Market Microstructure: The Automated Order Book

Philip N Creswell

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DECLARATION

Except where specific mention is made to other sources, the work presented in this thesis is the original work of the author. The work has not been submitted, in whole, or in part, for any other degree.

Philip N Creswell

ABSTRACT

This thesis examines the efficiency and implications of the market microstructure provided by the London Stock Exchange (LSE), extending the framework of O'Hara (1995), Parlour (1998) and Madhavan (2000) to accommodate the idiosyncrasies of the Stock Exchange Trading System (SETS) and the Stock Exchange Automated Quotation System (SEAQ).

First, we offer a comparison of the two trading platforms using the methodology of Haung and Stoll (1996) and Venkataraman (2001) to show that the SETS order book is a more efficient platform, although it has a limited ability to cope with large orders. We compare the results with those from other exchanges described in Biais *et al* (1995) and De Jong *et al* (1995).

We then offer a detailed analysis of the SETS order book, the aggregate behaviour of traders, and a detailed look at an investor's order choice between aggressive market orders and passive limit orders. Building on theories described in Glosten (1992), Keim and Madhavan (1995), Harris and Hasbrouk (1996), Griffiths *et al* (2000) and Grinblatt and Keloharju (2001) we ask such questions as, when and in what way does the spread and depth vary? How do market conditions affect the choice of orders and vice versa? And how do the official order book market and the unofficial dealer market coexist? We analyse the aggressiveness of orders sent to SETS, as Beber and Caglio (2003) and Ellul *et al* (2003) do for the NYSE, and explain how spread, depth and asymmetry of depth affect the choice between limit orders and market orders. We find that, as the market moves from a bull phase to a bear phase, overall order activity increases, the proportion of trading going through the order book increases, the quoted spread remains constant but the asymmetry of depth increases. We also find that daytime returns are higher during the bear market, due to the speculative nature of the continuous market (compared to the actions of the off market traders and the price set during the opening call auction). Finally, we differentiate between the behaviour of sellers and buyers; buyers are more heterogenous, and their decisions are more reliant on the time of day and market conditions.

As well as applying most of the market microstructure theory to the LSE for the first time, and building towards a short term forecasting model, we analyse the appropriateness of the categorisation of investors and some commonly used measures such as price impact and bid-offer spread, offering alternatives with practical application.

CONTENTS

1 INTRODUCTION

This study, along with many before it, is built around the aim of finding a way to make money. While this may seem a less than noble pursuit, the competition between profit seeking traders is the only path to an efficient market. Also, although it may seem like splitting hairs, investors cannot make money. They take it from others (i.e. for one investor to beat the market return, there must be at least one investor who does not match the market return). The question then is how to take this money from other investors who are trying to do the same. The Efficient Markets Hypothesis (EMH) in its strongest form will tell you that it is not possible, and that any trading gains are a product of chance. In the weaker form of the EMH, it states that you need better information than your competitors to succeed. Regulations have (we assume) removed the risk of insider trading, but this is just one interpretation of the term "information". This term that is used so widely, but defined so scarcely will be discussed at length later in this thesis. For now, we will simply state that having the ability to analyse market wide data in ways that no other investor can, is an informational advantage.

An alternative definition of market "efficiency" is that prices fully reflect all information i.e. the market value equals the true underlying value. This definition is used extensively in the market microstructure literature. To give an example of why these definitions are different, consider a fixed trading cost e.g. 0.5% stamp duty. Increasing the fixed cost makes it more difficult to exploit miss-pricing errors. Using the first definition, a sufficiently large trading cost would lead to an efficient market, since nobody can systematically make profits. But we may conclude that the market is less efficient, under the second definition, since the prohibitively expensive trading costs dissuade investors, leaving the market less liquid and more volatile.

The days of human intermediaries in the more liquid financial markets seem numbered. Investors can trade directly with other investors through automated order books, placing aggressive market orders that execute immediately, or more passive limit orders, which sit on the order book as a firm commitment to trade at a given price, for a given volume, until a counter party is found or the trade is withdrawn. Stock exchanges vary in terms of the detail they provide to market participants, regarding the standing limit orders. Some show the best prices on either side of the market. Some state the identity of the traders immediately after a trade. The London Stock Exchange (LSE) gives real time data showing the total depth and number of orders along with the top ten quotes on either side of the market: limit price, trading volume and the number of orders at that price. This is an enormous amount of information. A computer designed to analyse the order book in real time, storing the orders placed and drawing conclusions about the trading interests of the other market participants is beyond the capabilities of modern technology. It is for this reason that we can say that investors are not using this information (in a detailed and scientific way). This has two advantages. First, when the technology catches up, this may be the basis for a new trading strategy. Second, any conclusions drawn about the profitability of different strategies are not self fulfilling i.e. traders could not have found actions that were profitable in the past, and acted on them in a way that ensures the persistence of the result.

