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5 Transaction Costs in Dealer Markets: Evidence from the London Stock Exchange

Peter C. Reiss and Ingrid M. Werner

5.1 Introduction

New electronic trading technologies have drastically reduced the costs of financial transactions and put tremendous pressure on financial exchanges to lower their costs. In 1986, the London Stock Exchange (LSE) responded to these pressures by switching from a closed, floor-based, broker-dealer market to an open electronic quotation system dubbed SEAQ. The LSE's SEAQ system operates much like the National Association of Securities Dealers' Nasdaq dealer system. On SEAQ, competing market makers post bid and ask prices and guaranteed trade sizes. Although SEAQ also displays trade information, brokers and dealers still negotiate trades by phone. Besides changing its quotation systems, the LSE enacted new rules designed to encourage competition and narrow quoted spreads. These rules included the elimination of fixed commissions and member entry barriers, and the adoption of best execution rules. The exchange also imposed minimum quote sizes. The minimum quote size for a security is the number of shares market makers must stand ready to trade at their posted prices. On SEAQ, these minimums are large, equaling 2, and

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sometimes more, percent of a security's average daily trading volume. To reduce the capital risks associated with large trades, the exchange granted market makers the right to delay their disclosure. During 1991, SEAQ delayed releasing information on large trades for up to ninety minutes. Currently, they delay disclosing information on extremely large trades for up to one week!

The LSE's emphasis on liquidity over transparency has renewed debate about whether such rules affect the costs of financial transactions. A recent International Organization of Securities Commissions report (1993) observed that few studies have examined the determinants of transaction costs in dealership markets. Several empirical studies report substantial intersecurity and interday variation in Nasdaq and SEAQ dealer spreads. Few examine the relationship between spreads and transaction prices, or consider how exchange rules might affect spreads. This paper uses newly available SEAQ intraday quotation and transaction data to analyze the relationship between investor transaction costs and best bid-ask spreads. Using unique information in SEAQ data, we show that LSE rules lead dealers to offer systematic discounts from posted prices. These discounts vary across traders, securities, and trade characteristics.

We also argue that conventional transaction cost measures do not recognize important institutional features of dealership markets. On SEAQ, these include minimum quote sizes and best execution rules. These rules affect dealers' quoted prices and their willingness to offer traders discounts. Contrary to the assumptions of many theoretical models, SEAQ market makers do not compete by narrowing (symmetric) quotes. Indeed, they almost *never* narrow the quoted spread between their bid and ask prices. They instead compete by positioning their bid or ask on or at the market bid or offer. Curiously, they may maintain these positions for hours or days, offering traders discounts instead of changing what they advertise on SEAQ screens. We find, as some theoretical models do, that dealer discounts usually increase with the size of a trade. We also find puzzles. Surprisingly, discounts for customers, brokers, and market makers all decrease with market-maker concentration and increase with market depth. These heterogeneities raise new theoretical and empirical questions about how dealer competition affects the relation between quoted prices and transaction prices.

Section 5.2 begins with a review of prior research on transaction costs, particularly transaction costs in dealer markets. We then show that several standard transaction cost measures may over- or underrepresent dealer discounts from quoted spreads. We illustrate our arguments using SEAQ and Nasdaq intraday trade and quotation data for Cadbury Schweppes, a heavily traded FTSE-100 (Financial Times–Stock Exchange) equity. We find that SEAQ Cadbury quoted bid-ask spreads are slightly higher than Nasdaq spreads. More notable are differences in the price discounts offered by Nasdaq and SEAQ market makers. Though some research suggests that dealers offer only other dealers discounts from quoted prices, this is not true on SEAQ. SEAQ market makers grant discounts to medium and large retail orders more often than they do to each other. The median retail discount increases uniformly with order size, and applies to many orders larger than the Cadbury minimum quote size. We conclude the Cadbury example by developing a new measure of transaction costs, what we term the *adjusted apparent spread.* This measure reveals how dealers vary spreads and discounts with trade characteristics. We estimate these adjusted apparent spreads using quantile regression techniques. These regressions flexibly describe the distribution of Cadbury discounts conditional on trade size and trader identities.

Section 5.3 analyzes 1991 quotation data for 1,887 U.K. and Irish equities to isolate inter- and intrasecurity variations in quoted prices. We find striking variation. Best bid-ask spreads range from less than 1 percent of share value to over 50 percent! Much of this variation is systematic. As on Nasdaq, quoted and best bid-ask spreads decline as the number of posting market makers increases. It also appears that greater capital risks associated with higher minimum quote sizes may cause market makers to widen their spreads. Dealer participation in actively "making the market" also falls as turnover increases. At any instant, nearly one-third of the market makers in a heavily traded equity post noncompetitive prices. While our empirical methods do not disentangle the interplay among dealer concentration, spreads, and volume, we examine whether trade-size economies or order-processing costs could explain these correlations. We find limited evidence that they do.

Section 5.4 analyzes a smaller sample of sixty SEAQ securities divided equally among three market capitalization classes. Conventional transaction cost statistics imply that each capitalization class has best bid-ask spreads comparable to Nasdaq spreads. Our conditional apparent spread measures show that transaction costs for individual securities differ substantially because of differences in the extent of discounting. Some of these differences occur because trade characteristics differ across market capitalization classes. For instance, FTSE-100 equities appear to have lower transaction costs because they have relatively more discounted interdealer trades. Other differences occur because market makers and brokers charge different customers different prices. The median customer trade is never discounted by market makers, but nonregistered dealers give their median customers substantial discounts. We also show that market makers appear unwilling to give each other price breaks over the phone, but do when trading anonymously through interdealer brokers. Finally, we find some evidence that large orders receive greater discounts in less concentrated markets.

5.2 Measuring Transaction Costs in Dealer Markets

Investors incur several types of transaction costs each time they trade. These include commissions, differences between purchase and sale prices, and costs related to the price impact of trades. This paper exclusively analyzes differences between purchase and sales prices. We analyze spreads largely because we do not have detailed data on commissions. In 1991, the exchange estimated that commissions on trades between £50,001 and £100,000 averaged 0.23 percent of price. Smaller round lots paid as much as 6.11 percent, and orders greater than £1,000,000 an average of 0.15 percent.[1] These commissions only accentuate the spread-related size discounts we report below.

Prior theoretical and empirical market microstructure research has devoted considerable effort to modeling how market makers set spreads. Most conceptual models focus on a single market maker or specialist. These models show how factors such as limit order competition and a trade's size affect specialists' spreads. Many models, for instance, conclude that larger trades will be charged larger spreads. In inventory models, this occurs because of inventory risk; in adverse selection models, it occurs because large trades move prices.[2]

Empirical research on the determinants of spreads has struggled with the question of how to estimate transaction costs when transaction prices differ from dealers' posted quotes. Much of this research relies on New York Stock Exchange (NYSE) intraday transaction and quotation data. This research reveals that specialists vary their spreads in systematic ways (e.g., Brock and Kleidon [1992]; McInish and Wood [1992]; and Foster and Viswanathan [1993]). These findings have inspired new theoretical models of trade between different types of investors and market intermediaries.

Fewer papers have modeled the behavior of market makers in dealer quotation markets. Models by Ho and Stoll (1983), Grossman and Miller (1988), Glosten (1992), Madhavan (1992), Biais (1993), Dennert (1993), and others show that strategic interactions among market makers can considerably complicate relationships between spreads and trade characteristics. Consider, for example, the conclusion cited above that specialists will charge large orders larger spreads. In dealership markets, such a policy would give large traders an incentive to split trades among dealers. Absent centralized information on the identities of traders, dealers will have a harder time identifying and pricing informed trades. Recently, Glosten (1994) has shown that minimum tick sizes may similarly constrain dealers' abilities to charge large orders high spreads. His model also provides some intuition for how SEAQ minimum quote sizes may affect spreads. By forcing dealers to accept large and small trades at the same price, SEAQ rules on minimum quote size give market makers incentives to widen spreads. By widening spreads, SEAQ market makers can protect themselves against inventory imbalances and informed trades while simultaneously retaining an option to offer execution within their guaranteed quotes. What is unclear is whether competition will force market makers to offer discounts. Studies of NYSE specialists suggest that they offer only small orders

1. *Quality of Markets Review, Summer 1991* (London: London Stock Exchange, 1991), 17–24.

2. Some of these predictions carry over to models of dealer markets. For papers that model inventory risks, see, e.g., Garman (1976); Amihud and Mendelson (1980); and Ho and Stoll (1981, 1983). Admati (1991) surveys papers that model adverse selection risks.

discounts. Large floor trades receive less favorable execution at or outside the bid and ask.[3]

Few studies have examined the relation between quoted prices and transaction prices in dealer markets. Some descriptions of Nasdaq claim that only interdealer or Instinet transactions trade within the quoted spread. A recent study by the LSE's Quality of Markets Group estimated that nearly 35 percent of SEAQ trades occur within the best bid-ask spread.[4] Some researchers speculate that these are interdealer trades. Others interpret this statistic as evidence that SEAQ quoted prices do not contain much information. The LSE's *Quality of Markets Review* and Neuberger and Schwartz (1989) report that not all trades within the spread are dealer trades. These comparisons do not show, however, whether other characteristics also affect discounts. The analysis below shows that while many trades within the best bid-ask spread on SEAQ are interdealer trades, large customer trades also receive favorable execution. Small and very large trades usually do not.[5] We now illustrate how trader identities and other factors affect SEAQ transaction costs.

5.2.1 Cadbury Schweppes: An Introductory Example

We begin our analysis of SEAQ transaction costs by analyzing what conventional transaction cost measures reveal about the cost of trading Cadbury Schweppes, a heavily traded FTSE-100 stock. We analyze Cadbury for several reasons. First, by focusing on a single security we can more clearly describe SEAQ trading rules that might affect transaction costs. Second, during the period we studied Cadbury Schweppes, market makers had to accept trades as large as £100,000—quite large by Nasdaq and SEAQ standards. Third, Cadbury Schweppes shares also trade on Nasdaq as American Depository Receipts (ADRs). This dual trading of Cadbury shares allows us to compare transaction costs in two very similar dealer markets.

The Cadbury SEAQ data come from separate settlement and quotation records maintained by the LSE. The Nasdaq data come from the Institute for the Study of Security Markets. Subsequent sections and an appendix describe these data in greater detail. Table 5.1 provides conventional descriptive statistics on Cadbury transactions during 1991. The top section of the table contains transaction costs statistics developed in prior studies. Following convention, we express each as a percentage of Cadbury's average share price. For comparison, we also convert each to a pound sterling estimate of the spread cost on a median-size SEAQ trade (roughly 1,500 shares). These measures convey very

3. Lee (1993) finds liquidity premiums, defined as an absolute difference between trade prices and the bid-ask midpoints, that increase with trade size.

4. See *Stock Exchange Quarterly and Quality of Markets Review: Spring Edition* (London: London Stock Exchange, 1992), 27.

5. SEAQ does not require market makers to offer best execution to very large trades. For additional evidence on SEAQ size discounts, see Breedon (1993); De Jong, Nijman, and Röell (1993); and Hansch and Neuberger (1993).

Table 5.1 **SEAQ and Nasdaq Descriptive Statistics for Cadbury Schweppes**

	SEAQ			Nasdaq		
Average Transaction Cost Measure		Percent of Price	Cost for Median SEAQ Trade (pounds)		Percent of Price	Cost for Median SEAQ Trade (pounds)
Touch spread[a]		0.85	49.90		0.71	41.68
Roll's spread[b]		0.73	42.86		0.53	31.12
Effective spread[c]		0.72	42.27		0.60	35.23
Effective spread excluding trades outside touch		0.70	41.10		0.58	34.05
Weighted effective spread[d]		0.63	36.99		0.50	29.36
Weighted effective spread excluding trades outside touch		0.54	31.70		0.47	27.59
Percent Distribution of Trades by		Value	Number		Value	Number
Trades outside touch		7.6	2.3		2.3	1.6
Trades at touch		40.8	70.8		65.9	78.3
Trades inside touch		51.6	26.9		31.8	20.1
Bid-Ask Discounts		Average as Percent of Price	Estimated Discount for Median SEAQ Trade (pounds)		Average as Percent of Price	Estimated Discount for Median SEAQ Trade (pounds)
All trades[e]		0.075	4.40		0.052	3.05
Excluding trades outside touch		0.085	4.99		0.063	3.70
Percent Distribution of the Touch by	Minutes Market Is Open	Times When Trades Occur	Value of Trades Occurring	Minutes Market Is Open	Times When Trades Occur	Value of Trades Occurring
Touch < −0.01 pence	0.0	0.0	0.0	0.0	0.2	0.1

$-0.01 \leq$ Touch $<$ 0.50 pence	0.0	0.0	0.1	0.1	0.0	0.1
$0.50 \leq$ Touch $<$ 1.50 pence	0.5	0.7	1.0	8.4	6.3	8.3
$1.50 \leq$ Touch $<$ 2.50 pence	16.0	17.6	19.6	27.2	36.2	41.5
$2.50 \leq$ Touch $<$ 3.50 pence	46.5	46.6	45.6	22.9	25.1	24.0
$3.50 \leq$ Touch $<$ 4.50 pence	26.3	25.2	24.3	39.0	28.5	23.7
$4.50 \leq$ Touch $<$ 5.50 pence	10.7	9.8	9.3	2.4	3.0	1.7
$5.50 \leq$ Touch $<$ 6.50 pence	0.0	0.0	0.0	0.0	0.7	0.4
$6.50 \leq$ Touch $<$ 7.50 pence	0.0	0.0	0.0	0.0	0.1	0.1
Average touch by time (pence)	3.257			2.860		
Intraday standard deviation (pence)	0.547			0.649		
Interday standard deviation (pence)	0.484			0.595		

General Characteristics

Average transaction price (pounds)	3.84	3.96
Number of market makers	16	>25
Capital risk at minimum quote size (pounds)[f]	95,906	15,823
Number of trades	24,967	5,837
Average trade size (pounds)	58,115	42,044
Median trade size (pounds)	5,871	15,840
Total trading volume (1,000 pounds)	1,450,957	241,991

Sources: SEAQ data were drawn from the LSE computer records for the periods January 14–March 18, April 2–June 24, July 1–September 24, and October 14–December 27, 1991. The missing periods are due to retrieval problems. Nasdaq data were drawn from the Institute for the Study of Security Markets tapes for January 1–December 31, 1991. All statistics exclude trades before 8:30 (9:00) A.M. and after 4:30 (4:00) P.M. for SEAQ (Nasdaq).

[a]The touch spread is the average across transactions of 100 (Ask − Bid)/Trade Price.

[b]Roll's spread measure is two times the square root of minus the serial covariance of price changes.

[c]The effective spread is the average across transactions of 2 × 100 × |Trade Price − (Best Ask + Best Bid)/2|/Trade Price.

[d]The volume-weighted average of the equation in note c. See Lee and Ready (1991).

[e]The average discount is the average across transactions of 100 × |Trade Price − Best Quote|/Trade Price, where the Best Quote is the bid (ask) for a customer sell (buy).

[f]Capital risk is calculated based on the average stock price. The minimum quote size for Cadbury Schweppes is twenty-five thousand shares on SEAQ. Exceptions are given for two market-making firms who may post smaller quote sizes. The maximum quote size for Nasdaq trading of Cadbury Schweppes was one thousand ADRs.

different impressions of transaction costs, both on the same exchange (reading down columns) or between exchanges (reading across pairs of columns). SEAQ spread-related cost estimates range from 0.54 to 0.85 percent, a difference of £18 on the average trade. Nasdaq cost estimates range from 0.47 to 0.71, a difference of £13.5. On both exchanges, the difference between the best bid and ask is clearly a weak upper bound on costs. The average discount from the best bid or ask on SEAQ is 0.07 percent, or roughly £4.4 on a median-size trade.

