# The Cost of Trading on Competing Parallel Markets: SETS Vs. Dealers in London

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## Abstract

We examine impatient traders' strategic choice between the electronic central limit order book, SETS, and dealers' inventories when trading 30 of the largest FTSE-100 stocks on the London Stock Exchange. We find that although the liquidity available on SETS is often large some traders still choose to transact directly with dealers because this allows them to negotiate better and more flexible terms. We study execution costs for mid- and large-size trades and find that the two alternative trading venues have comparable fixed costs but off-SETS executions often receive price improvement. A large off-book imbalance does not increase the probability of on-SETS trading in contrast with the hypothesis that SETS is predominantly used by dealers for rebalancing their inventories. Furthermore, the evidence we collect corroborates the theories of "upstairs/downstairs" trading costs and refutes reputation-based pricing.



**JEL Classification**: C35, G15, G29

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## Introduction

The growing presence of alternative trading venues in equities markets each vying to trade the same stocks raises a number of important questions. *What is the relation between order flow fragmentation, market quality and price efficiency*?[1] *How much do public investors pay to transact and what are the determinants of execution costs on alternative trading venues?* The latter is of increased concern to institutional investors and regulators. Institutional investors have become aware of the fact that transaction costs can substantially reduce, if not eliminate, the expected returns on their investment strategies and as a result, adopt strategic trading behaviour in order to minimise execution costs (Bikker *et al*. 2004, Conrad *et al*. 2002, Keim and Madhavan 1997 and Chan and Lakonishok 1995). While regulators, on both sides of the Atlantic, are increasingly concerned about ensuring that when brokers choose execution venues they fulfil their fiduciary obligations of providing "*best execution*" for their clients' orders.[2]

This paper uses transaction data to study execution costs for UK blue chips trading on the London Stock Exchange's (LSE) most liquid segment and tests empirically the different theories characterising traders' choice among competing trading venues. Since October 1997, traders in these benchmark securities can choose to submit orders either to an electronic limit order-book, SETS, or a competing parallel dealer market for execution.[3]

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[1] Whether or not fragmentation impinges on market quality and price efficiency has been the subject of much theoretical debates and empirical research. Thus far, the empirical evidence has remained largely inconclusive (see Harris 2003, Levin 2003 and Davies *et al*. 2003 for excellent surveys).

[2] See for examples the United States Senate's July 2004 Hearings on "*Regulation NMS and Development in Market structure*", Myner's (2001) Report on Institutional Investment for the HM Treasury, the European Commission's (2002) proposed revisions of Investment Services Directive of 1993 and the Financial Services Authority (FSA)'s (2002) proposal on best execution.

[3] SETS is the acronym for **S**tock **E**xchange Electronic **T**rading **S**ervice. In recent years, the LSE has further modified the structure of its equity market (for example, by introducing opening and closing single-price call auctions). These new changes represent a significant convergence to the structure of other European exchanges.

Theoretical models of *upstairs* versus *downstairs* trading and reputation-based pricing predict that upstairs dealer markets offer better terms of trade for block transactions than downstairs order-driven systems (Bernhradt *et al*. 2003, Desgranges and Foucault 2002 and Seppi 1990). Previous results for the New York Stock Exchange (NYSE), the Paris Bourse and relatively smaller exchanges – Toronto (TSX), Australia (ASX) and Helsinki (HSE) – provide supporting evidence (Madhavan and Cheng 1997, Bessembinder and Venkataraman 2002, Smith *et al*. 2001, Fong *et al*. 2003 and Booth *et al*. 2001).

As regard to studies on the LSE, four papers are closely related to our work. Jain *et al.* (2003) examine the extent of informed trading on the two competing trading venues and report that the permanent price-impact of a trade is larger on SETS. Friederich and Payne (2002) study the determinants of order flow for the two trading systems using both trade-related and market-wide variables. Their results indicate that both the state of the order book and market conditions affect traders' choice of execution venue. These authors recognise that a large proportion of the retail order flow is traded off-SETS through specialised Retail Service Providers. Evidence indicates that many retail orders still require non-standard settlement conditions and this prevents them from trading directly on SETS (Davies *et al.* 2003). Hence, to model traders' choice of either SETS or the dealer market to trade FTSE-100 stocks, we consider it is more appropriate to focus on the cost of executing trades with size larger than that of a typical retail transaction.

Naik and Yadav (1999) find that the cost of trades executed by public investors declines after the introduction of SETS. The authors, however, assume dealers to be counterparty to all off-SETS trades reported by members acting in principal capacity and identify public trades on SETS as trades where one counterparty to the transaction acts as an agent. This approach seems too

restrictive for two reasons. First, it does not take into account that institutional traders often engage in total return swaps with members. In other words, members often execute clients' orders as principal trades so that their clients can avoid paying the stamp duty on stock purchases. Second, firms that are members of the London Clearing House.Clearnet can only trade as principal on SETS. An examination of the trading activity reveals that the vast majority of trades executed on SETS are between two members acting in principal capacity. Finally, Ellul (2000) investigates the volatility of trade prices and find that the volatility of prices is higher on SETS than on the dealer market.

We analyse the 30 largest market capitalisation stocks in the FTSE-100 Index on December 2, 2002, which survived through to February 28, 2003, a total of 62 trading days. Our sample includes only ordinary trades (identified in the database with trade types "AT" and "O" for on- and off-book trades, respectively) with standard settlement conditions (T+3 business days). Hence, we analyse only trades that can be potentially traded on either system. Furthermore, we classify ordinary trades with a value greater than £10,000 as mid- and large-size transactions, while those with a value lower than or equal to £10,000 as small, retail transactions.[4] We find that, for our sample stocks, SETS accounts for roughly 69 and 91 percent of the retail and mid- and large-size transactions, respectively.

We investigate the dynamics of liquidity demand and supply on SETS by analysing orders that generate multiple trades when matched against orders on the other side of the order-book. We refer to these events as *single order multiple trades* (SOMTs) and aggregate trades originated

[4] The choice of a £10,000 threshold was based on private communications between the authors and London Stock Exchange officials. Naik and Yadav (1999) note that "most of the public trading through SETS is in medium-size trades in the £10,000 to one normal market size (NMS) range". The NMS is defined approximately as 2.5% of the average total daily trading volume for a particular stock over a reference three-month period.

from the same order on SETS to form a single transaction. For the 30 sample stocks, we find that the aggregation process involves about 51% of the original order book trades and, once aggregated, SOMTs are roughly 29% of SETS trades. Further, we find that only 12% of SOMTs have price-impact as a result of "walking" the order-book. However, the additional cost per share is roughly one tick on average (see the column labelled ΔVWAP in Table 3). This suggests that SETS is relatively liquid for the stocks we examine and traders, when submitting orders in these stocks to SETS, behave strategically in order to minimise price-impact costs.

We first compute sample statistics for realised trading costs using a range of benchmark methods and compare the costs of trades executed on the two competing venues. We find that, on average, off-SETS trades obtain cheaper execution across all trade sizes. Furthermore, mid- and large-size trades have higher (lower) execution costs than retail trades on SETS (off-SETS). More important, small off-SETS trades seem to cross-subsidise larger off-SETS trades, which corroborates earlier findings of Reiss and Werner (1996).

Using the empirical framework of Madhavan and Cheng (1997), we model traders' choice of either on- or off-SETS executions and derive bias free estimates of the transaction cost functions. Our results reveal that for mid- and large-size transactions, the dealer market has lower variable costs, the differences in fixed costs between the two competing venues are statistically comparable and the marginal price-impact of trade size on SETS is decreasing. In addition, only in a handful of stocks do we find that the reputation of a trader influences the price he receives from direct contact and negotiation with dealers.

We find that the probability of a trader placing a large order with a dealer increases with trade size and the percentage spread prevailing one second prior to the trade. There is also evidence of

time-of-the-day effect on the probability of trading off-SETS. The probability of trading with dealers increases from the start of the trading day to 14:00 GMT and then decreases towards the close of the market. The increased activity on SETS after 14:00 GMT may be explained by the presence of American investors and by dealers actively trading on SETS in order to avoid carrying unwanted inventory overnight. Interestingly, we find that the probability of observing off SETS trades significantly *decreases* (*increases*) with larger trade imbalances on-SETS (off-SETS). These are important findings and suggest the following. First, there appears to be a pool of unexpressed liquidity outside SETS in that, traders are continuously monitoring the state of the order-book for profitable trading opportunities. Second, contrary to the inventory positioning hypothesis, dealers appear not to use SETS for rebalancing their inventories. Hence, SETS is not use as an inter-dealer trading system as suggested by Naik *et al.* 2003.

Our paper contributes to the literature in number of ways. First, it is the first work known to the authors that empirically examines the cost of executing large orders on the hybrid market employed to trade FTSE stocks. Second, we develop a detailed road map for studying LSE data. Third, our work complements and extends the earlier works of Madhavan and Cheng (1997), Smith *et al.* (2001), Fong *et al*. (2003), Bessembinder and Venkataraman (2002) and Boot *et al*. (2001) on cost of trading on hybrid markets.

The rest of the paper is organised as follows. Section 1 presents a review of the theoretical models and empirical studies on the cost of trading on hybrid markets. The market model for FTSE-100 stocks, data methodology and summary statistics on SETS and dealers trades are discussed in Section 2. Section 3 provides estimates of transaction costs for on- and off-SETS executions. In Section 4, we present the empirical framework used to model traders' choice of

on- and off-SETS executions and derive bias free estimates of transaction costs on the competing venues. Section 5 concludes.

## 1. Review of Related Theoretical Models and Empirical Works

The decisions of traders whether to place orders on SETS limit order-book ("downstairs" market) or off-the-book with dealers ("upstairs" market) for execution are, no doubt, complex and highly specific to the characteristics of their clients' orders and desired investment strategies. Nevertheless, after controlling for market conditions and trade complexity, it is reasonable to assume that traders would always choose, from among the available alternatives, the trading venue that offers the lowest expected cost of execution.[5] Fong *et al*. (2003) argue that investors prefer to choose among competing trading venues because it is in their own benefits to do so rather than the external influences of laws and regulations. Hence, the choice of trading venue is determined endogenously and the manner in which traders decide to choose one available alternative over another is of utmost importance to regulators and investors.

Fortunately, the microstructure literature is fairly rich in theoretical models that provide predictions on how the cost of transacting on different trading systems influences traders' decision on where to place orders for execution. Most models compare the pricing of trades on the two typical trading mechanisms, namely an auction and a dealer market. A similar parallel is also drawn between the "downstairs" order-driven system and the "upstairs" dealer market for large orders, a common feature of most exchanges. These models focus on how the inherent differences in the market design between the two systems - anonymous trading and simultaneous competition for order flow in the former, as opposed to non-anonymous trading and inter-

[5] Brokers have a fiduciary obligation of ensuring that their clients' orders receive "best execution" and hence, it is expected that they will choose the cheapest alternative to execute their clients' orders.

temporal competition among dealers in the latter - determine the prices received by traders for orders. We now discuss these models in turn.

### *1.1 "Upstairs" versus "Downstairs" Trading*

Burdett and O'Hara (1987), Seppi (1990) and Grossman (1992) provide models that compare the relative costs of trading block transactions in the "upstairs" and "downstairs" markets on the NYSE. These models predict that the upstairs market offers better terms of trade for block transactions than the downstairs market because the former is better able to resolve the two major issues confronting traders of large orders: (1) order exposure and (2) information content. These authors note that non-anonymous negotiations of trades in the upstairs market facilitate the sharing of risks among dealers and block traders.

Grossman (1992) argues that the upstairs market allows traders to reveal their true trading interests because they are less likely to face the risk of being either "picked-off" by informed traders or "front-run" by others. As a result, dealers are better able to assess the true pool of available liquidity and, thereby, to offer price improvements to traders. Seppi (1990) contends that traders of large transactions in the upstairs market can negotiate price improvements if they can credibly signal that their trades lack information. In his model, the signalling takes the form of a "no bagging" commitment in that, the block trader agrees not to trade ahead of the dealer subsequent to the execution of his order by the dealer. The dealer's threat of withdrawal of price improvements on future trades for violations of the implicit trading agreement binds repeated customers. The model predicts that traders would only seek price improvements if uninformed and when informed, they would choose to trade anonymously at the dealer's posted quotes rather than face the risk of future price sanctions.

Madhavan and Cheng (1997) measure and study execution costs of block trades executed downstairs and upstairs on the NYSE. Their findings reveal that the upstairs dealer market has marginally lower execution costs than the downstairs order-driven system. Moreover, they find that the variable (fixed) costs of block trades are lower (higher) upstairs than downstairs, consistent with Grossman (1992), Seppi (1990) and Burdett and O'Hara (1987). Similar results are obtained by Fong *et al*. (2003) for the ASX, Bessembinder and Venkataraman (2002) for the Paris Bourse, Smith *et al*. (2001) for the TSX and Booth *et al*. (2001) for the HSE.

### *1.2 Models Based on the Reputation of Traders*

Reiss and Werner (1996) discover that large orders receive the bulk of the price improvements from dealers on the LSE. More recent studies by Hansch *et al*. (1999) and Bernhardt *et al*. (2003) for the LSE, Huang and Stoll (1996) for the NASDAQ and Theissen (2000) for the Frankfurt Exchange also obtained similar results. Their findings contradict existing microstructure models, which predict that large orders receive worse prices. Bernhardt *et al.* (2003) and Desgranges and Foucault (2002) argue that price improvements in dealership markets are due to reputation-based pricing by dealers in which, dealers give repeated customers with high values of reputation capital price discounts on their orders.[6]

In Bernhardt *et al.* (2003), the value of the customer's reputation capital is based on the net present value of the order flow the dealer expects to receive from the client. They argue that since the competition for order flow among dealers is largely inter-temporal, dealers offer price improvements to those customers who trade with them more frequently in order to "lock-in"

[6] In these models, reputation capital arises endogenously due to the fact that dealers know the identities of traders placing orders (trading is a repeated face-to-face interactions). In contrast, the anonymous nature of trading in auction markets does not allow for the creation of reputation capital.

future order flow. They show that customers who receive price improvements would tend to submit larger sized orders to their relationship dealers.

In contrast, Desgranges and Foucault (2002) argue that the value of a trader's reputation capital is contingent on the dealer past trading profits with the client. Therefore, the dealer's pricing strategy implicitly takes into account the cost of adverse selection and thus, deters informed traders from exploiting their information advantage against their relationship dealers. Similar to Seppi (1990), their model predicts that informed traders will not request price improvements but rather will attempt to trade anonymously at the posted quotes of dealers in order to avoid irreversible damage to their trading reputation. In this model, therefore, the size of past trading profits dealers received from traders serves as a signal as to whether they are informed or not and thus, determines whether they can bargain for price improvements on orders.

Few empirical papers have examined the effects of reputation capital on the cost of trading in equities markets. This is probably due to the fact that proprietary information on the trading activities of dealers is yet to be made widely available to researchers and the difficulty involved in measuring reputation capital of traders. Madhavan and Cheng (1997) deal with the problem by treating reputation capital as a latent variable in their model of upstairs market of the NYSE. Smith *et al*. (2001) use an indicator variable that reflects the type of counterparties to a trade as their measure for reputation capital of block traders on the TSX. Bernhardt *et al*. (2003) use six trade-related proxy variables to measure the strength of the trading relationship between a dealer and his customers, and thus reputation capital, on the LSE's SEAQ system. Battalio *et al.* (2005) study the transaction costs incurred by migrating and new brokers to trade in a stock when that stock relocates on the floor of NYSE.

