Price formation and transparency on the London Stock Exchange

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Abstract

This paper contributes to the empirical market microstructure literature on the London Stock Exchange (LSE) by producing model-based estimates of the spread and its components. The paper applies the same approach to test for changes in the determinants of price formation following the January 1996 change in the market's publication rules. Our results suggest that order-processing costs are a far more important determinant of the LSE spread than the literature has so far presumed. Consistent with existing research findings, we find no discernible effect of post-trade transparency on market liquidity.

1 Introduction

The availability of a rich transaction data set from the London Stock Exchange (LSE) has enabled market microstructure researchers to test empirically a number of hypotheses pertaining to competitive dealer markets.(1) This paper contributes to and complements this growing literature by studying the determinants of price formation on the LSE and testing whether they were affected by a recent change in the Exchange's publication rules.

The empirical microstructure literature on the London Stock Exchange falls broadly into three groups. A first group of studies produces measures of the spread for either the market as a whole or for individual market-makers. Although all studies find that a substantial proportion of all trades are executed within the 'touch' (the term used in London for the inside spread), their results on the variation of spreads with trade size are less consistent. Reiss and Werner (1995) find that spreads fall with trade size, whereas Breedon (1993) and Board and Sutcliffe (1995, 1996) document a U-shaped pattern with giant trades exhibiting a sudden increase in spreads. Board *et al* (1997) and Naik and Yadav (1997) document stock-specific and market-maker specific variations of spreads with trade size.

A second group of studies (Snell and Tonks (1995, 1998), Vitale (1996) and Trebeschi (1997)) tests for evidence of adverse selection and inventory control effects on market-maker quoting behaviour.(2) This is done by estimating the reduced forms of structural models of monopolistic quote-setting models. Their

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(1) On 20 October 1997, the London Stock Exchange introduced SETS (Stock Exchange Electronic Trading Service), an electronic order book for trading FT-SE 100 stocks. SETS is running in parallel with the traditional telephone-based dealer market, albeit with no requirement for dealers to post firm bid and ask prices, and no obligation to honour trades up to a guaranteed trade size. There has been no change in the trading system of non FT-SE 100 stocks, although in March 1998, the LSE published a consultation document, which, amongst other issues, raised the subject of order book extension to FT-SE 250 stocks. Until 20 October 1997, and thus during the sample period analysed in this paper, the LSE—the world's third largest equity market by market capitalisation—operated as a pure dealer market with a market structure similar to the NASDAQ (Section 3 gives further details on pre-order book LSE institutional structure).

(2) The theoretical microstructure literature has explained the spread through the use of two main models. The models of inventory control of Stoll (1978), Amihud and Mendelson (1980), Ho and Stoll (1981) explain the spread as the market-maker's compensation for taking on positions that distance him from his 'optimal' position. The adverse selection models of Copeland and Galai (1983), Glosten and Milgrom (1985) and Easley and O'Hara (1987) explain the spread as the compensation market-makers seek from the risk of trading with a better informed counterparty.

results support the hypothesis that market-makers take into account inventory-holding costs when quoting prices, but find little evidence of information asymmetry effects. This is a surprising result given the focus of much of the theoretical literature on adverse selection(3) and the evidence to the contrary using data from US exchanges.(4)

One reason that existing tests may fail to identify information asymmetry effects is because they are based on models which abstract from market-makers' strategic incentives to capture informed order flow. The theoretical models of Leach and Madhavan (1992, 1993), Madhavan (1995) and Naik *et al* (1994) have demonstrated that such incentives can lead market-makers to offer better prices to informed investors in return for information which they can use in later trading. At first glance, these models appear to be most applicable to dealer markets where trading occurs over the telephone on a bilateral, non-anonymous basis. This enables the bilateral exchange of information and private negotiation described by the theory. In contrast, on electronic order-driven markets, order routing is automatic and often anonymous, so the strategic price-setting described above would prove much more difficult. Hansch and Neuberger (1996) find some empirical support for this type of behaviour when they show that the overall trading revenues of market-makers who take on loss-making trades are higher than the trading revenues of those who do not.

A third group of studies adds further insight into the behaviour of LSE market-makers by exploring the time series properties of market-maker inventories. Hansch *et al* (1998) find strong mean reversion effects for market-makers with very large inventory-holdings, but considerably weaker effects for market-makers with less extreme positions.(5) Using the same data set, Reiss and Werner (1998) study the extent to which market-makers trade with each other to unwind inventory. Their results suggest that market-makers are much more likely to engage in inter-dealer trading when they hold extreme inventory positions, but are much less likely to do so otherwise. Although the results of the second and third group of studies provide strong support for the hypothesis that dealer inventory control affects price formation in the direction predicted by

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(3) For a detailed review of the theoretical market microstructure literature, see O'Hara (1995) and Easley and O'Hara (1995).

(4) See, for example, the results of Hasbrouck (1988) and Madhavan and Smidt (1991).

(5) Overall, however, the results of Hansch *et al* (1998) suggest that mean reversion in LSE market-makers' inventories is stronger than mean reversion in NYSE specialists' inventories. They report an average mean half life of inventories of 2.5 days, which is much lower than the 7.3 days found by Madhavan and Smidt (1993) for NYSE specialists.

theory, they do not determine the extent to which they are responsible for quote-setting behaviour relative to other costs.

This paper aims to fill this gap in the literature by identifying and quantifying the determinants of market-maker quoting behaviour on the LSE. The paper employs a version of a spread model developed recently by Huang and Stoll (1997) which encompasses the well-known covariance models of Roll (1984), Choi *et al* (1988) and George *et al* (1991), and the trade indicator models of Glosten and Harris (1988) and Madhavan *et al* (1997).

The Huang and Stoll model has a number of features that recommend its application to LSE data. First, the model-based approach provides estimates of the traded spread based entirely on actual transaction prices rather than on quote data. This is important, as previous research has cast doubt on the relevance of quoted spreads as a measure of transaction costs: Reiss and Werner (1995) and Naik and Yadav (1997) document that only 30%-40% of all LSE trades occur within the narrowest quoted spread. Research has also shown that LSE market-makers maintain a constant quoted spread throughout the trading day (Reiss and Werner (1995), Board *et al* (1997), Naik and Yadav (1997)).

Second, while US transaction data typically require inference of the trade direction (whether a trade is a buy/sell) from the location of the trade price in relation to the mid-quote,[(6)] LSE data report the trade indicator variable for the vast majority of transactions. In a recent paper, Manaster and Mann (1998) find that the application of the Lee and Ready algorithm to the measurement of realised spreads can lead to seriously misleading conclusions. In light of these results, it is clearly very valuable to have data on trade direction.

Third, the Huang and Stoll model imposes minimal structure on the data, thereby reducing the possibility of model misspecification. Moreover, the model's flexibility allows us to test for the effects of institutional changes on the determinants of price formation. Indeed, we apply the model to test whether the January 1996 increase in post-trade transparency has affected the determinants of the spread.

(6) This is typically done by using the Lee and Ready (1991) algorithm. See eg Huang and Stoll (1997), Huang and Stoll (1996), Madhavan *et al* (1997), Bessembinder (1997), Bessembinder and Kaufman (1997) and Easley, Kiefer and O'Hara (1997).

Our findings suggest that order-processing costs are a far more important determinant of the LSE traded spread than the existing literature has so far presumed. We find that order-processing costs account for the entire traded spread for small trades and that they are a dominant component of the spread for larger trades. Consistent with some, but not all, existing studies, we find that trades exceeding the trade size for which market-makers are obliged to trade at the touch or better, receive significant price improvement. Finally, we find no evidence of a change in market liquidity following the January 1996 increase in post-trade transparency.

The structure of the paper is as follows. Section 2 describes our version of Huang and Stoll's spread model. Section 3 describes our data set and provides descriptive measures of the spread. Section 4 provides estimates of the traded spread and its determinants. Sections 5 and 6 examine whether the increase in post-trade transparency in January 1996 has led to any discernible changes in spreads and their determinants. Finally, Section 7 summarises our main findings and concludes.