Comparing spreads across exchanges, we find that Nasdaq has lower spread-related transaction costs. The best bid-ask statistics show that on a median-size SEAQ trade, Nasdaq traders save £8.2! The value-weighted Nasdaq measures also show that large Nasdaq trades receive substantial discounts from quoted prices. When one excludes trades outside the best bid-ask and weights spreads by value, however, it appears that there is no substantial difference between SEAQ and Nasdaq. The distribution of trade values about the best bid-ask prices provides one possible explanation for the difference narrowing. Although SEAQ has wider best bid-ask spreads, a larger percentage of large SEAQ trades go through inside the best bid-ask prices. The difference between the SEAQ value-weighted and the unweighted effective spreads suggests that SEAQ transaction costs fall substantially with the size of a trade. The difference between the effective spreads of £5.3 roughly equals the commission on a £2,300 trade.

Although the statistics in table 5.1 suggest that Cadbury traders receive better prices on Nasdaq, these average comparisons mask systematic differences in Nasdaq and SEAQ dealer discount policies. The middle section of table 5.1 shows how the timing of trades affects the cost comparisons in the top section. It reports the percentage distribution of the best bid-ask spread by minutes the markets are open, number of trades, and trade value. On SEAQ, for example, 26.3 percent of the time (two hours and six minutes of a trading day) a trader can expect to pay a four-pence spread. Roughly one-fourth of SEAQ trades and shares transact at this spread. On Nasdaq, however, the best bid-ask spread is around four pence 39 percent of the time, yet few trades or shares transact at this spread. There are several possible explanations for this phenomenon. Nasdaq traders might be in a better position to trade when spread costs are low, or Nasdaq market makers might compete more for trades during high-volume periods. Our general point is that traditional comparisons of average transaction costs do not distinguish between these explanations. In what follows, we propose measures that isolate these differences better.

Before developing our measures, we first describe features of Nasdaq and SEAQ that influence how we construct and interpret our measures. Figures 5.1 and 5.2 display quotation and trading histories for Cadbury on two arbitrarily chosen days, October 16 and 17, 1991. These figures illustrate where trades occurs relative to the best bid and ask on SEAQ and Nasdaq. The solid lines are the best bid and offer. London traders call this the "touch." The dashed vertical lines mark the official open and close on Nasdaq and the unofficial open and close on SEAQ. (The appendix describes the SEAQ data and trading procedures in greater detail.) Figures 5.1A and 5.1B show the unique information we have on SEAQ trades. They display customer orders, interdealer trades, and crossing trades. Figures 5.1C and 5.1D display the Nasdaq data. Like most publicly available data, the Nasdaq data do not identify trade counterparties. Figures 5.1A and 5.1B show that the SEAQ touch does not vary much during the course of the trading day. Most customer trades (dots and triangles) go through at the touch. By contrast, many dealer trades (circles and stars) execute within the touch. The figures also show that SEAQ market makers do not use a fixed tick-size rule when offering discounts. The black stars represent interdealer broker (IDB) trades executed on one of four anonymous electronic bulletin boards. The four IDB systems provide services similar to those offered to Nasdaq dealers by Instinet. Generally, it appears that SEAQ trades are distributed randomly throughout the day, and there are no obvious anomalies when Nasdaq opens. On both days, at least one customer sell order executes outside the touch. These trades seemingly violate SEAQ's best execution rule (see the appendix).

During this period, sixteen SEAQ market makers and over twenty-five Nasdaq market makers posted quotes and took trades. Though not pictured, each SEAQ market maker had a quoted spread of five pence. That is, the difference between their quoted bid and ask prices was five pence. Cadbury market makers maintained this spread virtually the entire year![6] Since the market touch was four pence or less on these two days, no SEAQ market maker ever simultaneously posted at the best bid and best ask. Unfortunately, we do not have similar information for Nasdaq. Other studies, however, suggest that Nasdaq market makers rarely post both the best bid and ask (see Chan, Christie, and Schultz [1995]).

Comparing contemporaneous touch spreads, we see that SEAQ has a slightly larger spread on October 16 and a smaller one on the 17th. These differences are not large enough to cause arbitrage. Figure 5.2 provides information about the size of trades. In each panel, we have scaled the area of the circles to represent the number of shares traded. This figure suggests that, in contrast to the NYSE, some but not nearly all large trades execute inside the touch. The IDB trades and broker trades are also larger than the average customer trade. Finally, the figure suggests that large interdealer trades usually, though not always, execute within the spread.

5.2.2 Estimating Transaction Costs: Adjusted Apparent Spreads

Table 5.1 and figures 5.1 and 5.2 together reveal substantial differences in transaction spreads. The obvious challenge is to devise measures that isolate

6. There are a few instances when market makers posted wider spreads (seven, eight, and ten pence) but these are extremely rare.

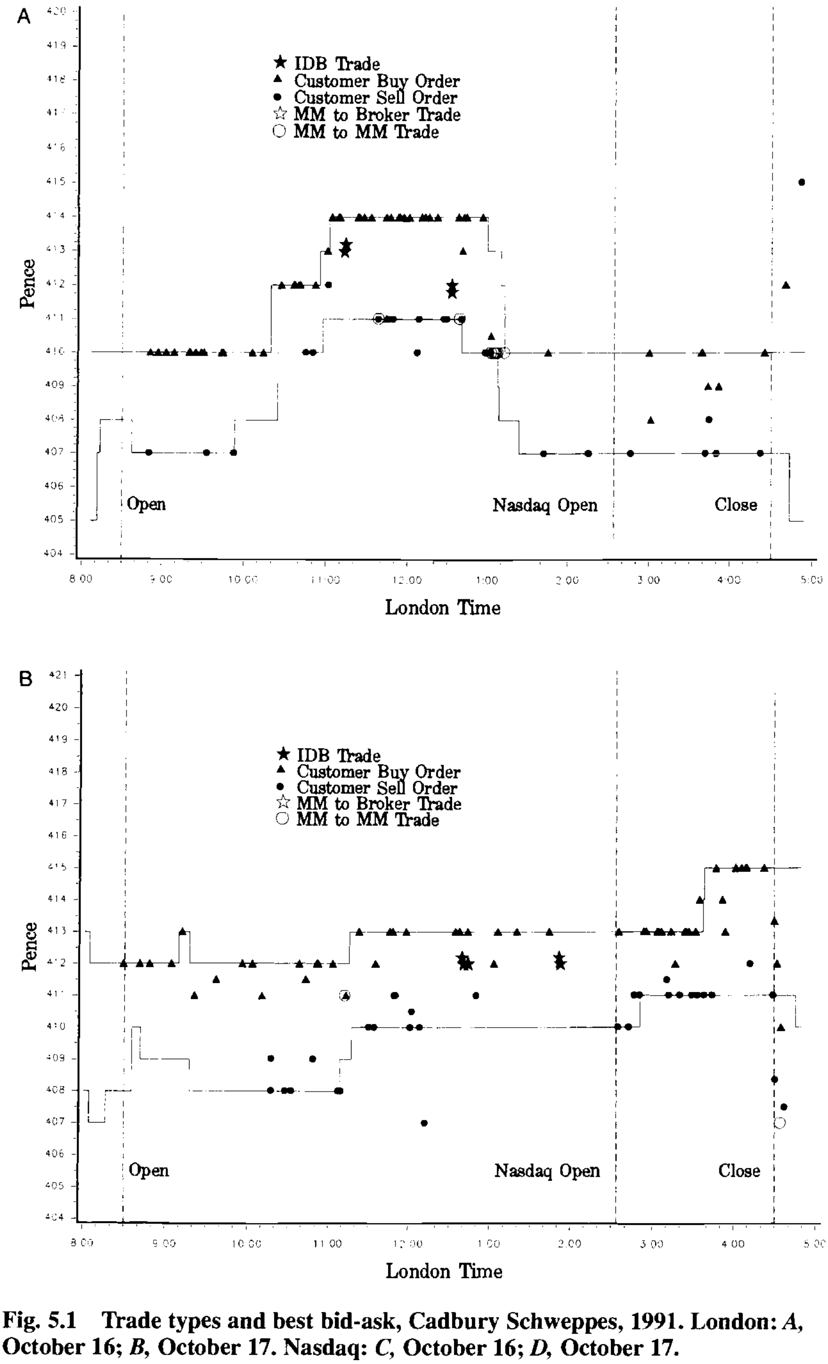
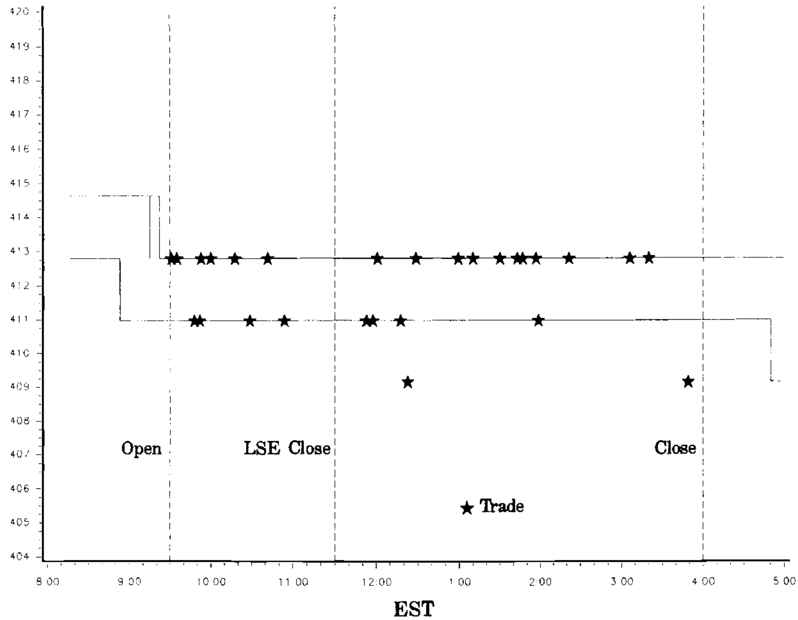


Fig. 5.1 Trade types and best bid-ask, Cadbury Schweppes, 1991. London: *A*, October 16; *B*, October 17. Nasdaq: *C*, October 16; *D*, October 17.

Notes: IDB = interdealer broker; *MM* = market maker.

C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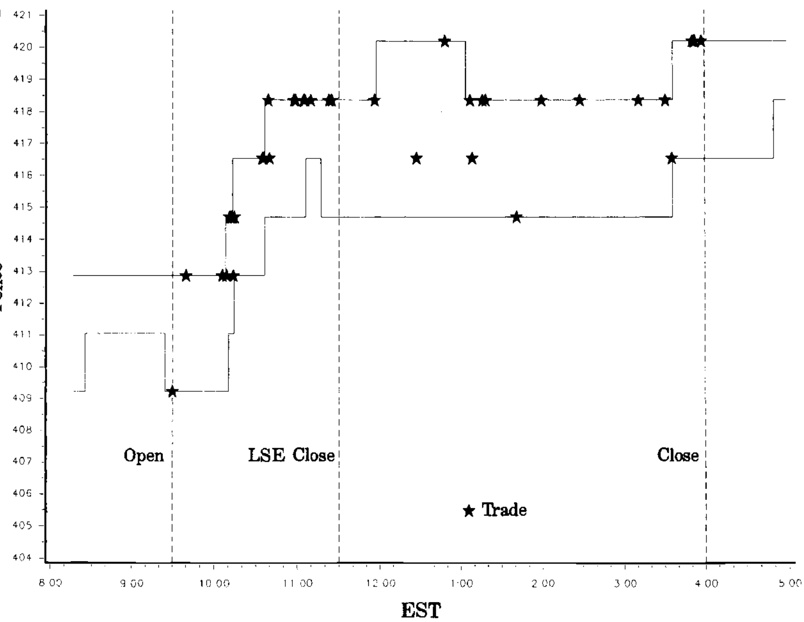
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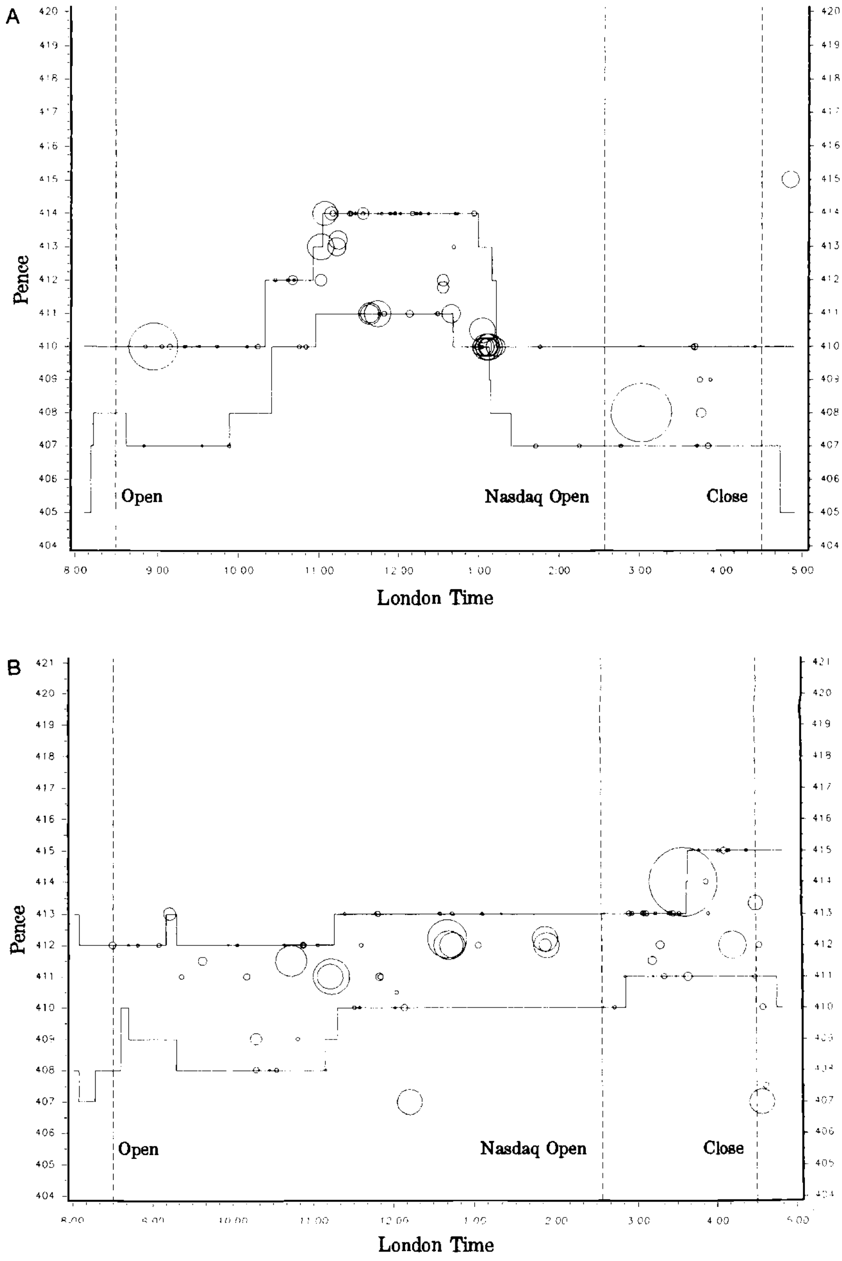
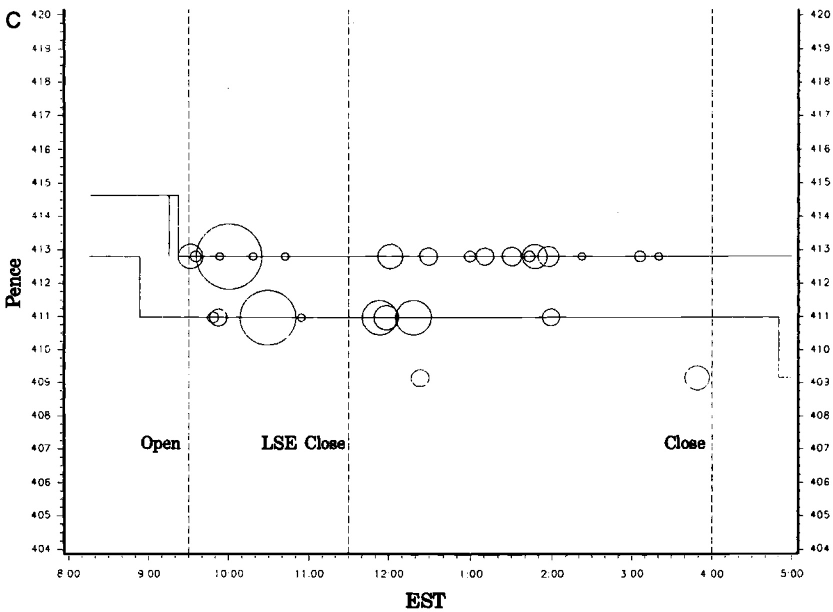


Fig. 5.2 Trade sizes and best bid-ask, Cadbury Schweppes, 1991. London: *A*, October 16; *B*, October 17. Nasdaq: *C*, October 16; *D*, October 17.

