.2195	1173
BRG	34506	1.0831	0.6724	76
BST	32931	1.8131	0.7020	374
BTY	55368	0.7764	0.3712	249
CWP	49156	1.6908	0.8710	274
GLX	64643	1.1337	0.6025	289
GRM	35804	1.7276	0.7970	241
HAN	40721	1.3658	0.8315	211
ICI	55334	0.9169	0.3802	411
NW	65008	0.8802	0.6079	76
RTZ	36294	0.8267	0.9083	-10
SBH	53571	0.8967	0.5560	123
SC	46947	0.668	0.3523	197
UL	38641	0.8193	0.9528	-14
VOD	71371	1.3377	0.5053	538
ZEN	54336	0.8464	0.4991	121
Mean	48664	1.09073	0.6651	238

Table 2B
Percentage Quoted Spreads: Overlapped Trading Time

The table presents quoted spreads as a percent of mid points for U.K. securities and their corresponding U.S. ADRs for the overlapped trading time. The sample period is January 1, 1995 to December 31, 1995. Heteroskedastic-consistent t-statistics are reported for test of the null hypothesis of equal U.S. and U.K. spreads. The # of observations is the sum of New York and London observations.

Ticker	# of Observations	LSE % Spread	NYSE % Spread	T-Statistic for H_0: Equal Spreads
BAB	11290	0.9543	0.4406	145
BAS	7118	1.1616	1.1792	-1
BCS	16666	0.7325	1.2764	-34
BP	18862	1.0871	0.2258	709
BRG	8596	1.0828	0.7496	37
BST	10130	1.8155	0.7510	214
BTY	15413	0.7737	0.3933	142
CWP	14344	1.6994	0.9348	147
GLX	21440	1.1256	0.6155	165
GRM	9626	1.7371	0.8732	132
HAN	13711	1.3786	0.8418	135
ICI	15762	0.9189	0.4005	239
NW	17254	0.8771	0.6346	47
RTZ	8035	0.8295	0.9655	-10
SBH	16722	0.8917	0.5732	74
SC	12991	0.6669	0.3809	105
UL	9194	0.8151	0.9925	-13
VOD	27905	1.3527	0.5328	314
ZEN	12502	0.8352	0.5069	78
Mean	14082	1.09133	0.6983	138

Table 3
Quoted and Effective Spreads

The table presents quoted and effective spreads as a percent of mid points for U.K. securities and their corresponding U.S. ADRs based on data for the entire trading day in each country. All quoted spreads are trade-weighted. The sample period is January 1, 1995 to December 31, 1995. Diff is computed as (% quoted spread - % effective spread) ÷ % quoted spread. An asterisk in the last NYSE column indicates that the heteroskedasticity-consistent p-value is less than 5% in test of the null hypothesis that Diff is the same on both exchanges. The # of observations is the sum of New York and London observations.

	LSE				NYSE			
Ticker	# of Obs.	% Quoted Spread	% Effective Spread	Diff	# of Obs.	% Quoted Spread	% Effective Spread	Diff
BAB	46129	0.9609	0.4784	0.5029	4195	0.3856	0.2648	0.2413*
BAS	36443	1.1587	0.5993	0.4836	932	1.1329	0.8215	0.2262*
BCS	74478	0.7285	0.4165	0.4274	1381	1.3008	0.8884	0.2684*
BP	78746	1.0890	0.5850	0.4631	25682	0.2115	0.1274	0.2810*
BRG	160770	1.0719	0.5949	0.4447	3578	0.6182	0.4602	0.1460*
BST	36488	1.7926	1.1626	0.3522	11571	0.6418	0.4846	0.1490*
BTY	274551	0.7665	0.4280	0.4420	8726	0.3475	0.2453	0.2059*
CWP	63626	1.6929	0.8368	0.5069	32688	0.8413	0.6551	0.1329*
GLX	111183	1.1448	0.6152	0.4643	132991	0.5739	0.5093	0.0561*
GRM	60682	1.7367	0.9089	0.4768	13954	0.7755	0.5342	0.2033*
HAN	107394	1.3864	0.9124	0.3411	120730	0.8073	0.7331	0.0466*
ICI	51167	0.9151	0.4845	0.4715	12472	0.3597	0.2700	0.1627*
NW	65888	0.8734	0.4872	0.4407	3923	0.5725	0.3834	0.2612*
RTZ	49991	0.8324	0.4879	0.4167	1851	0.9150	0.5488	0.3591*
SBH	59435	0.9053	0.4786	0.4735	6417	0.5354	0.3808	0.2045*
SC	90806	0.6698	0.3504	0.4770	7541	0.3303	0.2311	0.2173*
UL	49318	0.8187	0.4159	0.4915	939	0.9631	0.6580	0.2643*
VOD	35503	1.3645	0.7513	0.4519	41810	0.4720	0.3716	0.1167*
ZEN	57072	0.8454	0.4490	0.4721	3482	0.4953	0.3227	0.2921*
Mean	79456	1.0923	0.6023	0.4526	22888	0.6463	0.4679	0.2018