Given such a wealth of data, the question is where to start. Various academic papers (Allen and Gorton (1992), Harris and Hasbrouk (1996), Parlour (1998), Goettler *et al* (2003)) suggest theories defining how traders should react to market conditions, while others show the actual behaviour of traders (Barclay and Warner (1993), Keim and Madhavan (1995), Lee and Radhakrishna (2000), Grinblatt and Keloharju (2001)), but very few put the two pieces together. For example, one possible indicator for the orders that will be placed in the near future is the relative imbalance of depth on the order book. Parlour (1998) states that after a market buy order has

been submitted, the most likely order to follow is a limit sell order, thus moving the book back to equilibrium. Keim and Madhavan (1995) state that sell orders tend to be more aggressive. So if, in a stable market, there are an equal number of buyers and sellers, there would be more market sell orders than market buy orders, and more limit buy orders than limit sell orders. This suggests that in equilibrium, we might expect to see more standing limit orders on the buy side. Clearly, it is only when a comparison is made between the order imbalance on the book and the equilibrium, that a meaningful conclusion about future orders can be drawn. So the question of where to start might be to identify the equilibrium position of the order book.

Another place to start may be to look at how things have changed from the days before the automated order books. There is an extensive literature, both theoretical and empirical, explaining how market participants behave, how prices are set, what market intermediaries add to the process, how aspects of the microstructure (transparency, information services, barriers to entry, anonymity) affect the efficiency of the market, and why anomalies like the Monday effect, the January effect or the closed end fund puzzle exist. The data set obtained from the LSE does in fact lend itself to a comparison of the old and new trading systems. So, in keeping with Haung and Stoll (1996), Venkataraman (2001), La Plante and Muscarella (1997), Jong *et al* (1995), and other market comparisons, we compare the Stock Exchange Automated Quotation (SEAQ) system of competing market makers and the replacement Stock Exchange Trading System (SETS) automated order book. In a working paper, Naik and Yadav (1999) look at this "effect of market reform", but there is plenty of scope for alternative methodologies.

This thesis uses both of the suggested starting points, and makes the lengthy journey towards a potential trading strategy. Along the way, various gaps in the current body of literature are explored. For instance, the analysis of the bid-offer spread in a market with asymmetric depth is often qualified with a few caveats, but we rarely

find a solution or even an alternative. Another gap concerns the process of price setting in an automated order book market. The two popular theories of inventory risk and asymmetric information risk which explain the price setting process, do not easily extend to a market with no intermediary, and so a discussion follows about the price setting process. Another frequently side stepped issue is that of "alternative trading platforms". Most of the modern liquid markets (New York Stock Exchange (NYSE), Paris Bourse, Tokyo Stock Exchange, NASDAQ) are hybrid markets, usually mixing an element of automation for small trades and large trade market maker system. On the LSE, although the out dated market maker system was replaced with an automated order book, the firms that previously made the markets have continued to offer liquidity to traders who ask for it. In each of the markets mentioned above, the trading activity away from the official market (i.e. away from the NYSE trading floor, Paris Bourse order book or LSE SETS order book) makes up a significant proportion of the total trading.

The remainder of the thesis is split into 5 main sections. In chapter 2 we summarise the design features of the largest financial markets, and explain the rationale behind their design. Establishing the differences is important for two main reasons. Firstly, a practical application of a study of market microstructure is the design of the market itself. Studying the types of market used in practice, is a sign of what market officials believe to be the most efficient trading platform. Secondly, academic research has been carried out on several exchanges, and extending conclusions from one market to another is not always easy or even possible. This issue is discussed further in the literature review.

The literature review provides a summary of the important results, and so a context in which the analysis of the thesis may be placed. Market microstructure has become a broad subject and so there are several sections in this chapter. We provide a brief summary of the early models from which the subject germinated, and then show

many of the areas in which it has grown. The thesis touches on many areas and so it is important to lay this broad background to the subject. As well as establishing the previous results, there is extensive discussion of the results and an indication of how this relates to the analysis in later chapters. In particular, a discussion follows for any area that seems to be incompletely or incorrectly addressed. This is the basis of the analysis in the following chapters.

Chapter 4 looks at the differences between the SEAQ market makers and the SETS automated order book. This offers a rare comparison between stocks on the same exchange, subject to the same legislative requirements, but traded on different platforms. We use this comparison to evaluate the relative efficiency of each market design. We also scrutinise and offer an alternative to the methodology of previous research.

Chapters 5 and 6 look at the SETS order book in isolation. We begin by describing the profile of the limit orders sent to the order book, how they vary during the day and under what market conditions. We then investigate how and when market orders are sent to the market. This offers a detailed insight into how aggregate trader behaviour is affected by market conditions. Only with these foundations, can we draw conclusions about short term price forecasting. For instance, if the depth at best price is an indicator of short term price movements, we must first establish what the average depth at each side of the spread is, and how this is affected by other factors like time of day, and seasonal variations.