Note: Circle area is proportional to trade size.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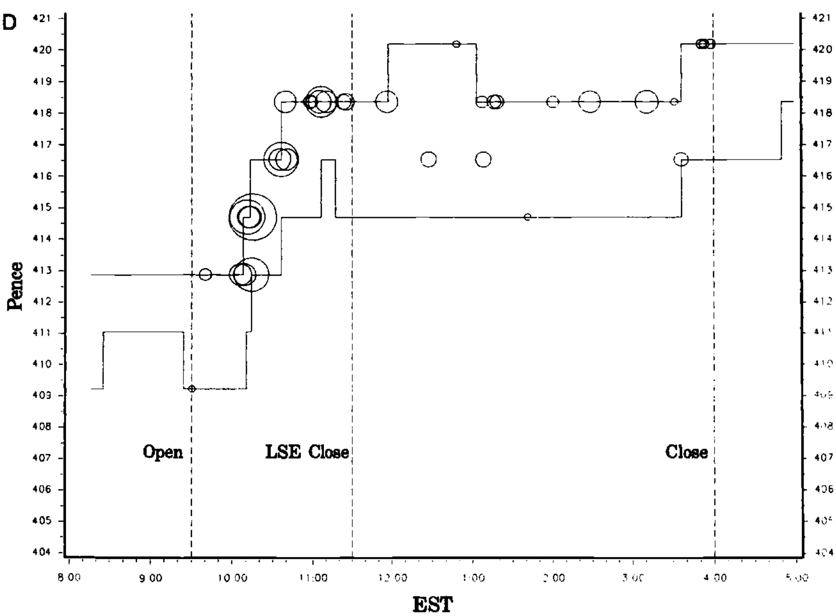
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these differences. Demsetz's (1968) original work suggested one should interpret the quoted spread as a security dealer's price for immediacy. In theory, the price of immediacy is the difference between an investor's purchase or sales price and the asset's "true" or "immediate" value. As Demsetz and others note, researchers and dealers rarely know an asset's true value. There is little agreement among researchers, however, on how to define or measure immediate value. The definition we adopt is the instantaneous cost of a round-trip transaction—what we call the apparent cost or *apparent spread* incurred by *simultaneously purchasing and selling shares*. We adopt this definition because it follows Demsetz's concept of immediacy and because it pairs the costs of comparable trades. The obvious practical problem with our definition is that one rarely observes comparable simultaneous buy and sell orders. To explain how we overcome this problem, we briefly summarize other approaches.

Prior researchers have measured transaction costs by averaging best bid-ask spreads or by inferring implicit spreads from neighboring transaction prices. Figure 5.3 illustrates several problems with these approaches. For simplicity, it presumes that the touch is constant. As in figure 5.2, the areas of the circles represent each trade's size. The effective spread at time $t - 1$, $2 \times E_{t-1}$, measures transaction costs as the deviation of price from the touch midpoint. This measure implicitly assumes that the midpoint is the asset's "true value," or that the discount on a reverse transaction would receive the same discount. Since on SEAQ the same dealer rarely posts both the best bid and ask, it is unclear why the touch midpoint is the best way to measure a SEAQ security's true value. Indeed, the Cadbury data reveal that the average of dealers' quotes can differ substantially from the touch midpoint. For instance, occasionally fifteen market makers will be at the ask and only one at the bid. Do these positions signal that the touch midpoint is not the "average" or true price? This question is difficult to answer. We would like in principle to have a measure of transaction costs that incorporates this information, since the positions of dealers may affect their willingness to offer discounts.

Figure 5.3 also displays another popular measure of spread-related transaction costs, those based on differences in neighboring buy and sell transaction

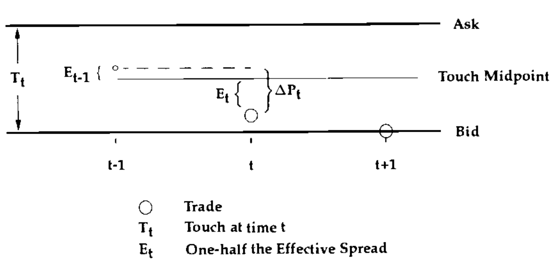


Fig. 5.3 Conventional spread measures

prices. At time t, ΔP_t measures the difference between a small buy and a large sell order. This implicit spread measure has the advantage that it does not require quotation information. The figure, however, reveals a potential drawback. Since it compares the discounts of different-size trades, it can mask size discounts. The same caveat applies to spread measures proposed by Roll (1984) and others. These measures estimate spreads from serial covariances of transaction price changes. Although subsequent research has refined Roll's measure to allow for drifting spreads and dealer inventories, few studies condition these serial covariances on other observable trade characteristics, such as order size. Some studies also have used regression analysis to condition price changes on past price changes and trade characteristics.[7] These regressions, however, usually do not relate price changes to information about the touch or dealers' quotes.

Figure 5.4 illustrates how we propose to use trade characteristics and price information to develop a measure of transaction costs. The figure displays a sell order receiving a discount D_t from the best quoted bid. We define the apparent spread on this transaction, AS_t, as the difference between the transaction price P_t and the quoted *ask.* The apparent spread provides an upper bound on transaction costs because SEAQ's best execution would guarantee a reverse purchase execution at or within the ask. An obvious question is, why is the quoted ask the appropriate benchmark for the reverse (round-trip) transaction? Aside from SEAQ best execution rules, there is no guarantee that a market maker will execute the reverse buy order at the touch.

Since we do not observe the reverse discount, we propose to estimate it. One possible estimate of what a market maker might offer is the discount D on the customer's original sale. If this discount is applied to the ask, we obtain the effective spread. If this discount is applied to a dealer's ask price above the market ask, then we can obtain a price that is outside the touch. This assignment rule therefore can violate the exchange's best execution rule. Since there is little reason to believe that the same dealer will execute the reverse transaction at the same discount, we propose an econometric model of discounts that uses past information to predict what dealers would offer under current conditions. Using this model, we construct an estimate of the reverse transaction discount $\hat{D}$ and then define the round-trip transaction cost as the *adjusted apparent spread,* that is, the difference between the apparent spread and the estimated discount, or $\widehat{AAS} = AS - \hat{D}$.

The key element of our approach is the econometric model that predicts discounts using trade information. Ideally, we should develop this model from a rich theory that predicts how dealers use information to set spreads and discounts. Formally, we would like to know the structure of $D = D(\Omega_t)$, where Ω_t

7. Compare Ho and Macris (1984); Glosten (1987); Glosten and Harris (1988); Stoll (1989); Harris (1990); Madhavan and Smidt (1991); Hasbrouck (1991); Lee and Ready (1991); and Lee, Mucklow, and Ready (1993).

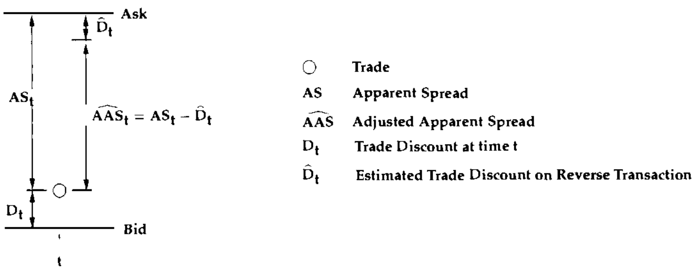


Fig. 5.4 Adjusted apparent spread

represents the market maker's information at the time of trade. Because we are unlikely to observe everything in Ω_t, we must adopt an alternative model. We formulate a conditional prediction model by assuming discounts are random draws from a density

$$f(D_t \mid \omega_t). \tag{1}$$

Here f represents the observed density function of discounts, and ω_t represents our information. By examining how the observed conditioning variables ω_t affect f, we hope to identify what factors determine dealer discounts, and thus transaction costs.

In principle, we would use a variety of statistical techniques to estimate how the conditioning variables ω_t affect f. We chose to use quantile regressions. These regressions describe how the quantiles (or percentiles) of D vary with ω_t (see Koenker and Basset [1978]). We chose conditional quantiles over means primarily to minimize the influence of misclassified trades, a problem present in most intraday transaction data sets. To underscore the point that these quantile regressions do not produce "structural" estimates of parameters underlying $D(\Omega_t)$, we suppress the coefficients from the underlying regressions and instead report point predictions and approximate standard errors. To the extent that we have statistical hypotheses, they are that particular variables do not explain observed discounts. In work not reported here, we have explored the robustness of our predictions using split-sample techniques. These checks convince us that the quantile estimates are reasonably accurate for all but very large trades.

5.2.3 Apparent Spreads for Cadbury Schweppes

To date, we have estimated very simple models of discounts and spreads. In future work, we plan to experiment with other conditioning variables, such as the direction of trades. The specifications we report here examine whether and how discounts vary with the trade counterparties (for SEAQ only), the size of trades, and the touch. While previous studies have examined the separate impact of the touch and the size of trades, our specifications allow for interactions between the two. To our knowledge, we are the first to estimate counterparty effects.

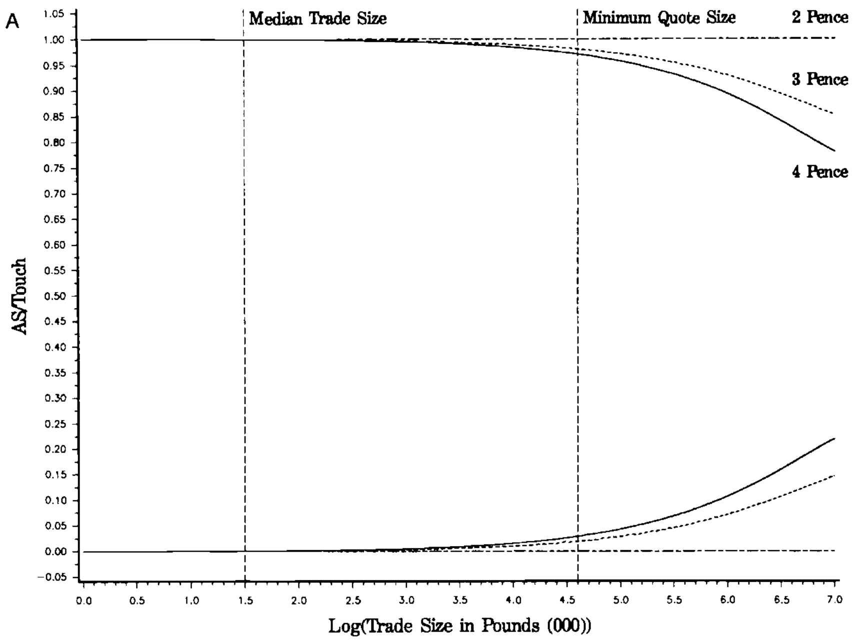
Since we do not use conditioning variables that would generate asymmetric discounts, we treat discounts symmetrically by modeling apparent spreads. We assume SEAQ apparent spreads (AS = Touch − Discount) equal

$$AS_i = \text{Touch} - \text{Discount}_i = \sum_{j=0}^{3}[\beta_{0,i} + \beta_{1,i}\,\text{Touch}] \times (\text{Trade Size}_i)^j + \varepsilon_i, \tag{2}$$

where i indexes types of trades (IDB, customer, market-maker, and broker trades), the β's are unknown coefficients, and ε is an unobserved error. In words, the apparent spreads are a polynomial in trade size and interactions with the touch at the time of the trade. We include touch interactions on the right-hand side to allow for the possibility that apparent spreads may depend on the (guaranteed) touch spread. The Nasdaq regressions have a similar structure. They use quartic polynomials in trade size and do not have coefficients that depend on trade types.

Figures 5.5A–5.5C plot the estimated apparent spread quartiles by size of trade, the touch, and trader identities. To simplify comparisons between SEAQ and Nasdaq, we have expressed the apparent spreads as a fraction of the prevailing touch. The vertical differences between the top horizontal curves and the horizontal axis equal the estimated apparent spread divided by the touch. The vertical differences between pairs of similarly shaped curves are the estimated adjusted apparent spreads, our measure of the cost of an instantaneous round-trip transaction. Figure 5.5A displays how the median cost for a SEAQ customer trade depends on the touch and the trade's size. The vertical dashed lines mark the median Cadbury trade size (approximately £4,500) and the largest trade Cadbury market makers must accept at their posted bid or ask prices (approximately £100,000). The median-size customer trade executes at the touch, no matter what the touch. As Cadbury's touch widens from two to three to four pence, the median large customer trade receives deeper and deeper discounts. At four pence, a trade larger than £1,000,000 receives roughly a 25 percent discount (one pence per share, or £2,600 total). These estimates confirm that only very large (usually institutional) trades are likely to receive discounts. Even these large trades, however, are not assured discounts. The graphs also show that trade discounts do not widen at the same rate as the touch. That is, when the touch widens by one pence, the total discount from the bid and the ask does not increase by one pence. This shows that market makers do not use discounts to maintain a constant pence spread.