2 Model

In this section, we develop a version of the Huang and Stoll (1997) (HS) model. We assume that the fundamental value of the asset V_t is determined immediately after the observation of the last trade occurring at t-1 and immediately prior to the posting of the bid and ask prices, and is given by

$$V_t = V_{t-1} + \alpha(S/2)Q_{t-1} + \varepsilon_t \qquad \textbf{(1)}$$

where Q_t is the trade indicator variable and is equal to +1 (-1) for a buyer (seller) initiated trade, $S/2$ is the traded half-spread and is defined as half the difference between the ask price $P_t(Q_t = +1)$ and the bid price $P_t(Q_t = -1)$, α is the percentage of the spread accounted for by adverse selection and ε_t is the public information innovation. For example, a buyer-initiated purchase ($Q_{t-1} = +1$) causes an increase in the fundamental value of the theoretical price V_{t-1} of an amount equal to $\alpha(S/2)$, to account for the probability that the buyer has private information. Notice that equation **(1)** assumes implicitly that consecutive trades are serially uncorrelated. If consecutive trades were correlated, the predictable part of the value of Q_{t-1} would be already incorporated in the determination of V_{t-1} and the second term of equation **(1)** would be equal to the unpredictable element in t-1 order flow.[(7)]

The quoted prices are given by

$$P_t = V_t + (S/2)Q_t + \beta(S/2)\Sigma_i Q_t + \eta_t \qquad \textbf{(2)}$$

with i=1, ...t-1,

where $\Sigma_i Q_i$ is the cumulative inventory-holdings of the market, β is the proportion of the spread accounted for by inventory-holding costs and η_t is the difference between the observed trade price and the theoretical price, and includes effects such as abnormal profits or price discreteness.[(8)] Notice that equation **(2)** defines the half-spread as the deviation of the quoted price from the fundamental value of the asset after it has been adjusted for inventory-holding costs.

Taking first differences of equation **(2)** and substituting the first difference of equation **(1)** into the result we obtain the market's pricing rule:

$$\Delta P_t = (S/2)\Delta Q_t + (\alpha+\beta)(S/2)Q_{t-1} + e_t \qquad \textbf{(3)}$$

where $e_t = \Delta\eta_t + \varepsilon_t$

Equation **(3)** shows that, in the absence of public information shocks and rounding errors ($e_t = 0$), trades of the same sign ($Q_t = Q_{t-1}$) induce a price change ΔP_t that exactly mirrors adverse selection and inventory-holding costs, whereas trades of the opposite sign induce larger price changes which reflect the 'bid-ask

(7) Huang and Stoll (1997) consider a modified model that estimates the spread and its components together with a trade reversal parameter. This is necessitated by the presence of strong positive serial correlation in their trade data. In contrast, our trade data indicate that the assumption of a trade reversal probability equal to a half is fairly reasonable. For example, for the seven stocks in our sample the maximum likelihood estimates for the probability of a trade reversal (à la Choi *et al* (1988)) lie between 0.41 and 0.47. Hence, we can safely employ the basic model described by equations **(1)** and **(2)**.

(8) Unlike the NYSE and NASDAQ which have a minimum tick size of £1/16 (recently halved from £1/8), there is no mandatory tick size on the LSE. The results of Board *et al* (1997) and Naik *et al* (1997) have shown that dealers rarely quote prices at fractions of a penny, suggesting that the market's effective tick size is £1/100.

bounce', that is, order-processing costs. Order-processing costs, in turn, consist of the back-office costs of order-handling and settlement.

Equation **(3)** can be re-arranged to give:

$$\Delta P_t = (S/2)Q_t + (\lambda-1)(S/2)Q_{t-1} + e_t \qquad \textbf{(4)}$$

with the proportion of the spread accounted for by adverse selection and inventory costs given by λ ($\lambda = \alpha+\beta$) and the proportion of the spread accounted for by order-processing costs given by 1-λ. Unlike a number of previous trade indicator models of the spread which identify separately adverse selection costs (eg Glosten and Harris (1988), Madhavan *et al* (1997)) combining inventory with order-processing costs, estimation of equation **(4)** enables the separate identification of order-processing costs and combines adverse selection with inventory-holding costs.

Following HS, model **(4)** can be generalised to examine the relationship between the spread and its components conditional on trade size

$$\Delta P_t = \Sigma_j \, (S^j/2)\, D^j_t + \Sigma_j \, (\lambda^j-1)(S^j/2)\, D^j_{t-1} + e_t \quad \text{for all } j \text{ considered} \quad \textbf{(5)}$$

where $D^j{}_t = Q_t$ if the trade at time t belongs to size category j, and 0 otherwise, S_j is the spread for size category j and λ_j is the proportion of the spread in size category j accounted for by adverse selection and inventory costs.

We estimate equation **(5)** using non-linear least squares, with Newey-West correction to account for the serial correlation in the error term e_t and any heteroskedasticity that may arise, among other things, from unequal time intervals between consecutive trades.[(9)]

(9) Similar to Huang and Stoll (1997), we first estimated model **(5)** using a GMM procedure with overidentified restrictions (due to the attractiveness of its weak distributional assumptions and the difficulties of applying maximum likelihood estimation procedures to transaction price data). For all stocks, we found that the Hansen test rejected these restrictions, suggesting that the use of exactly identified orthogonality conditions is more appropriate. Given that a GMM procedure with the same orthogonality conditions as the number of estimable parameters is equivalent to a least squares

3 Data

London Stock Exchange: Institutional basics

Between 26 October 1986 and 20 October 1997, the LSE was a pure multiple-dealer market. Competing dual-capacity market-makers were required to quote firm bid and ask prices for a guaranteed trading volume of 1 NMS[(10)] using SEAQ, an automated quote-dissemination system modelled after the NASDAQ. Members of the LSE could see on their SEAQ screens the three best bid and ask prices and the identities of the market-makers that were posting them. Order routing and trade execution was not automated and trading was conducted non-anonymously through bilateral communication over the telephone.

LSE rules provided 'best execution', ie between 08:30 and 16:30 GMT, market-makers were not allowed to execute trades at prices that were worse than the touch, unless these trades were larger than 1 NMS. Best execution rules, however, did not prevent market-makers from trading within the touch at prices agreed through bilateral negotiation. Indeed, consistent with earlier studies, we find that 28% of the trades in our sample took place within the touch.[(11)] Owing to its dealer market structure, the vast majority of trades on the LSE were either intermediated or initiated by market-makers. Market-makers traded with each other either directly over the telephone or indirectly through one of the four inter-dealer broker screens (IDBs), which provided them with an anonymous electronic order-driven trading facility to which only they had access.

Preparation of the data

We use data for all transactions in a sample of seven stocks that occurred between October 1995 and March 1996. The data consist of trade reports from all

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procedure with Newey-West correction (Greene 1993, page 379), the reported results were obtained using the latter.

(10) Normal Market Size: approximately equal to 2.5% of average daily trading volume. NMS figures are revised every quarter on the basis of the previous quarter's average daily trading volume.

(11) Moreover, orders did not necessarily flow to the market-maker quoting the best price on SEAQ. Hansch *et al* (1997), for example, find that approximately 70% of public trades were 'preferenced', ie they were executed by market-makers who were not quoting the best bid or the best ask price on SEAQ.

counterparties to each transaction. Each record identifies: the name of the stock, the date and time of the trade (up to the closer minute), the price, the quantity, the sterling value of transaction, whether the reporting party was a buyer or a seller, whether it was acting as a principal or an agent, and whether it was a registered market-maker, a broker-dealer (ie a LSE member but not a registered market-maker) or a LSE non-member.