Madhavan and Cheng (1997) and Smith *et al.* (2001) find that reputation capital is an important variable in explaining the differences in the costs of trading large transactions upstairs and downstairs on the NYSE and TSX, respectively. Bernhardt *et al.* (2003) also draw similar conclusions for LSE, arguing that the value of the trading relationship between a dealer and his customers can provide an explanation for price improvements on large orders reported for other dealership system such as NASDAQ, as well as the upstairs market of the NYSE. Finally, Battalio *et al*. (2005) find that specialists offer better prices to migrating brokers than new brokers to stocks that relocate on the floor of NYSE and hence, conclude that "*reputation plays an important role in the liquidity provision on process on the floor of the NYSE*". **In this paper, we adopt the approach of Madhavan and Cheng (1997) to empirically test for reputation-based pricing on the dealer market**.

### *1.3 Other Relevant Theoretical Models*

Snell and Tonks (2003), Rhodes-Kropf (2002), Bernhardt *et al.* (2002) and Vogler (1997) also advance models that examine the pricing of trades in equities markets. Snell and Tonks argue that neither pure auction nor dealer markets have material advantage over the other in the pricing of block trades. On the one hand, they point out that dealer markets offer better prices for block trades when there is high degree of information asymmetry because the sequential nature of the trading process allows dealers to discern the information signals of traders. On the other, they note that if liquidity shocks are the predominant source of price volatility, then auction markets are the preferred choice as the simultaneous competition for order flow among traders reduces the aggregate cost of trading.

Rhodes-Kropf (2002) provides an explanation for price improvements that does not depend on the value of a trader's reputation capital or information set. Intuitively, he argues that price improvements in dealership markets are due to the fact that some traders, especially institutional investors, whether informed or not, can demand improved terms of trade from dealers because of their market power. Vogler (1997) shows that traders receive better prices in dealership markets when compared to auction markets as long as dealers face no lengthy delays in *post-positioning* trades in the inter-dealer market. Bernhardt *et al.* (2001) examine the influence a cream-skimming exchange has on the cost of trading on a limit-order market. The authors find that all traders are made worse-off if the cream-skimming exchange is successful in capturing a significant proportion, if not all, of the retail order flow from the limit-order market. The model predicts that market-order traders pay a higher cost to trade than limit-order traders and the cream-skimming of order flow has minimal impact on the pricing schedule of dealers.

### *1.4 Review of Related Empirical Work*

Since the introduction of SETS, a few studies have examined the trading process for FTSE-100 stocks. Naik and Yadav (1999) focus on trading costs and find that with the introduction of SETS public investors face lower trading costs than during the previous SEAQ era. Gresse and Gajewski (2002) compare the cost of trading on the LSE and Euronext-Paris and their findings reveal that SETS (Euronext-Paris) offers better prices for large (small) orders. Other studies have investigated the effects that competition for orders between the parallel dealer market and SETS have on price formation, market quality and efficiency (Jain *et al*. 2003, Lai 2003, Ellul *et al.* 2003, Friederich and Payne 2002, Davies *et al.* 2002 and Ellul 2000).

Davies *et al.* (2002) and Lai (2002) find that prices for large FTSE stocks are mainly driven by SETS trades. Jain *et al*. (2003) examine the extent of informed trading on the competing venues. They find that SETS' trades are more informative than dealers' trades, consistent with the theoretical models discussed earlier. Finally, Friederich and Payne (2002) examine the determinants of the order flow on SETS and the competing dealer market, respectively, using trade-related and market-wide information variables. Consistent with Grossman (1992), Seppi (1990) and Burdett and O'Hara (1987), they find that trading on SETS tends to be low if the risk of execution or the level of informed trading is high.

In this paper, we examine the cost of trading FTSE stocks on SETS and the competing dealer market on the LSE. Our main contribution is that we analyse two independent trading systems (a dealer and pure auction markets) that closely resemble the archetypal markets envisioned in the theoretical models. In contrast to a number of exchanges such as New York, Toronto and Paris, the trading rules of the LSE do not enforce interaction between the two competing venues either in terms of price or size of trades. Thus, the special set-up of the London market provides an ideal environment for testing the theoretical models previously discussed.

## 2. Institutional Details, Data Methodology and Analysis

### *2.1 Market Model for FTSE-100 Stocks*

As previously mentioned, FTSE-100 stocks is traded on a hybrid system, where retail and institutional investors can choose to place orders on either SETS or with dealers for execution. Investors face no real restrictions on trading on either venue, except that the exchange requires that they trade through member firms. Orders, therefore, can be executed in one of the three

ways: (1) against standing limit orders on SETS, (2) against quotes of dealers on the competing dealership system or (3) partial execution on both venues.

Orders placed on SETS are executed via an electronic limit order-book in which, liquidity is supplied by orders residing on the book. All incoming orders are then matched against orders on the other side of book for possible execution. The off-SETS dealer market is analogous to the "upstairs" dealership system, where orders are either "shopped" or executed against the inventories of dealers. Negotiations on quotes are still fashioned after the informal phone-based system that existed during the SEAQ era. With the introduction of SETS, however, the exchange eliminated the Mandatory Quote Period and dealers are no longer required to quote firm prices or honour trades up to a guaranteed order size. Further, the exchange imposes no restrictions on the size or price of trades executed on the dealer market.[7] Hence, the supply of dealer services is entirely voluntary and unconstrained.

There are important differences in the trading environment between the competing venues. On SETS, trading is completely anonymous, information contains on the order-book is fully disclose and all trades are automatically reported and immediately published. Contrast with the non-anonymous trading (traders' identities are known to dealers), the general absence of information on available quotes and liquidity and the delay in the reporting of trades of dealers.[8] The differences in the degree of pre- and post-trade transparency between the two markets mean that members, who can trade as dealers and have unrestricted access to SETS, have an informational

[7] Although the exchange imposes no restrictions on the price of trades executed off-SETS, dealers are expected, nevertheless, to give traders prices that are at least as good as those discovered on SETS. A result of the Financial Service Authority's (FSA) rules of "best execution", which require, *inter alia*, that off-exchange's trades be priced no worse than the best prices on SETS.

[8] Dealers may delay the reporting of their trades by up to 3 minutes, except for Worked Principal Agreements and Protected Portfolio trades, which must be reported when completed. The exchange, however, immediately publishes all trades reported by dealers.

advantage over others in the trading of FTSE-100 stocks. This trading advantage is a by-product of: (1) a completely open limit order-book and (2) reporting delay of dealers' trades, which, in effect, gives dealers short-lived ownership of their trade information. *As a result, dealers are afforded the opportunity to strategically enter into profitable trade, as well as to manage their inventory risks through either pre- or post-positioning of orders*.[9]

In light of the above discussions, *one would expect that the dealer market to have lower cost execution costs than SETS for the trades in FTSE-100 stocks*. This is due to the fact that dealers have a profitable trading advantage over other traders and hence, can trade aggressively and pass on a portion of the trading benefits to their clients in the form of lower trading costs. In addition, the theoretical models previously discussed also predict that the dealer market would offer better prices for large transactions than SETS. In this paper, we collect evidence to*: (1) support or reject the theoretical models on the relative cost of transacting on pure dealership systems and auction markets, (2) evaluate whether the market for blue chip stocks in London is still predominately a dealer market and (3) determine whether dealers employ SETS as an inter-dealer system to position their inventories (see Naik et al. 2003)*.

### *2.2 Sample Selection and Data Preparation*

We select the 30 largest market capitalisation stocks in FTSE-100 Index during the period December 2, 2002 to February 28, 2003. Transaction and quotes data for these stocks were extracted from the "Trade Report" and "Best Prices" files of the Transaction Data Service (TDS)

[9] In addition to positioning trades on SETS, a dealer can also manage his inventory risks either by trading directly with other members on the dealer market or changing his 'upstairs' pricing schedule to attract orders.

of the LSE, respectively.[10] The stocks we choose contributed roughly 78% to the closing value of the Index on February 28, 2003. Appendix A provides summary information on these stocks.

In order to model the choice of execution venue, as well as to provide comparable estimates of the transaction costs on the competing venues, we prepare the data as follows. First, we distinguish between trades executed on-SETS and off-SETS with dealers. Second, we select only orders that are eligible to trade on either venue and are executed when both systems are operating simultaneously.

In relation to first issue, Madhavan and Cheng (1997) and Smith *et al*. (2001) employ ad hoc procedures based on trading rules to identify trades executed upstairs and downstairs on the NYSE and TSX, respectively. These procedures are prone to classification errors. Fortunately, the Trade Report contains identifiers that allow us to clearly distinguish between trades executed on- and off-SETS. Orders executed on SETS during continuous trading have a trade type identifier of "AT", while those executed during call auctions (open, close or intra-day after trading halts) are marked "UT". All other trade type identifiers relate to off-SETS executions.

As regard to the second issue, we consider only SETS "AT" and off-SETS ordinary ("O") trades executed during continuous trading and have a standard settlement period of T+3. This selection policy ensures that we make accurate inferences about traders' choice of either continuous dealership or rule-based order-matching system. Therefore, we exclude: (1) call auction trades, (2) off-SETS trades with non-standard settlement conditions, (3) ordinary off-SETS trades that were: (a) executed prior to and during the opening call auction, (b) matched after the close of

[10] The Best Prices contains records of all updates to the best bid and ask prices available on SETS. Dealers' quotes are not captured by any of the files of the TDS. However, SETS' prices are commonly recognised as the benchmark quotes in the market.

continuous trading at 16:30 GMT, (c) reported overnight or late (with trade time identifier "O" or "L") and (d) not published on time (with trade publication identifier "D"). Further, delayed and late reported trades are also excluded because it would be near impossible to accurately estimate their true price-impact.

Additional filters were applied to correct for cancelled, contra, post-contra, not-to-mark and late correction trades, which include deleting the original entries. We also omit trades if: (a) the absolute price change from the preceding trade exceeds 5%, (b) the absolute difference between the price of trade and the mid-quote of the best prices prevailing one second prior to the transaction is greater than 5% or (c) the price of the trade is zero.[11] We filter quotes to delete: (1) non-positive bid and ask prices and spreads and (2) bid and ask prices for which the absolute difference between the current and preceding mid-quote exceeds 5%. We consider only best limit-order prices posted during continuous trading to ensure conformity with the trade sample.

Similar to Lai (2003) and Saporta and Trebeschi (1999), to name but a few, we regroup SETS' trades that have the same timestamp and initiating member firm. These trades likely originate from a single order matching against multiple limit-orders residing on the order-book. The size and price of the regrouped trades are the aggregated volume and volume-weighted average price of the individual trades, respectively. The details of the method employed to regroup SETS' trades are shown in Appendix B. In contrast to Lai (2003), however, we do not regroup dealers'

[11] The price filter reflects, in part, the price stability rules for SETS traded stocks. The limit for price changes during SETS' continuous and VWAP sessions is 5%. There is no price stability rule for the dealer market. However, best execution rules require brokers to trade at prices that are no worse than concurrent prices on SETS. Hence, we use a 5% price limit for trades executed off-SETS in order to remove anomalous priced trades from the sample. We obtain similar results with a 10% price limit.

trades because it is not possible to uniquely identify multiple trades that relate to the execution of a single order.[12]

Finally, we classify trades as either buyer or seller initiated. For trades matched on SETS, we use the trade-sign identifier given in the Trade Report. The order initiating the trade is the most recently submitted order that removes liquidity from the order-book. As regard to off-SETS executions, we follow recent authors (Jain *et al*. 2003 and Lai 2003) and reverse the direction of trade-sign identifier. The trade-sign identifier in this case relates to the reporting side of the market of the member firm in accordance with the exchange's reporting rules 3520-3524. We, therefore, adopt the convention that all dealers' trades are initiated by their clients.

After applying the various filters, selection criteria and aggregation procedures, we are left with a total of 2,712,258 trades or roughly 65% of the original sample for the 30 selected stocks. In Appendix C, we report the number of trades excluded at the various stages of the data preparation for each of the stock in the sample.

### *2.3 Analysis of Trading on the Dealer Market and SETS*

Our sample of trades for the 30 stocks accounts for 97% of the transactions and 82% of volume and value executed on the exchange in these securities during normal trading hours and after-hours off-SETS. Thus, the vast majority of transactions in these blue chip stocks occurs during the hours 8:00 to 16:30 GMT and is mainly of the types "O" and "AT". Interestingly, we find that ordinary dealer trades ("O") account for a disproportionate large percent of the transactions executed off-SETS and these transactions mostly occur during normal trading hours. Indeed, the

[12] A client might trade with multiple dealers or split a large order into smaller trades to execute over time. It seems unlikely, however, that a dealer trading as principal would break a client's order into multiple trades and report them at the same time.

sample of ordinary trades represents 91% of the trades and 60% of the volume and value execute with dealers. After-hours trades are only 6% of off-SETS trading but represent 32% of total volume and value executed. Therefore, after-hours trades are, on average, generally quite large.

We find that SETS accounts for roughly 82% of the sample of 2,712,258 trades and therefore, dealers' executions only represent 18% of the sample. For the 62 trading days, the sample of trades represents a total volume and value of roughly 41,424 million shares and £141,383 million, respectively. SETS executions account for 69% and 68%, respectively, of these values. We divide the sample into retail (less than or equal to £10,000) and mid- and large size (greater than £10,000) transactions and report summary statistics for both category of trades in Tables 1 and 2. Table 1 provides the mean volume and value of retail transactions executed on- and off-SETS, while Table 2 contains similar statistics for mid- and large size trades.

In term of the number of retail versus mid- and large-size transactions, the latter dominate with roughly 61% of the sample. An examination of the distribution of trade sizes reveals that SETS accounts for a larger share of both retail (69%) and mid- and large-size (91%) transactions. We also find that SETS accounts for 77% (69%) of the total volume and value of retail (mid- and large size) transactions. These findings indicate that traders tend to concentrate their trading in these blue chip stocks on SETS. Nevertheless, a comparison of the average size and value of trades executed on both venues suggest that dealers provide an important liquidity provision for very small retail and very large institutional orders.

For the sample of stocks, the mean volume and value of retail trades executed with dealers are at least 1.5 times smaller than those matched on SETS. Further, these transactions represent a sizeable proportion of the trading off-SETS (68% of the trades). This can be explained by the

trading structure of the LSE, where large sell-side firms run proprietary trading systems ("Retail Service Providers") offering immediacy and price improvement for retail orders (see Davies *et al*. 2003). With respect to mid- and large-size trades, the mean volume and value placed with dealers are, on average, approximately 5 times larger than SETS trades (see Table 2). This indicates that dealers are very important source of liquidity for very large transactions.

Summarising, we find that traders on the LSE use SETS extensively to execute both retail and mid- and large-size orders but the competing dealer market are preferred by traders to execute very large transactions. Indeed, we find that the mean value of mid- and large-size trades placed with dealers is, on average, 5 times larger than those matched on SETS. This suggests that the liquidity provision of dealers complements SETS in the trading of FTSE stocks.[13] Nevertheless, SETS seems fairly liquid to accommodate even large orders in highly capitalisation stocks such as Glaxosmithkline (GSK), British Petroleum (BP), HSBC Holdings (HSBA) and Vodafone (VOD). For these stocks, the mean value executed on SETS, on average, exceeds £75,000 (see Table 2). In the ensuing section, we present a novel approach to assess the liquidity of an electronic limit order-book from transaction data.

### *2.4 Assessing the Liquidity of SETS from Transaction Data*

In the TDS, there is no readily available information on the state of the limit-order book at the time an order is submitted for execution and therefore, no way of assessing the liquidity of SETS without first reconstructing its order-book. However, an examination of the price-impact of aggressively placed limit-orders can shed some light on this important issue.

[13] Lai (2003), Davies *et al*. (2003), Ellul *et al*. (2003) and Naik and Yadav (1999) also find that the dealer market complements SETS for the trading of FTSE stocks.