Figure 5.5B summarizes the variation in customer transaction costs holding the touch constant at three pence (the sample median). The three curves represent the first, second (median), and third apparent spread quartiles. Vertical differences between similar curves again equal estimated adjusted apparent



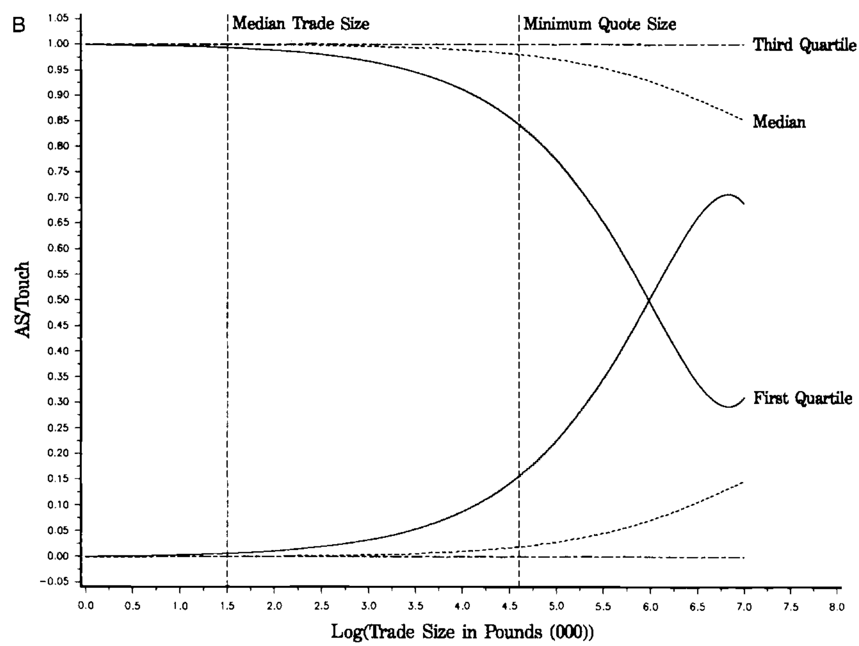
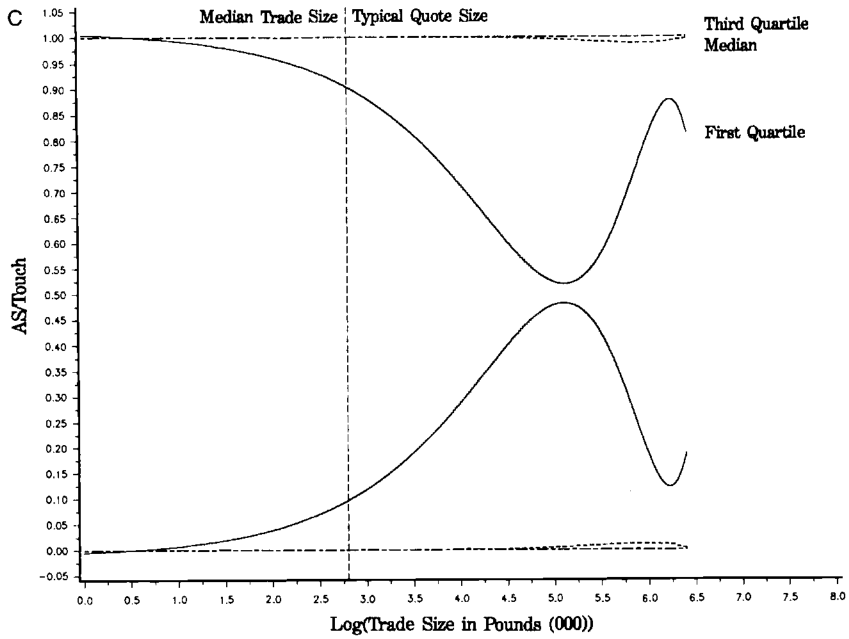
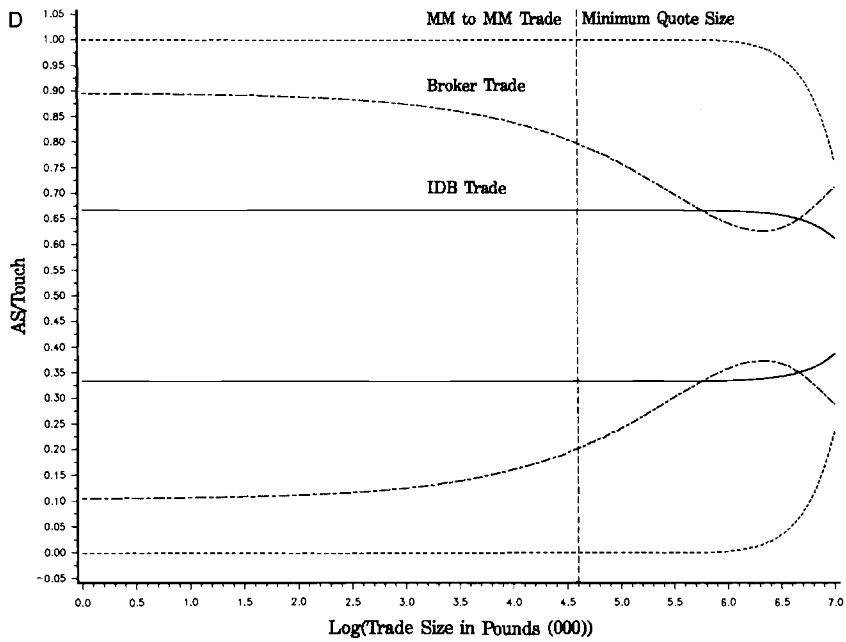


Fig. 5.5 Apparent spread by log(trade size), Cadbury Schweppes, 1991. Customer trades: *A*, London, median apparent spread/touch. *B*, London, apparent spread/touch quartiles. *C*, Nasdaq, apparent spread/touch quartiles. Dealer trades: *D*, London, median apparent spread/touch.

Notes: IDB = interdealer broker; *MM* = market maker.


C
Median Trade Size
Typical Quote Size
Third Quartile
Median
First Quartile
AS/Touch
Log(Trade Size in Pounds (000))


D
MM to MM Trade
Minimum Quote Size
Broker Trade
IDB Trade
AS/Touch
Log(Trade Size in Pounds (000))

spreads. Note that there is no interquartile difference in apparent spreads at or below the median trade size. In other words, nearly all small retail orders pay the quoted spread. This finding appears at odds with asymmetric information models that predict small uninformed trades will receive more favorable execution. Upper-quartile customer trades appear to receive no discount up to the minimum quote size of £100,000. Surprisingly, beyond the minimum quote size the dispersion in discounts increases. Nearly 25 percent of customer trades larger than £400,000 receive at least 50 percent discount, implying the adjusted apparent spread is zero or negative. The infrequency of large trades, however, reduces the precision of our estimates.

The frequency with which we observe trades of a given type and size is a key determinant of the statistical precision of our estimates. Generally, we observe many more small trades than we do large, and many more trades at three pence than we do at two or four pence. A plot of apparent spreads by trade size also reveals that market makers tend to clump discounts on whole pence, though the exchange does not have tick-size rules. To provide an indication of the precision of our point estimates across ranges of trade values, we calculated standard errors using Chamberlain's (1993) suggested approximations. These estimated standards confirm that the (point) precision of our estimates in figure 5.5B deteriorates as the size of the trade increases. At the median trade size, the standard deviation of the median apparent spread to touch ratio is 0.02. Thus, at a touch of three pence, a 95 percent confidence interval for the median apparent spread is 2.79 to 2.91 pence. For transactions near £150,000, the standard deviation rises to 0.04, by £300,000 it is 0.10, and by £400,000 it is 0.19. Thus, we do not estimate apparent spreads precisely beyond two to three times the minimum quote size (£100,000).

Figure 5.5C shows the estimated distribution of spreads for Nasdaq, holding the touch constant at three pence. We estimate that more than 50 percent of Nasdaq trades execute at the touch and thus receive no discount. Lower-quartile trades receive discounts at most sizes. The Nasdaq quartiles are more curved than SEAQ quartiles, with discounts of 50 percent effectively eliminating the spread for trades over £150,000. At larger sizes, the discount diminishes and then appears to increase. Since we observe few trades in this range, we do not attach much significance to this increase. For now, we tentatively conclude that Nasdaq and SEAQ market makers have roughly comparable discount policies.

Finally, figure 5.5D displays how the median spreads of IDB, market maker–to–market maker, and dealer-to-dealer (or market maker) trades vary with a trade's size. Our calculations assume the touch is three pence. Because the SEAQ data do not identify which of the two SEAQ dealers initiates a trade, we classify dealer trades as buy (sell) orders based on whether the observed price is above (below) the touch midpoint. The vertical dashed line indicates the minimum quote size. Each type of interdeal trade has a median size roughly equal to the minimum quote size. The median market maker–to–

market maker trade below £400,000 pays the full spread. This is perhaps not too surprising, since dealers negotiate these trades over the phone and market makers cannot tell whether the order is for the market maker or a customer. When market makers deal anonymously with each other using IDBs, however, they discount the spread by about one-third, or one pence. This also is not surprising, since IDB users purchase for (sell from) their own account so that they can subsequently sell to (buy from) a customer. SEAQ brokers seem to grant market makers and other brokers deep discounts. This results from an exchange rule requiring that dealers, when acting as a principal in a trade, have to deal at better prices than the touch. The median broker discount reaches a maximum of more than one-third the touch, or one pence, for trades around £540,000. Curiously, we observe few broker trades compared to the number of market maker–to–market maker trades.

5.3 Intersecurity Variations in Quoted and Touch Spreads

The Cadbury example suggests that transaction costs vary systematically with trader identities and order sizes. This leads us to question whether the Cadbury example is representative of SEAQ transaction costs. Ideally we would like to answer this question by using quantile regressions to estimate which factors affect each SEAQ security's adjusted apparent spread. These calculations would allow us to distinguish between security, security class, and exchange-specific variations in transaction costs. Unfortunately, our data and econometric methods currently do not allow us to analyze a large sample of SEAQ securities. The main obstacle we face is the time required to match separate transaction and quotation records. The exchange transaction records, for example, require extensive checking to identify IDB trades and to match "shape" trades (see the appendix).

Although we continue to work toward a longer-term goal of matching all SEAQ quotation and transaction data, this paper examines two narrower SEAQ samples. This section analyzes the fourth quarter 1991 quotation records of 1,887 U.K. and Irish equities. The main advantage of this sample is its broad coverage. These securities accounted for over 95 percent of 1991 SEAQ trading volume. Its main drawback is it contains only quotation information. Consequently, we can make statements only about how quoted prices and volumes vary across securities. Section 5.4 uses matched quotation and transaction data on sixty of these securities to find whether customers pay quoted spreads.

The Cadbury results suggest that we should find differences in spreads across securities, if only because the size of trades and characteristics of traders will vary across securities. The main issue we address here is, are there other factors that may cause residual differences? We can think of several, including the inherent riskiness of securities, the amount of total trading volume, and the number and identities of market makers.

Previous studies of Nasdaq spreads have found significant cross-section variation in best bid-ask spreads. Much of this variation appears related to trading volume, with spreads declining rapidly as share volume increases and dealer concentration decreases. Some researchers interpret these relations as evidence of the benefits of market-maker competition. That is, market makers compete harder when there are more market makers. Other researchers attribute the decline to the high cost of marketing low-volume equities. What is unclear is why dealers of low-volume stocks have high costs. Given the similarities in the SEAQ and Nasdaq quotation systems, we also might expect to see spreads on SEAQ securities fall as trading volume increases. Indeed, we do. This raises the issue, how should one interpret the rate at which spreads decline? Our answer is that the decline reveals the economies of scale in market making.

Several rules introduced by the LSE in the mideighties encourage market-maker competition on SEAQ. First, the exchange allows free entry into market making, provided market makers have adequate capital. Second, the exchange allows market makers to quit or add securities on short notice. Third, the major costs of making markets, the market makers' time and capital, are largely fixed and not sunk costs. Together these conditions suggest that even market makers for small-volume stocks face substantial (potential) competition. Provided there is some slope to the demand for any individual market maker's services, this competition will result in a familiar monopolistic competition equilibrium: competitive entry will make each market maker's demand curve tangent to their average dealing-cost curve. If trading volume in a stock increases, competing market makers will enter, and reestablish the tangency condition. Afterward, each market maker will operate at a higher volume and charge a lower spread (since average dealing costs decline with volume). Thus, in a monopolistically competitive dealer market, the fall in spreads with trading volume reveals the shape of market makers' average dealing cost function and the extent of scale economies (see Bresnahan and Reiss [1991]). Also, this theory predicts that it is the number of actual and not potential competitors that best predicts the decline in spreads. For example, if the number of market makers that could potentially make a market increases from two to ten, we would see no change in spreads. Whereas, if the ten entered, we would see a decrease in spreads.

Table 5.2 and figure 5.6 report how the distribution of quoted spreads and best bid-ask spreads vary across the 1,887 SEAQ equities. We condition spreads on the number of market makers posting quotes, as opposed to the number of market makers eligible to post quotes. We note again that this conditioning does not have a causal interpretation. Instead, we base this conditioning on the monopolistic competition prediction that securities with little trading volume will have few dealers, and that each of these dealers will have higher costs. The spreads underlying the table and figure are quarterly medians of average daily spreads. We calculated a security's average daily spread by aver-

Table 5.2 **SEAQ Quote Statistics by Number of Market Makers**

Number of Market Makers	Number of Securities	Quoted Spread (% of price) Quartiles 1	2	3	Touch Spread (% of price) Quartiles 1	2	3	Median Cost for 1,000-Share Trade at Touch[a] (pounds)	Median Number of Market Makers at Best Ask	Best Bid	Neither	Median Number of Quote Postings[b] per Day and Market Maker	Median-Minimum Quote Size (pounds)
1	22	6.19	14.84	28.57	6.19	14.83	28.57	57.28	1.00	1.00	0.00	1.00	386
2	551	5.18	9.01	15.38	4.65	8.02	13.95	29.97	2.00	2.00	0.00	1.00	374
3	454	3.76	6.47	11.11	3.12	5.25	9.17	23.82	2.00	2.00	0.00	1.00	454
4	355	3.11	5.51	10.75	2.43	4.31	8.45	19.40	2.74	2.69	0.00	1.00	1,800
5	211	1.68	4.05	7.48	2.32	2.79	5.15	15.55	2.96	2.89	0.00	1.20	3,345
6	158	2.01	2.76	4.50	1.38	2.02	3.70	16.27	3.06	3.00	0.06	1.50	8,052
7	89	1.95	2.68	4.60	1.37	1.91	3.39	19.95	3.13	3.21	0.87	1.71	20,888
8	43	1.68	2.52	3.54	1.22	1.77	2.53	21.04	4.01	3.92	0.77	2.12	23,775
9	34	1.68	2.04	3.32	1.04	1.57	2.31	20.42	4.49	4.03	1.08	3.56	39,026
10	25	1.40	1.82	3.29	0.97	1.44	2.48	14.77	5.39	5.14	1.02	4.20	51,300
11	22	1.53	2.51	3.74	1.10	1.65	2.40	20.17	4.98	4.69	1.44	3.64	61,120
12	30	1.28	1.75	3.31	0.91	1.16	2.13	20.02	4.14	4.30	3.56	5.79	86,310
13	59	1.31	1.57	2.29	0.88	1.29	1.61	19.83	6.57	5.69	2.00	5.46	76,860
14	66	1.28	1.60	2.33	0.79	1.13	1.67	15.54	6.20	5.27	2.87	5.25	137,480
15	53	1.35	1.59	2.31	0.74	1.12	1.65	14.93	5.04	4.71	5.17	6.07	133,310
16	20	1.26	1.43	1.99	0.69	0.90	1.23	13.69	4.85	4.92	6.81	6.03	152,070
17	7	0.95	1.30	1.53	0.69	0.79	0.91	15.01	7.44	6.14	4.37	7.35	142,541

Notes: Based on 1,887 U.K. and Irish equities with more than twenty days of trading activity during the period October 14–December 27, 1991. The number of sample observations exceeds 1,887 because some securities experienced changes in the number of market makers during the sample period. The underlying data are daily averages (8:30 A.M. to 4:30 P.M.) of minute-to-minute quotation histories. Quantiles are computed by calculating medians across days by security and across market-maker concentrations.

[a]The median cost for trade at the touch is estimated as the difference between the touch and the touch midpoint times the value of a thousand-share trade.

[b]Number of quote postings = 1.0 means that one quote was posted at the start of trading and was not changed during the day.