Apart from trades between a LSE member and a non-member for which the member reports both sides of the trade, all other trades are reported from all counterparties to the transaction enabling cross-checking. The data on price, quantity and counterparty identities are likely to be accurate, because they originate from the LSE's internal transaction validation system that is used for settlement purposes. However, as noted by a number of other researchers,[12] there is some doubt about the accuracy of the time stamps. Indeed, we encountered a small number of cases where the buyer's time stamp differed from the seller's time stamp. In these cases we applied an arbitrary rule and always used the time stamp of the seller. We also adjusted the data for so called 'contra-trades' (trades that are reversed by agreement of both parties) and aggregated multiple trades which related to a single transaction.[13]

As mentioned in Section 1, an advantage of LSE transaction data over US transaction data is that they report the trade indicator variable (the variable Q_t in equation **(1)**) for the vast majority of trades. In particular, the direction of the trade is given for all public trades (96% of trades in our sample). Moreover, it is possible to determine the direction of IDB trades using the reports of the different counterparties to an IDB trade (see also Reiss and Werner (1998)). The market-maker who 'hits' a sell (buy) order displayed on the IDB's screen is charged a transaction fee by the IDB and thus reports to the LSE the same quantity but a higher (lower) transaction value than the transaction value reported by the 'poster' of the order. Hence, the data allow us to determine which counterparty was posting the limit order, thus offering liquidity, and which counterparty initiated the transaction, thus absorbing liquidity.

The rest of the trades in our sample were direct trades between market-makers (like Board and Sutcliffe (1995) we refer to these trades as 'IMM' trades). For IMM

(12) See, for, example Neuberger (1992) and the Appendix in Reiss and Werner (1995).
(13) These multiple recorded trades are known in the Exchange as 'shapes'. Shapes usually originate from broker-dealers who have executed a number of client orders in one single transaction but who report them separately for settlement purposes.

trades, we inferred the trade direction from quote data from the Lee and Ready (1991) algorithm. We assigned trades with a price greater (less) than the mid-quote prevailing at the time of the transaction as buyer (seller)-initiated. In the cases where the price equalled the mid-quote we used the 'tick-test'.[14]

Although considerable care was devoted to preparing the data, there are some features of the LSE's trade-reporting system that prevent us from obtaining a perfectly accurate sequence of transactions. First, members are only required to report their trades within three minutes of their inception. Second, anecdotal evidence suggests that a substantial number of large customer trades are carried out on a 'protected basis'. Protected trades occur when a market-maker offers potential price improvement to a customer providing that he gets time to 'work' the trade before it is actually booked. These trades are therefore reported at a different time than the time of their inception. Third, so-called 'baskets' are reported to have occurred at the mid-quote, whereas in fact they were executed as part of a portfolio of trades, the price of which will usually be different than the sum of the mid-quote prices of all of its components. Unfortunately, our data set does not identify either category of trades, and as such does not give us any indication of their prevalence.[15]

Sample selection

The purpose of our sample selection was to choose a small number of stocks with volume characteristics that are representative of FT-SE 100 and FT-SE 250 stocks.

In a recent paper, Hansch (1997) has demonstrated that the inventory time series behaviour of LSE stocks with ADRs is different from that of stocks without ADRs. This result suggests that price formation for such stocks could be rather different as well. As the purpose of this paper is to learn more about price formation in general, we chose to eliminate stocks with ADRs[16] listed on LSE, on NYSE, or on the NASDAQ. For similar reasons, we eliminated stocks with options traded on LIFFE because investors in these stocks have hedging

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(14) The tick-test classifies trades as follows: if the trade price is greater (less) than the price of the previous transaction it is classified as buyer (seller)-initiated.

(15) Wells (1995) estimates that basket trades contribute to 7% of volumes. Board and Lai (1997) apply a variety of filters and find that the percentage of baskets in volume can be as high as 13% and as low as 3%.

(16) ADRs (American Depositary Receipts) are dollar-denominated instruments representing ownership of a fixed number of shares of their underlying securities. A number of UK companies have ADRs listed on LSE and/or one of the major US exchanges.

opportunities not available to investors in other stocks. This first selection left us with 20 stocks from the FT-SE 100 and with 170 stocks from the FT-SE 250.

The second step was to choose randomly one FT-SE 100 stock from a high, a medium, a low, and a very low volume category. Unfortunately, all 20 of the selected FT-SE 100 stocks were found to be among the average and lowest volume FT-SE 100 companies. We therefore decided to abandon the traded option criterion when choosing a high and a medium volume FT-SE 100 stock. Our sample of FT-SE 100 stocks is: Prudential, ASDA, Guardian Royal Exchange (GRE) and Whitbread. Both Prudential and ASDA have an option traded on LIFFE, but in the case of ASDA this is not actively traded.

The third step was to pick randomly three stocks from the 170 remaining FT-SE 250 stocks, namely Caradon, Argos and Charter.

A natural choice for size categories is as follows: Small if the trade size is up to 1 NMS (recall that during our sample period market-makers were required to trade at the touch or better for trades up to 1 NMS); Med1 if the trade size is greater than 1 NMS and up to 3 NMS; Med2 if the trade size is greater than 3 NMS and up to 6 NMS (trades in this category were subject to a 90-minute publication delay in the first three months of our sample period, but were published immediately in the last three months of the sample period); and Large if the trade size is greater than 6 NMS (trades greater than 6 NMS were subject to a 60-minute publication delay in the last three months of our sample period).

Descriptive statistics

Summary statistics for our seven stocks are presented in Table A.[17] The number of trades for the six-month period ranks from 32,819 for Prudential to 1,866 for Charter, which records a higher percentage of IDB and IMM, trades. By contrast, the average customer trade for the other six stocks lies between £34,068 (ASDA) and £62,157 (GRE). Consistent with Reiss and Werner (1995) and Board and Sutcliffe (1995), IDB and IMM trades are larger in size than customer trades for all stocks in our sample. It also appears that the majority of trades can be termed Small (up to 1 NMS): except for Charter, they account for at least 80% of all trades. Charter further distinguishes itself with a higher average customer trade of £120,939. Charter is also unusual in that it has 13% of trades above 3 NMS and

(17) In this and all subsequent tables in the paper we list stocks in descending order according to number of trades.

a further 10% above 6 NMS. The corresponding percentages for the other six stocks—both FT-SE 100 and FT-SE 250—lie between 1% and 3%.

Table B presents summary statistics of two descriptive spread measures, the effective spread and the touch, both in pennies (Columns 2 and 3 respectively) and in percentage terms (Columns 4 and 5 respectively). The effective spread is defined as twice the absolute difference between the traded price and the touch mid-quote (Huang and Stoll (1996)). Both spread measures are reported for the sample as a whole, as well as for the four trade size categories.(18)

We can draw a number of observations from Table B. First, average percentage effective spreads are found to lie between 0.36% (Whitbread) and 1.14% (ASDA) for FT-SE 100 stocks, and between 0.50% (Argos) and 1.24% (Caradon) for FT-SE 250 ones. Hence, the less actively traded FT-SE 250 stocks do not necessarily have higher percentage spreads. Second, the effective spread is significantly smaller (at the 5% level) for Med1 and Med2 trades than for Small trades for all stocks except for Prudential and Charter. Third, four stocks in our sample (Whitbread, GRE, Caradon and Argos) display the U-shape pattern found by some, but not all, the earlier empirical studies, with effective spreads for trades greater than 6 NMS significantly greater than Med1 and Med2 trades.

Table C reports the frequency of executed trades at, in and out of the touch for all stocks in our sample and for different size categories. Consistent with the results reported in Table B, we find that the occurrence of price discounts (trades inside the touch) is lowest for Small trades and highest for Med1 and Med2 trades, with Large trades more likely to occur outside the touch than trades in any of the other three size categories.(19)

4 Determinants of the traded spread

Empirical results

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(18) Notice that for trade sizes greater than 1 NMS the touch is only given for comparative purposes because market-makers are not required to trade at the touch for sizes greater than 1 NMS.