Whenever an order is submitted to an electronic limit-order book, the system automatically checks whether the order offers a better price than residing limit-orders. If this is the case, the system then tries to match the order with limit-orders residing on the opposite side of the book. On SETS, order execution is done in a "discriminatory" fashion that is, if an order is large enough to execute against several residing limit-orders at different price lines, each transacts at its limit price. An order, therefore, can generate: (1) a single trade, (2) multiple trades at the prevailing best price or (3) multiple trades at different limit prices. We refer to orders that generate multiple trade events as *single order, multiple trades* (SOMTs) and those that generate a single trade event as *single order, single trades* (SOSTs).[14]

We identify SOMTs as trades that have the same time-stamp and initiating member. We then aggregate the size of these trades to form a single transaction. In contrast, SOSTs will either have different time-stamps or initiating members.[15] We study the price-impact of SOMTs in order to assess the depth available on SETS at the time of order submissions. We consider two measures of the price-impact: (1) the price change (ΔPrice) and (2) the volume-weighted average price change (ΔVWAP) and computations are as follows:

$$\Delta \text{Price}_t = I_t \times \left(P_t^l - P_t^f\right) \qquad (1)$$

$$\Delta \text{VWAP}_t = I_t \times \left(VWAP_t - P_t^f\right). \qquad (2)$$

$I_t$ is an indicator variable that takes a value of $+1$ $(-1)$ for a buy (sell) trade; $P_t^f$ and $P_t^l$ are the prices of the first and last trade, respectively, in the sequence of transactions in a SOMT and $VWAP_t$ is the volume-weighted average price of these trades. For SOMTs that impact on prices,

[14] Beltran *et al*. (2004) refer to these orders as "*aggressive trades*" and the exchange as "*multiple fill-orders*".
[15] In Appendix B, we outline the procedure use to identify and aggregate these trades.

we compute volume-weighted averages of measures (1) and (2) for each stock. These averages together with summary statistics for SOMTs and SOSTs are reported in Table 3.

Before aggregating SETS' trades, we find that 51% of the 3,254,342 transactions relate to SOMTs. After aggregating, however, SOMTs now account for roughly 29% of the 2,228,602 aggregated trades. Of that amount, only 12% had price-impact that is, execute across multiple price lines. In total, this represents only 3.6% of the aggregated trades and hence, a vast majority of the orders placed on SETS execute at the best prices. In Comparison, Beltran *et al*. (2004) find that, on average, 15.2% of the orders in the DAX-30 stocks on Xetra (Duetsche Börse's electronic trading system) are matched by limit orders residing beyond the best prices.

We find that price-impact SOMTs have mean size and value that are, on average, larger than that of non price-impact SOMTs and SOSTs (see Table 3). Further, price-impact SOMTs, on average, hit marginally more limit-orders in executing than non price-impact SOMTs. Price-impact SOMTs hit an average of 2.9 limit-orders, compared with 2.6 for non price-impact SOMTs.[16] The findings for the individual stocks are generally consistent with the overall sample averages. VOD is the only exception in which the average limit-order hits, size and value of non price-impact SOMTs are larger than the corresponding averages for price-impact SOMTs.

We also examine the maximum number of limit-orders hit by any single SOMT in executing and find that, in a few stocks, it is possible to have SOMTs match against more than 20 limit-orders

[16] These values are not reported in the table but the average number of limit-order hits per transaction is computed as the total number of original trades aggregated into SOMTs divided by the total number of SOMTs. We compute this statistics for both price-impact and non price-impact SOMTs. By definition, the average number of limit-order hits by SOSTs in executing is one.

without moving prices. Interestingly, in the case of VOD, a SOMT contemporaneously hit a total of 152 limit-orders in executing, all at the first price line (the top of the order-book). [17]

For each stock, we divide the average price-impact of SOMTs by its corresponding tick size and the results reveal that the average price-impact per stock range from 1.04 to 2.20 tick sizes for the ΔPrice measure and 0.68 to 1.52 for the ΔVWAP measure. This indicates that the price-impact is often greater than 1 tick size and when an order has price-impact, a large part of the order executes at inferior prices. The finding is consistent with the argument that larger orders will consume liquidity beyond what is available at the best prices and hence, incurs additional execution cost (that is, price-impact).

We estimate the ΔVWAP additional liquidity cost incurs by price-impact SOMTs to be roughly £37.2 million on a total market value traded of £7,275.4 million over the sample period, which is roughly £470 or 50 basis points on an average order of £93,766 in the 30 FTSE stocks. Finally, we compare the price-impact of SOMTs of large-cap to that of smaller-cap stocks in our sample and consistent with the microstructure literature, we find that large orders of smaller-cap stocks have greater price-impact. For instance, the ΔVWAP measure range from 0.68 of a tick size for VOD to 1.52 tick sizes for Avia (AV.).

Summarising, we find that only 3.6% of the trades on SETS execute beyond the best prices and the resulting ΔVWAP price-impact cost is no more than 1.52 tick sizes for the stock with the largest price-impact. Our findings suggest the following. First, the available depth at the best prices is often fairly large. Second, trading on SETS tends to be concentrated at the best prices and the immediate adjacent price lines but no more than two tick sizes from the market. Third,

[17] The trade was a principal-sell transaction for 1,549,933 shares (£1,751,424.29) on February 26, 2003:14:50:17.

traders appear to time the placement of their orders to coincide with periods of high liquidity and thus, narrower spread and larger depth at the top of the limit order-book. Overall, the evidence indicates that SETS can in fact accommodate large orders in the 30 stocks we examine if, of course, the order is properly timed and traders are very much concern about minimising the price-impact of their trades on SETS.

## 3. The Cost of Trading on the Competing Venues

The evidence in the preceding section suggests that traders behave strategically in placing orders on SETS and the competing dealership system in order to minimise the price-impact of their trades. When the top of the order-book is fairly liquid, they post larger orders for execution. In times of an illiquid order-book, however, they trade with dealers off-SETS. In this section, we compare transaction costs on the competing venues for trades in the 30 FTSE stocks we examine.

Fong *et al*. (2003), Bessembinder and Venkataraman (2002), Smith *et al*. (2001) and Madhavan and Cheng (1997) find that block transactions in the upstairs market tend to be executed at better terms than those matched downstairs. Their findings, however, are probably influenced by the trading rules of the respective exchanges, which enforce interactions between the upstairs and downstairs markets either in terms of price or size of trades.[18]

Friederich and Payne (2002) argue that these constraints reduce the ability of traders to route trades off the main trading venue and the incentives member firms may have to supply liquidity to such trades. Smith *et al.* (2001) note that the pricing rule for trades executed upstairs on the TSX results in member firms sending most orders immediately to the downstairs market for

[18] The Paris Bourse imposes both quantity and price constraints for trading off its order-book, while on the NYSE, trades negotiated upstairs must be exposed to the "crowd" on the floor of the exchange for possible price improvement. The TSX and ASX impose price and trade size constraints, respectively.

execution. Bessemember and Venkataraman (2002) find that upstairs dealers on the Paris Bourse, when faced with a large order to execute, first trade against the order-book to widen the spread in order to cross the order upstairs at a higher price. In contrast to these exchanges, the LSE does not impose price or quantity constraints on trades place with dealers. Hence, the LSE is ideal to examine the costs of transacting on alternative venues on the same exchange.

We use the benchmark method to compute the cost of trading on SETS and the dealer market and chose five benchmarks to serve as proxies for the unobserved fundamental price of the security. These are the opening, closing and value-weighted average prices on the day of the trade and the midpoint of the best limit-order prices prevailing one second (effective half-spread) and three minutes prior to the trade.[19] The opening price benchmark is the opening call auction price for each stock. However, on trading days when the opening auction fails to generate a market-clearing price for a particular stock, we use the price of the first order-book trade in the stock on the day in question. For the closing price benchmark, we use the closing auction price for each stock.

Since trades executed on the dealer market may be delayed up to three minutes before reporting and subsequent publication by the exchange, we compare the price of each trade to the midpoint of the best limit-order prices prevailing three minutes prior to trade. The 3-minute mid-quote and the opening price benchmarks capture the effects of any leak of information on trading cost. We compute the cost of a trade executed at time *t* as follows:

$$Cost_t = \left[ I_t \times \left( \frac{P_t - P_t^*}{P_t^*} \right) \right] \times 10{,}000 \qquad (3)$$

[19] These price benchmarks are widely used to measure transaction costs and evaluate trading performances (see Harris 2003).

where the cost is measured in basis points, $I_t$ is the sign of the trade, $P_t$ is the price of trade and $P_t^*$ is the proxy price benchmark for the fundamental value of the security. For each stock in our sample, we weight the cost estimate of each trade by its size and sum over all trades to compute an average cost of trading for retail and mid- and large-size transactions.

Our measure of the total price-impact of a trade is the 3-minute cost estimate, while the closing price cost estimate proxies the temporary price-impact (the short-term cost of liquidity). Therefore, consistent with the transaction cost literature, we approximate the permanent price-impact of a trade, the trade's information value, as the difference between the 3-minute (total price-impact) and closing price cost estimates (temporary price-impact). In Table 4, we report the cost of retail transactions on- and off-SETS, while Table 5 contains the estimates for mid- and large-size trades. Finally, we test the significance of the difference in the cost of trading on- and off-SETS using a Wilcoxon two-sample test.

We find that traders obtain better execution, on average, across all trade sizes on the dealer market than SETS. The finding is invariant to different price benchmarks we use (see Tables 4 and 5) to compute transaction cost. In 17 of the 30 stocks, retail investors pay an effective-half spread to trade that is statistically lower on the dealer market than on SETS. For the portfolio of 30 stocks, the effective-half spread for a retail trade with dealers is roughly 4.87 basis points, compared with 5.51 basis points for a similar transaction on SETS. With respect to mid- and large-size trades, the evidence also indicates that wholesale investors obtain statistically better prices for these orders on the dealership system than on SETS. Only in one stock do we find that dealer market has higher effective-half spread than SETS. On average, wholesale investors pay an effective-half spread of roughly 1.5 basis points to trade the 30-stock portfolio with dealers

and about 8.6 basis points on SETS. It is important to note that average size of mid- and large-size trades executed with dealers are roughly 5 times larger than those matched on SETS. Hence, the relative difference in effective-half spread between the competing venues for mid- and large-size orders is, in fact, substantial.

A comparison of the effective-half spread of the two trade-size categories on the respective trading venue reveal that wholesale investors pay more to trade on SETS than retail investors. This is consistent with the argument that larger orders on an electronic order-book will incur larger spreads. In contrast, we find that for the dealer market, retail investors are the ones who pay a higher spread to trade.[20] This suggests that wholesale investors are better able to negotiate much more favourable prices with dealers than retail investors. It also indicates that retail investors cross-subsidise the trading cost of large traders.

Consistent with the liquidity and adverse selection models of Demsetz (1968) and Easley and O'Hara (1987), we find that smaller-cap stocks and larger-sized orders incur larger effective-half spread than larger-cap stocks and smaller-sized orders. We also find evidence to support the "information leakage" hypothesis of Keim and Madhavan (1996) and documented for the upstairs market of the NYSE by Madhavan and Cheng (1997), Keim and Madhavan (1996) and Burdett and O'Hara (1987). The pre-trade price benchmark cost estimates ("opening" and "3-min") for mid- and large-size trades off-SETS are consistently larger than the cost estimates computed using benchmark prices at the time of the trade ("spread") and following the trade ("closing"), respectively (see Table 5).

[20] Lai (2003) also report similar results for FTSE-100 stocks.

Interestingly, pre-trade price movements are also evident for trades executed on SETS. Madhavan and Cheng (1997) report similar findings for the downstairs market of the NYSE and suggest that information on large upstairs trades is leaked to the downstairs market. Ellul (2002) and Board and Sutcliffe (1995) focus on the pre-position activities of dealers in London. We hypothesise, however, that large trades on SETS tend to be momentum trades that is, traders, on average, buy (sell) when the market is increasing (decreasing).[21]

In term of total price-impact ("3-min"), we find that trades on SETS, especially mid- and large-size transactions, have a larger price-impact than trades executed with dealers (see Tables 4 and 5). We find little evidence to suggest that prices tend to reverse following trades on either venue. For the 30 stocks, the sample average temporary price-impact ("Closing") for mid- and large-size trades on SETS is negative 0.69 basis points, compared with negative 2.32 basis points off-SETS. Further, trades on SETS have a higher permanent price-impact, difference between the 3-minute ("3-min") and closing price estimates ("closing"), than those executed on the dealer market (see Table 5). This suggests that large trades on SETS have a higher information value than trades executed with dealers, which is consistent with the findings in Jain *et al*. (2003) and the theoretical models of Seppi (1990), Easley and O'Hara (1987) and Grossman (1992).

## 4. Empirical Analysis of the Choice of Trading Venue and the Expected Transaction Costs

### *4.1 Model Specification*

In the preceding section, we find that traders who execute orders with dealers receive, on average, better prices than those who choose to trade on SETS. However, traders will choose the venue that offers the lower expected cost of execution. Hence, the choice of execution venue is

[21] Note that for the majority of stocks the opening price and 3-minute benchmark trading costs are consistently larger than the effective-half spread and the closing price benchmark cost estimates (see Table 5).

endogenously determined and thus, influences the *ex post* transaction costs. The inability to recognise and control for traders self-selection in the choice of execution venue will lead to incorrect inferences about relative cost of transacting on the competing venues for trades in FTSE stocks. With this caveat in mind, our objective in this section is to determine how traders decide between on- and off-SETS executions and use the information to adjust the cost estimates for selection bias. As a result, we would be better able to make correct inferences about the cost of transacting on- and off-SETS.

We correct for selection bias using a similar modelling approach of Madhavan and Cheng (1997).[22] For brevity, we will provide the basic theoretical construct of the model and refer interested readers to Madhavan and Cheng (1997, pages 191-194) and Maddala (1983, pages 223-227 and 283-287) for a more detailed derivation of the model. The general structure of the model is as follows:

$$y_i^d = \beta_d' X_i + \varepsilon_i^d, \tag{4}$$

$$y_i^u = \beta_u' X_i - \theta_i + \varepsilon_i^u, \tag{5}$$

$$u_i^* = \alpha' W_i + (\beta_d' - \beta_u') X_i + \theta_i, \tag{6}$$

$$u_i^* = \gamma' Z_i + \theta_i, \tag{7}$$

$$u_i = \begin{cases} 1 & \text{if} \quad u_i^* > 0 \\ 0 & \text{otherwise.} \end{cases} \tag{8}$$

The realised trading cost incurred by traders on- and off-SETS, respectively, is given by the cost functions (4) and (5), where $y_i^d$ is the cost incurred by trader $i$ for trades executed on-SETS and $y_i^u$ for trades off-SETS with dealers. $X_i$ is a $k$ x 1 vector of explanatory variables that is

[22] Conrad *et al*. (2003) also used the procedure to correct for self-selection in order to draw inferences on the cost of trading on crossing networks, ECNs and traditional exchanges in United States.

assumed to be common to both markets. While $\varepsilon_i^d$ and $\varepsilon_i^u$ are stochastic disturbances that capture venue specific shocks that influence the realised trading cost on the respective markets. Consistent with the reputation-based pricing model, the cost function face by trader $i$ for off-SETS trades include a reputation variable $\theta_i$ to capture the effects of the trader's reputation signal on trading costs he incurs when trading with dealers. Note that reputation variable, $\theta_i$, is unobserved and hence, it is missing variable that need to be estimated from the model.

The decision of trader $i$ whether to place order on SETS or with dealers for execution is given by (6), where $u_i^*$ is a latent variable that captures the difference in the expected cost of trading between the venues, $X_i$ and $\theta_i$ are given as before and $W_i$ is a vector other explanatory variables that influence his decison. We can re-write (6) as (7), where $Z_i = (W_{i,} X_i)$. Although the latent variable $u_i^*$ is unobserved, we can observe whether a trade was executed on- or off-SETS. Therefore, we define an indicator variable $u_i$ (8) which equal to 1 if the trader chooses to trade off-SETS and 0 otherwise. $\gamma_i$, $\beta_d'$, $\beta_u'$ and $\alpha'$ are vectors of coefficients.