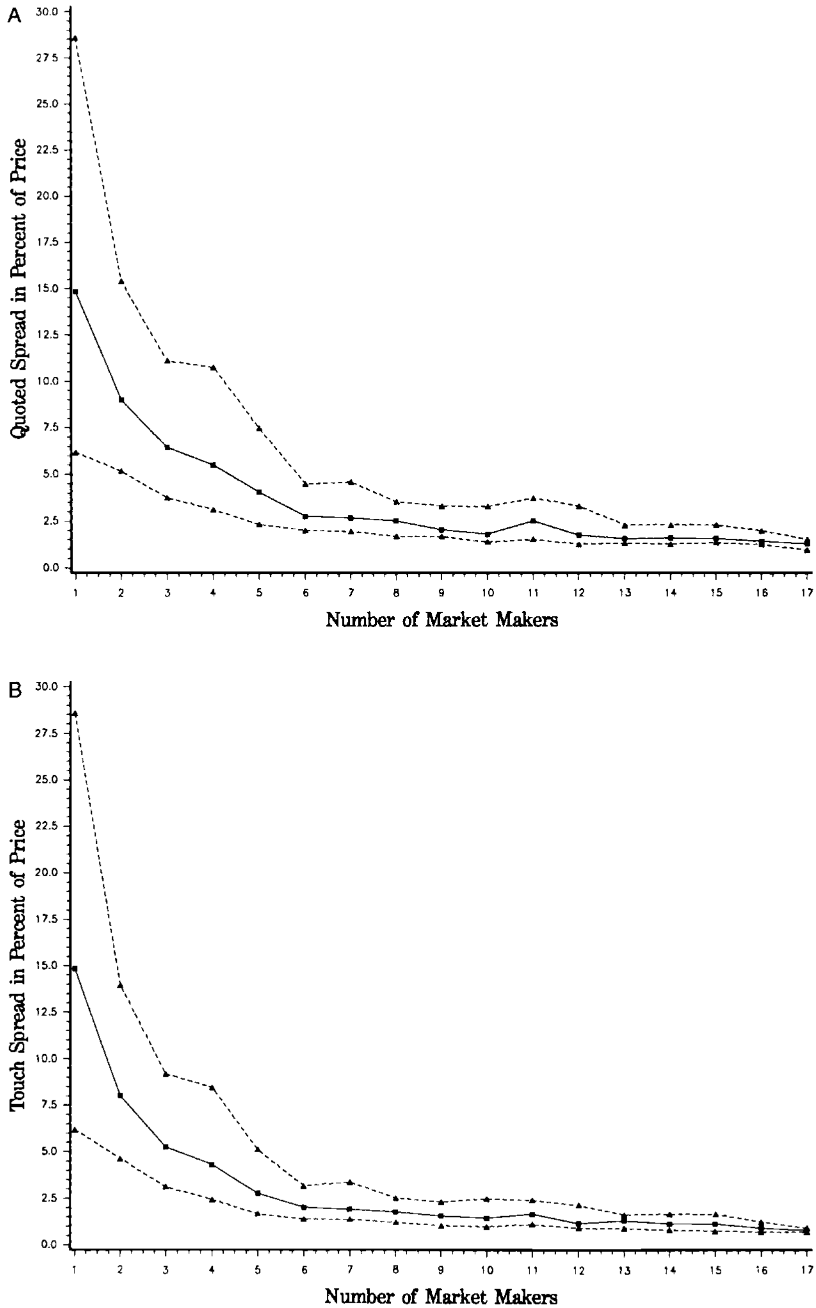


Fig. 5.6 Spread quartiles by number of market makers for 1,887 SEAQ ordinary equities, fourth quarter 1991. ***A,*** **quoted spread.** ***B,*** **touch spread.**

aging minute-to-minute spreads during the quotation period: 8:30 A.M. to 4:30 P.M. To summarize the variation in these median spreads given a particular number of quoting market makers (i.e., market structure), we report the *quartiles of these medians.* Thus, the median of the median touch spreads of monopoly dealers is 14.83 percent of price. The median touch spread in the highest six monopoly markets is greater than 28.57 percent of price, and so on. Table 5.2 shows that the difference in the median touch spreads for markets with one versus five market makers is 12 percent of price. The interquartile range for five market makers is only 2 percent of price. This large drop suggests there are scale economies at small volumes, and that low-volume dealers have excess capacity. The median minimum quote sizes in the far right column, which are based on the past twelve months' trading volume, confirm that customer transaction costs, as measured by touch spreads, fall with trading volume.

Figure 5.6A graphically displays how quickly the interquartile range and medians of quoted spreads fall as market concentration decreases and share volume increases. Figure 5.6B does the same for touch spreads. The figures and table suggest that dealers achieve most scale economies in markets with minimum quote sizes of £15,000 to £25,000, which roughly corresponds to a market with five to eight dealers. Table 5.2 provides additional evidence. It shows that the median cost of a thousand-share trade executed at the touch falls from £57.28 when trading with a monopolist to around £16–£20 when trading with a dealer with four to seven competitors. The quoted spreads of the largest stocks in our sample, the FTSE-100 equities, exhibit little interquartile dispersion, conditional or unconditional on the number of market makers. A monopolistic competition model would predict that these dealers are near the bottom of their average dealing-cost curves, which roughly corresponds to minimum quote sizes of £50,000 to £75,000. Based on the exchange's rule for calculating minimum quote sizes, this corresponds to an annual trading volume of between £500 and £700 million.

The figure and table 5.2 reveal other interesting regularities. Touch spreads fall at roughly the same rate as quoted spreads. In percentage terms, the gap between the two widens as the number of market makers increases. This perhaps suggests that market makers allow themselves more leeway in moving quotes when they face greater competition. The relation is still somewhat odd, since there is no obvious reason why quoted (as opposed to equilibrium spreads) should change with the number of competitors. Table 5.2 also reveals how dealers' posting behavior may affect the difference between quoted and touch spreads. Columns ten through twelve of table 5.2 show that market makers are usually either at the best bid, best ask, or setting quotes outside the market. For instance, the median security with nine market makers will have four market makers at the best bid and four at the best ask. The gap between the touch and quoted spread suggests the four dealers setting the best ask are not the same four setting the best bid. The remaining market maker straddles both the best bid and ask. By doing so, this market maker avoids most of the inventory and information risks associated with unsolicited trades.

The second to last column of table 5.2 reports the median number of times per day a market maker changes its price quotes. Although we know of no obvious benchmark for this number, we were struck by how infrequently market makers adjust their stated willingness to take trades. One might attribute constant quoted prices to infrequent turnover, yet even FTSE-100 market makers change their quotes less than once per hour! One explanation for these persistent prices is that the large minimum quote sizes substantially increase market makers' capital risk. This risk causes them to widen spreads. By fixing wide spreads, they retain the option to vary transaction prices without changing quotes. We now consider how frequently they offer discounts from the touch spread.

5.4 Further Evidence on Apparent Spreads

The analyses in sections 5.2 and 5.3 reveal substantial variation in spreads by security, trader, time, and trade size. This section estimates an econometric model that isolates the contribution of these factors to apparent spreads. Our data sample consists of fourth-quarter 1991 quotation and transaction histories for sixty SEAQ securities. We randomly chose the sixty securities so that they would equally represent large (i.e., FTSE-100), medium, and small capitalization SEAQ securities. We limited the sample to sixty securities because of the time required to match and check quotation and trade data. The fourth quarter is the most recent we have (see the appendix).

The three market capitalization classes roughly divide the sixty securities into three volume, market-structure, and price-size classes. Tables 5.3 and 5A.1 provide information on these classes and the sample securities. Comparing tables 5.2 and 5.3, it appears that the sample represents the range of SEAQ dealer concentration and trading volumes. During the mandatory quotation period, the FTSE-100 securities averaged 106 trades per day, totaling £7,156,000, compared to 13 trades totaling £646,000 for medium equities and 5 trades totaling £83,000 for smaller equities. The average number of market makers ranges from 12.6 for FTSE-100 equities, to 6.2 and 4.7 for medium and small equities. The quoted and touch spread statistics in table 5.3 also span those in table 5.2.

Table 5.3 provides median quoted, touch, effective, and adjusted apparent spreads for each security. Although these medians mask intrasecurity variation in transaction costs, they reveal considerable variation in spreads within and across size classes. Most of this intersecurity variation occurs because these securities have different security prices, and not because they have different pence spreads. For instance, Cadbury Schweppes (CBRY) has median touch, apparent, and effective spreads of three pence. So does Abbey National (ANL). The percentage differences in table 5.3 occur because Abbey's price is two-

Table 5.3 **SEAQ Median Spreads as a Percentage of Average Trade Price**

FTSE-100 Size Class					Medium-Size Class					Smaller-Size Class				
Security Code	Adjusted Apparent Spread	Touch Spread	Effective Spread	Quoted Spread	Security Code	Adjusted Apparent Spread	Touch Spread	Effective Spread	Quoted Spread	Security Code	Adjusted Apparent spread	Touch Spread	Effective Spread	Quoted Spread
BT.A	0.56	0.56	0.56	0.83	SVC	1.05	1.26	0.84	1.69	ANU	4.45	4.45	4.45	5.93
GUIN	0.67	0.67	0.67	1.17	BOS	1.24	1.24	1.24	1.55	SEP	3.63	3.63	3.63	6.05
MKS	0.70	0.70	0.70	1.05	THK	1.07	1.29	1.07	2.15	LILY	2.74	4.12	2.74	5.49
RTZ	0.77	0.77	0.77	1.35	BNZL	2.87	3.44	2.29	4.59	BDN	2.65	2.65	2.65	3.53
LLOY	0.78	1.05	0.78	1.31	COST	4.59	4.59	4.59	7.64	BYNS	3.31	3.31	3.31	4.96
ANL	1.08	1.08	1.08	1.43	WOLV	1.21	1.38	1.21	1.73	OWN	1.31	1.75	1.31	1.75
SUN	0.96	0.96	0.96	1.28	SCPA	1.19	1.79	1.19	2.39	SNGT	0.99	1.49	0.99	1.49
CBRY	0.73	0.73	0.73	1.22	HETH	1.01	1.42	1.01	1.42	GDG	1.62	3.24	1.62	3.24
WHIT	0.68	0.68	0.68	1.13	PFG	1.12	1.12	1.12	1.56	ROG	12.15	18.23	12.15	18.23
LGEN	0.94	1.08	0.81	1.34	PFA	0.76	1.02	0.81	1.27	WHWY	6.61	6.61	6.61	13.22
ABF	0.67	0.67	0.67	1.12	LEIH	1.13	1.51	1.13	1.89	EXG	4.31	6.47	4.31	8.62
UBIS	0.78	0.78	0.78	1.30	BRFD	8.95	8.95	8.95	13.43	SMN	6.27	6.27	6.27	9.41
RR.	1.53	1.53	1.53	2.29	SPX	1.21	1.62	1.21	2.02	MSY	2.46	2.95	2.46	3.93
RBOS	1.48	1.77	1.18	2.37	BODD	1.87	2.49	1.87	3.11	SMP	11.07	11.07	11.07	16.60
RMC	0.93	1.31	0.93	1.87	SREL	2.29	2.29	2.29	3.06	RHT	3.10	3.10	3.10	5.17
WILC	1.13	1.50	1.13	1.88	BLGH	2.40	2.40	2.40	3.20	HAMP	5.26	5.26	5.26	7.89
TATE	0.80	0.80	0.80	1.33	FRG	1.61	2.14	1.61	2.68	PDG	2.80	2.80	2.80	2.80
AW	0.85	1.14	0.85	1.42	LVLL	11.99	11.99	8.99	14.99	ELWK	8.59	8.59	8.59	11.45
NFDS	0.55	0.55	0.55	0.92	THT	1.60	1.60	1.60	2.13	COI	14.52	18.16	10.89	18.16
NFC	1.36	1.36	1.36	2.27	ATV	2.48	3.47	2.48	4.96	BFG	4.85	7.28	4.85	9.70
Overall	0.71	0.86	0.57	1.14		1.31	1.75	1.31	2.19		2.28	2.28	2.28	3.43

Source: Data were drawn from the LSE's computer records for the period October 14–December 27, 1991.

thirds Cadbury's price. Although on other exchanges the fixed spread might occur because of tick-size rules, the LSE does not regulate tick sizes. Thus, it is puzzling that absolute SEAQ spreads do not vary more with price. We also observe that the variation here is similar, though perhaps more substantial, than that reported for Nasdaq firms by Stoll (1989). He reports spreads for Nasdaq/National Market System stock size deciles. They range from 1.2 to 6.9 percent of price. A recent study by Chan, Christie, and Schultz (1995) using a more recent time period reports higher average percentage spreads for large Nasdaq stocks.[8]

The within-class variation in spreads and discounts in table 5.3 does not appear related to dealer concentration or volume. Compare, for example, the two oil companies, Richmond Oil and Gas (ROG) and Crossroads Oil (COI). They have the same touch and the same number of market makers. Richmond, however, has a much greater median discount. The greater discount granted the median Richmond trade may reflect Richmond's larger average trade size. Yet, if trade size explains this difference, then why do we not observe greater differences between Richmond and other securities?

As suggested by the analyses in sections 5.2 and 5.3, the interclass differences in spreads might reflect differences in trade counterparties and the volume of trade. Table 5.4 reports information on the distribution of trade counterparties and trade sizes for each of the three size classes. Most trades in each class are "customer bargains," that is, trades where a retail customer is a counterparty. Market makers execute between 60 and 75 percent of these trades. This is somewhat surprising, since the exchange has more than three hundred brokers and just twenty-seven market makers. When brokers do trade with customers, they typically execute large transactions. Relative to other trades, we rarely observe agency crosses, or customer-to-customer trades. Curiously, these trades occur more frequently among smaller (less liquid) issues. The average FTSE-100 equity has 106 customer trades per day, which vastly exceeds the number of customer trades for medium (13) and small (5) equities. Although the number of trades per day differs substantially, the average and median trade sizes do not.[9] Thus, this table suggests that average trade sizes alone do not explain differences in median spreads.

The next section of table 5.4 examines whether interdealer trade discounts differ. If particular types of interdealer trades receive large discounts, then we might expect this to affect average spreads. As a group, the FTSE-100 sample equities have considerably more interdealer trades than either the medium or small equities. Table 5.3, however, shows that the smaller equities receive greater percentage discounts. Thus, the total volume of interdealer trades does

8. Several studies report lower spreads for NYSE stocks. For instance, Kleidon and Werner (1993) report an average quoted spread of 0.6 percent for S&P 100 stocks in 1991.

9. Median trade sizes (not reported in table 5.4) are FTSE-100 £3,744, medium-size £4,550, and small equities £2,625.

Table 5.4 **SEAQ Trading Volume by Type of Trade**

	FTSE-100 Size Class			Medium-Size Class			Small-Size Class		
Type of Trade	Number of Trades	Pound-Volume (% of total)	Average Trade Size (1,000 pounds)	Number of Trades	Pound-Volume (% of total)	Average Trade Size (1,000 pounds)	Number of Trades	Pound-Volume (% of total)	Average Trade Size (1,000 pounds)
Customer trades									
MM sells to customer	39,333	28.9	54	6,922	35.7	42	1,990	37.0	26
Customer sells to MM	67,471	33.1	36	6,791	40.2	49	3,185	36.5	16
Dealer sells to customer	487	1.2	183	230	3.1	111	32	3.0	133
Customer sells to dealer	557	1.5	201	121	2.4	161	32	4.4	193
Customer sells to customer	222	0.7	229	113	1.8	130	88	12.8	203
Total volume	108,070	65.4	44	14,177	83.2	48	5,327	93.7	25
Interdealer trade									
MM sells to MM	3,400	10.0	216	431	3.4	64	107	1.4	19
IDB trades	8,168	19.6	176	783	9.9	94	125	3.5	39
MM sells to dealer	1,401	2.5	132	241	2.5	87	52	1.0	26
Dealer sells to MM	1,500	2.5	123	105	0.9	73	32	0.4	16
Dealer sells to dealer	3	0.0	109	2	0.1	229	0	0.0	0
Total volume	14,472	34.6	176	1,562	16.8	83	316	6.3	28
All trades	122,542	£7,348,199	60	15,739	£821,199	52	5,643	£140,049	25

Source: Data were drawn from the LSE's computer records for the period October 14–December 27, 1991.