(19) Despite the fact that best execution rules prevent dealers from executing trades of sizes up to 1 NMS at prices worse than the touch, Table C reports a number of instances where this appears to have occurred (see also Board *et al* (1997) for a similar result using a different sample period). A probable explanation for this result lies in the inaccuracy of time stamps discussed in the previous subsection. Recalling that the computation of the effective spread requires the matching of transaction price data with the best bid and best ask quotes prevailing at the time of the transaction, we can see that incorrect time stamping of either the price or the quote data results in mismatching.

In this section, we obtain model estimates of the spread and its components.

We begin by estimating equation **(5)** allowing for four trade categories (j=4). In particular we let $D^1{}_t = Q_t$ if the trade at time t is Small and 0 otherwise, $D^2{}_t = Q_t$ if the trade at time t is Med1 and 0 otherwise, $D^3{}_t = Q_t$ if the trade at time t is Med2 and 0 otherwise, and $D^4{}_t = Q_t$ if the trade at time t is Large and 0 otherwise. We also let (1- λ_1), (1- λ_2), (1- λ_3), (1-λ_4) be the order-processing cost component (OPC) of the spread for Small, Med1, Med2 and Large trades respectively, where $\lambda_1, \lambda_2, \lambda_3, \lambda_4$ are the sums of the adverse selection and the inventory-cost components of the spread for Small, Med1, Med2 and Large trades respectively.

The results of this estimation are reported in Panel A in Table D. When comparing the model-based estimates of the traded spread reported in Columns 3-6 with the effective spread and the touch spread measures reported in Columns 2 and 3 of Table B, we see that for all stocks and for almost all size categories the estimated traded spread is lower than the effective spread (the only exception being the effective spread estimate for Large trades for ASDA), suggesting that these measures may overestimate the spread component of LSE execution costs. The results relating to the order-processing cost component of the spread suggest that they make up the bulk of the spread for Small trades. Order-processing cost estimates for all other size categories are mixed and have often theoretically implausible values (ie values exceeding unity) and large standard errors.

Next, we consider two constraints that impose overidentifying restrictions on specification **(5)** with four trade size categories. The first constraint requires the spread and its components to be equal across trade size categories, which, in effect, constrains equation **(5)** to be equal to equation **(4)**. The second constraint imposes the restriction that the traded spread and its components are equal across size categories with the exception of the Small trade size category. The results of over-identifying restrictions for the first and second constraints are reported in Panel B (Columns 2 and 4 respectively) of Table D. Clearly, the χ^2 statistics reject the null hypothesis of no variation of spreads and its components across size categories for all seven stocks in our sample, suggesting that equation **(4)** is an inappropriate specification. By contrast, the χ^2 statistics fail to reject the null hypothesis that the traded spread and its component are equal for Med1, Med2 and Large size categories, for all stocks, except Whitbread, for which the value of the χ^2 implies only a marginal rejection (P-value is 3.9%).

The over-identifying tests reported in Panel B suggest that a more appropriate specification of equation **(5)** will allow for two size categories (j=2), with $D^1{}_t$

equal to Q_t for Small trades at time t and equal to zero otherwise, and with D^2_t equal to Q_t for trades in Med1, Med2 and Large size categories at time t and zero otherwise.

Panel C of Table D presents the estimation results for the two-size category specification. We first note that estimated spreads on small trades are always wider than those on the larger trades. These differences are significant for all but one stock (GRE). Second, order-processing costs account for at least 95% of the traded spread in Small size. Indeed, Wald coefficient tests (not reported here for brevity) fail to reject the hypothesis that the order-processing cost component of Small trades is equal to one for all seven stocks in our sample. This is a striking result and suggests that the spread cost of the vast majority of trades (recall from Table A the large percentage of 1 NMS trades) is entirely due to order-processing costs. Third, order-processing costs decline with trade size for all but one stock (Prudential). This latter result, however, is significant at the 5% level for only three stocks (Whitbread, Argos and Charter).

Our results are interesting in several respects. Order-processing costs are found to be the dominant factor explaining trading costs averaging 99% of the small traded spread and 80% of the spread for trade sizes greater than 1 NMS. At first sight, the latter result is consistent with theoretical models suggesting that adverse selection and order-processing costs are increasing in trade size. It is important, however, to bear in mind that the component of the spread for larger trade sizes is significantly different from the component of the spread for smaller trade sizes for only three out of the seven stocks in our sample.

Consistent with some of the earlier papers that used descriptive measures of the LSE spread, our model-based traded spreads are found to be significantly lower for trades above 1 NMS, where the market-maker's obligation to trade at the touch or better disappears. Interestingly, these results hold for all stocks, regardless of their trading activity, suggesting that trades in our less actively traded FT-SE 250 stocks do not present higher adverse selection or inventory risks than trades in the more actively traded FT-SE 100 stocks.

At this stage it is interesting to contrast our findings with those of HS who study 20 actively traded NYSE stocks and with 1 size category (equation **(4)**). They report average order-processing costs of 88%. When estimating the model with different size categories, they find a significant decline in order-processing costs. Consistent with the theoretical model of Easley and O'Hara (1987), they find spreads to rise with trade size. Unlike ours, their results present a picture of price formation that is closer to the early theoretical models of market microstructure.[20]

Comparison with the literature and discussion

Given this dissimilarity, it is useful to evaluate our results in the context of the earlier empirical literature on the LSE and to examine the suitability of the Huang and Stoll (HS) model for our purposes.

Our two main findings—that adverse selection and inventory costs make up a very small percentage of the traded spread and that spreads decline with trade size —can certainly be explained by the theoretical models of dynamic trading. As mentioned in our Introduction, in these models, market-makers and their customers negotiate price improvement in exchange for information that can be exploited in later trading rounds. To do so, a market-maker may be willing to grant a favourable price and forgo compensation for either inventory-holding risk or adverse selection risk. Such behaviour would be a possible explanation for our results. It is also consistent with earlier empirical findings of Hansch and Neuberger (1996) who suggest that London market-makers make little revenue from spreads, but do generate money from position-taking.

A sceptical reader may disagree with this interpretation and argue that adverse selection and inventory control effects form a much greater percentage of the spread than our findings suggest, but that the HS model fails to capture them. In what follows we discuss certain idiosyncrasies of the London market that could affect the interpretation of the model's results, without invalidating its use.

First, the model assumes that market-makers update prices to reflect new information or inventory shocks without any delay (see equations **(1)** and **(2)**).[21] Previous research, however, has found evidence of inertia on the part of some London market-makers (see Board *et al* (1997)). The HS model, as indeed many other market-maker models, were developed with the NYSE and its specialist market-makers in mind. The explicit contractual arrangements of the NYSE are

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(20) Unlike our results, the Huang and Stoll (1997) results are subject to the Manaster and Mann (1998) criticism which casts doubt on tests that rely on the Lee and Ready trade classification algorithm. Interestingly, the Manaster and Mann evidence also suggests that in futures markets, market-makers are willing to reduce the spread they charge customers to exploit their information advantage (ie to make a well-timed trade).
(21) We thank the referee for bringing this point to our attention.

such that market-makers are less likely to quote prices that are not fully up to date. In London, no such contractual obligations exist, so it is not inconceivable that market-makers would be slower in updating their prices. This could be an alternative explanation as to why our results on the sum of asymmetric information and inventory effects are weaker than those in the US literature.

Second, as we discussed in Section 3, the accuracy of the timing sequence of trades in our data set cannot be guaranteed. This is a concern to anyone interested in the London market. At the same time, the various research methodologies applied on London data and described earlier are affected by potential timing inaccuracies to varying degrees, yet their respective results seem to support each other.

Clearly, both the nature of the LSE data and the behaviour of London market-makers have features that distinguish them from their US counterparts. Nonetheless, one should bear in mind that the HS model has been successfully applied to US data and has revealed the presence of inventory and, to a lesser extent, adverse selection cost components. In contrast and consistent with our results, none of the existing LSE studies discussed earlier has found any strong evidence of adverse selection risk, whereas the evidence on inventory control behaviour applies mainly to extreme inventories.