Under the assumption of normality of error terms in the respective equations and normalising the variance of $\theta_i$ to be 1, it can be shown that consistent estimates of coefficients in the cost functions can be estimated simultaneously by the following structural equation:

$$\begin{aligned} E[y_i] &= E[y_i|u_i = 1]\Pr[u_i = 1] + E[y_i|u_i = 0]\Pr[u_i = 0] \\ &= \beta_d' X_i + (\beta_u' - \beta_d')X_i\Phi_i + \phi_i(\sigma_u - \sigma_d), \end{aligned} \tag{9}$$

where $E[y_i]$ is the expected trading cost, $X_i$ is the vector of explanatory variables in (4) and (5), $\Phi_i = \Phi(\gamma' Z_i)$, $\phi_i = \phi(\gamma' Z_i)$, $\Phi(\cdot)$ denotes the cumulative standard normal distribution, $\phi(\cdot)$

denotes the standard normal density function, $\sigma_u = \text{cov}[-\theta_i + \varepsilon_i^u, \theta_i]$ and $\sigma_d = \text{cov}[\varepsilon_i^d, \theta_i]$. The estimation of (9) involves two steps. First, the parameters of the binary choice model (7) is estimated by the probit method, using all the observations on $y_i$. The maximum likelihood estimates of $\gamma$ are then used to compute the predicted probabilities $\hat{\Phi}_i = \Phi(\hat{\gamma}' Z_i)$ and $\hat{\phi}_i = \phi(\hat{\gamma} Z_i)$ for each observation in the sample. Finally, the predicted probabilities $\hat{\Phi}$ and $\hat{\phi}$ are substituted for $\Phi$ and $\phi$, respectively, in (9) to obtain consistent OLS estimates of the parameters. Estimating (9) enables us to compare the relative costs of trading on both venues.

*4.2 Choice of Explanatory Variables*

Similar to Madhavan and Cheng (1997), the vector of explanatory variables in the cost functions for SETS and the dealer market, respectively, is given by $X_i = [1, q_i]$, where $q_i$ is the size of the trade, measured as the log difference between the size of the trade and the normal market size (NMS) of the stock. The latent reputation variable $\theta_i$ is treated as part of the error term in (5). Therefore, (4) and (5) become:

$$y_i^d = \beta_0^d + \beta_1^d q_i + \varepsilon_i^d, \qquad (10)$$

$$y_i^u = \beta_0^u + \beta_1^u q_i + \xi_i^u, \qquad (11)$$

where $\xi_i^u \equiv -\theta + \varepsilon_i^u$. Consistent with the information- and liquidity-based models, the cost of trading on both venues should increase with the size of the trade and as such, we expect sign on coefficients $\beta_1^d$ and $\beta_1^u$ to be positive. In addition, consistent with the models of the upstairs intermediation process in Burdett and O'Hara (1987), Seppi (1990), Grossman (1992) and Keim and Madhavan (1996), we expect following conditions to hold: $\beta_1^d > \beta_1^u$ and $\beta_0^d < \beta_0^u$. It

implies that the marginal impact of trade size is lower on the dealer market but SETS has lower fixed cost of trading.

We hypothesise that the decision on where to trade not only depends on the size of the trade but also liquidity conditions on both venues at the time of order placement. In this regard, a trader is expected to choose to trade off-SETS (on-SETS) when the order-book (dealer market) lacks available liquidity for his orders. We use two variables to proxy the liquidity of the order-book at the time of the trade. The first is the percentage spread, $s_i$, prevailing one second prior to the trade, defined as the ratio of the bid-ask spread to the midpoint of the best prices times 100. The second is the trade imbalance on SETS, $Simb_i$, computed as the log difference of the absolute value of the quantity of buyer-initiated less seller-initiated trades in the 5-minute time interval prior to the trade and the NMS of the stock. A similar measure ($Dimb_i$) is computed to proxy the liquidity condition at the time of trade on the dealer market.

Ellul *et al.* (2002) find that the opening and closing trades in small-cap stocks on the LSE are more likely to occur on the dealer market than during the two daily call auctions. While for large-cap stocks, they find that the call auction or a combination of the call auction and dealers is more likely to be used than only the dealership system. Friederich and Payne (2002) find that during the first half-hour of the trading day SETS accounts for a low percent of market activity. These findings suggest that the time-of-the-day may have an influence on traders' choice of execution venue. Hence, we include nine dummy variables in the probit model in order to capture this effect on the probability of trading on- and off-SETS. These are constructed as follows: one each for the second and last half-hour of the trading day and seven one-hour dummy variables for each hour between 9:00 and 16:00 GMT. We estimate the following probit model:

$$u_i^* = \gamma' Z_i = \gamma_0 + \gamma_1 q_i + \gamma_2 s_i + \gamma_3 Simb_i + \gamma_3 Dimb_i + \gamma_i' DT_i, \qquad (12)$$

where $q_i$, $s_i$, $Simb_i$ and $Dimb_i$ are as defined above, $DT_i$ is a 9x1 vector of time-of-the-day dummy variables and $\gamma_i$ is 9x1 vector of coefficients. Finally, the estimated reduced-form cost function corrected for selection bias is:

$$y_i = \beta_o + \beta_1 q_i + \beta_2 \hat{\Phi}_i + \beta_3 q_i \hat{\Phi}_i + \beta_4 \hat{\phi}_i + \varepsilon_i, \qquad (13)$$

where all variables in the model are as described above. The model has meaningful economic interpretations that enable us to make inferences about the relative costs of trading on the competing venues. First, we expect $\beta_1 = \beta_1^d > 0$ that is, the cost of trading on SETS should increase as the size of the trade increases, consistent with adverse selection models. Second, the difference in the fixed costs between SETS and the competing dealer market is given by $\beta_2 = (\beta_0^u - \beta_0^d)$. It reasonable to assume that the dealer market will have higher fixed trading costs than SETS (an electronic centralised limit-order market) because of additional cost involve in locating counterparties to trades. Hence, we expect $\beta_2 > 0$.

The theoretical models discussed predict the following $\beta_3 = (\beta_1^u - \beta_1^d) < 0$ that is, the marginal cost of trade size is expected to be lower on the dealer market than SETS. Madhavan and Cheng (1997) argue that the restriction $\beta_4 = (\sigma_u - \sigma_d) < 0$ holds. Note that $\sigma_u = \text{cov}[-\theta_i + \varepsilon_i^u, \theta_i] = -\text{var}[\theta_i] + \text{cov}[\varepsilon_i^u, \theta_i]$ and $\sigma_d = \text{cov}[\varepsilon_i^d, \theta_i]$. They assume that $\text{cov}[\varepsilon_i^u, \theta_i] = \text{cov}[\varepsilon_i^d, \theta_i]$ and thus, $\beta_4 = -\text{var}[\theta_i] < 0$. Therefore, if reputation is important to the pricing of trades on the dealer market then $\beta_4$ is expected to be negative and significant.

*4.3 Estimation Results*

We estimate the model for the 30 stocks using the sample of mid- and large-size trades. We exclude retail transactions from the estimation sample because these trades are typically placed with RSPs for execution and hence, there is a high probability of being traded off-SETS. Table 2 contains the descriptive statistics for the sample of mid- and large-size trades.

The dependent variable in the cost function equation (13), $y_i$, is the signed-trade log difference between the midpoint of the best quotes 3 minutes preceding the trade to the price of the trade. The probit model (12) is estimating the probability of trader $i$ selecting the dealer market for order execution that is, $E[u_i = 1] = \Phi(\gamma' Z_i)$. Finally, we follow Long and Ervin (2000) and use the heteroscedasticity-consistent standard errors ("HC3") of MacKinnon and White (1985) to draw inferences about the statistical significant of the coefficient values in (13). In Table 6, we report the estimation results for the probit model, while Table 7 contains that of the estimated cost function.

Consistent with our prior expectations, we find that the probability of trading with dealers increases with the size of the trade and mid- and large-size orders tend to migrate to the competing dealer market in times of an illiquid order-book, measured by percentage spread at the time of order placement (see Table 6). Surprisingly, and consistent for all 30 stocks, we find that the probability of trading with dealers decreases as the trade-imbalance, $Simb_i$, on SETS increases. One possible explanation for the result is that there exist pools of unexpressed liquidity off-SETS in that, traders continuously monitor the state of the order-book, waiting to trade aggressively to profit from favourable trading or order placement opportunities. This implies that traders adopt an order-imbalance strategy. Scharfstein and Stein (1990) argue that

an increase in order arrivals on one side of book implies greater market activity and thus, forces traders to transact quickly, generating order entries on the opposite side of book. Our findings are also consistent with this trading model.

Interestingly, we find no relation between the probability of trading off-SETS with dealers and the trade-imbalance, $Dimb_i$, on the dealer market. In fact, for the majority of stocks we examine, the coefficient value generally does not have the expected sign and is not significant. *Hence, the empirical result does not support the hypothesis of Naik et al. (2003) that dealers use SETS as an inter-dealer trading system to re-balance their inventories*. Finally, we find that the influence of time on the probability of trading off-SETS increases as trading progresses to 14:00 GMT but decreases to the close of the market. This result is consistent across the sample and suggests that dealers are very much concerned about the risk of carrying inventories overnight.

The estimation results for the cost function (13) reveal the following (see Table 7). First, *the marginal price-impact of mid- and large-size trades on SETS, $\beta_1$, decreases (increases) with trade size greater (less) than the NMS, which is inconsistent with theoretical models of adverse selection*. Our result is perhaps more consistent with the trading model of Mendelson and Tunca (2000), in which discretionary liquidity traders vary the size of their orders to match the available liquidity in the market, equalising trading costs across trade sizes.[23]

Second*, the difference in fixed costs of trading between the competing venues, $\beta_2$, is not statistically significant*. Hence, we do not find evidence to support the argument that the cost of locating counterparties to trade is larger on a fragmented dealership system than a centralised

[23] The analysis of SOMTs reveals that 96.4% of trades on SETS execute at the best prices. This suggests that traders perhaps condition the size of their orders on the available depth at the top of the order-book (see Section 2).

electronic limit-order book. Ellul (2000) argues that if internalisation and preferencing arrangements are characteristics of the upstairs market then large traders may not incur search costs. Davies *et al.* (2003) and Hansch *et al*. (1999) find that preferencing arrangements are common features of trading in London. Therefore, order preferencing offers one possible explanation for the comparable fixed trading costs on the dealer market and SETS.

Third, we obtain the correct sign on the coefficient value $\beta_3$ but only in 12 of the 30 stocks is it significant. This suggests that marginal price-impact of mid- and large-size trade is lower on the dealer market than on SETS. *Moreover, the competing dealer market has lower variable costs than SETS*. Our finding is consistent with models of the upstairs/downstairs trading and corroborates the empirical findings of Madhavan and Chang (1997) for the NYSE. Finally*, we do not find evidence to support the conjecture of reputation-based pricing on the dealer market*. In only 5 of the 30 stocks do we find that the coefficient $\beta_4$ to have the correct sign and significant. Overall, therefore, the result suggests that a trader's reputation signal does not appear to influence the price he receives from dealers for face-to-face negotiations.

We advance several explanations for the empirical evidence to reject the model of reputation-based pricing on the dealer market. First, perhaps the client selection process is far more efficient in London than in New York in that only traders with good reputation transact with dealers. Second, the functional form of the cost functions for the dealer market and SETS are incorrectly specified. In order words, we fail to capture all the relevant information on the characteristics of a trader submitting orders for execution on- and off-SETS in our model of

transaction costs for both venues.[24] Conrad *et al*. (2002) argue that as the number of execution venues increases, the ability of brokers to negotiate trades will be a decisive factor in the determination of transaction costs. Consequently, a broker with a high trading ability, regardless of the strength of his reputation signal, may choose to transact on SETS rather than pay the high liquidity cost to trade with dealers. Our model does not capture this effect on traders' choice of execution venue and transaction costs. Third, errors-in-variables due to the incorrect classification of dealers' trades as either buyer or seller initiated. Our empirical findings reported in the next section rule out this possibility.

Summarising, we control for selection bias in our cost estimates for trades executed on- and off-SETS and test the theory of reputation-based pricing on the dealer market. Our empirical results reveal the dealer market has lower variable costs than SETS but fixed costs on both venues are statistically comparable. Further, the empirical evidence does not support the conjecture of reputation-based pricing on the dealer market.

### *4.4 Robust Tests*

We perform a number of diagnostic tests in order to verify the robustness of our results. First, we examine whether using different threshold values for mid- and large-size trades will alter the results. Naik and Yadav (1997) find that 82% (52%) of the value (number) of all trades routed through SETS is in the range of 25,000 to one NMS. In addition, we find that the size and value of dealers' trades are as much as 5 times larger than those on SETS. As a result, we re-estimate the model using three different sizes of trades: (1) greater than £100,000 in value, (2) larger than one NMS and (3) £10,000 to 8 times the NMS. In all three cases, we find that for the majority of

[24] Note that if either of (4) or (5) is incorrectly specified, then the assumption that $\text{cov}[\varepsilon_i^u, \theta_i] = \text{cov}[\varepsilon_i^d, \theta_i]$ is no longer valid (see Section 5.2).

stocks the general results of the probit model are similar to those presented above.[25] While we observe some changes in signs and values of the coefficients in final stage regression, they are no longer significant for most of stocks. Moreover, we still find that the probability of transacting on the dealer market decreases as liquidity imbalances on SETS increase and a trader's reputation has no bearing on the price-impact of trades off SETS.

The second specification test we perform is to investigate whether the influence of a trader's reputation figures predominately in the permanent price-impact of a trade or applies only to principal-agent trading relationship (see Seppi 1990, Bernhardt *et al*. 2003 and Degranges and Foucault 2002). We follow Madhavan and Cheng (1997) and re-estimate the model with the permanent price-impact of a trade as the dependent variable in the regression model. We compute the permanent price-impact of a trade as the signed-trade log return, in percent, from midpoint of the best quotes prevailing 3 minutes preceding the trade to closing price of the stock on the day of the trade. The results of the probit model are similar to those reported in Table 7. More important, we find that for the majority of stocks the reputation of the trader has no influence on the permanent price-impact of a trade on the dealer market. Overall, the explanatory power of the model falls, the marginal impact of trades on SETS no longer decreases with the size of the trade and neither SETS nor the competing dealer market has material advantage over the other in terms of fixed or variable costs of trading.

To test whether a trader's reputation applies only to principal-agent trading relationship, we re-estimate the model using only principal-agent trades on SETS and member-non-member transactions off SETS, where the member transacts for his own account, and find no evidence to

[25] For the values exceeding one NMS, the model could not be estimated for a few stocks due to the small size of the sample.

support the hypothesis. Finally, we examine the robustness of our results to different methods of assigning trades executed with dealers as either buyer or seller initiated. Tanggaard (2003) argues that misclassification of trades gives rise to the well known problem of errors-in-variables and thus, it poses a major challenge for accurate statistical inferences. As a result, we re-compute the various cost of trading estimates reported earlier using the trade-sign algorithms of Cai and Dufour (2003) and Lee and Ready (1991) to assign dealers' trades.[26] In Table 9, we report the sample cost estimates for both algorithms and that of the sign-reversal method.

The results suggest that inferences about the costs of trading on the competing venues are perhaps sensitive to the algorithm chosen to assign dealers' trades. The 3-minute and effective-half spread cost estimates are lower on SETS when the algorithms of Lee and Ready and Cai and Dufour are used to assign off-SETS trades. We, therefore, re-estimate the model using the algorithms of Lee and Ready and Cai and Dufour to assign dealers' executions. In both instances, the results of probit model remain largely unchanged. We find, however, that for the majority of stocks, SETS has lower fixed and variable costs, the marginal price-impact of trades on SETS decreases with the size of the trade and $\beta_4$ is positive and significant, which implies that the reputation of a trader has no impact on the prices he receives from dealers for mid- and large-size trades.