2 MARKET BACKGROUND

2.1 Types of Market

It is difficult to find a unanimous decision regarding the primary aim of a stock exchange. Many academics seem to assume that a better market is one with lower transaction costs. Goettler *et al* (2003) show that reducing transaction costs is not always in the interest of traders, arguing that the net welfare of the population should be used as the benchmark. The 2002 President of the World Federation of Exchanges, Antonio Zoido[1], states that "the crucial contribution bourses make to every economy is asset price discovery." The objectives of the exchange become even less clear when you introduce the conflict of interests of shareholders (owners of the exchange), investors (trading on the exchange), and the economy as a whole. This confusion leads to a myriad of market design options. Before launching into a description of the London Stock Exchange, it is worthwhile defining the major features of stock exchanges. This provides a context and a platform from which to compare the worldwide exchanges.

1. Market Makers - Some markets have human intermediaries. The obligations of these intermediaries varies in many ways. The number of market makers also varies significantly.
2. Monopolistic Specialist - where a single market maker is appointed by the exchange.
3. Automated order books – No human intermediary. Market orders are matched against limit orders by an electronic mechanism.

[1] Information taken from www.worldfederationofexchanges.com

4. Continuous Markets – Markets may open for a number of hours during the day. Trades may execute at any time during the trading day, or at specific times. Some markets offer a batch auction as the opening or closing procedure for an otherwise continuous market.
5. Call Auction – Traders post orders with a quantity and price during an auction period. At the end of the period a strike price is set automatically, or by a specialist.
6. Transparency – What information is available at the time of the trade, regarding the identity and trading interests of other parties?
7. Access to information – Who has access to the market? How many information gathering firms are present in the market, and who has access to these? Are they cost prohibitive for smaller investors?
8. Fixed Costs – Although the market spread is present in all markets, they vary in terms of stamp duty or other costs such as commission.
9. Cross-listed stocks - traders may be able to buy stocks on a choice of markets.
10. Upstairs markets – Some markets offer an alternative execution route, through member firms that arrange trades with other member firms. This facility is typically used for large block trades.
11. Off market trades – Many markets are regulated in such a way that allows their stocks to be traded away from the market. This is the case for most of the developed markets, due to monopoly rules.
12. Derivatives markets – Options and Futures are rarely traded for individual stocks, although it is usually possible to arrange such derivatives.

2.2 History of the LSE

Michie (1999) provides a comprehensive history of the London Stock Exchange (LSE). The LSE was formed with the agreement of several proprietors, in 1801. The purpose back then was to provide a venue for members to trade in their listed

securities. They faced competition for this service from many places: the coffee houses that the LSE was born from, the Rotunda of the Bank of England and the Royal Exchange. At that time, it was by no means certain that the self-regulating, members organisation would out last its competitors to become the largest stock exchange in London. By 1900, the LSE was the largest and most important stock exchange in the world. While the fortunes of the London Stock Exchange closely followed the rise and fall of the British Empire, the conflict between the owners and the members led to the market's competitive position. However, it was the strong position that the member firms had established that fuelled the decline in the second half of the twentieth century.

The members profited from the activities of the LSE, and didn't want anything to change. However, the increasing use of technology and alternative trading systems used in the USA and across Europe could no longer be ignored. Later than was desirable, from the point of view of the exchange, the LSE introduced an automated quotation system. The Stock Exchange Automated Quotation (SEAQ) system was modelled on that employed by the NASDAQ, and was fully implemented by 1986. While the LSE believed this to be the best exchange system at the time, even improving on NASDAQ, it was soon apparent that their new technology was obsolete. The profits earned by the member firms were under threat once more. Several years and one sacked director of the LSE later the Stock Exchange Trading System (SETS) was introduced, in October 1997. This system was an automated order book, modelled on the Paris Bourse.

2.3 Regulation and Tax

Providing a comprehensive history of the changes to the regulation of the LSE, along with tax changes and other factors that affect the efficiency of the market would take

a great deal of time, so we will simply introduce some of the important events of recent years.