Notes: The number of trades is cumulative for the entire sample period and includes all firms in each group. *IDB* = interdealer broker; *MM* = market maker.

not obviously appear related to discounts. Table 5.4, however, also shows that the four IDB systems account for an appreciable fraction of total interdealer trades. This suggests that market makers can take advantage of discounts offered on electronic systems that are not offered over the phone. Together, these results suggest that, while differences in the mix of customer and interdealer trades can explain some variation in spreads and discounts, they are not the only sources of variation.

Table 5.5 describes how median apparent spreads and discounts differ with trade counterparties. To facilitate comparison, it contains apparent spreads and discounts expressed as fractions of the prevailing touch. No adjustment is made for differences in the size of trades or trading volume. As in the Cadbury example, the median trade between a customer and a market maker receives no discount. The median customer trade through a broker does receive a discount. These discounts are small for FTSE-100 securities and large (one-quarter to one-third of the touch) for medium- and small-size class securities. Customer crosses receive large discounts. This is not too surprising, since these trades usually involve large institutions swapping equity "baskets." Median interdealer trades receive modest discounts, more so in the medium and smaller equity size classes. Most IDB trades and trades between dealers occur at or close to touch midpoints.[10] Infrequent dealer crosses usually occur at one-half the touch. The table also shows that asymmetries exist. For example, the median discount on a medium-class customer buy from a dealer is 25 percent of the touch. The corresponding discount for a customer sell is 8 percent. This asymmetry reinforces our earlier point that dealer discounts may have little to do with the touch midpoint.

Following the Cadbury Schweppes analysis, we can use quantile regressions to decompose apparent spreads for these sixty securities into volume, trader, and security-specific components. In principle, we could proceed by estimating separate regressions for each security. In practice, this approach is computationally and descriptively unwieldy. We instead estimated separate models for each size class. These specifications include security fixed effects. Additionally, because spreads differ across securities in relation to the security's price, we scaled the apparent and touch spreads by security prices. Experimentation with functional forms led us to the following specification describing customer trades for security j:

$$(3) \qquad \frac{AS_j}{P_j} = \beta_0 + \frac{\text{Touch}_j}{P_j} \times \left[\theta_j + \beta_{00}\frac{\text{Touch}_j}{P_j} + \sum_{i=1}^{4}\left[\beta_i + \beta_{0i}\frac{\text{Touch}_j}{P_j}\right](\text{Trade Size})^i\right] + \varepsilon.$$

10. The negative adjusted apparent spreads occur because we separately estimate median spreads and discounts.

Table 5.5 **SEAQ Median Apparent Spreads and Discounts by Type of Trade (percentage of touch)**

	FTSE-100 Size Class			Medium-Size Class			Smaller-Size Class		
Type of Trade	Apparent Spread	Discount	Adjusted Apparent Spread	Apparent Spread	Discount	Adjusted Apparent Spread	Apparent Spread	Discount	Adjusted Apparent Spread
Customer trades									
MM sells to customer	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00
Customer sells to MM	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00
Dealer sells to customer	1.00	0.02	0.98	0.75	0.08	0.67	0.75	0.00	0.75
Customer sells to dealer	0.98	0.00	0.98	0.92	0.25	0.67	1.00	0.25	0.75
Customer sells to customer	0.75	0.25	0.50	0.60	0.40	0.20	0.75	0.25	0.50
Interdealer trades									
MM sells to MM	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00
IDB trades	0.50	0.50	0.00	0.42	0.58	−0.16	0.50	0.50	0.00
MM sells to dealer	0.50	0.50	0.00	0.58	0.67	−0.09	0.64	0.50	0.14
Dealer sells to MM	0.50	0.50	0.00	0.33	0.42	−0.09	0.50	0.36	0.14
Dealer sells to dealer	0.75	0.25	0.50	0.73	0.27	0.46	NA	NA	NA
Median touch spread		3 pence			4 pence			2 pence	

Source: Data were drawn from the LSE's computer records for the period October 14–December 27, 1991.

Notes: Reported numbers are medians across trades for all securities in each group. *IDB* = interdealer broker; *MM* = market maker.

In words, we represent the conditional quantiles of apparent spreads as a quartic in the trade's pound value interacted with the touch and the square of the touch. The coefficient β_0 is the apparent spread when the touch is zero. The coefficient θ_j is a security-specific fixed effect that captures differences in discounts from the touch across securities. The polynomial in size and the squared touch give added flexibility to the shape of the conditional median discount function. To capture differences in customer and noncustomer trades, we included additional zero-one dummy variables interacted with the touch and the touch squared when the trade involved an IDB, a dealer, or two market makers.

Table 5.6 summarizes the results of the conditional median regressions for each size class. The first panel describes the fit. While there is no natural measure of fit, the average absolute error is small, and the conditional medians explain about 60 percent of the variation in apparent spreads (over price). Figure 5.7 plots actual versus fitted values for the medium-size class. It shows that the model does reasonably well explaining the substantial variation in apparent spreads. The security-specific fixed effects explain little of the variation in apparent spreads. In future work, we plan to investigate whether there are more complicated security-specific size and trader effects. The other three panels in table 5.6 suggest that the model explains a large fraction of the variation across securities, but also that there are exceptions. The interquartile range statistics (columns 3 and 6) show that trade size, touch, and trade type explain variation in apparent spreads. The large absolute errors and standard deviations show, however, that there are outlying spreads the model does not explain. We do not have an explanation for these unusual spreads, although most occur because of trades outside the quoted spread. These observations may represent match or coding errors.

Figures 5.8A–5.8C display estimated conditional median apparent spreads for customer trades by size class. The vertical distance between the upper curves and the horizontal axis is the estimated apparent spread. As in the Cadbury example, the vertical distance between similar curves equals the adjusted apparent spread. Each median is evaluated at the average of the firm effects. Figure 5.8A plots median adjusted apparent spreads for FTSE-100 equities as the touch ranges from 0.5 to 1.5 percent of price. These estimates are similar to those for Cadbury. Medium and large trades (£75,000–£500,000) receive only slight discounts when the touch is 0.5 percent of price. As the touch widens, the median FTSE-100 trade obtains a greater discount.

Figures 5.8B and 5.8C repeat the format of figure 5.8A for medium- and small-size equities. The sample average touches are 1.3 percent of price for the medium-size class and 2.3 percent of price for the small class. For the medium-size class, median spreads fall monotonically as the size of the trade increases. The same is true for the small-size class, but the decline is less pronounced. For instance, when the touch is 1 percent of price, trades greater than £4,500 receive virtually no discount. Table 5.3 shows that a 1 percent touch-to-price

Table 5.6 **Summary of Apparent Spread Quantile Regressions**

	FTSE-100 Size Class	Medium-Size Class	Smaller-Size Class
Sample size	122,542	15,722	5,546
Parameters	42	42	42
Apparent spread/transaction price mean (%)	0.83	3.09	3.73
Apparent spread/transaction price median (%)	0.82	3.30	4.00
Apparent spread/transaction price standard deviation (%)	0.44	3.86	3.45
Quantile standard error	0.25	1.38	1.34
Average error	−0.05	−0.20	−0.30
Average absolute error	0.10	0.47	0.50

					Regression Error		
Security Code	Median AS/P (1)	Standard Deviation of AS/P (2)	Interquartile Range of AS/P (3)	Quantile Regression Average Absolute Error (4)	Standard Deviation (5)	Interquartile Range (6)	$(1-x^2)$ $x=(5)/(2)$ (7)
				FTSE-100 Size Class			
BT.A	0.51	0.26	0.28	0.05	0.21	0.00	0.35
GUIN	0.61	0.30	0.41	0.10	0.19	0.14	0.60
MKS	0.69	0.25	0.19	0.07	0.19	0.00	0.42
RTZ	0.75	0.29	0.75	0.09	0.21	0.00	0.48
LLOY	0.79	0.31	0.43	0.11	0.21	0.12	0.54
ANL	1.05	0.91	0.36	0.04	0.20	0.00	0.95
SUN	0.90	0.44	0.40	0.18	0.38	0.26	0.25
CBRY	0.73	0.28	0.29	0.09	0.21	0.04	0.44
WHIT	0.66	0.27	0.38	0.09	0.19	0.18	0.50
LGEN	1.00	0.42	0.36	0.14	0.35	0.19	0.31
ABF	0.65	0.31	0.42	0.14	0.26	0.21	0.30
UBIS	0.78	0.30	0.29	0.11	0.22	0.13	0.46

(*continued*)

Table 5.6 (continued)

Security Code	Median AS/P (1)	Standard Deviation of AS/P (2)	Interquartile Range of AS/P (3)	Quantile Regression Average Absolute Error (4)	Regression Error: Standard Deviation (5)	Regression Error: Interquartile Range (6)	$(1-x^2)$ $x=(5)/(2)$ (7)
RR.	1.47	0.55	0.76	0.12	0.35	0.00	0.60
RBOS	0.64	0.59	0.64	0.27	0.50	0.35	0.28
RMC	0.98	0.48	0.53	0.19	0.40	0.19	0.31
WILC	1.08	0.49	0.61	0.21	0.36	0.29	0.46
TATE	0.77	0.31	0.32	0.10	0.23	0.06	0.45
AW.	0.92	0.94	0.39	0.12	0.27	0.03	0.92
NFDS	0.57	0.21	0.31	0.06	0.13	0.00	0.62
NFC	1.35	0.50	0.79	0.15	0.31	0.00	0.62
Medium-Size Class							
SVC	1.05	0.35	0.45	0.11	0.23	0.01	0.57
BOS	1.20	0.37	0.44	0.14	0.28	0.16	0.43
THK	1.13	0.59	0.75	0.22	0.44	0.23	0.44
BNZL	2.56	1.29	1.50	0.47	0.82	0.59	0.60
COST	4.37	1.66	2.57	0.78	1.33	1.16	0.36
WOLV	1.20	0.40	0.47	0.20	0.35	0.19	0.23
SCPA	1.30	0.67	0.64	0.30	0.52	0.34	0.40
HETH	1.02	0.34	0.42	0.18	0.31	0.21	0.17
PFG	1.06	0.39	0.39	0.21	0.34	0.25	0.24
PFA	0.76	0.48	0.63	0.27	0.43	0.30	0.20
LEIH	1.09	0.47	0.66	0.23	0.36	0.36	0.41
BRFD	7.41	2.85	3.82	1.14	1.95	1.48	0.53
SPX	1.36	0.56	0.75	0.22	0.36	0.38	0.59
BODD	1.82	0.81	1.22	0.32	0.52	0.50	0.59
SREL	2.23	0.84	1.34	0.38	0.67	0.69	0.36
BLGH	2.36	0.85	0.27	0.51	0.81	0.76	0.09

FRG	1.57	0.69	0.97	0.40	0.60	0.53	0.24
LVLL	13.95	7.11	9.39	2.22	5.31	2.78	0.44
THT	1.45	0.46	0.60	0.13	0.27	0.01	0.66
ATV	2.67	1.21	1.44	0.45	0.85	0.47	0.51
				Smaller-Size Class			
ANU	3.69	1.63	1.67	0.76	1.31	0.85	0.35
SEP	3.59	1.41	0.89	0.83	1.19	1.25	0.29
LILY	1.80	0.94	1.49	0.36	0.60	0.46	0.59
BDN	8.22	2.90	4.61	1.15	1.93	2.07	0.56
BYNS	3.17	2.23	2.79	0.73	1.41	0.56	0.60
OWN	1.71	2.05	1.28	0.25	0.61	0.00	0.91
SNGT	1.02	0.37	0.49	0.16	0.34	0.00	0.16
GDG	4.23	2.15	4.16	1.04	1.83	1.17	0.28
ROG	6.45	2.39	1.61	0.94	1.60	1.23	0.55
WHWY	6.45	2.59	1.83	1.00	1.89	0.91	0.47
EXG	2.37	0.80	0.06	0.03	0.68	0.01	0.28
SMN	6.25	1.99	0.86	1.17	1.94	2.45	0.05
MSY	1.29	0.44	0.86	0.18	0.37	0.31	0.29
SMP	12.50	5.30	5.69	3.00	4.43	3.74	0.30
RHT	1.73	2.65	4.44	0.71	1.47	0.52	0.69
HAMP	3.47	5.28	3.52	1.11	1.82	1.62	0.88
PDG	2.96	3.57	1.86	0.61	1.41	0.51	0.84
ELWK	4.17	2.48	2.86	0.89	1.59	0.75	0.59
COI	1.82	1.45	0.91	0.17	0.31	0.22	0.95
BFG	2.39	1.64	1.37	0.64	0.68	0.02	0.83

Note: The median apparent spreads in table 6.5 differ because they are median spreads divided by average price.

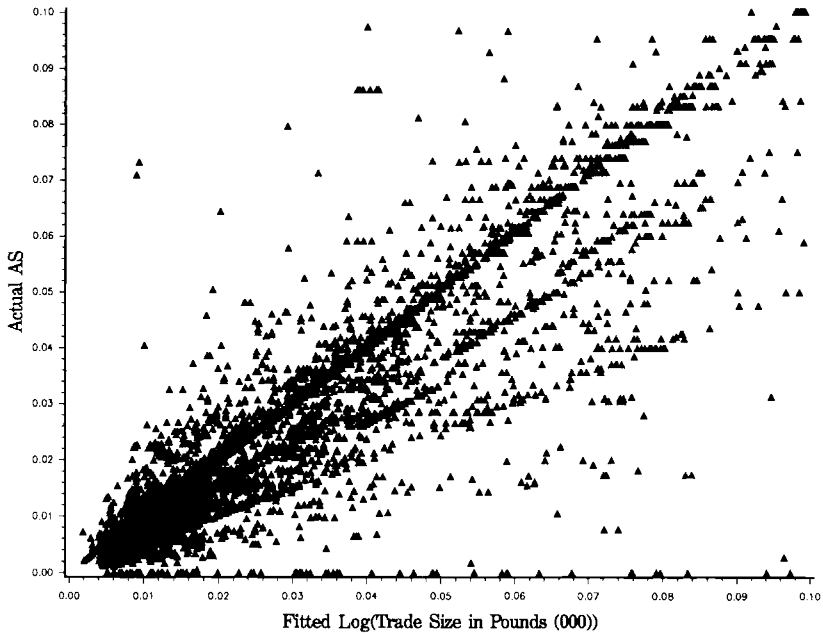


Fig. 5.7 Apparent spread by log(trade size) for a medium size class sample, fourth quarter 1991. Actual apparent spread versus median predicted apparent spread.

Note: AS = apparent spread.

ratio is at the low end of medium- and small-size class spreads. The median FTSE-100 trade receives a larger discount the wider the touch, although for the very largest trades (not pictured) there is evidence that such discounts disappear. These differences in discounts across size classes suggest that large orders have either very different competitive consequences or cost consequences for market makers.