[26] Cai and Dufour (2003) show that the sign-reversal method would incorrectly classify trades involving two members trading as principal. We choose to test the robustness of our results using the algorithms of Lee and Ready and Cai and Dufour because the former is widely use to assign trades on most North American markets, while the latter was developed mainly to classify dealers' trades in London.

## 5 Conclusions

We examine traders' strategic choice of an electronic limit order-book, SETS and face-to-face negotiations with dealer to execute orders in the 30 largest capitalisation FTSE-100 stocks. We find that traders frequently use SETS to execute their orders in both retail and mid- and large-size transactions. We analyse the price-impact of trades on SETS and we find that SETS has sufficient liquidity to accommodate large orders. Nonetheless, traders still prefer to trade with dealers for the very large transactions because this allows them to negotiate better and more flexible terms.

We study the execution costs for mid- and large-size trades and find that the dealer market has lower variable costs but the fixed costs on both venues are statistically comparable. Further, we do not evidence to support the model of reputation-based pricing on the dealer market and the conjecture that SETS is predominately use by dealers to re-balance their inventories. Interestingly, we find that the probability of trading with dealer market decreases with large on-SETS trade imbalance. This indicates that traders are continuously monitoring the state of the order-book for profitable trading and order placement opportunities.

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# APPENDIX A

### Summary Information for the 30 Stocks Sample

Our sample consists of 30 stocks in FTSE-100 Index. We only select those stocks that were a SETS traded security for the 62 trading days in sample and as at the end of the sample period, one of the 30 largest capitalisation stocks in the Index. The table shown below provides summary information for the 30 selected stocks. All summary information relate to the last trading day in sample, February 28, 2003.

| Name of Security | Stock Symbol | Normal Market Size (in shares) | Market Capitalisation (£Mn.) | % Weight in the FTSE-100 Index |
|---|---|---|---|---|
| **Anglo American Plc.** | AAL | 100,000 | 13,471 | 1.54 |
| **AstraZeneca Plc.** | AZN | 100,000 | 35,433 | 4.05 |
| **Aviva Plc.** | AV. | 200,000 | 8,900 | 1.02 |
| **Barclays Plc.** | BARC | 200,000 | 24,077 | 2.75 |
| **BG Group Plc.** | BG | 200,000 | 8,578 | 0.98 |
| **BHP Billiton** | BLT | 200,000 | 8,144 | 0.93 |
| **Bp Plc.** | BP | 200,000 | 89,391 | 10.21 |
| **British American Tobacco Plc.** | BATS | 200,000 | 10,128 | 1.16 |
| **British Sky Broadcasting Group Plc.** | BSY | 200,000 | 9,129 | 1.04 |
| **BT Group Plc.** | BT.A | 200,000 | 14,176 | 1.62 |
| **Cadbury Schweppes Plc.** | CBRY | 200,000 | 6,600 | 0.75 |
| **Compass Group Plc.** | CPG | 200,000 | 6,090 | 0.70 |
| **Diageo Plc.** | DGE | 200,000 | 19,802 | 2.62 |
| **Glaxosmithkline** | GSK | 200,000 | 67,292 | 7.69 |
| **HBOS Plc.** | HBOS | 200,000 | 25,004 | 2.86 |
| **HSBC Holdings (U.K.) Plc.** | HSBA | 200,000 | 64,509 | 7.37 |
| **Imperial Tobacco Group Plc.** | IMT | 75,000 | 7,224 | 0.83 |
| **Lloyds TSB Group Plc.** | LLOY | 200,000 | 19,697 | 2.25 |
| **Marks & Spencer Group Plc.** | MKS | 200,000 | 6,973 | 0.80 |
| **National Grid Transco Plc.** | NGT | 200,000 | 12,613 | 1.44 |
| **Prudential Plc.** | PRU | 200,000 | 6,706 | 0.77 |
| **Reckitt & Benckiser Plc.** | RB | 75,000 | 7,008 | 0.80 |
| **Rio Tinto Plc.** | RIO | 100,000 | 13,677 | 1.56 |
| **Royal Bank of Scotland Group Plc.** | RBS | 200,000 | 41,955 | 4.79 |
| **Scottish Power Plc.** | SPW | 150,000 | 6,736 | 0.77 |
| **Shell Transport & Trading Co. Plc.** | SHEL | 200,000 | 35,794 | 4.09 |
| **Standard Chartered Plc.** | STAN | 150,000 | 8,121 | 0.93 |
| **Tesco Plc.** | TSCO | 200,000 | 11,691 | 1.34 |
| **Unilever Plc.** | ULVR | 200,000 | 16,476 | 1.88 |
| **Vodafone Group** | VOD | 200,000 | 77,231 | 8.82 |
| **Sample** | | | **682,686** | **78.36** |

# APPENDIX B

### Procedure for Regrouping of Trades Executed on SETS

The table shown below illustrates the procedure used to group multiple trades occurring at same time but which relate to the execution of a single order. The table presents eight scenarios, all of which were obtained from our sample data. We regroup trades if:

1. the time of execution is the same for all trades
2. the buying or selling member is the same for all trades
3. the direction of the trade is identical for all trades

The package of trades shown in Scenario 2 is an example of a single order, multiple trades (SOMTs) and we regrouped those trades to form a single trade with an aggregated trade size of 360 and a volume-weighted average price of 247.83. Those reported as Scenario 6, are treated as two separate trades. The first is a single order, single trade (SOST), while the other is a SOMT. The remaining scenarios are treated as SOSTs and are not regrouped.

| Scenarios | Trade Time | Member: Buy | Member: Sell | Trade Size | Trade Price | Trade Sign | Treatment | Grouped Volume | Grouped Price |
|---|---|---|---|---|---|---|---|---|---|
| **1** | 08:36 | 1235 | 2344 | 50 | 246 | Buy | | 50 | 246 |
| | 08:37 | 1235 | 2344 | 100 | 246 | Buy | | 100 | 246 |
| **2** | **08:56** | **3621** | **1235** | **60** | **247** | **Sell** | **Grouped** | **360** | **247.83** |
| | **08:56** | **4201** | **1235** | **100** | **248** | **Sell** | | | |
| | **08:56** | **1235** | **1235** | **200** | **248** | **Sell** | | | |
| **3** | 09:10 | 6201 | 2344 | 150 | 239 | Buy | | 150 | 239 |
| | 09:10 | 2344 | 2344 | 100 | 239 | Sell | | 100 | 239 |
| **4** | 09:15 | 6527 | 5341 | 1,000 | 250 | Sell | | 1,000 | 250 |
| | 09:15 | 5191 | 6527 | 10,000 | 251 | Buy | | 10,000 | 251 |
| **5** | 10:20 | 5258 | 5258 | 100 | 253 | Sell | | 100 | 253 |
| | 10:20 | 5258 | 4955 | 200 | 254 | Buy | | 200 | 254 |
| **6** | 10:26 | 5258 | 6579 | 100 | 253 | Sell | | 100 | 253 |
| | **10:26** | **6527** | **6579** | **200** | **254** | **Buy** | **Grouped** | **1,700** | **254.59** |
| | **10:26** | **6527** | **4955** | **1,000** | **254** | **Buy** | | | |
| | **10:26** | **6527** | **5090** | **500** | **256** | **Buy** | | | |
| **7** | 11:30 | 6118 | 6003 | 23,357 | 250 | Buy | | 23,357 | 250 |
| | 11:30 | 6514 | 6003 | 15,000 | 250 | Buy | | 15,000 | 250 |
| **8** | 12:15 | 4217 | 4806 | 2,000 | 255 | Sell | | 2,000 | 255 |
| | 12:15 | 4217 | 7213 | 50,347 | 260 | Sell | | 50,347 | 260 |

# APPENDIX C:

## Data Preparation Statistics

In the table shown below we report filtering statistics for the data preparation stage. Error trades relate to cancelled, contra, post-contra, late correction, not-to-mark and incorrectly priced trades. Late/ delayed refers to trades reported late or published with delay. While pre-opening denotes trades executed off-SETS prior to or during the opening auction. It also includes off-SETS trades executed before an order-book trade on days when the opening auction fails to generate market clearing conditions. Trades executed off-SETS after the close of the continuous trading session of SETS are reported in the column labelled "after-hours". While those executed during the opening and closing auctions are shown in the columns named "opening" and "closing" auction, respectively. Regrouping loss relates to the number of trades loss as a result of reshaping of order-book transactions to take into account multiple trades, single-order transactions (the number of trades loss as a percentage of on-SETS trades is bracketed). Special trades refer to worked principal agreements, result of option, volume-weighted average price, crosses at the same price, broker to broker, non protected portfolio, riskless principal, single protected transactions and non-standard settlement trades. Sample series is the data use in our analysis and includes only T+3 dealers' ("O") and order-book ("AT") trades executed during the continuous trading session of SETS.

| Stock Symbol | Unfiltered Series | Error Trades | Late/ Delayed | Pre-opening | After-hours | Opening Auction | Closing Auction | Regrouping Loss (%) | Special Trades | Sample Series |
|---|---|---|---|---|---|---|---|---|---|---|
| **AAL** | 68,642 | 668 | 502 | 56 | 646 | 62 | 1,503 | 16,622 (**28**) | 971 | 47,612 |
| **AZN** | 155,722 | 1,302 | 1,027 | 81 | 1,893 | 273 | 3,520 | 38,300 (**29**) | 4,385 | 104,941 |
| **AV.** | 139,655 | 1,552 | 882 | 90 | 1,508 | 212 | 2,885 | 31,513 (**29**) | 7,808 | 93,205 |
| **BARC** | 250,056 | 2,537 | 1,528 | 224 | 2,117 | 269 | 3,454 | 57,024 (**31**) | 22,141 | 160,762 |
| **BG** | 86,055 | 697 | 597 | 54 | 1,069 | 197 | 2,339 | 20,424 (**29**) | 5,113 | 55,565 |
| **BLT** | 77,085 | 596 | 515 | 34 | 1,097 | 108 | 1,775 | 19,954 (**29**) | 676 | 52,330 |
| **BP** | 232,595 | 2,516 | 1,590 | 107 | 2,448 | 512 | 4,234 | 62,252 (**34**) | 10,523 | 148,413 |
| **BATS** | 81,825 | 843 | 703 | 73 | 1,207 | 141 | 2,142 | 21,377 (**31**) | 2,000 | 53,339 |
| **BSY** | 107,395 | 1,027 | 799 | 65 | 1,351 | 134 | 2,847 | 25,890 (**29**) | 3,040 | 72,242 |
| **BT.A** | 142,219 | 1,825 | 1,120 | 112 | 1,587 | 225 | 3,053 | 32,735 (**33**) | 11,091 | 90,471 |
| **CBRY** | 98,676 | 1,075 | 679 | 190 | 1,222 | 114 | 1,992 | 21,278 (**28**) | 4,184 | 67,942 |
| **CPG** | 86,826 | 830 | 638 | 89 | 1,177 | 60 | 1,888 | 20,743 (**29**) | 2,436 | 58,965 |
| **DGE** | 130,890 | 1,272 | 940 | 107 | 1,765 | 242 | 2,880 | 33,694 (**31**) | 3,536 | 86,454 |
| **GSK** | 215,453 | 2,357 | 1,429 | 113 | 2,423 | 482 | 4,310 | 56,828 (**34**) | 8,361 | 139,150 |
| **HBOS** | 168,647 | 1,676 | 968 | 188 | 1,616 | 116 | 2,967 | 35,913 (**29**) | 11,779 | 113,424 |
| **HSBA** | 222,148 | 2,394 | 1,593 | 116 | 2,288 | 336 | 4,335 | 63,218 (**35**) | 7,103 | 140,765 |
| **IMT** | 65,496 | 539 | 483 | 43 | 942 | 67 | 1,674 | 16,823 (**30**) | 996 | 43,929 |
| **LLOY** | 261,346 | 3,682 | 1,856 | 242 | 2,130 | 365 | 3,731 | 54,709 (**30**) | 34,052 | 160,579 |
| **MKS** | 83,985 | 870 | 611 | 226 | 1,082 | 59 | 2,177 | 19,135 (**30**) | 5,323 | 54,502 |
| **NGT** | 103,422 | 1,064 | 845 | 65 | 1,352 | 147 | 1,917 | 24,611 (**31**) | 6,648 | 66,773 |
| **PRU** | 137,409 | 1,521 | 933 | 125 | 1,461 | 214 | 2,618 | 32,043 (**29**) | 6,232 | 92,262 |
| **RB** | 75,592 | 739 | 569 | 49 | 1,159 | 123 | 1,833 | 19,772 (**31**) | 1,563 | 49,785 |
| **RIO** | 105,669 | 933 | 773 | 69 | 1,486 | 140 | 2,389 | 27,292 (**31**) | 2,395 | 70,192 |
| **RBS** | 208,606 | 2,141 | 1,414 | 115 | 2,261 | 263 | 3,511 | 50,934 (**31**) | 12,838 | 135,129 |
| **SPW** | 79,900 | 633 | 517 | 58 | 867 | 160 | 1,837 | 17,510 (**29**) | 4,426 | 53,892 |
| **SHEL** | 186,403 | 1,664 | 1,200 | 114 | 1,636 | 217 | 3,265 | 44,416 (**30**) | 8,719 | 125,172 |
| **STAN** | 88,855 | 769 | 620 | 81 | 820 | 44 | 1,670 | 21,054 (**27**) | 1,774 | 62,023 |
| **TSCO** | 129,294 | 1,665 | 726 | 171 | 1,686 | 215 | 2,371 | 31,489 (**35**) | 12,111 | 78,860 |
| **ULVR** | 110,412 | 1,150 | 839 | 66 | 1,232 | 152 | 2,076 | 26,750 (**30**) | 3,884 | 74,263 |
| **VOD** | 267,934 | 3,513 | 1,897 | 203 | 3,223 | 879 | 4,860 | 81,977 (**40**) | 12,065 | 159,317 |
| **Sample** | **4,168,212** | **44,050** | **28,795** | **3,326** | **46,751** | **6,528** | **82,053** | **1,026,280** (**31**) | **218,173** | **2,712,258** |

**Table 1**
**Summary Statistics for Retail Trades**

This Table reports overall number, mean volume and value of retail trades executed on- and off-SETS for our 30 sample stocks. Retail trades are defined as trades with value no greater than £10,000. The sample consists of all T+3 "AT" and "O" trades executed during the continuous trading session of SETS for the 62 trading days from December 2, 2002 to February 28, 2003.