The Financial Service Authority (FSA) took over the responsibility of many of the regulatory bodies like the Securities and Investment Board (SIB) and the Personal Investment Authority (PIA). The change may have made little practical difference, but it may have distracted from the number of financial scandals of recent years. Shortfalls due to non-payment of Lloyds members, losses due to mis-selling of private pensions, mortgage endowments or split capital investment trusts all lead to a lack of trust of the financial industry. The failure of regulatory bodies must have an impact on the markets. And what of the regulations that did work? Rules such as those aimed at policing money laundering have an impact on the aggregate trading behaviour. Illegal money that once churned through the financial markets quickly (and usually with a loss) is, we assume, no longer present. And what of other illegal activity? Insider trading is policed far more effectively now than it ever was. Similarly, the rules are constantly evolving to cope with traders who deliberately manipulate the market. This activity is illegal, but it is so difficult to define that it is hard to regulate, without specific rules and examples. And investors evolve in exactly the same way that the regulations try to. The reason that the laws exist is because someone has tried it, and probably profited from it.

The UK tax rules are generally considered to be the most complex in the world, as a result of the years of tax evolution. An example of an outdated tax is the stamp duty imposed on share transactions. LSE is one of the few exchanges that must charge a stamp duty of 0.5% on every domestic share transaction. The implications of this fixed charge will be discussed in detail later on. Another tax related issue concerns pension funds. Until 1997, pension funds paid no tax on UK dividends. Pension funds represent a large proportion of the UK market, and the loss of this tax relief, along with changes to the pension fund valuation rules, meant that equity was no

longer as attractive to pension funds. Ironically, the instant shortfall faced by pension funds, meant that they became net buyers over the short term. The ageing population, the distrust of the financial industry, the worry over retrospective tax changes, the limits imposed on what pension funds can be used for, the availability of other tax efficient investments, all add up to a changing demand for UK shares.

2.4 SEAQ

Until 1986, information was gathered and trades were arranged in person and over the phone[2]. The introduction of the Stock Exchange Automated Quotations (SEAQ) system didn't affect the settlement procedure, but it did significantly improve the distribution of information. Member firms who nominate themselves as "market makers" for a given stock are obliged to quote firm prices, for trades up to the Normal Market Size (NMS), throughout the trading day. The Normal Market Size represents the average order size and is calculated as a percentage of the average daily trading volume.

Market makers compete for order flow by posting a bid and offer price electronically. SEAQ also shows the quote size (which may be bigger than NMS) and the time that the quote was last updated. As well as the current market maker quotes, SEAQ displays a number of other pieces of information: the closing price on the previous trading day, the NMS, the last 5 trade prices, the volume traded so far that day, and the daily highs and lows of the trade price and the mid market price. Although the last 5 trades are shown on screen, there may be delays of up to 90 minutes before trades are reported to the market. Furthermore, trades that take place under the "block trade scheme" can be reported much later.

[2] information taken from Michie (1999) and www.LSE.co.uk

While the prices quoted by SEAQ market makers are firm, trades frequently take place at prices better than the best quoted price. Because orders are still arranged over the phone, a broker has the opportunity to bargain with the market maker. If a broker is acting on behalf of a third party, they must trade at the best price possible. The potential for price improvement makes this difficult to regulate.

2.5 SETS

SETS was introduced in October 1997 for the FTSE 100 stocks only. Having made the switch from SEAQ to SETS, companies did not switch back in the event of dropping out of the top 100. As a result of this, SETS became the trading mechanism for the top 130 or so stocks on the FTSE 350. From time to time, other liquid FTSE 250 stocks were added to SETS and then in September 1999, following a review of the criteria for SETS listing, a further 30 stocks switched over. There are currently in the region of 170 companies on SETS.

SETS is an automated order book market. However, a significant proportion of trading volume occurs through the member firms, which used to be market makers for these stocks, before the switch was made from SEAQ to SETS. The relative proportions of trading are discussed in subsequent chapters, but note that, although the formal market mechanism is an automated order book, in many respects SETS is a hybrid market.

The trading day starts with a call auction period. Investors are invited to submit limit orders or market orders between 07:50 and 08:00. During this time, a notional crossing price and the volume that would trade at that price is displayed on screen. The crossing price is calculated automatically as the price at which the greatest volume would trade. After a random period of up to 30 seconds, the auction closes and all market orders and limit orders within the crossing price trade at that price. In

the event of a crossing price being set that would lead to unexecuted market orders (i.e. market orders on one side are greater than all orders on the other) the auction period is extended by 2 minutes. This is known as a Market Order Extension (MOE). In the event of the crossing price deviating from the transaction price of the last automated trade by more than 10%, a further 5 minutes is added to the auction period. This is known as a Price Monitoring Extension (PME). Each period of extension ends with a random period of up to 30 seconds.

After the opening, if the price of consecutive automated trades differ by more than 5%, then an Automatic Execution Suspension is called. Trading is suspended for 5 minutes, and in the event of notionally unexecuted market orders a further 2 minutes. This price monitoring function is disabled between 10:02 and 10:30 on index expiry days, when the price is expected to fluctuate significantly.