5 Liquidity and transparency: The issues

Institutional background

In most decentralised multiple dealer markets, such as government bond and foreign exchange markets, transactions remain largely undisclosed. In contrast, the LSE equity market was characterised by a high degree of post-trade transparency, where post-trade transparency is defined as the availability of information on executed transactions. However, in comparison with other equity markets, the LSE had lower post-trade transparency, primarily as a result of publication delays for large customer transactions.

The rationale for delaying the publication of block trades has been the subject of a controversial debate. On the one hand, it has been argued that delayed publication reduces market-makers' exposure to inventory and adverse selection risks by allowing them time to 'work' block trades before they get published. According to this argument, delayed publication, *ceteris paribus,* improves liquidity. On the other hand, it has also been argued that delayed publication decreases the speed with which information is incorporated in prices without conferring any benefits on market liquidity. Finally, some commentators have cast doubts on the relevance of delayed publication rules altogether. According to their argument, regardless of publication regime, market-makers are able to choose their own level of 'optimal transparency' by adjusting their level of protected trading.

Partly as a result of the controversial nature of the debate, LSE rules on post-trade transparency have been subject to frequent changes. The most recent change became effective on 1 January 1996 when the existing delay of 90 minutes for all trades above 3 NMS was replaced by a delay of 60 minutes only for customer trades larger than 6 NMS. Moreover, inter-dealer trades that were subject to the same publication delays as other trades became subject to immediate publication. No changes were made to a special treatment for transactions exceeding 75 times NMS that can be subject to a publication delay of up to five days.[22]

Empirical evidence

Breedon (1993) and Gemmill (1996) do not detect any statistically significant effect of changes in publication regimes on either the size of the bid-ask spread or the speed of price adjustment. However, both authors find that, on average, the spreads of large trades relative to the spreads of small trades were narrower under the regime with the longest publication delay. In particular, Gemmill finds that relative spreads were narrower for three of the four years of the longest publication delay regime (February 1989-December 1993), but that in 1990 the opposite result holds. He attributes this result to differences in relative market volatility between the two different periods.

Board and Sutcliffe (1995) report that market-makers did not make full use of the publication delay to unwind their positions. Board and Sutcliffe (1996) find that the change in the publication rules of 1 January 1996 resulted in a dramatic decrease in the value of trades subject to delayed publication with no accompanying reduction in the number of block transactions or any widening of their bid-ask spreads.

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(22) For details on the changes in post-trade transparency regime between Big Bang and the introduction of SETS and for an overview of the empirical literature in the field see Ganley *et al* (1998).

Objectives

In the next section we assess how the last change in the LSE's transparency regime (prior to the introduction of SETS) has affected trading patterns, spread size and its components. We begin by following Board and Sutcliffe (1995,1996) and test a number of hypotheses relating to changes in the distribution of trading as well as to changes in the levels of spreads. We then apply our version of the HS spread model to test whether the increase in post-trade transparency has increased adverse selection and inventory-holding costs. The advantage of the latter methodology is that it focuses on the effects of post-trade transparency on the determinants of price formation, rather than on changes in spread levels, which may well be due to changes in market-wide factors (such as stock-specific market volatility).

6 Liquidity and transparency: Empirical results

In this section, we present the summary statistics and the estimation results for the two sub-periods in our sample. These are the three months preceding the increase in post-trade transparency (October 1995-December 1995) (which we refer to as Period 1) and the period thereafter (January 1996-March 1996) (which we refer to as Period 2).

Consistent with the findings of Board and Sutcliffe (1995, 1996), the results in panels A and B of Table E show that the distribution of trades across size categories is unaffected by the change in trade publication. In particular, we do not detect a tendency of traders to avoid the 3-6 NMS category and to trade instead in the 6 NMS category. The percentage of trades in the 3-6 NMS category increases (insignificantly) for two stocks (ASDA and Argos) and falls significantly for three others (GRE, Caradon and Charter).

More noticeably, the percentage of trades above 6 NMS decreases significantly for all stocks except Prudential. Similarly, we do not observe a significant decline in the use of IDB or IMM trades.

Table F records summary spread statistics for Period 1 and Period 2. These results are also consistent with those of Board and Sutcliffe (1995, 1996). For five out of seven stocks we fail to reject t-tests of the null hypothesis that the effective spreads in the 3 NMS to 6 NMS category are equal in the two sample periods (recall that trades in this category were subject to delayed publication in Period 1 and subject to immediate publication in Period 2). The exceptions are Caradon, where we see a significant drop in the effective spread from 2.33 to 1.43 pence, and ASDA, which experiences a reduction from 0.84 to 0.62 pence. However, these changes appear to be related more to decreases in the volatility of these stocks than to changes in the transparency regime.[23] Overall, these results contradict the hypothesis that spreads increased as a result of the increase in post-trade transparency.

Panels A and Panel B in Table G record estimation results of the two-size category versions of equation **(5)** for Period 1 and Period 2 respectively. The P-values in Panel B correspond to χ^2 tests of the joint null hypothesis that order-processing costs for the two-size category model are identical in Periods 1 and 2. These tests show clearly the failure to reject the null hypothesis of equal order-processing costs between the two different periods. These results contradict the hypothesis that the increase in transparency has led to higher adverse selection and inventory costs.

7 Conclusions

Much of the existing empirical literature covering the LSE has either focused on the production of descriptive measures of the spread or on the identification of inventory-holding and adverse selection effects.

This paper contributes to this literature by producing model-based estimates of the spread and by measuring its components. Unlike the US literature on the topic, these measures do not rely on the Lee and Ready trade classification algorithm because the data report the trade indicator variable for all public trades. The paper also applies the same model-based approach to test for changes in the determinants of price formation following the January 1996 change in the market's publication rules.

Our results suggest that:

- Order-processing costs are a far more important determinant of LSE spreads than has thus far been presumed. Indeed, order-processing costs account for the entire traded spread for trades up to the mandatory trade size and for the bulk of the traded spread for larger trades.

(23) In the case of ASDA and Caradon, the standard deviation of transaction returns fell sharply from Period 1 to Period 2 (from 2.13% to 1.37% for ASDA and from 1.22% to 0.88% for Caradon).

- The estimated traded spread for trades above the mandatory size of 1 NMS is smaller than the spread for smaller trades.

- Consistent with the findings of Breedon (1993), Gemmill (1996) and Board and Sutcliffe (1996), we find no effect of the change in publication regime on either the distribution of trades or spreads. More significantly, we find no effect of the change in publication regime on the adverse selection and inventory-holding cost components of the traded spread.

The introduction of the electronic order book, SETS, in October 1997 offers a unique opportunity to study how changes in a market's organisational structure affect price formation. Preliminary statistics released by the Stock Exchange indicate that less than a third of total volume is traded on SETS with the rest being traded bilaterally on the telephone in the 'upstairs' dealer market (there is no compulsory interaction between the order book and upstairs trading). In light of the pre-SETS evidence presented in this paper, we conclude by offering some tentative hypotheses on how the introduction of SETS may have affected the market.

First, anecdotal evidence suggests that dealers commit less capital now than they did before SETS was introduced and consequently face considerably less inventory risk. The results in this paper suggest that it is unlikely that this would have had a major impact on 'upstairs' spreads. Second, the available transaction data, while sketchy, indicate that the vast majority of trades conducted on SETS are small trades of 1 NMS or less with large trades being conducted almost exclusively on the 'upstairs' market (see for example the results of Board and Wells summarised in a survey by the London Financial News, 5/10/98). Our results clearly show that pre-SETS, trades less than 1 NMS received worse execution than large trades. It would be interesting to test whether SETS has decreased the execution costs associated with these trades. Third, as the introduction of SETS coincided with a further increase in the LSE's post-trade transparency, concerns were expressed once more with regards to transparency's impact on liquidity. The evidence in this paper suggests that it is possible to increase transparency without affecting liquidity.