| Stock Symbol | On-SETS | | | Off-SETS | | |
|---|---|---|---|---|---|---|
| | Trades | Mean Volume | Mean Value (£) | Trades | Mean Volume | Mean Value (£) |
| **AAL** | 14,680 | 557 | 4,968 | 2,316 | 354 | 3,168 |
| **AZN** | 21,616 | 210 | 4,418 | 7,860 | 138 | 2,921 |
| **AV.** | 32,835 | 1,081 | 4,623 | 11,224 | 637 | 2,754 |
| **BARC** | 45,624 | 1,273 | 4,727 | 23,291 | 839 | 3,158 |
| **BG** | 23,015 | 1,881 | 4,511 | 4,099 | 1,205 | 2,899 |
| **BLT** | 18,751 | 1,413 | 4,442 | 2,011 | 994 | 3,144 |
| **BP** | 21,380 | 1,150 | 4,589 | 20,286 | 680 | 2,723 |
| **BATS** | 18,359 | 752 | 4,474 | 2,757 | 545 | 3,242 |
| **BSY** | 22,087 | 740 | 4,538 | 4,108 | 572 | 3,527 |
| **BT.A** | 25,505 | 2,509 | 4,597 | 19,462 | 1,363 | 2,511 |
| **CBRY** | 22,978 | 1,287 | 4,552 | 9,149 | 675 | 2,406 |
| **CPG** | 22,710 | 1,504 | 4,613 | 5,744 | 949 | 2,924 |
| **DGE** | 24,713 | 727 | 4,646 | 7,837 | 496 | 3,189 |
| **GSK** | 23,953 | 407 | 4,672 | 20,272 | 253 | 2,908 |
| **HBOS** | 27,079 | 804 | 4,907 | 19,094 | 511 | 3,140 |
| **HSBA** | 23,983 | 691 | 4,705 | 16,865 | 354 | 2,411 |
| **IMT** | 15,583 | 499 | 4,855 | 3,362 | 310 | 3,026 |
| **LLOY** | 42,418 | 1,177 | 4,892 | 25,501 | 792 | 3,324 |
| **MKS** | 20,012 | 1,437 | 4,470 | 6,062 | 820 | 2,552 |
| **NGT** | 20,822 | 1,054 | 4,392 | 10,034 | 473 | 1,988 |
| **PRU** | 34,296 | 1,111 | 4,492 | 8,816 | 797 | 3,177 |
| **RB** | 15,563 | 454 | 4,885 | 2,389 | 346 | 3,648 |
| **RIO** | 19,530 | 376 | 4,551 | 5,556 | 266 | 3,233 |
| **RBS** | 26,134 | 344 | 4,939 | 15,075 | 259 | 3,720 |
| **SPW** | 21,096 | 1,251 | 4,413 | 8,545 | 856 | 2,999 |
| **SHEL** | 26,890 | 1,184 | 4,474 | 16,244 | 882 | 3,343 |
| **STAN** | 22,041 | 696 | 4,771 | 3,546 | 375 | 2,589 |
| **TSCO** | 22,936 | 2,581 | 4,674 | 15,403 | 1,404 | 2,533 |
| **ULVR** | 19,852 | 826 | 4,577 | 8,650 | 657 | 3,641 |
| **VOD** | 31,013 | 3,639 | 4,207 | 24,847 | 2,526 | 2,925 |
| **Sample** | **727,454** | **1,121** | **4,619** | **330,405** | **711** | **2,991** |

**Table 2**
**Summary Statistics for Mid- and Large-Size Trades**

This Table reports overall number, mean volume and value of mid- and large-size trades executed on- and off-SETS for our 30 sample stocks. Mid- and large-size trades are defined as trades with value greater than £10,000. The sample consists of all T+3 "AT" and "O" trades executed during the continuous trading session of SETS for the 62 trading days from December 2, 2002 to February 28, 2003.

| Stock Symbol | On-SETS | | | Off-SETS | | |
|---|---|---|---|---|---|---|
| | Trades | Mean Volume | Mean Value (£) | Trades | Mean Volume | Mean Value (£) |
| **AAL** | 28,271 | 5,249 | 46,728 | 2,345 | 35,844 | 319,379 |
| **AZN** | 70,621 | 2,780 | 58,501 | 4,844 | 17,510 | 366,337 |
| **AV.** | 44,930 | 8,015 | 34,226 | 4,216 | 44,272 | 188,076 |
| **BARC** | 82,347 | 12,131 | 45,147 | 9,500 | 66,498 | 246,788 |
| **BG** | 25,986 | 15,389 | 36,973 | 2,465 | 96,994 | 234,704 |
| **BLT** | 29,496 | 13,842 | 43,617 | 2,072 | 100,764 | 316,575 |
| **BP** | 98,363 | 24,172 | 96,324 | 8,384 | 95,748 | 382,631 |
| **BATS** | 29,348 | 7,933 | 47,210 | 2,875 | 66,415 | 395,234 |
| **BSY** | 41,038 | 8,287 | 51,087 | 5,009 | 48,787 | 302,207 |
| **BT.A** | 40,100 | 27,041 | 49,528 | 5,404 | 128,142 | 234,057 |
| **CBRY** | 32,037 | 11,286 | 40,103 | 3,778 | 59,432 | 210,156 |
| **CPG** | 27,330 | 11,379 | 35,079 | 3,181 | 65,428 | 204,036 |
| **DGE** | 49,150 | 7,898 | 50,592 | 4,754 | 47,254 | 302,681 |
| **GSK** | 84,994 | 6,601 | 75,670 | 9,931 | 24,953 | 286,234 |
| **HBOS** | 61,026 | 7,198 | 43,920 | 6,225 | 36,530 | 224,056 |
| **HSBA** | 93,557 | 15,113 | 103,079 | 6,360 | 59,712 | 408,658 |
| **IMT** | 23,130 | 4,024 | 39,244 | 1,854 | 35,014 | 345,949 |
| **LLOY** | 82,358 | 11,296 | 47,524 | 10,302 | 59,144 | 246,293 |
| **MKS** | 25,552 | 12,303 | 38,378 | 2,876 | 69,210 | 217,397 |
| **NGT** | 32,919 | 11,464 | 47,910 | 2,998 | 84,221 | 351,234 |
| **PRU** | 44,323 | 9,476 | 37,781 | 4,827 | 51,315 | 200,133 |
| **RB** | 28,521 | 4,678 | 49,555 | 3,312 | 28,601 | 302,881 |
| **RIO** | 40,970 | 4,122 | 49,874 | 4,136 | 22,185 | 268,999 |
| **RBS** | 85,401 | 3,941 | 56,413 | 8,519 | 17,255 | 249,516 |
| **SPW** | 22,066 | 8,688 | 30,785 | 2,185 | 48,944 | 173,484 |
| **SHEL** | 75,764 | 15,567 | 58,800 | 6,274 | 66,471 | 251,793 |
| **STAN** | 33,927 | 6,021 | 41,461 | 2,509 | 45,595 | 315,914 |
| **TSCO** | 34,827 | 28,997 | 52,272 | 5,694 | 144,505 | 260,511 |
| **ULVR** | 41,874 | 9,283 | 51,468 | 3,887 | 40,942 | 227,490 |
| **VOD** | 90,382 | 134,251 | 155,356 | 13,075 | 320,132 | 371,099 |
| **Sample** | **1,500,608** | **14,948** | **53,820** | **153,791** | **67,594** | **280,150** |

**Table 3**
**Analysis of the Impact of Orders on SETS**

This table reports summary statistics for the impact of orders on SETS for the sample of 30 stocks. We grouped the statistics into three categories: (1) single-order, multiple trades (SOMTs) that impact on prices as the order walk up/down the order-book in executing; (2) SOMTs that had no impact on prices when match against more than one limit-order on the other side of book; and (3) single-order, single trades (SOSTs) that hit only one limit-order in executing. Grp. trades ("regrouped trades') is the number of SOMTs, while ind. trades ("individual trades") relate to the total number of individual trades generated or limit-order hits in matching orders. Max (min.) denotes maximum (minimum) and refer to the maximum (minimum) number of limit-order hits by any one SOMTs. Mean vol. ("mean volume") and mean value ("mean value") refer to the average size and value of orders, respectively. We compute two measures of price impact associated with SOMTs: (1) ΔPrice, computed as the volume-weighted mean of the signed trade difference between the opening and closing prices of the sequence of trades that comprises the SOMT and (2) ΔVWAP, computed as the volume-weighted mean of the signed trade difference between the volume-weighted average price of the package of the trades that constitutes the SOMT and the price of the first transaction in the trade sequence. Both measures are reported in penny. Finally, Q, H and W denote the tick size of the various stocks. Q, H and W are equal to 0.25, 0.50 and 1.00 of a penny, respectively.

| Stock Symbol | SOMTs with Price Impact | | | | | | | SOMTs with no Price Impact | | | | | SOSTs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Grp. Trades | Ind. Trades | Max/ (Min.) | Mean Vol. | Mean Value (£) | ΔPrice | ΔVWAP | Grp Trades | Ind. Trades | Max/ (Min.) | Mean Vol. | Mean Value (£) | Ind. Trades | Mean Vol | Mean Value (£) |
| **AAL$^{H}$** | 1,845 | 5,386 | 14 (2) | 10,629 | 94,244 | 0.83 | 0.59 | 9,371 | 22,452 | 11 (2) | 5,969 | 53,193 | 31,735 | 2,553 | 22,739 |
| **AZN$^{W}$** | 4,764 | 13,718 | 15 (2) | 5,322 | 111,196 | 1.72 | 1.08 | 20,869 | 50,215 | 15 (2) | 3,412 | 71,746 | 66,604 | 1,556 | 33,030 |
| **AV.$^{Q}$** | 4,313 | 12,317 | 11 (2) | 12,669 | 53,492 | 0.55 | 0.38 | 17,034 | 40,543 | 10 (2) | 7,758 | 33,330 | 56,418 | 3,701 | 15,795 |
| **BARC$^{Q}$** | 6,538 | 19,096 | 31 (2) | 19,298 | 71,821 | 0.41 | 0.27 | 30,749 | 75,215 | 24 (2) | 13,942 | 51,877 | 90,684 | 5,537 | 20,607 |
| **BG$^{Q}$** | 1,497 | 4,175 | 8 (2) | 20,477 | 49,273 | 0.34 | 0.23 | 12,094 | 29,840 | 15 (2) | 16,083 | 38,612 | 35,410 | 6,157 | 14,795 |
| **BLT$^{Q}$** | 1,890 | 5,464 | 12 (2) | 23,023 | 72,245 | 0.39 | 0.27 | 11,354 | 27,734 | 11 (2) | 15,397 | 48,522 | 35,003 | 6,184 | 19,494 |
| **BP$^{Q}$** | 3,054 | 9,283 | 16 (2) | 48,503 | 189,543 | 0.35 | 0.22 | 34,201 | 90,224 | 20 (2) | 36,073 | 144,139 | 82,488 | 12,370 | 49,271 |
| **BATS$^{H}$** | 1,353 | 4,237 | 12 (2) | 15,191 | 89,895 | 0.69 | 0.48 | 12,088 | 30,581 | 14 (2) | 9,159 | 54,525 | 34,266 | 3,366 | 20,047 |
| **BSY$^{H}$** | 2,310 | 6,615 | 10 (2) | 15,224 | 93,752 | 0.73 | 0.51 | 14,722 | 36,307 | 12 (2) | 9,440 | 58,124 | 46,093 | 3,955 | 24,396 |
| **BT.A$^{Q}$** | 1,577 | 4,759 | 11 (2) | 45,023 | 82,099 | 0.32 | 0.22 | 18,196 | 47,749 | 16 (2) | 31,230 | 57,151 | 45,832 | 11,108 | 20,377 |
| **CBRY$^{Q}$** | 1,905 | 5,389 | 10 (2) | 18,760 | 67,114 | 0.38 | 0.25 | 12,476 | 30,270 | 10 (2) | 12,432 | 44,035 | 40,634 | 4,930 | 17,526 |
| **CPG$^{Q}$** | 2,020 | 5,634 | 13 (2) | 16,269 | 50,024 | 0.42 | 0.27 | 11,728 | 28,857 | 14 (2) | 11,946 | 36,792 | 36,292 | 4,744 | 14,629 |
| **DGE$^{H}$** | 2,385 | 7,178 | 14 (2) | 14,181 | 90,744 | 0.78 | 0.51 | 18,781 | 47,682 | 14 (2) | 9,727 | 62,267 | 52,697 | 3,598 | 23,066 |
| **GSK$^{W}$** | 3,227 | 10,309 | 24 (2) | 13,678 | 155,819 | 1.40 | 0.90 | 31,263 | 81,009 | 34 (2) | 8,761 | 100,616 | 74,457 | 3,395 | 38,904 |
| **HBOS$^{H}$** | 3,766 | 10,689 | 14 (2) | 12,651 | 76,641 | 0.74 | 0.50 | 20,806 | 49,796 | 10 (2) | 8,535 | 52,121 | 63,533 | 3,711 | 22,667 |
| **HSBA$^{H}$** | 2,427 | 7,745 | 16 (2) | 33,795 | 229,482 | 0.60 | 0.43 | 33,117 | 91,017 | 22 (2) | 23,611 | 161,011 | 81,996 | 6,909 | 47,166 |
| **IMT$^{H}$** | 1,534 | 4,526 | 10 (2) | 6,912 | 67,220 | 0.97 | 0.65 | 9,451 | 23,282 | 11 (2) | 4,214 | 41,103 | 27,728 | 1,818 | 17,736 |
| **LLOY$^{Q}$** | 6,175 | 17,994 | 17 (2) | 18,699 | 77,555 | 0.46 | 0.32 | 29,375 | 72,265 | 16 (2) | 13,517 | 57,242 | 89,226 | 5,242 | 21,979 |
| **MKS$^{Q}$** | 1,674 | 4,795 | 11 (2) | 18,018 | 55,942 | 0.40 | 0.27 | 10,861 | 26,875 | 10 (2) | 12,885 | 40,235 | 33,029 | 5,238 | 16,333 |
| **NGT$^{Q}$** | 2,033 | 5,868 | 12 (2) | 18,129 | 75,432 | 0.39 | 0.27 | 13,346 | 34,122 | 14 (2) | 13,723 | 57,326 | 38,362 | 4,675 | 19,555 |
| **PRU$^{Q}$** | 4,386 | 12,520 | 20 (2) | 15,740 | 61,759 | 0.53 | 0.36 | 17,198 | 41,107 | 11 (2) | 9,033 | 36,420 | 57,035 | 4,097 | 16,330 |
| **RB$^{W}$** | 1,339 | 4,050 | 13 (2) | 9,166 | 95,749 | 1.46 | 0.97 | 11,280 | 28,341 | 16 (2) | 5,362 | 56,853 | 31,465 | 2,153 | 22,879 |
| **RIO$^{W}$** | 2,022 | 6,132 | 13 (2) | 7,797 | 94,240 | 1.40 | 0.92 | 15,452 | 38,634 | 11 (2) | 5,010 | 60,591 | 43,026 | 1,930 | 23,367 |
| **RBS$^{W}$** | 4,896 | 14,444 | 13 (2) | 7,272 | 103,744 | 1.59 | 0.96 | 28,524 | 69,910 | 15 (2) | 4,925 | 70,466 | 78,115 | 2,170 | 31,094 |
| **SPW$^{Q}$** | 1,850 | 5,097 | 11 (2) | 11,457 | 40,539 | 0.45 | 0.29 | 9,983 | 24,246 | 10 (2) | 8,938 | 31,647 | 31,329 | 3,437 | 12,177 |
| **SHEL$^{Q}$** | 3,033 | 8,714 | 13 (2) | 26,794 | 100,454 | 0.33 | 0.21 | 26,135 | 64,870 | 11 (2) | 20,898 | 78,918 | 73,486 | 7,944 | 30,047 |
| **STAN$^{H}$** | 2,285 | 6,518 | 19 (2) | 10,571 | 72,533 | 0.79 | 0.55 | 12,209 | 29,030 | 9 (2) | 6,472 | 44,569 | 41,474 | 2,807 | 19,336 |
| **TSCO$^{Q}$** | 1,089 | 3,292 | 13 (2) | 38,427 | 69,492 | 0.31 | 0.21 | 17,050 | 46,336 | 15 (2) | 34,208 | 61,661 | 39,624 | 11,205 | 20,206 |
| **ULVR$^{H}$** | 1,367 | 3,861 | 10 (2) | 15,946 | 87,938 | 0.64 | 0.43 | 16,045 | 40,301 | 12 (2) | 11,733 | 65,104 | 44,314 | 4,402 | 24,399 |
| **VOD$^{Q}$** | 657 | 2,068 | 24 (2) | 202,983 | 232,997 | 0.26 | 0.17 | 35,226 | 115,792 | 152 (2) | 229,607 | 265,670 | 85,512 | 47,072 | 54,499 |
| **Sample** | **79,211** | **231,873** | | **24,420** | **93,766** | **0.698** | **0.46** | **560,984** | **1,434,602** | | **20,133** | **67,862** | **1,587,867** | **6,265** | **24,482** |