The trading day ends with the Volume Weighted Average Price (VWAP) period from 16:10 to 16:30. The VWAP is calculated for all trades in this period and is used for index purposes. The day closes with another auction process between 16:30 and 16:35. The process is similar to the opening auction. A 2 minute MOE and two 5 minute PMEs may follow, each with a random period of up to 30 seconds. This means that the closing price may be set as late as 16:48.

Continuous trading throughout the day, operates as most other automated order books. Investors can submit a number of different orders. All orders are for a designated size. The primary choice is what price a trader is willing to accept. Departing from the traditional definitions, a "Limit Order" is an order that has a limit price less than the prevailing offer price, for a buy order, or greater than the bid price for a sell order. A "Market Order" can have a limit price, but the limit price is at least as great as the offer price for a buy order or as low as the bid price for a sell order. Further conditions can be attached to market orders. An "Execute and

Eliminate" order matches against all existing limit orders within the limit price, and cancels the remainder of the order. A "Fill or Kill" order matches against all existing limit orders, but if the whole order cannot be filled, then no trade takes place, and the order is cancelled immediately.

When a dealer is given an order to trade in a SETS stock, they enter the SETS page for that stock. The page shows a number of important figures designed to aid the decision of how to trade. The best bid and offer prices are shown, along with the volume on each side and the number of orders that make up the total volume at that price. For orders placed behind the best price, the system displays the price and volume of the next nine prices. It also shows cumulative figures for the total volume and the weighted average price at each step. It also shows the price of the last trade, the opening price, the highs and lows of the day, the volume weighted average price for the day, the total volume for the day both on and off the market as well as the last 5 trade prices.

2.6 Worldwide Exchanges

With an ever globalising economy, we might expect to see a change in the financial market trading mechanisms. Exchange officials have shown a preference for automated order book markets, primarily because they offer a level playing field to all investors, irrespective of geographical location. Whether this objective is met, or in fact if it is desirable, is up for debate, but what we can say is that stock exchanges around the world are changing all the time. It is particularly important to be aware of changes made to markets frequently used for empirical research, in order to put results into context, and explain changes in investor behaviour. The papers reviewed in this thesis are in general fairly recent, and so changes made to exchanges more than 15 years ago have been ignored.

2.6.1 NYSE

The NYSE is the largest stock market in the world. It is also one of the most complex and interesting hybrid markets in existence. The unusual market design is a result of the pressures placed by the member firms that derive profits from the trading activity, as well as collectively owning the exchange. This situation is similar to that faced by the LSE in the early 1990s. The NYSE continues to face competition, and some fundamental changes have recently been taken. These will be discussed below.

The market opens with a call auction. Limit orders and market-on-open orders are submitted to the NYSE OARS system. When the market opens, the specialist sets a price that absorbs the order imbalance. This procedure is less strictly defined than the opening procedure on SETS. This is an example of the impact that the designated specialist can have on the stock price. The value of this human intermediation is often discussed in the literature.

Orders can either be sent electronically to SuperDOT (the successor to Designated Order Turnaround (DOT)) or they can be handled by a floor broker. A specialist resides over the order book, and publishes the best price quotes on either side of the market, along with the associated depth. The depth can include limit orders and the specialist's own position. If a market order is received, it is matched against the depth at best price provided by the limit orders, with strict time priority, before the specialist's quoted depth is filled. Market orders and limit orders can be submitted with conditions attached such as Fill-or-kill, Good Till Close, Stop-loss and Market-on-close.

Unlike SETS, and many other order book markets, market orders are not matched automatically against the standing limit orders. Instead, the specialist has the option to match the trade or stop the order. The specialist guarantees that a stopped order will execute at a price at least as good as the average price that it would receive if matched against the order book. The specialist may pass this order on to a floor trader, who will try to match the order in a trading pit, or the specialist will trade directly with his own inventory (at a price better than the market spread). Irrespective of execution method, all trades are reported within 90 seconds and published with no delay.

We mentioned above that orders may be routed through the SuperDOT order book to the floor brokers, but many orders are sent through brokers directly to the floor traders. It is usually the larger trades that bypass the order book in this way. There is also an informal upstairs dealer market. They must execute trades within the quoted spread, and once arranged, they must formally cross the orders on the trading floor. Although the issue is rarely addressed, it should be stated that the brokerage firms charge a commission for their service. Collated information regarding the amount of commission they charge is difficult to find. Importantly, there is no commission for orders routed through SuperDOT, although if traders do not have access to the order book, a broker may charge a commission for that service.

Due to the liquidity in the market, trading halts are rarely called. Specialists have the right to ask for a trading halt, but given their obligation to maintain a continuous liquid market, they are reluctant to use this facility often. A market wide trading halt would be called automatically in the event of a decline in the DJIA (Dow Jones Industrial Average) of more than 10%.