Table A: Descriptive statistics

Panel A	Market Value (10/95) (£ mn)	Number of trades	Customer	IDB	IMM	Small	Med1	Med2	Large
			Percentage of trades (%)						
Prudential	7193.34	32,819	92.36	5.43	2.21	94.12	4.09	1.27	0.51
ASDA	3021.01	24,250	89.68	7.63	2.69	92.49	5.64	1.17	0.70
Whitbread	2948.53	13,011	90.63	5.53	3.84	90.55	6.74	1.88	0.83
GRE	1913.40	10,802	84.69	10.79	4.53	84.26	11.59	3.06	1.09
Caradon	1296.83	7,996	89.38	8.19	2.43	86.86	8.48	3.07	1.59
Argos	1500.77	6,634	90.99	5.98	3.03	83.75	9.96	3.47	2.83
Charter	745.87	1,866	75.94	17.95	6.11	53.22	23.96	12.57	10.25

Panel B	Mean trade size (no of shares)				Mean trade size (£)			
	All	Customer	IDB	IMM	All	Customer	IDB	IMM
Prudential	16,223	12,083	52,558	100,212	69,236	51,351	223,407	438,618
ASDA	43,487	32,879	125,727	163,789	45,128	34,068	130,886	170,514
Whitbread	9,363	6,347	33,493	45,821	63,328	42,879	226,778	310,736
GRE	30,504	25,169	51,322	80,709	75,591	62,157	126,993	204,445
Caradon	32,941	26,005	62,809	187,615	66,291	52,323	127,625	373,726
Argos	10,228	8,029	34,118	29,086	59,255	46,434	198,650	168,953
Charter	15,194	14,536	19,806	9,828	12,652	120,939	165,322	81,880

The table lists descriptive statistics for the seven stocks in our sample. A customer trade is a trade between a market-maker and a non market-maker customer, an IDB trade is a trade between two market-makers dealing with each other indirectly and anonymously through an inter-dealer broker. IMM trades are direct telephone trades between two market-makers. ëSmallí is a trade which is less or equal to 1 NMS (Normal Market Size). ëMed1í is a trade which is greater than 1 NMS and less or equal to 3 NMS. ëMed2í is a trade greater than 3 NMS and less or equal to 6 NMS. ëLargeí is a trade greater than 6 NMS. The NMSs for the seven stocks in our sample are: 75,000 shares for Prudential for the period between October 1995 and December 1996 and 50,000 shares for the remaining sample period, 100,000 shares for ASDA for the period October 1995 to December 1995 and 200,000 shares for the remaining period, 25,000 shares for Whitbread, 50,000 shares for GRE, 50,000 shares for Caradon, 10,000 shares for Argos, 5,000 shares for Charter. Average prices for the seven stocks in our sample are: 425.86p for Prudential, 104.4p shares for ASDA, 679.79p for Whitbread, 251.75p for GRE, 203.96p for Caradon, 585.99p for Argos, 840.26p shares for Charter.

Table B: Summary spread statistics (October 1995 ñ March 1996)

PRUDENTIAL	Spread(p)	Touch(p)	Spr/mid(%)	Touch/mid(%)
Small	2.26	2.26	0.53	0.53
	(6.75)	(0.71)		
Med1	2.04	2.15	0.48	0.51
	(8.97)	(0.75)		
Med2	2.45	2.12	0.57	0.50
	(9.04)	(0.86)		
Large	4.82	2.11	1.13	0.49
	(20.13)	(0.73)		
All	*2.27*	*2.25*	*0.53*	*0.53*
	(7.02)	*(0.71)*		

WHITBREAD	Spread(p)	Touch(p)	Spr/mid(%)	Touch/mid(%)
Small	2.51	2.79	0.37	0.41
	(1.74)	(0.88)		
Med1	1.88	2.59	0.28	0.38
	(1.66)	(0.88)		
Med2	1.99	2.67	0.29	0.39
	(1.93)	(0.83)		
Large	2.47	2.69	0.37	0.41
	(2.28)	(0.94)		
All	*2.46*	*2.78*	*0.36*	*0.41*
	(1.75)	*(0.89)*		

ASDA	Spread(p)	Touch(p)	Spr/mid(%)	Touch/mid(%)
Small	1.22	1.10	1.17	1.05
	(2.82)	(0.45)		
Med1	0.84	1.02	0.82	0.98
	(1.92)	(0.45)		
Med2	0.86	0.99	0.84	0.96
	(1.22)	(0.42)		
Large	0.86	0.93	0.85	0.91
	(1.00)	(0.41)		
All	*1.19*	*1.09*	*1.14*	*1.04*
	(2.76)	*(0.45)*		

GUARDIAN ROYAL EXCHANGE	Spread(p)	Touch(p)	Spr/mid(%)	Touch/mid(%)
Small	2.73	2.44	1.10	0.97
	(7.13)	(0.74)		
Med1	1.90	2.32	0.75	0.93
	(2.17)	(0.78)		
Med2	2.02	2.38	0.80	0.96
	(1.72)	(0.75)		
Large	2.79	2.32	1.15	0.96
	(4.08)	(0.79)		
All	*2.61*	*2.42*	*1.05*	*0.97*
	(6.61)	*(0.74)*		

CARADON	Spread(p)	Touch(p)	Spr/mid(%)	Touch/mid(%)
Small	2.59	3.17	1.27	1.56
	(1.98)	(0.87)		
Med1	1.86	3.06	0.93	1.51
	(1.53)	(0.89)		
Med2	1.92	3.08	0.97	1.54
	(1.74)	(0.97)		
Large	2.99	3.03	1.52	1.53
	(2.79)	(0.83)		
All	*2.51*	*3.16*	*1.24*	*1.55*
	(1.97)	*(0.87)*		

CHARTER	Spread(p)	Touch(p)	Spr/mid(%)	Touch/mid(%)
Small	4.42	4.98	0.53	0.59
	(5.26)	(1.87)		
Med1	3.89	4.66	0.46	0.56
	(5.39)	(1.76)		
Med2	3.49	4.78	0.42	0.57
	(4.03)	(1.86)		
Large	3.95	5.14	0.47	0.62
	(3.58)	(1.91)		
All	*4.14*	*4.89*	*0.49*	*0.58*
	(5.03)	*(1.85)*		

ARGOS	Spread(p)	Touch(p)	Spr/mid(%)	Touch/mid(%)
Small	3.05	3.02	0.52	0.52
	(4.32)	(0.92)		
Med1	2.40	2.75	0.40	0.47
	(4.29)	(0.98)		
Med2	2.06	2.87	0.35	0.49
	(2.15)	(0.86)		
Large	2.31	2.75	0.40	0.49
	(2.8)	(0.94)		
All	*2.93*	*2.98*	*0.50*	*0.51*
	(4.23)	*(0.93)*		

The table lists descriptive measures of the spread for the seven stocks in our sample. ëSpreadí is the effective spread and is equal to twice the absolute difference between the transaction price and the prevailing mid-quote. The touch is the difference between the best bid and the best ask. The figures in brackets are the standard errors of the mean spreads reported above them.

Table C: Percentage of trades at, in and out of the touch

(%)		Small	Med1	Med2	Large
PRUDENTIAL	At	70.97	44.30	40.79	26.83
	Inside	24.95	49.27	46.19	37.80
	Out	4.08	6.43	46.19	35.37
ASDA	At	75.69	42.50	42.86	43.90
	Inside	18.97	48.64	45.05	37.80
	Out	5.35	8.86	12.09	18.29
WHITBREAD	At	73.47	49.53	38.40	29.52
	Inside	23.56	45.42	52.74	47.62
	Out	2.97	5.05	8.86	22.86
GRE	At	54.00	47.94	44.41	30.36
	Inside	35.65	43.98	40.89	40.18
	Out	10.35	8.09	14.70	29.46
CARADON	At	51.91	33.38	28.51	34.15
	Inside	44.12	62.77	61.28	43.90
	Out	3.98	3.85	10.21	21.95
ARGOS	At	66.80	41.65	32.74	32.97
	Inside	28.34	49.92	57.40	49.45
	Out	4.86	8.42	9.87	17.58
CHARTER	At	48.23	40.84	21.80	31.03
	Inside	45.68	51.24	67.77	54.60
	Out	6.10	7.92	10.43	14.37

The table lists the percentage of trades in, inside and out the touch. The touch is the difference between the best ask and bid price prevailing at the time of the transaction.