Table 4
Percentage Effective Spread By Share Volume

The table presents the entire trading day's average percentage effective spread for three share volume categories during 1995 on the London Stock Exchange and the New York Stock Exchange. In forming the share volume categories, share volume on the LSE is adjusted by the ADR ratio to restate it in ADR units. An asterisk in the NYSE column for spread indicates that the heteroskedasticity-consistent p-value is less than 5% in test of the null hypothesis that the percentage effective spreads are the same on both exchanges.

	Share Volume = ½ NMS				½ NMS < Share Volume = NMS				Share Volume > NMS			
	LSE		NYSE		LSE		NYSE		LSE		NYSE	
Ticker	Number of Obs.	Eff. Spread	Number of Obs.	Eff. Spread	Number of Obs.	Eff. Spread	Number of Obs.	Eff. Spread	Number of Obs.	Eff. Spread	Number of Obs.	Eff. Spread
BAB	41363	0.4776	3821	0.2670*	2731	0.4369	249	0.2464*	2035	0.5514	125	0.2323*
BAS	31866	0.6031	922	0.8273*	2208	0.5525	7	0.3164	2369	0.5927	3	0.2323
BCS	67510	0.4180	1345	0.8930*	3506	0.3713	16	0.9221*	3462	0.4334	20	0.5552
BP	74467	0.5820	23533	0.1281*	2231	0.6331	1545	0.1178*	2048	0.6442	604	0.1242*
BRG	156529	0.5923	3516	0.4595*	1921	0.5939	37	0.5158	2320	0.7690	25	0.4833*
BST	32102	1.1700	11014	0.4842*	1471	1.0746	246	0.4983*	2915	1.1257	311	0.4888*
BTY	265058	0.4277	8263	0.2437*	4871	0.4162	303	0.2727*	4622	0.4530	160	0.2757*
CWP	57894	0.8318	32456	0.6551*	3314	0.8249	162	0.6547*	2418	0.9719	70	0.6586*
GLX	98133	0.6064	130546	0.5112*	6261	0.6178	1266	0.4050*	6789	0.7401	1179	0.4162*
GRM	51374	0.9004	13569	0.5328*	3971	0.9037	229	0.5852*	5337	0.9940	156	0.5797*
HAN	101705	0.9064	118695	0.7348*	2456	0.9476	899	0.6266*	3233	1.0743	1136	0.6432*
ICI	43051	0.4828	10952	0.2692*	3372	0.4439	673	0.2777*	4744	0.5280	847	0.2731*
NW	58379	0.4836	3844	0.3816*	3694	0.4562	59	0.4635	3815	0.5721	20	0.4894
RTZ	42757	0.4758	1793	0.5479*	2923	0.5066	40	0.5777	4311	0.5953	18	0.5707
SBH	50919	0.4787	6189	0.3800*	3720	0.4633	179	0.3996*	4796	0.4889	49	0.4150
SC	84867	0.3498	7337	0.2300*	3531	0.3242	158	0.2815	2408	0.4114	46	0.2323*
UL	45582	0.4186	930	0.6611*	2254	0.3547	4	0.6376	1482	0.4271	5	0.0971*
VOD	26213	0.7437	36661	0.3679*	4631	0.6925	2395	0.3662*	4659	0.8526	2754	0.4255*
ZEN	49161	0.4466	3216	0.3212*	3423	0.4101	103	0.3166*	4488	0.5046	163	0.3571*
Mean	72575	0.5998	22032	0.4682	3289	0.5802	451	0.4464	3592	0.6700	405	0.3973