The tick size[3] before the 23rd of June 1997 was one eighth of a dollar. After this date, the tick size for stocks above $1, was reduced to one sixteenth of a dollar, only to be changed again recently, when the NYSE was decimalised. Following decimalisation, on the 24th of January 2002, the NYSE introduced "OpenBook", which meant that all market participants can see the depth at every price. Previously, traders could only see the best bid and offer price, while the specialist was privy to the information about limit orders. This change was intended to improve the efficiency of the market. Whether it succeeds, remains to be seen. One thing that is certain is that the specialist has lost his strategic advantage. The specialist will still be expected to offer liquidity when others do not, and he will still rank behind other traders at the same limit price. On the plus side, the specialist is physically close to the trading floor, and can still exploit this position. Importantly, nearly all of the research on the NYSE takes data from before 2002, and so it should be considered as a closed order book market.

2.6.2 NASDAQ

It is significant that America still has several distinct markets. American companies can choose to list on either or both of the two largest financial markets in the world. One reason that the two markets coexist is that they operate in such different ways, and so offer different advantages to listed companies.

NASDAQ is a dealer market. Competing dealers, or "market makers" post best bid and ask prices electronically. There are often between 30 and 60 market makers for each of the active stocks. Market makers must satisfy certain requirements (such as solvency and administrative issues), but they are not obliged to maintain a stable market, in the same way as a NYSE specialist. The NASDAQ dealers are free to

[3] "tick size" is the minimum price movement for quoted prices.

maximise their own profits, subject to the rules described below, and it is this competition that leads to a stable market.

Investors can send market orders or limit orders to a dealer. These orders do not execute automatically, but are dealt with by the dealer. If a dealer accepts a limit order, then they must not trade ahead of it. For a given limit price they must execute the trades in the order they were received. These rules are similar to those imposed on the NYSE specialist. Market makers may have arrangements set up with certain clients where they promise to match the best price quoted on the market. These are known as "Preferred Orders", and they explain why the market maker with the best quote does not always get the order flow.

Dealers must quote firm prices for up to 1000 shares. In addition to the telephone based market maker trading platform, NASDAQ offered a Small Order Execution System (SOES, superseded by SuperSOES) for trades of up to 1000 shares. This was designed for smaller investors who may be unable to bargain with market makers in the way that larger players can. Market orders are routed directly to the broker with the best price, or a broker nominated as part of the order.

2.6.3 Paris Bourse

By 1990, the Paris Bourse had switched from a daily call auction to a computerized limit order market. The market model was very successful, and has been used as a benchmark for many other exchanges around the world. In 2001, the Euronext Market Model was implemented, and the exchanges in Belgium, France and the Netherlands effectively merged. Although the physical venues for each of the exchanges still exist, the rules and regulations are set collectively, and the market is considered as a single entity. Much of the previous research was carried out on the

Paris Bourse, before this merger, and so the description and the references that follow, concern the Bourse before the merger.

The Paris Bourse opens with a call auction. The market opens at 08:30 and orders are added or deleted from the order book until 10:00. This is known as the "tatonnement process, through which the markets discover the economic price" (Biais *et al* 1999). At 10:00, a price is set that maximises the initial trading volume. Biais *et al* (1999) tell us that "the majority of the orders placed during the preopening period obtain execution" and that the opening batch trade accounts for 10% of the daily trading volume. The market remains open until 17:00.

The Paris Bourse allows orders similar to the NYSE. One important difference is that traders can submit large limit orders with part of the depth hidden. This depth is only revealed when another trader submits a market order larger than the exposed depth. The automated matching process strictly adheres to time priority. Screens are usually updated within a second of an order being submitted, but just after the opening and just before the closing, when the flow of orders is very thick, the screens take approximately 1 minute to update. This delay makes the choice of order type particularly important. The tick size varies by price, from 0.01 for stocks less than FF 5 up to 1 for FF 500 stocks or more. This is a finer subdivision than the NYSE (pre-decimalisation) and so the potential for front running[4] the best price, makes time priority less important on the Paris Bourse.

The term "market order" is used inconsistently, around the world. On the Paris Bourse, market orders are effectively limit orders at the opposite side's price. If the size of the order is larger than the opposite side depth, the remainder of the order is left on the order book. This means that a limit order with a limit price greater than the opposite side price is more aggressive than a limit order. "Paris Bourse officials

[4] "Front running" is the practice of placing a limit order just inside the spread, thus gaining priority

have suggested to us that this mechanism helps to educate small traders, previously familiar with the daily call market, to limit their market impact in the newly created continuous market" Biais *et al* (1995)

Although a fully automated order book, the Paris Bourse does employ market makers or 'animateur de marche' for the smaller stocks listed on the exchange. These market makers, now known as PLP (Permanent Liquidity Providers), are responsible for maintaining liquidity in the less liquid markets. They sign a commercial agreement with the exchange, agreeing to quote a spread at least as narrow, and a depth at least as high as the limits set out in the contract. They must also agree to trade exclusively on their own account.