Table D: Model estimates

Panel A		Traded spread (p)				OPC component of spread (%)			
		Small	Med1	Med2	Large	Small	Med1	Med2	Large
PRUDENTIAL	Coeff	1.85	0.81	1.90	2.75	0.96	1.28	0.80	0.56
	St. error	(0.05)	(0.24)	(0.43)	(0.69)	(0.03)	(0.47)	(0.29)	(0.28)
ASDA	Coeff	0.85	0.63	0.55	0.25	0.97	0.80	0.68	2.38
	St. error	(0.03)	(0.09)	(0.16)	(0.17)*	(0.03)	(0.12)	(0.31)	(1.67)*
WHITBREAD	Coeff	2.31	1.53	1.53	1.21	1.00	0.55	0.78	1.13
	St. error	(0.03)	(0.09)	(0.25)	(0.31)	(0.01)	(0.05)	(0.25)	(0.21)
GRE	Coeff	1.65	1.24	1.67	1.41	0.95	0.64	0.71	1.20
	St. error	(0.14)	(0.40)	(0.19)	(0.55)	(0.05)	(0.40)	(0.11)	(0.38)
CARADON	Coeff	2.24	1.32	0.77	1.59	0.98	0.80	1.30	0.65
	St. error	(0.04)	(0.11)	(0.21)	(0.37)	(0.02)	(0.08)	(0.34)	(0.19)
ARGOS	Coeff	2.49	1.69	1.36	1.33	1.01	0.68	0.44	0.91
	St. error	(0.09)	(0.21)	(0.26)	(0.20)	(0.03)	(0.21)	(0.35)*	(0.19)
CHARTER	Coeff	3.42	2.22	2.13	2.24	1.04	0.76	0.65	0.84
	St. error	(0.24)	(0.42)	(0.58)	(0.73)	(0.08)	(0.14)	(0.23)	(0.27)

* Denotes that the coefficient is not statistically significant at the 5% level.

Panel B	**First constraint**: The traded spread and its components are equal across all size categories		**Second constraint:** The traded spread and its components are equal across Med1, Med2 and Large categories	
	χ^2	P-value	χ^2	P-value
PRUDENTIAL	51.1061	0.000	5.0818	0.279
ASDA	57.8528	0.000	5.4738	0.242
WHITBREAD	151.6374	0.000	10.0894	0.039
GRE	15.8548	0.015	5.9647	0.202
CARADON	190.5187	0.000	7.1101	0.130
ARGOS	46.7863	0.000	3.1030	0.541
CHARTER	31.2200	0.000	0.3900	0.983

Table D (continued)

Panel C		Traded spread (p)		OPC component of spread (%)	
		Small	> 1 NMS	Small	> 1 NMS
PRUDENTIAL	Coeff	1.85	1.22	0.96	0.98
	St. error	(0.04)	(0.25)	(0.03)	(0.17)
ASDA	Coeff	0.86	0.58	0.97	0.84
	St. error	(0.03)	(0.07)	(0.03)	(0.12)
WHITBREAD	Coeff	2.31	1.51	1.00	0.64
	St. error	(0.03)	(0.09)	(0.01)	(0.05)
GRE	Coeff	1.65	1.35	0.95	0.70
	St. error	(0.14)	(0.30)	(0.05)	(0.13)
CARADON	Coeff	2.24	1.23	0.98	0.85
	St. error	(0.04)	(0.10)	(0.02)	(0.07)
ARGOS	Coeff	2.49	1.50	1.00	0.69
	St. error	(0.09)	(0.14)	(0.03)	(0.10)
CHARTER	Coeff	3.42	2.21	1.04	0.75
	St. error	(0.24)	(0.34)	(0.08)	(0.11)

Panel A reports the results of estimating $DP_t = S_j (S^j/2) D^j_t - S_j (1- l^j)(S^j/2) D^j_{t-1} + e_t$, where j is equal to Small, Med1, Med2 and Large size categories, S^j is the spread for size category j, $1- l^j$ is the order-processing cost component (OPC) of the spread for size category j, l^j is the sum of the adverse selection and inventory-holding cost component of the spread for size category j, and D^j_t is a dummy variable that takes the value of 1 if the trade at time t is in category j and it is buyer-initiated, takes the value of -1 if the trade at time t Is in category j and it is seller-initiated, and is zero otherwise. The equation was estimated using least squares with Newey-West correction. Panel B reports c^2 tests of two constraints imposed on the same equation. Panel C reports the results of estimating $DP_t = S_j (S^j/2) D^j_t + S_j (l^j -1)(S^j/2) D^j_{t-1} + e_t$, where j is equal to Small (less or equal to 1 NMS) and greater than 1 NMS, S^j is the spread for size category j, $1- l^j$ is the order-processing cost component (OPC) of the spread for size category j, l^j is the sum of the adverse selection and inventory-holding cost component of the spread for size category j, and D^j_t is a dummy variable that takes the value of 1 if the trade at time t is in category j and it is buyer-initiated, takes the value of -1 if the trade at time t is in category j and it is seller-initiated and takes the value of zero otherwise. The equation was estimated using least squares with Newey-West correction.

Table E: Descriptive statistics for different publication regimes

Panel A	No trades	Customer	IDB	IMM	Small	Med1	Med2	Large
Period 1		% of trades	% of trades	% of trades	% of trades	% of trades	% of trades	% of trades
Prudential	14,609	92.39	5.25	2.36	94.83	3.70	1.12	0.35
ASDA	13,366	90.06	7.06	2.88	90.33	6.86	1.70	1.10
Whitbread	5,113	90.03	5.85	4.13	89.62	7.18	1.94	1.27
GRE	5,556	85.21	10.31	4.48	83.19	11.90	3.58	1.33
Caradon	3,474	89.00	8.18	2.82	84.55	9.24	3.81	2.40
Argos	2,633	90.13	6.57	3.30	81.81	10.98	3.29	3.92
Charter	805	74.91	19.38	5.71	47.09	23.27	16.20	13.43

Panel B	No. trades	Customer	IDB	IMM	Small	Med1	Med2	Large
Period 2		% of trades	% of trades	% of trades	% of trades	% of trades	% of trades	% of trades
Prudential	18,210	92.34	5.57	2.08	95.24	3.28	1.02	0.46
ASDA	10,884	89.21	8.32	2.46	90.97	6.56	1.76	0.72
Whitbread	7,898	91.02	5.33	3.65	91.16	6.45	1.83	0.55
GRE	5,246	84.14	11.28	4.57	85.40	11.25	2.50	0.85
Caradon	4,522	89.67	8.20	2.12	88.64	7.88	2.49	0.99
Argos	4,001	91.55	5.60	2.85	85.02	9.29	3.58	2.11
Charter	1,061	76.70	16.80	6.41	58.00	24.36	9.70	7.95

The table lists descriptive statistics for two subperiods in our sample. Panel A reports results on the distribution of trades by type of counterparty and by trade size for Period 1, the subperiod with the less post-trade transparent regime of October 1995-December 1996. Panel B reports results on the distribution of trades by type of counterparty and by trade size for Period 2, the subperiod with the more post-trade transparent regime of January 1996-December 1996.