**Table 4**
**Cost Estimates for Retail Transactions for On- and Off-SETS**

This table contains cost estimates for retail transactions for 30 of largest FTSE-100 stocks trading on- and off-SETS on the LSE. A retail transaction is defined as any trade having a value less or equal to £10,000. Our sample covers the trading period from December 2, 2002 to February 28, 2003. The cost of retail transactions is computed as follows:

$$\left[ I_t \times \left( \frac{P_t - P_t^*}{P_t^*} \right) \right] \times 10{,}000$$

where the cost is measured in basis points, $I_t$ is the direction of the trade, $P_t$ is the price of trade at time $t$ and $P_t^*$ is the proxy benchmark price for the fundamental value of the security at the time of trade execution. We use five benchmark prices: opening ("Opening) and closing ("Closing") prices on the day of the trade, the midpoint of the best limit-order prices on SETS one second ("Spread") and 3 minutes ("3-min") preceding the trade at time $t$ and the value-weighted average price ("VWAP") on the day of the trade. For each stock in our sample, we weight the cost estimate of each transaction by its size and sum over all transactions to compute a sample estimate for the cost of retail transactions for the 62 trading days. Finally, we use the Wilcoxon two-sample test to investigate the statistical significance of the difference in the trading cost (for each of the five measures) between the two venues. ** indicates that the test statistic is significant at the 5% level.

| Stock Symbol | On-SETS | | | | | Off-SETS | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Opening** | **3-min** | **Spread** | **VWAP** | **Closing** | **Opening** | **3-min** | **Spread** | **VWAP** | **Closing** |
| **AAL** | 3.56** | 4.89** | 5.03 | 3.31 | -1.00 | 7.20 | 5.43 | 5.48 | 4.05 | 2.91 |
| **AZN** | 1.92 | 3.02** | 3.88** | 0.67** | -4.02** | -0.61 | 3.20 | 4.07 | 0.06 | -1.83 |
| **AV.** | 7.79** | 6.72** | 6.33** | 3.37** | -1.15** | -21.84 | 5.67 | 6.27 | -13.86 | -20.21 |
| **BARC** | -9.19** | 2.51 | 4.60** | -2.94** | -1.14** | -63.07 | 2.24 | 3.95 | -19.10 | -15.34 |
| **BG** | -1.00** | 5.52** | 6.56** | 3.82 | 3.40** | -19.31 | 5.73 | 7.05 | 0.26 | 8.20 |
| **BLT** | 5.19 | 4.79 | 5.10 | 2.69 | -2.87 | 7.21 | 5.01 | 4.58 | 4.95 | 1.13 |
| **BP** | 0.30** | 3.29 | 4.07** | 1.86** | 3.43 | -10.22 | 3.57 | 3.76 | 0.50 | 0.90 |
| **BATS** | 3.32** | 5.29** | 5.32** | 3.95 | 2.31 | -11.25 | 5.33 | 5.41 | 0.05 | -1.52 |
| **BSY** | 4.82** | 5.20 | 5.65** | 4.41** | 2.92 | -28.66 | 5.09 | 5.61 | -1.12 | 2.88 |
| **BT.A** | 7.13** | 7.29** | 7.69** | 5.83** | 2.45 | -27.38 | 5.65 | 7.25 | -3.64 | 7.07 |
| **CBRY** | 7.18** | 4.48 | 4.87** | 3.49** | -3.82** | -16.38 | 4.45 | 4.96 | 4.16 | 8.91 |
| **CPG** | 9.62 | 7.31 | 6.76 | 4.92** | -1.81** | 11.15 | 7.66 | 7.58 | 4.05 | -2.88 |
| **DGE** | -0.44 | 4.24 | 4.82** | 1.08 | 1.34 | -1.21 | 4.16 | 4.64 | 0.98 | 3.96 |
| **GSK** | -2.81** | 3.39 | 4.76** | 3.28 | 5.57** | 5.10 | 4.10 | 4.21 | 2.34 | -0.08 |
| **HBOS** | -1.39** | 4.49** | 5.27** | 0.10** | -1.29** | -80.25 | 4.85 | 5.76 | -21.24 | -3.62 |
| **HSBA** | 0.61 | 2.48** | 3.55** | 2.24** | 2.96** | -0.14 | 2.55 | 2.70 | 3.45 | 8.31 |
| **IMT** | 7.42** | 5.81 | 5.73 | 4.82** | 2.92** | 24.38 | 5.21 | 5.83 | 9.83 | 7.67 |
| **LLOY** | -7.31** | 3.54** | 4.64** | 1.04** | 0.62** | -82.86 | 2.74 | 4.02 | -12.68 | -9.22 |
| **MKS** | 10.51** | 6.11 | 6.04** | 3.70 | 1.87 | -7.80 | 5.51 | 6.52 | 0.88 | 4.27 |
| **NGT** | 7.93 | 4.32** | 4.70** | 3.10** | -1.48** | 3.42 | 4.23 | 4.84 | 4.79 | 8.70 |
| **PRU** | 7.99** | 5.78 | 6.39 | 4.28** | 1.29 | -93.00 | 5.10 | 6.17 | -12.10 | 4.32 |
| **RB** | 8.57** | 6.85** | 6.52** | 4.54 | 1.63 | -22.93 | 5.79 | 6.07 | 2.29 | 2.60 |
| **RIO** | 1.58 | 4.26 | 4.88** | 1.77 | 2.43** | 2.57 | 4.87 | 4.41 | 1.25 | -0.89 |
| **RBS** | -1.50** | 3.94 | 4.53** | 1.96** | 1.06 | -29.98 | 3.29 | 3.90 | -6.41 | 3.47 |
| **SPW** | 11.99** | 6.24** | 6.40** | 6.24** | -1.06** | -10.90 | -5.91 | -5.33 | 2.44 | 14.16 |
| **SHEL** | -3.78 | 2.61** | 3.69** | -1.70** | -3.93** | -4.00 | 3.40 | 3.46 | 0.96 | 1.30 |
| **STAN** | 10.77** | 4.55 | 5.42** | 4.26** | -1.76** | 4.98 | 4.26 | 5.64 | 5.66 | 10.22 |
| **TSCO** | 4.97** | 5.59** | 7.16** | 3.87 | -0.27** | -21.39 | 5.12 | 5.97 | 1.36 | 4.77 |
| **ULVR** | 15.51** | 3.41 | 4.84** | 3.16 | 8.77** | 3.02 | 4.57 | 4.64 | 3.15 | 4.83 |
| **VOD** | 10.12** | 8.57** | 10.16** | 10.64** | 4.79** | -3.72 | 6.54 | 7.20 | 1.66 | 3.75 |
| **Sample** | **3.60** | **4.88** | **5.51** | **3.13** | **0.57** | **-16.26** | **4.31** | **4.87** | **-1.03** | **1.96** |

**Table 5**
**Cost Estimates for Mid- and Large-Size Transactions On- and Off-SETS**

This table contains cost estimates for mid- and large-size transactions for 30 of largest FTSE-100 stocks trading on- and off-SETS on the LSE. We define mid- and large-size transactions as any trades having value greater than £10,000. Our sample covers the trading period from December 2, 2002 to February 28, 2003. The cost of trading is computed as follows:

$$\left[ I_t \times \left( \frac{P_t - P_t^*}{P_t^*} \right) \right] \times 10{,}000$$

where the cost is measured in basis points, $I_t$ is the direction of the trade, $P_t$ is the price of trade at time $t$ and $P_t^*$ is the proxy benchmark price for the fundamental value of the security at the time of trade execution. We use five benchmark prices: opening ("Opening) and closing ("Closing") prices on the day of the trade, the midpoint of the best limit-order prices on-SETS one second ("Spread") and 3 minutes ("3-min") preceding the trade at time $t$ and the value-weighted average price ("VWAP") on the day of the trade. For each stock in our sample, we weight the cost estimate of each transaction by its size and sum over all transactions to compute a sample estimate for the cost of mid- and large-size transactions for the 62 trading days. Finally, we use the Wilcoxon two-sample test to investigate the statistical significance of the difference in the trading cost (for each of the five measures) between the two venues. ** indicates that the test statistic is significant at the 5% level.

| Stock Symbol | On-SETS | | | | | Off-SETS | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Opening | 3-min | Spread | VWAP | Closing | Opening | 3-min | Spread | VWAP | Closing |
| **AAL** | 18.24** | 7.98** | 6.90** | 7.59** | -1.98 | -4.99 | -2.08 | -3.30 | -4.35 | -11.99 |
| **AZN** | 14.36** | 7.58** | 5.18** | 6.05 | -1.94** | 8.03 | 1.04 | -4.19 | 4.82 | -25.74 |
| **AV.** | 21.78 | 11.51** | 8.79** | 4.27 | -1.81 | 20.67 | 6.27 | 1.78 | 5.85 | 17.38 |
| **BARC** | 13.73** | 9.07** | 6.39** | 6.55** | 0.07** | 21.97 | 1.62 | -0.28 | 1.26 | -13.62 |
| **BG** | 20.53 | 8.53** | 7.98** | 8.60** | 4.07** | 26.67 | 3.70 | 2.18 | 1.94 | -1.39 |
| **BLT** | 16.37 | 7.33** | 6.85** | 5.46 | -2.73 | 13.45 | 6.02 | 4.04 | 4.59 | 1.53 |
| **BP** | 9.75** | 7.18** | 4.95** | 4.97** | 3.84 | 0.73 | 2.52 | 0.48 | 0.57 | -2.40 |
| **BATS** | 13.94 | 7.42** | 6.56** | 5.20 | -1.94** | 18.24 | -2.13 | -2.85 | 3.30 | -17.02 |
| **BSY** | 18.73 | 8.51** | 7.17** | 5.27** | -1.82 | 22.17 | 0.29 | -1.32 | -2.54 | -14.21 |
| **BT.A** | 13.56** | 11.62** | 9.11** | 4.90** | 0.20 | -2.64 | 19.33 | 22.00 | 10.86 | 6.02 |
| **CBRY** | 10.44 | 7.00** | 6.36** | 4.78 | -4.25** | 9.20 | 4.55 | 4.09 | 3.83 | 4.72 |
| **CPG** | 13.99 | 9.59** | 8.06** | 4.95 | -2.33 | 19.76 | 6.96 | 4.10 | 3.52 | 8.39 |
| **DGE** | 8.28** | 7.12** | 6.04** | 3.90** | 1.07 | 27.24 | 2.49 | 1.79 | 4.40 | -2.66 |
| **GSK** | 12.58** | 8.28** | 5.96** | 6.19** | 3.51 | 4.96 | 1.49 | -0.93 | -0.31 | -3.01 |
| **HBOS** | 15.83** | 9.69** | 7.42** | 8.64** | 1.12 | 48.90 | 3.18 | 1.03 | -1.00 | -5.25 |
| **HSBA** | 11.17 | 5.66** | 4.34** | 4.66 | 1.40** | 9.51 | 1.93 | 1.24 | 3.24 | 6.12 |
| **IMT** | 10.89 | 7.87** | 7.09** | 4.31** | -3.08 | -3.07 | 1.74 | 0.75 | -2.14 | -6.46 |
| **LLOY** | 12.40** | 9.19** | 6.62** | 3.59** | -1.78 | -23.69 | 8.06 | 5.22 | -5.03 | 9.61 |
| **MKS** | 16.81** | 8.42** | 7.89** | 4.92** | 1.21** | 12.34 | 4.07 | 3.32 | 2.65 | 8.96 |
| **NGT** | 16.70** | 6.44** | 5.50** | 5.23** | -3.45 | -2.87 | 0.78 | 0.22 | -1.88 | -3.09 |
| **PRU** | 20.52** | 12.67** | 8.78** | 3.17** | -6.37 | -4.20 | 2.75 | 0.62 | -15.90 | -21.16 |
| **RB** | 17.05** | 11.00** | 8.14** | 5.05** | -1.81 | -3.25 | 5.91 | 4.17 | -1.33 | -7.87 |
| **RIO** | 15.88 | 7.82** | 6.38** | 5.83** | -0.90** | 32.83 | 0.58 | 0.16 | -0.43 | -16.19 |
| **RBS** | 6.88** | 8.20** | 6.07** | 5.52** | 2.30 | 24.88 | 2.07 | 1.64 | 1.22 | 7.86 |
| **SPW** | 13.25** | 8.54** | 8.32** | 6.74** | -1.41 | -31.37 | 2.14 | -3.32 | -0.98 | -4.25 |
| **SHEL** | 9.44** | 6.78** | 4.59** | 3.92 | 0.04 | -0.24 | 0.77 | -0.56 | 0.86 | -4.21 |
| **STAN** | 23.52** | 8.92** | 7.34** | 7.50 | -0.03 | 26.38 | 4.26 | 2.48 | 0.70 | -1.07 |
| **TSCO** | 15.89** | 8.76** | 8.39** | 6.29** | -2.70 | 9.44 | 4.00 | 2.53 | 0.52 | -3.42 |
| **ULVR** | 13.51** | 7.50** | 6.06** | 5.69** | -0.51** | 13.31 | -0.14 | -0.56 | 0.98 | 12.34 |
| **VOD** | 14.10** | 11.46** | 10.70** | 7.62** | 1.21 | 4.89 | 1.89 | -0.77 | 4.09 | 12.51 |
| **Sample** | **14.67** | **8.59** | **6.99** | **5.58** | **-0.69** | **9.98** | **3.20** | **1.53** | **0.78** | **-2.32** |

**Table 6**
**Estimates for the structural Probit Model**

The table reports results of the structural probit model for the individual stocks in the sample. The model is estimating the probability of a trade being placed off-SETS for execution. In Section 4, we discuss the details of the model. Our sample includes only mid- and large-size trades executed during the continuous trading session of SETS and of the types "O" and "AT". We exclude late reported, delayed published and non-standard settlement trades from the sample. The table's columns contain the estimated coefficients of the independent variables in the model. Trade size is the log of trade size normalised by the stock's normal market size (NMS). % spread denotes the prevailing percentage spread one second prior to the block trade, defined as the ratio of the bid-ask spread to the quotation midpoint times 100. Book Imbal. (Dealers Imbal.) is the log of 5-minute interval absolute trade imbalance on SETS (off-SETS) prior to the trade nornalised by the stock's NMS. Dt1 and Dt9 are time indicator variables for the second and last half-hour of the trading day, respectively. While Dt2 to Dt8 are one-hour dummy variables for each trading hour between 9:00 am to 4:00 pm, respectively. ***, ** and * indicate that the coefficient is statistically significant at the 1%, 5% and 10% levels for a Wald Chi-square test, respectively.