The Paris Bourse has an upstairs block trading market, where dealers arrange trades through private negotiation. Orders can be routed to either market, and although the upstairs dealers must at least match the weighted-average price in the downstairs market, they operate distinctly. Block trades may be reported with a greater delay than the automated trades. Block trading in French stocks also takes place on SEAQ international. De Jong *et al* (1993) find that between 30% and 50% of the trading volume of the ten most traded stocks occurs on LSE. These trades are not bound by the same time and price priority rules as on the Paris Bourse. They are also reported with greater delay.

2.6.4 Tokyo

Very little research has been published in the international journals using data from the Tokyo Stock Exchange, but as one of the largest exchanges outside of America it is worth mentioning. In April 1999, Tokyo switched from a floor trading market to a fully automated market. The automated order book market operates under two systems: Itayose and Zaraba. These are roughly equivalent to the call auction and

the continuous trading mechanism employed by SETS on the LSE. The market is open for three hours in the morning and three hours in the afternoon. The first hour in the morning and the first half hour in the afternoon are Itayose periods, and Zaraba is used for the remainder. The Tokyo Stock Exchange has no human intermediation at all. This structure naturally exposes investors to wide fluctuations and the risk of poor liquidity, and so they employ measures to cope with large price movements. If prices vary by more than a set limit from the previous trade, Zaraba is halted and Itayose operates for 5 minutes. Limits vary from 1% for small stocks to less than 0.1% for larger stocks. If the crossing price implied by Itayose is still outside the tolerances, the period is extended for a further 5 minutes and the limit is increased. This is repeated until the crossing price is within the limit, or until the daily price limits are met. Daily price limits vary from roughly 30% for small stocks to 10% for large stocks. If a trade price under either of the mechanism would break this rule, then a further period of Itayose is called. Traders on the Tokyo Stock Exchange can submit orders with various conditions such as market on close, fill or kill, execute and eliminate as per SETS, and also a "limit order at the most recently executed price" or "limit order at one tick prior to the most recently executed trade" or "market orders with the remaining shares turned into a limit order at the first executed price".

2.6.5 Toronto

Member firms are allowed up to 15 minutes to fill the order in the upstairs market. The upstairs market represents the larger trades, and roughly 50% of the trading volume. The crossing price must be at or within the downstairs market spread.

The downstairs market is an automated limit order book. There is strict price priority, but time priority applies up to a maximum volume. After the "priority volume" is filled, the rest of the volume at that price is filled in proportion to

volume. Hidden orders must be disclosed before they are filled, by cancelling and resubmitting, thus losing time priority.

Designated market makers have a role similar to the NYSE specialist, although the focus is on small orders. They have no direct contact with the upstairs market where the block trades occur. Market Makers have very little power. They may choose to take part in up to 50% of the trades that would execute on the order book anyway, but they cannot gain priority over existing orders at the same price. Furthermore, in the event of the depth at the best price being below the Minimum Guaranteed Fill (MGF) limit, they may be forced to trade at the market price.

2.7 Size and Performance

Table 2.1 shows the market capitalization of the world wide stock exchanges. The figures ignore derivatives and collective investment vehicles such as Investment Trusts and Closed-end Funds. They also exclude foreign companies listed, which explains why the LSE appears to have a relatively small percentage of the world market share. However, we can still identify the major markets as NASDAQ, Tokyo, Euronext and of course NYSE, which according to the end of 2002 figure represents almost 40% of the world market capitalization.

Table 2.2 shows the trading activity on each of the exchanges. Again we can see that the most active exchanges in descending order are NYSE, Nasdaq, LSE, Euronext, Tokyo. Based on the 2002 figures, Nasdaq has roughly 70% and LSE has roughly 40% as much trading volume as NYSE. The difference between this picture and the one painted by the market capitalisation statistics reflects two things. Firstly, the trading volume includes foreign companies and investment funds. Secondly, Nasdaq and SEAQ are dealer markets. With a market maker standing between each trade, we effectively double count the trading interest from the real investors.

Table 2.1

Important Notice : When using these data, please always mention World Federation of Exchanges as the source of information.