Table 5A
Quote Clustering on the London Stock Exchange

The table presents the percentage of bid quotes that occurs under various tick categories during 1995 on the London Stock Exchange. Index is a summary measure of the clustering across tick categories.

		Tick categories in pennies									
Ticker	Index	0	1	2	3	4	5	6	7	8	9
BAB	0.00047	0.101	0.092	0.091	0.093	0.096	0.107	0.110	0.105	0.109	0.095
BAS	0.01966	0.158	0.069	0.082	0.146	0.039	0.153	0.072	0.099	0.143	0.039
BCS	0.00964	0.129	0.062	0.129	0.125	0.065	0.127	0.059	0.120	0.121	0.063
BP	0.00961	0.131	0.063	0.117	0.132	0.063	0.134	0.063	0.117	0.118	0.062
BRG	0.00164	0.098	0.093	0.090	0.083	0.087	0.099	0.107	0.127	0.115	0.102
BST	0.00050	0.097	0.100	0.103	0.103	0.104	0.109	0.107	0.102	0.090	0.085
BTY	0.00007	0.098	0.095	0.099	0.101	0.101	0.101	0.102	0.105	0.100	0.097
CWP	0.02037	0.153	0.074	0.077	0.158	0.039	0.151	0.076	0.090	0.144	0.037
GLX	0.02170	0.176	0.056	0.098	0.129	0.045	0.165	0.061	0.100	0.130	0.041
GRM	0.01834	0.152	0.066	0.076	0.146	0.044	0.149	0.074	0.103	0.147	0.043
HAN	0.00051	0.109	0.108	0.097	0.098	0.102	0.105	0.095	0.086	0.093	0.107
ICI	0.02215	0.161	0.069	0.071	0.153	0.039	0.153	0.073	0.092	0.151	0.037
NW	0.00960	0.136	0.063	0.126	0.123	0.064	0.123	0.055	0.116	0.125	0.068
RTZ	0.02237	0.164	0.071	0.082	0.150	0.031	0.147	0.076	0.092	0.153	0.035
SBH	0.01177	0.149	0.064	0.129	0.118	0.057	0.124	0.052	0.116	0.126	0.064
SC	0.01433	0.123	0.048	0.124	0.136	0.064	0.155	0.062	0.121	0.119	0.048
UL	0.03708	0.187	0.024	0.119	0.131	0.032	0.181	0.037	0.126	0.136	0.027
VOD	0.00002	0.102	0.101	0.102	0.100	0.099	0.098	0.100	0.101	0.098	0.099
ZEN	0.03307	0.189	0.041	0.100	0.133	0.032	0.183	0.049	0.109	0.136	0.029
Mean	0.01331	0.138	0.072	0.101	0.124	0.063	0.135	0.075	0.107	0.124	0.062

Table 5B
Trade Clustering on the London Stock Exchange

The table presents the percentage of trades that occurs under various tick categories during 1995 on the London Stock Exchange. Index is a summary measure of the clustering across tick categories.