Table F: Summary spread statistics

PRUDENTIAL	Spread(p)		Touch(p)	
	Per. 1	Per. 2	Per. 1	Per.2
up to 1	2.29	2.25	2.48	2.08
	(3.07)	(8.87)	(0.70)	(0.66)
1 to 3	1.95	2.09	2.35	1.97
	(2.05)	(8.77)	(0.75)	(0.74)
3 to 6	2.11	2.34	2.42	1.91
	(3.78)	(4.94)	(0.85)	(0.77)
above 6	4.92	5.44	2.42	1.91
	(7.04)	(27.68)	(0.73)	(0.74)
All	*2.28*	*2.26*	*2.47*	*2.08*
	(3.07)	*(9.02)*	*(0.70)*	*(0.67)*

ASDA	Spread(p)		Touch(p)	
	Per. 1	Per. 2	Per. 1	Per. 2
up to 1	1.29	1.15	1.06	1.14
	(3.12)	(2.46)	(0.45)	(0.44)
1 to 3	0.94	0.71	0.99	1.07
	(2.31)	(0.96)	(0.42)	(0.50)
3 to 6	0.84	0.62*	0.96	1.04
	(1.23)	(0.52)	(0.42)	(0.47)
Above 6	0.87	0.90	0.90	1.10
	(1.04)	(1.05)	(0.39)	(0.41)
All	*1.26*	*1.11*	*1.05*	*1.14*
	(3.03)	*(2.37)*	*(0.45)*	*(0.44)*

GUARDIAN ROYAL EXCHANGE	Spread(p)		Touch(p)	
	Per. 1	Per. 2	Per. 1	Per. 2
up to 1	3.40	2.05	2.47	2.41
	(9.83)	(1.57)	(0.77)	(0.71)
1 to 3	2.06	1.72	2.40	2.24
	(2.73)	(1.26)	(0.78)	(0.77)
3 to 6	2.12	1.86	2.33	2.44
	(1.78)	(1.62)	(0.74)	(0.75)
above 6	3.01	2.42	2.30	2.36
	(3.27)	(5.17)	(0.89)	(0.58)
All	*3.19*	*2.01*	*2.45*	*2.39*
	(9.04)	*(1.61)*	*(0.77)*	*(0.71)*

WHITBREAD	Spread(p)		Touch(p)	
	Per. 1	Per. 2	Per. 1	Per. 2
up to 1	2.46	2.54	2.85	2.76
	(1.41)	(1.92)	(0.89)	(0.88)
1 to 3	1.95	1.83	2.57	2.60
	(1.64)	(1.67)	(0.85)	(0.90)
3 to 6	1.86	2.08	2.59	2.72
	(1.94)	(1.93)	(0.85)	(0.81)
above 6	2.80	1.97	2.79	2.52
	(2.55)	(1.71)	(0.85)	(1.06)
All	*2.42*	*2.48*	*2.82*	*2.75*
	(1.47)	*(1.91)*	*(0.89)*	*(0.88)*

	CARADON			
	Spread(p)		Touch(p)	
	Per. 1	Per. 2	Per. 1	Per. 2
up to 1	2.77	2.46	3.37	3.02
	(2.32)	(1.67)	(0.93)	(0.78)
1 to 3	2.13	1.62	3.23	2.91
	(1.72)	(1.28)	(0.98)	(0.76)
3 to 6	2.33	1.43*	3.22	2.92
	(1.88)	(1.43)	(1.02)	(0.90)
above 6	3.57	1.91	3.15	2.81
	(3.18)	(1.34)	(0.86)	(0.73)
All	*2.71*	*2.36*	*3.35*	*3.01*
	(2.29)	*(1.66)*	*(0.94)*	*(0.79)*

	ARGOS			
	Spread(p)		Touch(p)	
	Per. 1	Per. 2	Per. 1	Per. 2
Up to 1	2.93	3.13	2.98	3.04
	(3.53)	(4.75)	(0.79)	(0.99)
1 to 3	2.02	2.70	2.57	2.89
	(2.01)	(5.42)	(0.87)	(1.03)
3 to 6	1.93	2.14	2.85	2.89
	(2.21)	(2.12)	(0.80)	(0.90)
above 6	2.14	2.52	2.87	2.61
	(2.12)	(3.45)	(0.92)	(0.95)
All	*2.77*	*3.04*	*2.93*	*3.01*
	(3.33)	*(4.73)*	*(0.82)*	*(1.00)*

	CHARTER			
	Spread(p)		Touch(p)	
	Per. 1	Per. 2	Per. 1	Per. 2
up to 1	4.79	4.20	5.01	4.96
	(7.22)	(3.61)	(1.95)	(1.81)
1 to 3	3.84	3.92	4.54	4.75
	(6.92)	(4.00)	(1.67)	(1.83)
3 to 6	3.34	3.90	4.62	4.98
	(4.20)	(4.32)	(1.82)	(1.89)
above 6	3.86	4.06	5.24	5.01
	(3.69)	(3.46)	(1.91)	(1.92)
All	*4.23*	*4.09*	*4.87*	*4.91*
	(6.41)	*(3.77)*	*(1.88)*	*(1.83)*

This table reports the average of the effective spread and the touch for two subperiods in our sample: Period 1 (October 1995-December 1996) and Period 2 (January 1996-March 1996). The measures are defined as in Table B. Standard errors are in brackets. A * means that the spread has significantly changed between the two periods.

Table G: Estimation results for different publication regimes*

Panel A	Spread(p)		OPC(%)	
Period 1	Small	Large	Small	Large
Prudential	1.98	1.04	0.99	0.98
	(0.03)	(0.21)	(0.01)	(0.18)
ASDA	0.76	0.64	0.94	0.81
	(0.04)	(0.81)	(0.05)	(0.15)
Whitbread	2.31	1.14	1.01	0.68
	(0.07)	(0.25)	(0.04)	(0.12)
GRE	1.50	1.40	0.93	0.71
	(0.30)	(0.55)	(0.10)	(0.23)
Caradon	2.16	0.95	0.96	0.78
	(0.05)	(0.10)	(0.02)	(0.11)
Argos	2.53	1.79	0.99	0.65
	(0.11)	(0.24)	(0.04)	(0.13)
Charter	3.31	2.42	1.22	0.84
	(0.49)	(0.59)	(0.19)	(0.17)
Average	2.08	1.33	1.01	0.78

Panel B	Spread(p)		OPC(%)		
Period 2	Small	Large	Small	Large	P-value
Prudential	1.74	1.29	0.93	0.98	0.52
	(0.07)	(0.38)	(0.05)	(0.25)	
ASDA	0.96	0.43	0.99	0.96	0.45
	(0.03)	(0.06)	(0.02)	(0.14)	
Whitbread	2.30	1.54	0.99	0.74	0.72
	(0.05)	(0.14)	(0.01)	(0.08)	
GRE	1.77	1.27	0.96	0.68	0.90
	(0.04)	(0.10)	(0.02)	(0.07)	
Caradon	2.16	0.95	0.96	0.78	0.43
	(0.05)	(0.10)	(0.02)	(0.11)	
Argos	2.46	1.28	1.01	0.73	0.87
	(0.14)	(0.18)	(0.04)	(0.16)	
Charter	3.50	1.99	0.94	0.64	0.39
	(0.27)	(0.35)	(0.07)	(0.14)	
Average	2.129	1.249	0.971	0.787	

* All coefficients are significant at the 5% level.

Panel A and B report the results of estimating $DP_t = S_j\,(S^j/2)\,D^j_t - S_j\,(1- l^j)(S^j/2)\,D^j_{t-1} + e_t$ for Period 1 (October 1995 - December 1995) and Period 2 (January 1996 - March 1996) respectively, where *j* is equal to Small and greater than 1 NMS size categories, S^j is the spread for size category *j*, $1- l^j$ is the order-processing cost component (OPC) of the spread for size category *j*, l^j is the sum of the adverse selection and inventory-holding cost component of the spread for size category *j*, and D^j_t is a dummy variable that takes the value of 1 if the trade at time *t* is in category *j* and it is buyer-initiated, takes the value of -1 if the trade at time *t* is in category *j* and it is seller-initiated and is zero otherwise. The equations were estimated using least squares with Newey-West correction. Column 6 in Panel B reports the P-values of a c^2 test of the joint hypothesis that the OPC for the Small category spread in Period 1 (October 1995 - December 1995) is equal to the OPC for the Small spread in Period 2 (January 1996 - March 1996) and the OPC for the > 1 NMS spread in Period 1 is equal to the OPC spread for the > 1 NMS spread in Period 2.

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