Figure 5.8D shows the estimated apparent spreads granted by dealers of FTSE-100 securities, holding the touch constant at 1 percent of price. Again, these results parallel those in the Cadbury example. Dealer trades have a profile similar to customer discounts, though the discount levels differ. Market makers do not discount the median trade. Brokers discount the spread by one-third when dealing with each other, and IDB trades execute at roughly the touch midpoint. Translated into adjusted apparent spreads and not adjusting for the direction of trades, this corresponds to a one-third broker-to-broker spread and no IDB spread.

5.5 Conclusions

This study used unique SEAQ transaction and quotation data to document SEAQ spreads and market-maker discounts. To the best of our knowledge, this is the first study to account simultaneously for differences by type of trade, trade volume, and security. We began by first developing a new measure of transaction costs, the adjusted apparent spread. This measure calculates the hypothetical cost of an (immediate) round-trip transaction using information on dealers' quotes and investors' transactions. Specifically, we used quantile regressions to model how these spreads varied with trade, trader, and security characteristics. Our estimates reveal that medium to large trades on average receive discounts from the touch spread. These discounts increase, the wider the touch. Small and very large trades pay the touch (and sometimes more). Dealers and market makers price customer trades differently. Market makers discount only very large trades; dealers regularly discount medium and large trades. Market makers rarely discount trades with other market makers over the phone, but do so when trading anonymously using IDBs.

The practice of discounting the touch raises many fascinating questions that need further study. We would like to develop theoretical models that explain why dealers grant discounts and how discounts affect spreads. We also would like to understand why dealers link these discounts to size. The pattern we observe suggests that neither simple asymmetric information nor inventory risk models can easily explain why dealers widen spreads and then selectively discount. The anonymous role of IDBs in interdealer trades also deserves further study. Finally, it would be useful to develop a monopolistic competition model of market making that recognizes how market makers spread their dealing costs across securities.

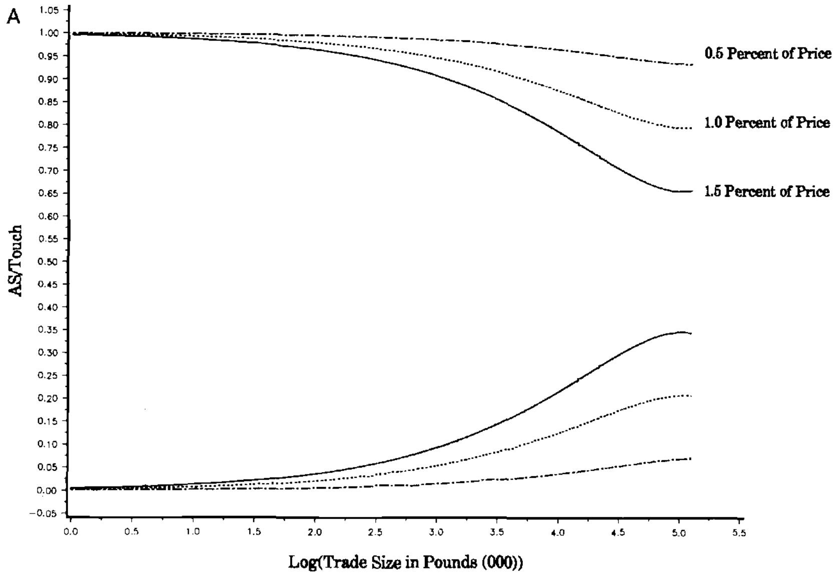
Our empirical analysis is preliminary and leaves many issues untouched or partially addressed. We clearly should estimate adjusted apparent spreads using information about who originates trades. We also need to extend the data samples to explore whether dealers individually have different discount policies. Other market-maker information also should enter our regressions. For instance, although we condition on the touch at the time of trade, we do not control for market depth at the bid and the ask, or past information. Additional variables might include market indexes, and capital or price risk measures.

Finally, our findings suggest that researchers should not use average spreads to measure the efficiency of a market. Instead, one should compare measures that hold constant characteristics that market makers "price." While our research does not provide an analytical understanding of how dealers decide on quoted and transaction prices, it provides a place to begin.

Appendix

Quotation and Transaction Data

The Cadbury Schweppes Nasdaq transaction data come from the Institute for the Study of Security Markets. On Nasdaq, Cadbury Schweppes shares



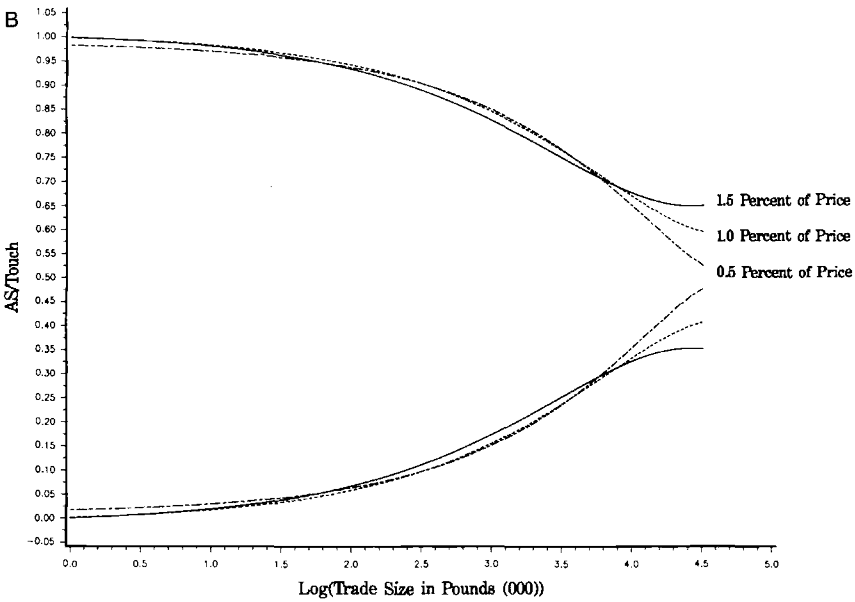
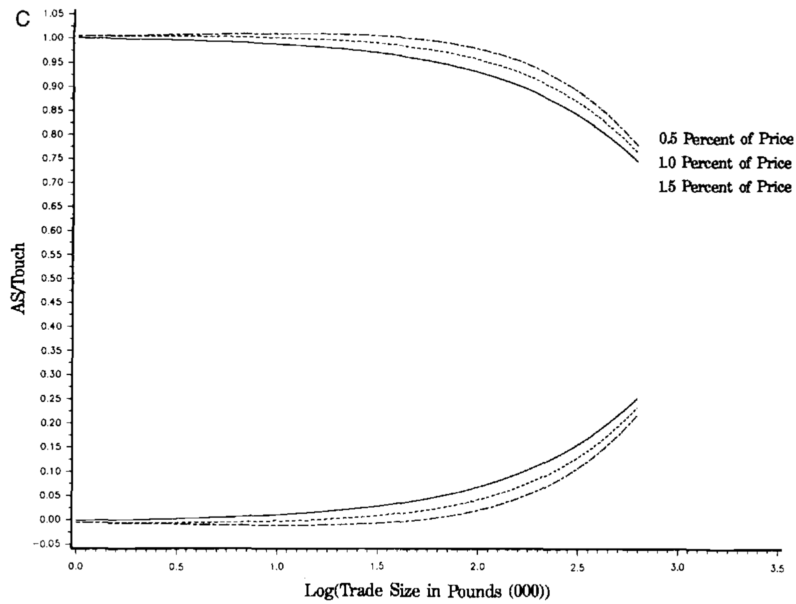
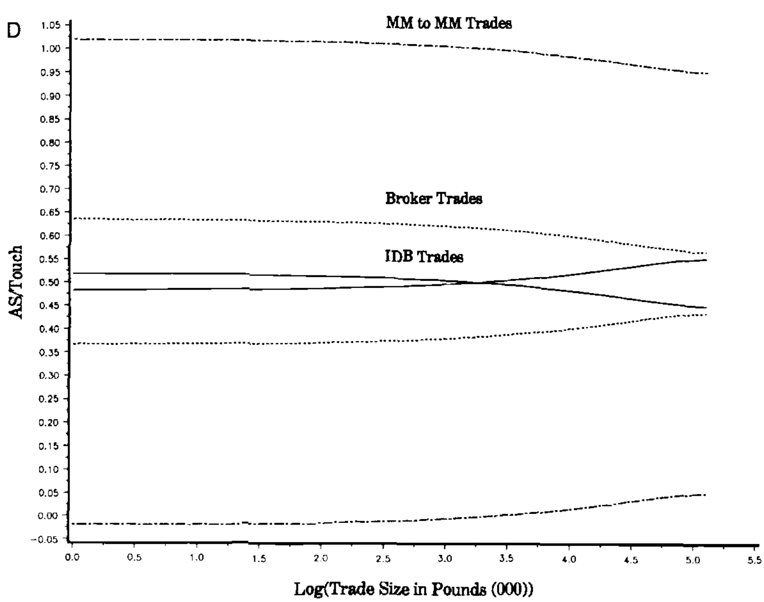


Fig. 5.8 Apparent spread by log(trade size) and touch, fourth quarter 1991. Customer trades, median apparent spread/touch: *A*, FTSE-100 size class sample; *B*, medium-size class sample; *C*, small-size class sample. Dealer trade median AS/ touch: *D*, FTSE-100 size class sample.

Notes: AS = apparent spread; *IDB* = interdealer broker; *MM* = market maker.


C
0.5 Percent of Price
1.0 Percent of Price
1.5 Percent of Price
AS/Touch
Log(Trade Size in Pounds (000))


D
MM to MM Trades
Broker Trades
IDB Trades
AS/Touch
Log(Trade Size in Pounds (000))

trade as ADRs. We converted the Nasdaq shares to pound-equivalent shares using daily FT-Actuaries foreign exchange rates quoted in London.

The SEAQ data come from the Quality of Markets Group at the LSE. Both the SEAQ transactions and quotations data required extensive editing to match samples and dealer codes. For the Cadbury analysis, we use all overlapping trade and quotation data. These data cover January 14 to March 18, April 2 to June 24, July 1 to September 24, and October 14 to December 31. In sections 5.3 and 5.4 we use October 14 to December 31. The quotation data cover two thousand U.K. and Irish ordinary shares. Some securities are missing data because of retrieval problems, new listings, delistings, or trading halts. SEAQ rules require market makers to quote guaranteed prices and volumes between 8:30 A.M. and 4:30 P.M. London time. Dealers sometimes post prices for up to one-half hour before the mandatory open and close. These quotes are not binding. During the mandatory quote period, market makers must accept trades as large as 2.5 percent of the security's previous twelve months' average daily trading volume. Dealers must also offer "best execution." During 1991, this meant SEAQ market makers had to execute trades at less than the minimum quote size or inside the prevailing touch. Market makers away from the touch had to execute orders at the touch price (or better) or transfer the order to another market maker.

We obtained transaction data for 907 larger U.K. and Irish securities. Approximately 840 of these equities appear in the quotation sample. The transaction data come from end-of-day settlement reports filed with the Central Checking Section of the LSE. These reports do not necessarily reproduce the original ticker tape. Each trade has two time stamps, one reported by the seller and one by the buyer. We use the seller's time stamp unless it indicates a trade outside the prevailing touch. If the seller's time stamp would classify the trade as outside the touch, we check the buyer's time stamp. If the buyer's time stamp puts the trade at or within the touch, we use the buyer's time. If neither time stamp appears valid, we use the seller's time. This reduces the number of trades that execute outside the touch, but does not eliminate them. Trades outside the touch are sometimes "average price" basket trades. Dealers execute baskets using prearranged pricing formulas. The data also contain coding anomalies. The most significant are "shapes." Shapes occur when a dealer matches several customer orders with one (sometimes two) other customer order(s). These appear in the data as a series of unbalanced customer transactions.

Pilot Sample with Quotes and Transactions

We constructed the sample of sixty securities by randomly sampling names from a list of all SEAQ equities. We first assigned securities on this list to market capitalization classes based on their March 31, 1991, market capitalization.[11] We then randomly sampled within classes, rejecting any security lacking

11. *Quality of Markets Companies Book 1991* (London: London Stock Exchange, 1991), table 1, "1000 largest listed UK companies by market valuation," 19–38.

complete data. We also required that it have a minimum quote size of at least two thousand shares and more than seven hundred trades between March 31, 1990, and March 31, 1991. We chose the twenty FTSE-100 firms so that they would overlap with previous LSE studies.

Table 5A.1 provides additional information on the sixty firms.

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Table 5A.1 **Descriptive Statistics for Transaction Sample**

Code	Firm	Market Capitalization (million pounds)	Average Price (pounds)	Median Trade Size (pounds)	Normal Market Size (pounds)	Transactions in Mandatory Quote Period	Number of Market Makers
			FTSE-100 Firms				
BT.A	British Telecommunications	20,882	3.60	2,494	360,000	13,571	15
GUIN	Guinness	8,062	5.99	6,902	299,500	8,724	14
MKS	Marks & Spencer	6,432	2.85	3,267	213,750	12,937	14
RTZ	RTZ	5,530	5.20	5,820	260,000	7,296	13
LLOY	Lloyds Bank	4,171	3.83	5,908	191,338	5,845	14
ANL	Abbey National	3,564	2.79	576	139,495	19,122	14
SUN	Sun Alliance Group	3,002	3.13	13,600	78,138	2,486	12
CBRY	Cadbury Schweppes	2,681	4.11	6,015	102,666	5,309	16
WHIT	Whitbread	2,298	4.41	6,071	110,227	3,285	14
LGEN	Legal & General	2,242	3.72	7,782	92,939	2,771	12
ABF	Associated British Foods	2,121	4.48	21,950	44,801	900	10
UBIS	United Biscuits Holdings	1,752	3.84	7,860	96,000	3,207	16
RR.	Rolls-Royce	1,557	1.31	774	65,371	8,798	15
RBOS	Royal Bank of Scotland	1,440	1.69	7,867	84,563	4,572	14
RMC	RMC Group	1,348	5.35	14,910	53,466	1,397	12
WILC	Willis Corroon	1,084	2.66	24,808	66,411	1,406	7
TATE	Tate & Lyle	1,147	3.76	7,720	93,985	3,083	14
AW	Anglian Water	1,061	3.52	3,480	88,000	1,958	13
NFDS	Northern Foods	965	5.44	4,891	54,400	2,639	8
NFC	NFC	884	2.20	4,158	32,932	2,559	5
Average		**3,611**	**3.69**	**7,843**	**126,399**	**5,593**	**12.6**

			Medium-Size Firms				
SVC	Salvesen (Christian)	583	2.37	4,720	23,700	813	9
BOS	Body Shop	501	3.23	3,480	32,269	1,907	5
THK	Tiphook	446	4.65	12,925	23,250	1,978	6
BNZL	Bunzl	400	0.87	5,832	43,500	614	7
COST	Costain Group	362	0.65	2,220	16,319	2,839	11
WOLV	Wolverhampton & Dudley	324	5.78	5,880	11,560	203	6
SCPA	Scapa Group	284	1.67	16,191	8,370	454	7
HETH	Heath (C.E.)	263	4.93	9,905	14,790	305	7
PFG	Provident Financial	251	4.47	9,821	8,940	300	6
PFA	Proudfoot (Alexander)	225	3.93	62,730	19,650	250	5
LEIH	Leigh Interests	208	2.65	11,400	13,234	454	6
BRFD	Berisford International	181	0.22	2,050	5,459	618	7
SPX	Spirax-Sarco Engineering	169	2.47	7,816	4,936	148	5
BODD	Boddington Group	157	1.61	7,335	4,816	454	6
SREL	Suter	145	1.31	2,810	13,087	306	4
BLGH	Bullough	139	1.25	6,500	6,228	114	4
FRG	FR Group	127	1.87	17,226	9,342	359	6
LVLL	Lovell (Y.J.) Holdings	118	0.33	950	1,650	895	4
THT	Thorntons	110	1.88	1,386	5,633	532	5
ATV	Anglia Television Group	100	2.02	4,812	4,039	525	7
Average		**255**	**2.41**	**9,799**	**13,539**	**703**	**6.2**