		Tick categories in pennies									
Ticker	Index	0	1	2	3	4	5	6	7	8	9
BAB	0.00146	0.118	0.086	0.089	0.086	0.12	0.097	0.1	0.096	0.113	0.096
BAS	0.00182	0.127	0.088	0.097	0.107	0.083	0.111	0.09	0.098	0.113	0.087
BCS	0.00363	0.124	0.078	0.1	0.109	0.093	0.134	0.079	0.098	0.112	0.073
BP	0.00137	0.107	0.091	0.099	0.1	0.085	0.125	0.108	0.097	0.104	0.083
BRG	0.00268	0.098	0.086	0.085	0.083	0.095	0.091	0.093	0.12	0.135	0.115
BST	0.0009	0.111	0.086	0.089	0.095	0.112	0.113	0.1	0.09	0.099	0.104
BTY	0.00066	0.103	0.087	0.091	0.092	0.111	0.109	0.092	0.103	0.108	0.101
CWP	0.00044	0.107	0.093	0.097	0.102	0.09	0.107	0.104	0.104	0.106	0.089
GLX	0.00119	0.118	0.085	0.099	0.103	0.099	0.117	0.101	0.098	0.099	0.082
GRM	0.00077	0.115	0.102	0.103	0.105	0.086	0.1	0.089	0.1	0.11	0.091
HAN	0.00085	0.102	0.105	0.114	0.107	0.093	0.098	0.11	0.098	0.081	0.092
ICI	0.00363	0.138	0.078	0.108	0.108	0.086	0.121	0.085	0.095	0.105	0.075
NW	0.00368	0.131	0.083	0.12	0.121	0.083	0.112	0.078	0.09	0.104	0.076
RTZ	0.00221	0.136	0.081	0.102	0.102	0.094	0.113	0.091	0.099	0.099	0.084
SBH	0.0027	0.112	0.095	0.123	0.125	0.097	0.113	0.079	0.086	0.092	0.078
SC	0.0027	0.107	0.073	0.091	0.104	0.089	0.127	0.1	0.11	0.12	0.079
UL	0.00689	0.143	0.072	0.105	0.114	0.079	0.137	0.076	0.101	0.112	0.061
VOD	0.00027	0.106	0.098	0.097	0.105	0.093	0.097	0.095	0.105	0.108	0.095
ZEN	0.00839	0.145	0.063	0.104	0.111	0.073	0.143	0.079	0.103	0.118	0.061
Mean	0.00243	0.118	0.086	0.101	0.104	0.093	0.114	0.092	0.100	0.107	0.085

Table 6A
Quote Clustering on the New York Stock Exchange

The table presents the percentage of bid quotes that occurs under various tick categories during 1995 on the New York Stock Exchange. Index is a summary measure of the clustering across tick categories.

		Tick categories in eighths							
Ticker	Index	0	1	2	3	4	5	6	7
BAB	0.00127	0.125	0.110	0.129	0.115	0.149	0.134	0.129	0.109
BAS	0.00169	0.126	0.106	0.112	0.139	0.110	0.129	0.152	0.126
BCS	0.01859	0.185	0.089	0.164	0.086	0.178	0.086	0.158	0.054
BP	0.00032	0.136	0.125	0.128	0.118	0.114	0.125	0.128	0.126
BRG	0.00813	0.188	0.129	0.136	0.069	0.134	0.100	0.129	0.114
BST	0.00081	0.138	0.116	0.131	0.111	0.113	0.138	0.131	0.123
BTY	0.00144	0.128	0.113	0.142	0.124	0.140	0.116	0.135	0.102
CWP	0.00251	0.128	0.104	0.117	0.133	0.126	0.155	0.141	0.097
GLX	0.00108	0.128	0.131	0.123	0.108	0.111	0.118	0.143	0.138
GRM	0.00073	0.128	0.109	0.128	0.116	0.133	0.118	0.141	0.127
HAN	0.00573	0.112	0.075	0.100	0.167	0.140	0.143	0.128	0.136
ICI	0.00123	0.143	0.113	0.124	0.104	0.140	0.126	0.119	0.132
NW	0.00769	0.177	0.079	0.112	0.098	0.149	0.116	0.158	0.111
RTZ	0.02958	0.200	0.058	0.140	0.068	0.228	0.092	0.151	0.064
SBH	0.00173	0.138	0.119	0.135	0.134	0.136	0.108	0.134	0.096
SC	0.00273	0.149	0.106	0.124	0.119	0.148	0.108	0.144	0.102
UL	0.03911	0.237	0.060	0.145	0.053	0.204	0.070	0.177	0.055
VOD	0.00136	0.110	0.115	0.140	0.145	0.137	0.120	0.123	0.110
ZEN	0.00122	0.132	0.124	0.125	0.129	0.139	0.113	0.138	0.100
Mean	0.00668	0.148	0.104	0.129	0.112	0.144	0.117	0.140	0.106

Table 6B
Trade Clustering on the New York Stock Exchange

The table presents the percentage of trades that occurs under various tick categories during 1995 on the New York Stock Exchange. Index is a summary measure of the clustering across tick categories.