| Stock Symbol | Intercept | Trade Size | % Spread | Book Imbal. | Dealers Imbal. | Dt1 | Dt2 | Dt3 | Dt4 | Dt5 | Dt6 | Dt7 | Dt8 | Dt9 | Log likelihood |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **AAL** | -0.18 | 0.63*** | 1.33*** | -0.47*** | 0.05 | 0.24 | 0.40*** | 0.46*** | 0.46*** | 0.50*** | 0.34*** | 0.32*** | 0.24*** | 0.26*** | -6380.73 |
| **AZN** | -0.45*** | 0.45*** | 2.04*** | -0.31*** | -0.02 | 0.17*** | 0.40*** | 0.48*** | 0.53*** | 0.57*** | 0.43*** | 0.37*** | 0.33*** | 0.26*** | -15462.52 |
| **AV.** | -0.06 | 0.52*** | 1.15*** | -0.38*** | 0.01 | 0.23*** | 0.27*** | 0.27*** | 0.27*** | 0.21*** | 0.18*** | 0.15*** | 0.16*** | 0.09 | -12367.83 |
| **BARC** | -0.63*** | 0.33*** | 1.64*** | -0.11*** | 0.03** | 0.09** | 0.22*** | 0.19*** | 0.28*** | 0.24*** | 0.19*** | 0.07** | 0.06** | 0.08** | -28178.92 |
| **BG.** | -0.10 | 0.63*** | 0.65*** | -0.34*** | 0.00 | 0.22** | 0.29*** | 0.34*** | 0.35*** | 0.39*** | 0.28*** | 0.25** | 0.12 | 0.16 | -6776.79 |
| **BLT** | -0.23*** | 0.65*** | 0.88*** | -0.31*** | 0.06 | 0.27*** | 0.33*** | 0.31*** | 0.40*** | 0.38*** | 0.36*** | 0.36*** | 0.24*** | 0.23*** | -5847.19 |
| **BP** | -1.49*** | 0.15*** | 2.56*** | -0.14*** | 0.00 | 0.08** | 0.32*** | 0.42*** | 0.44*** | 0.45*** | 0.26*** | 0.18*** | 0.10*** | 0.11*** | -28230.14 |
| **BATS** | -0.14 | 0.60*** | 1.26*** | -0.37*** | -0.00 | 0.28*** | 0.47*** | 0.57*** | 0.57*** | 0.56*** | 0.43*** | 0.38*** | 0.43*** | 0.39*** | -7536.91 |
| **BSY** | 0.13** | 0.56*** | 1.83*** | -0.42*** | 0.06* | 0.10* | 0.21*** | 0.24*** | 0.31*** | 0.27*** | 0.18*** | 0.14*** | 0.13*** | 0.10* | -12633.48 |
| **BT.A** | -0.84*** | 0.37*** | 1.60*** | -0.17*** | -0.02 | 0.12** | 0.27*** | 0.30*** | 0.34*** | 0.35*** | 0.30*** | 0.20*** | 0.16*** | 0.10** | -14897.86 |
| **CBRY** | -0.06 | 0.57*** | 1.20*** | -0.22*** | 0.02 | 0.11 | 0.36*** | 0.43*** | 0.39*** | 0.40*** | 0.35*** | 0.29*** | 0.19** | 0.15** | -9984.44 |
| **CPG** | 0.37*** | 0.68*** | 0.75*** | -0.29*** | 0.10*** | 0.17* | 0.26*** | 0.26*** | 0.26*** | 0.23** | 0.13 | 0.09 | 0.08 | 0.05 | -8126.34 |
| **DGE** | -0.33*** | 0.45*** | 1.68*** | -0.46*** | 0.07** | 0.15** | 0.35*** | 0.43*** | 0.47*** | 0.48*** | 0.35*** | 0.30*** | 0.19*** | 0.10* | -13882.12 |
| **GSK** | -1.08*** | 0.18*** | 1.39*** | -0.33*** | 0.05* | 0.10*** | 0.36*** | 0.46*** | 0.50*** | 0.46*** | 0.31*** | 0.25*** | 0.20*** | 0.14*** | -30326.41 |
| **HBOS** | -0.54*** | 0.36*** | 1.59*** | -0.33*** | 0.04 | 0.11** | 0.26*** | 0.31*** | 0.34*** | 0.38*** | 0.24*** | 0.19*** | 0.19*** | 0.20*** | -18912.75 |
| **HSBA** | -1.42*** | 0.20*** | 3.02*** | -0.16*** | 0.01 | 01.3*** | 0.37*** | 0.44*** | 0.51*** | 0.55*** | 0.36*** | 0.24*** | 0.19*** | 0.08** | -22449.60 |
| **IMT** | 0.23* | 0.76*** | 0.81*** | -0.34*** | 0.03 | 0.01 | 0.38*** | 0.34*** | 0.42*** | 0.47*** | 0.31** | 0.29** | 0.17 | 0.04 | -4722.11 |
| **LLOY** | -0.78*** | 0.28*** | 1.64*** | -0.09*** | 0.04*** | 0.19*** | 0.27*** | 0.29*** | 0.34*** | 0.36*** | 0.25*** | 0.13*** | 0.13*** | 0.15*** | -30323.96 |
| **MKS** | 0.11 | 0.66*** | 0.79*** | -0.24*** | 0.05 | 0.14 | 0.20** | 0.32*** | 0.24*** | 0.28*** | 0.16* | 0.09 | 0.05 | 0.02 | -7336.27 |
| **NGT** | -0.33*** | 0.57*** | 0.84*** | -0.27*** | 0.01 | 0.35*** | 0.51*** | 0.53*** | 0.51*** | 0.50*** | 0.42*** | 0.28*** | 0.26*** | 0.16* | -8155.78 |
| **PRU** | -0.17*** | 0.50*** | 1.32*** | -0.23*** | -0.08*** | 0.24*** | 0.34*** | 0.37*** | 0.39*** | 0.32*** | 0.18*** | 0.14*** | 0.15*** | 0.09* | -13435.94 |
| **RB** | -0.07 | 0.56*** | 1.17*** | -0.26*** | 0.01 | 0.25*** | 0.29*** | 0.28*** | 0.34*** | 0.33*** | 0.24*** | 0.19*** | 0.09 | 0.05 | -8685.01 |
| **RIO** | -0.64*** | 0.44*** | 1.83*** | -0.31*** | -0.04 | 0.31*** | 0.61*** | 0.61*** | 0.67*** | 0.71*** | 0.53*** | 0.41*** | 0.40*** | 0.31*** | -11917.46 |
| **RBS** | -0.96*** | 0.21*** | 2.21*** | -0.45*** | 0.06* | 0.07** | 0.29*** | 0.31*** | 0.39*** | 0.46*** | 0.25*** | 0.22*** | 0.18*** | 0.16*** | -27109.02 |
| **SPW** | -0.12 | 0.56*** | 0.81*** | -0.54*** | 0.14*** | 0.10 | 0.49*** | 0.45*** | 0.48*** | 0.40*** | 0.32*** | 0.16* | 0.13 | 0.04 | -6178.52 |
| **SHEL** | -1.44*** | 0.18*** | 2.63*** | -0.28*** | 0.01 | 0.15*** | 0.47*** | 0.53*** | 0.61*** | 0.55*** | 0.32*** | 0.28*** | 0.26*** | 0.21*** | -21141.02 |
| **STAN** | -0.24*** | 0.63*** | 0.98*** | -0.39*** | 0.07* | 0.27*** | 0.51*** | 0.55*** | 0.62*** | 0.63*** | 0.49*** | 0.45*** | 0.44*** | 0.31*** | -7031.62 |
| **TSCO** | -0.71*** | 0.43*** | 1.31*** | -0.14*** | 0.05*** | 0.20*** | 0.42*** | 0.47*** | 0.43*** | 0.34*** | 0.23*** | 0.29*** | 0.22*** | 0.15*** | -14456.31 |
| **ULVR** | -0.88*** | 0.32*** | 1.55*** | -0.50*** | 0.04 | 0.33*** | 0.50*** | 0.60*** | 0.65*** | 0.62*** | 0.39*** | 0.34*** | 0.30*** | 0.30*** | -12229.90 |
| **VOD** | -1.77*** | 0.07*** | 2.85*** | -0.06*** | 0.02*** | 0.04*** | 0.22*** | 0.21*** | 0.29*** | 0.29*** | 0.16*** | 0.08*** | 0.03 | 0.01 | -38313.65 |

**Table 7**
**Endogenous Simultaneous Switching Regression Model Estimates**

The table reports the coefficient and "HC3" heteroscedastic-consistent standard errors estimates of Mackinnon and White (1985) for the endogenous simultaneous switching regression model for the stocks in our sample. Our sample include only mid- and large-size transactions executed during the continuous trading session of SETS and of the types "O" and "AT" for the 62 trading days from December 2, 2002 to February 28, 2003. We exclude non-standard settlement, late reported and delayed published trades from the sample. The dependent variable, $y_t$, is price-impact of the trade computed as the signed-trade log return, in percent, from the midpoint of the best limit-order prices prevailing 3 minutes prior to the trade to the price of the trade. We estimate the following model along the general line of Madhavan and Cheng (1997):

$$y_t = \beta_0 + \beta_1 q_t + \beta_2 \hat{\Phi} + \beta_3 q_t \hat{\Phi}_t + \beta_4 \hat{\phi}_t$$

where $q_t$ is the log of the trade size normalised by the NMS of the respective stock, $\hat{\Phi} = \Phi\left(\hat{\gamma}' Z_t\right)$ and $\hat{\phi} = \phi\left(\hat{\gamma}' Z_t\right)$, where $\hat{\gamma}$ denotes the estimated coefficient of the continuous response variable $u_t^*$ based on the estimates of the structural probit model. ***, ** and * indicate that the coefficient is statistically significant at the 1%, 5% and 10% levels for a two-tailed test, respectively.

| Stock Symbol | $\beta_0$ | | $\beta_1$ | | $\beta_2$ | | $\beta_3$ | | $\beta_4$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. |
| **AAL** | -0.057** | 0.025 | -0.024*** | 0.006 | -0.012 | 0.163 | -0.054 | 0.058 | 0.258 | 0.172 |
| **AZN** | -0.085*** | 0.020 | -0.021*** | 0.004 | -0.057 | 0.074 | -0.142*** | 0.034 | 0.298** | 0.125 |
| **AV.** | -0.454*** | 0.066 | -0.108*** | 0.014 | -0.057 | 0.116 | 0.131 | 0.090 | 1.503*** | 0.331 |
| **BARC** | -0.205*** | 0.027 | -0.040*** | 0.005 | 0.081 | 0.093 | 0.068*** | 0.030 | 0.692*** | 0.150 |
| **BG** | -0.022 | 0.057 | -0.016 | 0.012 | 0.135 | 0.126 | -0.094 | 0.085 | 0.014 | 0.268 |
| **BLT** | 0.016 | 0.027 | -0.008 | 0.007 | -0.111 | 0.100 | 0.034 | 0.065 | 0.274 | 0.176 |
| **BP** | 0.065*** | 0.014 | 0.013*** | 0.003 | 0.613*** | 0.219 | -0.106*** | 0.027 | -0.362*** | 0.201 |
| **BATS** | -0.011* | 0.064 | -0.014 | 0.014 | 0.358** | 0.147 | -0.302** | 0.125 | -0.540 | 0.419 |
| **BSY** | -0.167*** | 0.033 | -0.045*** | 0.007 | 0.031 | 0.039 | -0.003 | 0.037 | 0.447*** | 0.129 |
| **BT.A** | 0.065 | 0.051 | 0.005 | 0.012 | 0.365** | 0.171 | -0.155** | 0.062 | -0.243 | 0.299 |
| **CBRY** | -0.099 | 0.084 | -0.030 | 0.019 | 0.055 | 0.129 | -0.026 | 0.124 | 0.297 | 0.438 |
| **CPG** | -0.118 | 0.076 | -0.044** | 0.018 | 0.114 | 0.080 | 0.036 | 0.103 | 0.377 | 0.323 |
| **DGE** | 0.057* | 0.032 | 0.004 | 0.006 | 0.234** | 0.094 | -0.229*** | 0.051 | -0.455** | 0.203 |
| **GSK** | 0.093*** | 0.017 | 0.018*** | 0.003 | 0.042 | 0.107 | -0.162*** | 0.022 | -0.154*** | 0.125 |
| **HBOS** | -0.140*** | 0.044 | -0.029*** | 0.008 | 0.124 | 0.134 | -0.158*** | 0.051 | 0.325 | 0.0260 |
| **HSBA** | 0.046*** | 0.008 | 0.006*** | 0.001 | 0.110 | 0.129 | -0.034* | 0.020 | 0.023 | 0.120 |
| **IMT** | 0.001 | 0.037 | -0.134 | 0.009 | -0.046 | 0.086 | 0.029 | 0.086 | 0.241 | 0.243 |
| **LLOY** | -0.170*** | 0.021 | -0.032*** | 0.004 | 0.022 | 0.089 | 0.006 | 0.024 | 0.735 | 0.118 |
| **MKS** | -0.046 | 0.117 | -0.027 | 0.029 | 0.169 | 0.240 | -0.110 | 0.229 | 0.002 | 0.706 |
| **NGT** | -0.027 | 0.036 | -0.018*** | 0.008 | 0.011 | 0.150 | -0.021 | 0.086 | 0.160 | 0.280 |
| **PRU** | -0.143*** | 0.040 | -0.040*** | 0.009 | 0.201 | 0.069 | -0.145*** | 0.047 | 0.275 | 0.177 |
| **RB** | -0.083 | 0.060 | -0.030 | 0.014 | -0.012 | 0.120 | 0.051 | 0.086 | 0.491 | 0.312 |
| **RIO** | -0.042 | 0.038 | -0.018 | 0.008 | -0.031 | 0.120 | -0.061 | 0.062 | 0.220 | 0.254 |
| **RBS** | -0.025 | 0.020 | -0.002 | 0.003 | -0.034 | 0.124 | -0.133*** | 0.025 | 0.227 | 0.143 |
| **SPW** | 0.277** | 0.117 | 0.047* | 0.027 | 0.737** | 0.289 | -0.627 | 0.215 | -1.821** | 0.729 |
| **SHEL** | 0.093*** | 0.019 | 0.021*** | 0.003 | 0.448** | 0.243 | -0.177*** | 0.036 | -0.400 | 0.259 |
| **STAN** | 0.041 | 0.031 | -0.000 | 0.007 | -0.198* | 0.113 | 0.071 | 0.083 | 0.416* | 0.238 |
| **TSCO** | -0.092* | 0.049 | -0.035*** | 0.012 | 0.071 | 0.161 | 0.006 | 0.066 | 0.367 | 0.294 |
| **ULVR** | 0.037 | 0.028 | 0.004 | 0.005 | -0.405** | 0.186 | -0.050 | 0.324 | 0.379 | 0.236 |
| **VOD** | 0.121*** | 0.015 | 0.015*** | 0.003 | 0.601*** | 0.140 | -0.092*** | 0.020 | -0.524*** | 0.154 |

**Table 8**
**Cost of Trading Estimates Derived from Different Algorithms of Assigning Dealers' Trades**

The table reports the cost of trading estimates for the sample stocks using the trade-sign algorithms of Lee and Ready (1991), Cai and Dufour (2003) and sign-reversal to assign off-SETS' trades as either buy or sell. "Retail" and "Block" (mid- and large-size) trades are as defined previously. The various cost of trading estimates are as defined above and computation is given by Equation 3. The trading cost estimates are measured in basis points.

| Trading Venue | Trade Size | Trading Cost Estimates | | | | | Trade Sign Algorithm |
|---|---|---|---|---|---|---|---|
| | | Opening | 3-min | Spread | VWAP | Closing | |
| **SETS** | **Retail** | **3.60** | **4.88** | **5.51** | **3.13** | **0.56** | |
| Off-SETS | Retail | -5.15 | 7.43 | 8.07 | 2.72 | 3.47 | Lee & Ready (1991) |
| Off-SETS | Retail | -7.90 | 5.25 | 5.66 | 0.80 | 1.70 | Cai & Dufour (2003) |
| Off-SETS | Retail | -16.26 | 4.31 | 4.87 | -1.03 | 1.96 | Reversal of Sign |
| **SETS** | **Block** | **14.68** | **8.59** | **7.00** | **5.62** | **-0.69** | |
| Off-SETS | Block | 3.22 | 18.32 | 24.98 | 12.78 | 24.49 | Lee & Ready (1991) |
| Off-SETS | Block | 17.37 | 8.98 | 8.33 | 4.96 | 2.80 | Cai & Dufour (2003) |
| Off-SETS | Block | 9.98 | 3.20 | 1.53 | 0.78 | -2.32 | Reversal of Sign |