(*continued*)

Table 5A.1 (continued)

			Small-Size Firms				
ANU	Anglo United	92	0.34	2,950	8,500	171	4
SEP	Southend Property Holdings	88	0.83	4,654	2,490	118	3
LILY	Liley	86	0.36	1,720	3,600	296	7
BDN	Bridon	77	1.13	1,545	11,346	186	6
BYNS	Bayens (Charles)	69	0.60	5,392	3,022	281	5
OWN	Owners Abroad	63	1.14	4,680	11,406	1,409	4
SNGT	Silentnight Holdings	56	2.01	4,900	4,030	290	5
GDG	Gardiner Group	54	0.62	16,062	6,200	87	5
ROG	Richmond Oil and Gas	48	0.16	2,000	802	163	2
WHWY	Wheway	45	0.30	1,950	1,501	262	7
EXG	Excalibur	40	0.46	3,060	926	89	4
SMN	Starmin	37	0.16	1,625	479	155	5
MSY	Misys	33	2.04	10,400	6,120	137	5
SMP	St. Modwen Properties	30	0.18	454	900	109	4
RHT	Resort Hotels	30	0.97	2,805	9,665	526	6
HAMP	Hampson Industries	29	0.38	1,436	1,902	81	4
PDG	Pendragon	25	1.78	232	5,349	311	5
ELWK	Elswick	23	0.09	793	1,309	321	5
COI	Crossroads Oil	22	0.28	702	560	31	2
BFG	Bennet & Fountain Group	21	0.21	1,024	1,030	128	6
Average		**48**	**0.70**	**3,419**	**4,057**	**258**	**4.7**

Sources: Market capitalization on March 31, 1991, as reported in *Quality of Markets Companies Book 1991* (London: London Stock Exchange, 1991), table 3. Transactions data were drawn from the LSE computer records for the period October 14–December 27, 1991. The average price is calculated based on all trades during the sample that took place during the mandatory quote period. The median trade size is based on the pound value of all trades during the mandatory quote period for the sample. Normal market sizes in number of shares are from the computer records of the LSE. The pound value of the normal market sizes are the number of shares times the average price of transactions.

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Comment F. Douglas Foster

The paper by Reiss and Werner provides an interesting introduction to price formation and trading costs on the London Stock Exchange (LSE). The authors appear to be less interested in testing a specific set of hypotheses. Rather, their paper provides a thorough overview of the LSE, with a particular interest in how trading costs in this market can be measured, and how these costs compare with other exchanges (in particular with the Nasdaq market in the United

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States). The authors demonstrate that (1) bid-ask quotes on the LSE are relatively large and rarely change. Competition in this market is related, in part, to discounts from the quoted bid-ask spread; and (2) different classes of investors (customers, market makers, brokers, and interdealer broker [IDB] trades) appear to be offered different discounts from the best bid and ask (the touch). Because of these effects, simply using the quoted bid-ask spread to measure trading costs can be very misleading. Reiss and Werner provides us with a very carefully constructed analysis of trading data that describes this problem, with particular attention to the role of the trade size and customer identity in determining trading costs.

In my view, the most important innovation in the paper is the estimation technique used to isolate trading costs. Because the bid-ask quotes seldom change, and because transaction reporting can be delayed, an important part of measuring transaction costs is the estimation of the discount offered from the touch. Reiss and Werner suggest a cost measure that is based on an immediate purchase and sale of the stock (or the converse). Using the current trade, they compute the apparent spread, which is the current quote less the discount on the first transaction. To get the round-trip trading costs, the authors then estimate the *expected* discount on the offsetting trade and subtract this amount from the adjusted spread. This value, defined to be the adjusted apparent spread, becomes the trading cost of interest (although in their figures the authors only report the apparent spread value). This cost measure is an important innovation. It reflects the discount offered in the current trade, as well as the discount likely to be offered on the return trade. Importantly, it appears that the extent of the discount is related to the characteristics of the order in very interesting ways.

Because of the emphasis on an empirical overview, Reiss and Werner spend less time discussing why the trading environment on the LSE evolved the way it has. They leave the details of a specific model for other research. This raises a natural question. If a specific model were to be tested, are Reiss and Werner's techniques likely to be useful for a direct test of that model? For example, Hansch, Naik, and Viswanathan (1993) in a related paper suggest that LSE market makers quote larger spreads and then execute trades inside the spread for three reasons: (1) following an informational change, it gives the market makers some elbow room before they alter their quotes; (2) it enables them to service customer orders without frequently adjusting their quotes, and thus signaling their inventory; and (3) the process of negotiation reveals something about the identity of the customer as well as the motive of the trade. Does the current work of Reiss and Werner allow us any additional insights to these arguments? If not, what more needs to be done?

Reiss and Werner condition on the information in the order flow and estimate trading costs using quantile regressions. For Cadbury Schweppes, this functional form is given in expression (2). Specifically, the authors use the trade size and the interaction between the touch and the trade size, as well as the traders' identity, to estimate the (adjusted) apparent spread. This bring us to the most controversial part of the paper. Why are these variables the correct ones to condition on? Why condition on them in this form (trade size and the interaction between trade size and touch)? Can this conditioning set be related to a theoretical model, or to the intuition given by Hansch, Naik, and Viswanathan?

This complication in choosing a conditioning set becomes more complex when the authors estimate trading costs across a sample of stocks. Expression (3) gives the functional form used for such tests. At first it appears that they use expression (2) and scale it by dividing both sides by the transaction price. However, now the authors condition on touch and trade size in a different way—the form of the interactions is significantly different. Little explanation is offered for the change, and it is not clear which specification is appropriate. This serves to highlight the need for a theoretical basis for quote formation on an interdealer market like the LSE.

In summary, the paper provides a fascinating array of evidence on the market structure of the LSE. In presenting this information, the authors raise more questions than any one paper can hope to address. The estimation procedure that is used is innovative in that it provides an economically relevant, forward-looking measure of costs. Its drawback, however, is that without a firm theoretical footing it is difficult to interpret, and will be controversial to many readers. Linked to a rigorous model of quote formation, this procedure promises to be an effective method of estimating costs. In my mind, the most interesting insight of the paper is "[b]y widening spreads, SEAQ market makers can protect themselves against inventory imbalances and informed trades while simultaneously retaining an option to offer execution within their guaranteed quotes." This insight echoes that of Hansch, Naik, and Viswanathan (1993) and suggests an interesting path for theoretical researchers who wish to understand better interdealer competition. Interested theorists should read Hagerty's and McDonald's chapter in this volume for a related theoretical paper.

Reference

Hansch, O., N. Naik, and S. Viswanathan. 1993. Market Making on the London Stock Exchange: An Empirical Observation. Working paper, London Business School.

Comment Bernard S. Black

This paper has a lot of interesting data in it as well as the most careful measure of effective buy-sell spread that I've seen. It is no criticism of the authors to say that their data raises as many questions as it solves.

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One weakness is the theoretical model of competition among market makers as oligopolistic competition, of the kind that once characterized the steel or auto industry, where the oligopolists earn positive economic profits, or perhaps dissipate potential oligopoly profits through various inefficiencies. I think this is implausible. Entry costs into the business of making a market in common stock are likely to be low by the standards of nonfinancial industries. For firms that are already making markets in other stocks, entry costs into making a market in the stock of a particular company are surely small.

So even if there are only a small number of market makers in the stock of ABC Corporation, there is lots of *potential* competition from broker-dealers who *could* become market makers in ABC Corporation if the market price of liquidity services—the effective buy-sell spread—is significantly above the cost of producing this product. That potential competition ought to keep effective buy-sell spreads close to competitive levels.

How then does one explain the strong picture that the authors present in figure 5.6 of declining spreads with increasing number of market makers? The alternate story that I'd like to offer posits several features of market making.

1. *Some* costs associated with making a market in ABC Corporation stock are largely independent of trade volume, including keeping up with information about ABC's business and about trading in ABC stock. These costs must be borne even if trading volume is zero. At low trading volumes, the need to recover these costs may significantly increase effective spreads. As trading volume increases, these costs become smaller per trade.

2. These information-collection costs of market making decline with the number of *other* market makers. Market maker 17 can, in large part, skimp on its own research and instead rely on market transactions, and on quoted spreads from other market makers, to find out what's happening in the market for ABC stock. Conversely, market maker 1, with a larger market share, can't learn much from the behavior of piggybacking market makers like 17. So there can be an equilibrium where one or a few market makers enjoy high volume, which they use to cover their relatively high information-gathering costs, while market makers like 17, with low volume, can offer competitive spreads because they incur low information-gathering costs. In this respect, market making is quite unlike conventional product markets, where competitor 17 can't piggyback on the capital investments made by number 1.

3. Some trades are more information intensive than others. On average, larger trades will come from more knowledgeable traders. Market maker 17 won't dare handle these trades. These trades will primarily flow to market makers like number 1 that invest heavily in gathering information.

If we had the data to look behind the simple correlation that the authors present between effective spreads and the *number* of market makers, and could disaggregate the data, I would want to examine the market share of different market makers, broken down in various ways, including trade size. That might tell us whether the model of the industrial organization of market making that I've described captures some of the truth—perhaps more than the authors' model of oligopolistic competition.

This model, where small market makers piggyback on the information-gathering efforts of large market makers, could also provide a window into one of the puzzles in the data—why doesn't any one market maker offer a quoted spread equal to the touch? The combination of quoted spreads greater than the best published bid-ask spread, and relatively frequent discounts, may hide from other market makers some of the information that a particular market maker has collected. That's a speculation in search of a model, I recognize.

I would like also to comment on two surprising features of the data. First, we apparently have large-company percentage spreads of about 0.6 percent for S&P 100 stocks, on the NYSE, 0.9 percent on SEAQ for FTSE-100 stocks, and, depending on the study, between 1.2 percent and 2 percent on Nasdaq for large-company stocks. These are large differences, for markets that increasingly compete with each other, both for listings and order flow.

I'd like to know whether these are really comparable numbers. If they are, then I would like to know why these price differences survive. One reason might be *nonprice* differences in the quality of execution. Let me offer two examples. A thousand-share trade on the NYSE is exposed on the floor and sometimes is executed between the best quoted bid and the best quoted asking price. That narrows the effective spread. But it takes time—a minute or two. Maybe speed of execution, which reduces transaction costs, explains why third markets can take transactions away from the NYSE even though their apparent price is higher. But this is not necessarily a happy outcome. The advantages of speed might accrue to the broker, not to the customers.

There is a way to find out who benefits from sending trades to third markets, suggested by Jack Coffee. The SEC could require brokers to offer clients an explicit choice: faster execution or the possibility of a better price. My bet: the vast majority of small investors would opt for a better price.

Second example: informed traders like to hide their trades. Maybe London competes with the NYSE by offering secrecy, in return for a higher effective spread. We might prefer that delayed transaction reporting not be allowed. I'm one of the people who think that price disclosure has important external benefits. But for present purposes, we could *explain* a difference in effective spreads based on these kinds of nonprice factors.

Second data feature: the authors report that "IDB trades"—broker-to-broker-dealer trades intermediated by interdealer brokers—occur at better prices than direct broker-to-broker trades. At first impression, this makes no sense. Shouldn't it be, if anything, the other way around?

Let me offer a possible explanation. The better pricing accorded to IDB trades could reflect a gentlemen's understanding that only informationless trades go through IDB. Such an understanding, even if it would break down in the United States, could survive in the much more close-knit British investment community. IDB brokers could kick cheaters out of the club by refusing to take their orders. Information trades would then go direct broker to broker, and properly get worse pricing.

Here the authors ought to *ask* British dealers about the reasons that might underlie this difference. They might get a simple, plausible explanation rooted in price discrimination between high-information and low-information trades.

Authors' Reply

Increased competition between exchanges for order flow has renewed debates about which trading systems offer "better execution." As the discussion at this conference testifies, the quality of execution is a difficult concept to measure. Many studies regard the quality of execution as synonymous with the spread cost of an average trade. Our paper illustrates why in dealer markets average comparisons may mask or, worse, obscure systematic differences in transaction costs. In particular, on SEAQ, the practice of discounting the posted quotes raises new questions about how one should assess the quality of execution in dealer markets. We are grateful to our discussants and conference participants for their observations about our overall approach and our methods. We now briefly revisit several of these points and relate them to our overall objective.

We began studying SEAQ dealer markets thinking that we could use existing models and measures to explain SEAQ dealer pricing policies. Interviews with SEAQ officials and market makers quickly convinced us that SEAQ rules led to behavior not captured by standard models or measures. We thus began with a narrower objective, how to summarize these differences. Our adjusted apparent spread measure recognizes that both minimum quote sizes and best execution rules affect quoted spreads and the ultimate relation of transaction prices to quoted prices.

Our paper emphasizes that one must condition comparisons of transaction costs on factors that dealers use when pricing trades. The estimations in this paper use simple quantile regression equations to make this point. As Douglas Foster observes, these specifications should ideally come from a model of dealer behavior. They should probably also contain other variables. We agree. Unfortunately, we were unable to find a structural model in the literature that captures dealer interaction in markets like SEAQ. We also note that it will be difficult to obtain an empirically tractable model of dealer behavior. Nevertheless, Foster's point is well taken and is one we plan to pursue. Our regression results are thus best viewed as a first attempt at describing the facts that require explanation.

Besides the findings highlighted in Douglas Foster's comment, we again emphasize the important interactions between trade size and the touch at the time of trade. Medium to large trades receive favorable execution, whereas small and very large trades at best get "best execution." Favorable execution increases, the wider the spread. These findings contrast with the predictions of some theoretical models and the results of previous empirical studies. As Foster notes, our finding that quotes change infrequently is also noteworthy. Hansch, Naik, and Viswanathan (1993) also make this observation. While their story suggests reasons for why spreads might move infrequently, it does not explain why we see systematic patterns by the size of the touch, trade size, and trader identity. Finally, contrary to the predictions of some second-price auction models, we find order flow does not always go to a SEAQ dealer advertising the best price. There are at least two reasons for this. First, dealers have the option to take trades at the best bid and offer. Second, traders know that dealers discount.

Bernard Black raises an interesting observation about market-maker trading and IDB discounts. We disagree, however, that what we observe is the result of a "gentlemen's agreement" among SEAQ dealers. An alternative story, suggested to us by several market makers, is that market makers use direct negotiation only as a last resort. That is, they use the phone to resolve inventory imbalances only after they have exhausted all other means. (These include all four IDBs and customers.) This explanation suggests that the difference in transaction costs we observe between phone trading and IDB trading reflects a dealer "impatience" cost.

Black also rightly observes that we omit important nonprice differences in the quality of execution, such as the speed of execution (immediacy) and information disclosure. We agree. We did not mean to suggest that our apparent spreads capture all that is important. While we would like to measure these dimensions, it is very difficult to measure the speed of execution without time-stamped order information. Similarly, it is difficult to quantify the costs of reduced transparency without knowing where and when information arrives.

Reference

Hansch, O., N. Naik, and S. Viswanathan. 1993. Market Making on the London Stock Exchange: An Empirical Observation. Working paper, London Business School.

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