		Tick categories in eighths							
Ticker	Index	0	1	2	3	4	5	6	7
BAB	0.00168	0.134	0.097	0.125	0.115	0.142	0.129	0.143	0.115
BAS	0.00216	0.161	0.114	0.114	0.106	0.129	0.127	0.113	0.135
BCS	0.02411	0.207	0.056	0.147	0.1	0.2	0.085	0.142	0.062
BP	0.00076	0.143	0.124	0.137	0.12	0.118	0.116	0.127	0.113
BRG	0.0067	0.176	0.136	0.155	0.085	0.119	0.101	0.129	0.096
BST	0.00111	0.144	0.12	0.125	0.116	0.109	0.12	0.144	0.122
BTY	0.00281	0.133	0.091	0.125	0.138	0.154	0.108	0.136	0.114
CWP	0.00161	0.125	0.103	0.109	0.122	0.141	0.126	0.149	0.125
GLX	0.00223	0.163	0.121	0.117	0.109	0.128	0.104	0.13	0.127
GRM	0.00111	0.14	0.11	0.12	0.115	0.137	0.11	0.131	0.137
HAN	0.00423	0.133	0.098	0.096	0.124	0.175	0.126	0.116	0.127
ICI	0.00224	0.163	0.13	0.125	0.1	0.126	0.121	0.119	0.116
NW	0.0073	0.191	0.091	0.135	0.1	0.13	0.097	0.14	0.117
RTZ	0.01201	0.196	0.097	0.128	0.067	0.159	0.103	0.148	0.102
SBH	0.00248	0.153	0.11	0.126	0.131	0.147	0.106	0.126	0.101
SC	0.00138	0.151	0.117	0.139	0.116	0.132	0.115	0.117	0.112
UL	0.02754	0.222	0.075	0.156	0.068	0.183	0.063	0.161	0.07
VOD	0.00221	0.125	0.101	0.116	0.135	0.16	0.124	0.128	0.111
ZEN	0.00108	0.131	0.105	0.129	0.116	0.144	0.121	0.135	0.117
Mean	0.00551	0.157	0.105	0.128	0.110	0.144	0.111	0.133	0.112

Table 7
Correlations between Spreads and Clustering Measures

The table presents the correlations across firms of mean quoted spreads, trade clustering, bid clustering, and ask clustering. The number in parentheses is the p-value for test of the null hypothesis that the correlation is zero. The sample period is January 1, 1995 to December 31, 1995. The U.K. price data are in pounds and the U.S. price data are in dollars. There is one observation per stock. The upper triangle contains the LSE correlations and the lower triangle the NYSE correlations.

	Spread	Trade Clustering	Bid Clustering	Ask Clustering
Spread	1	0.58763 (0.0082)	0.97736 (0.0001)	0.97737 (0.0001)
Trade Clustering	0.94372 (0.0001)	1	0.6624 (0.0020)	0.66236 (0.0020)
Bid Clustering	0.93316 (0.0001)	0.90287 (0.0001)	1	1 (0.0001)
Ask Clustering	0.93318 (0.0001)	0.90293 (0.0001)	1 (0.0001)	1

Table 8
Quoted Depth

The table presents the quoted depth during 1995 on the London Stock Exchange and the New York Stock Exchange. Depth on the LSE is represented by the "NMS," the normal market size or the minimum quantity that a market maker is obliged to quote for a firm two-way price on the LSE's Stock Exchange Automated Quotation System. The NMS has been adjusted by the ADR ratio to restate it in ADR units. Depth on the NYSE is the average of bid and ask depths. An asterisk in the NYSE Depth columns indicates that the heteroskedasticity-consistent p-value is less than 5% in test of the null hypothesis that the depth is the same on both exchanges.

Ticker	LSE NMS	NYSE Entire Trading Day	NYSE Overlap Trading Time
BAB	10,000	3,874*	4,227*
BAS	25,000	3,760*	4,571*
BCS	18,750	4,556*	5,168*
BP	16,667	9,214*	9,224*
BRG	20,000	4,874*	5,577*
BST	20,000	13,492*	13,916*
BTY	10,000	5,316*	5,960*
CWP	33,333	13,398*	13,678*
GLX	25,000	56,137*	55,981*
GRM	12,500	6,749*	6,385*
HAN	40,000	65,613*	66,349*
ICI	6,250	7,188*	7,452*
NW	12,500	3,769*	4,405*
RTZ	6,250	1,908*	2,276*
SBH	10,000	3,617*	3,886*
SC	16,667	4,200*	4,617*
UL	12,500	2,484*	3,031*
VOD	10,000	20,306*	19,600*
ZEN	8,333	3,935*	4,474*
Mean	16,513	12,336	12,673

Table 9

Trade Size By Share Volume

The table presents the entire trading day's average share volume per trade for three share volume categories during 1995 on the London Stock Exchange and the New York Stock Exchange. Share volume on the LSE is adjusted by the ADR ratio to restate it in ADR units. An asterisk in the NYSE column indicates that the heteroskedasticity-consistent p-value is less than 5% in test of the null hypothesis that the trade sizes are the same on both exchanges.

	Share Volume = ½ NMS				½ NMS < Share Volume = NMS				Share Volume > NMS			
	LSE		NYSE		LSE		NYSE		LSE		NYSE	
Ticker	% of Total Obs	Trade Size	% of Total Obs	Trade Size	% of Total Obs	Trade Size	% of Total Obs	Trade Size	% of Total Obs	Trade Size	% of Total Obs	Trade Size
BAB	0.90	594	0.91	890*	0.06	8758	0.06	8429*	0.04	26420	0.03	24691
BAS	0.87	1434	0.99	555*	0.06	20789	0.01	20029	0.07	74061	0.00	475900
BCS	0.91	652	0.97	559*	0.05	13211	0.01	11094*	0.05	47585	0.01	64860*
BP	0.95	799	0.92	1198*	0.03	12854	0.06	11050*	0.03	42022	0.02	29979
BRG	0.97	479	0.98	820*	0.01	15779	0.01	14042*	0.01	59029	0.01	60832
BST	0.88	1329	0.95	862*	0.04	16006	0.02	14925*	0.08	57234	0.03	54253
BTY	0.97	206	0.95	562*	0.02	8767	0.04	8276*	0.02	30366	0.02	22321*
CWP	0.91	1933	0.99	609*	0.05	28753	0.00	23143*	0.04	93092	0.00	86238
GLX	0.88	1338	0.98	592*	0.06	21634	0.01	19816*	0.06	78811	0.01	67856*
GRM	0.85	881	0.97	529*	0.07	10526	0.02	9312*	0.09	44224	0.01	33042*
HAN	0.95	1656	0.98	901*	0.02	31320	0.01	28607*	0.03	110303	0.01	97244*
ICI	0.84	324	0.88	538*	0.07	5405	0.05	4622*	0.09	21743	0.07	18615*
NW	0.89	522	0.98	607*	0.06	8811	0.02	9147	0.06	32783	0.00	37040
RTZ	0.86	366	0.97	371	0.06	5270	0.02	4482*	0.09	23897	0.01	11960*
SBH	0.86	570	0.96	765*	0.06	8700	0.03	8099*	0.08	33412	0.01	45880
SC	0.93	643	0.97	779*	0.04	14706	0.02	10726*	0.03	51899	0.01	56845
UL	0.92	585	0.99	412*	0.05	10268	0.00	9950*	0.03	33620	0.00	94300*
VOD	0.74	1120	0.87	801*	0.13	8959	0.06	8596*	0.13	32984	0.07	36374*
ZEN	0.86	419	0.92	535*	0.06	7205	0.03	5449*	0.08	26370	0.05	15314*
Mean	0.89	834	0.96	678	0.05	13564	0.03	12094	0.06	48413	0.02	70186