MARKET CAPITALIZATION OF SHARES OF DOMESTIC COMPANIES
(Main & Parallel Markets)

(000.000 of US$)

(Excluding Investment Funds)

Time zone	Exchange	End 1990	End 1991	End 1992	End 1993	End 1994	End 1995	End 1996	End 1997	End 1998	End 1999	End 2000	End 2001	End 2002	
North America	Amex	102302	124454	88797	105116	86036	103147	97911	124606	126307	90745	82717	60223	45691	0.20%
	Bermuda	NA	NA	NA	NA	NA	NA	NA	NA	1500	1323	2160	2469	2175	0.01%
	Chicago	NA	NA	NA	NA	NA	NA	NA	NA	298	245	184	134	122	0.00%
	Mexico	41054	102764	138745	200865	130246	90694	106770	156595	91746	154044	125204	126258	103941	0.46%
	Nasdaq	310800	490685	618774	791706	793669	1159940	1511824	1726390	2243734	5204620	3597086	2739675	1994494	8.75%
	NYSE	2692123	3484340	3798238	4212956	4147937	5654815	6841988	8879631	10277900	11437597	11534613	11026587	9015271	39.57%
	TSX Toront	241924	265697	241875	326549	315054	366345	486978	567635	543394	789180	766204	611493	570223	2.50%
South America	Buenos Air	3615	18640	18623	44055	36867	37784	44692	59252	45333	55848	45839	33384	16549	0.07%
	Lima	812	1118	2630	5113	8178	10907	12583	15485	9869	12092	9750	9790	11441	0.05%
	Santiago	13636	27990	29595	44887	68195	72928	65971	72046	51866	68228	60401	56310	49828	0.22%
	Sao Paulo	11201	32152	45416	96779	189303	147636	216906	255478	160886	227962	226152	186238	126762	0.56%
Europe, Afr Middle Eas	Athens	15309	12921	10724	13597	12819	16527	23558	33784	80126	196847	107503	83481	66040	0.29%
	Budapest	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	11909	10367	13017	0.06%
	Copenhage	39063	44793	30140	41651	48784	57692	71074	93766	98881	105293	107665	85145	76750	0.34%
	Deutsche B	355311	392470	346891	460754	499278	577365	664913	825233	1086749	1432167	1270243	1071749	686014	3.01%
	Euronext	-	-	-	-	-	-	-	-	-	-	2271728	1889455	1538654	6.75%
	Helsinki	22721	14237	12205	23595	38308	44137	62579	73322	153811	349394	293635	190456	138833	0.61%
	Irish	NA	NA	NA	NA	NA	25836	34738	49371	66596	68773	81883	75298	59938	0.26%
	Istanbul	19065	15508	9756	36613	21605	20772	30312	61095	33646	112716	69659	47150	34217	0.15%
	Italy	148766	158811	123659	145300	185971	209522	256595	344665	565975	728240	768363	527467	477075	2.09%
	JSE South	136869	167958	148675	215883	240026	277109	239579	211599	150670	180463	131321	84344	116544	0.51%
	Ljubljana	-	-	-	-	216	297	891	1876	2985	2854	3100	3461	5578	0.02%
	London	850012	986107	928393	1150557	1145290	1346641	1642582	1996225	2372738	2855351	2612230	2164716	1800658	7.90%
	Luxembour	10456	11276	11921	19314	28518	30443	32411	33892	37931	35939	34016	23783	24551	0.11%
	Malta	-	-	-	7	19	377	409	422	788	3862	2024	1357	1374	0.01%
	Oslo	26130	21997	17840	27542	36459	44587	56879	66503	46273	63695	65267	69445	68103	0.30%
	Spanish Ex	111449	127297	98847	118869	123616	150914	241028	290355	399848	431649	504222	468203	461560	2.03%
	Stockholm	92015	97055	78079	106968	130603	172550	240382	264711	278708	373278	328339	236514	179117	0.79%
	Swiss Exch	157635	173766	189117	270879	284721	398088	400285	575339	701576	693133	792316	625909	547020	2.40%
	Tehran	NA	NA	1333	1149	2360	6535	12869	11476	11115	17243	5893	7385	11761	0.05%
	Tel-Aviv	8274	13228	27884	47518	31130	35116	34463	44371	39230	63472	65338	58229	40774	0.18%
	Vienna	26320	26040	21680	28322	30792	32513	33629	37280	35544	33023	29935	25204	33578	0.15%
	Warsaw	-	146	227	2719	3057	4564	8413	12135	20461	29577	31429	26155	28849	0.13%
Asia, Pacifi	Australian	107936	142404	133555	202014	216826	243475	311865	295766	328854	427655	372794	375598	380087	1.67%
	Colombo	917	1936	1439	2501	2857	1998	1865	2096	1705	1584	1074	1332	1680	0.01%
	Hong Kong	83386	121881	171984	385043	269508	303705	449219	413323	343567	609090	623398	506073	463055	2.03%
	Jakarta	8081	6823	12038	32824	47241	66454	90857	29050	22078	64045	26813	22998	30067	0.13%
	Japan (Tok	2928534	3117297	2318929	2906299	3592194	3545307	3011161	2160585	2439549	4463298	3157222	2264528	2069299	9.08%
	Korea	110301	96466	107661	139584	191778	181955	139122	41881	114593	306128	148361	194470	215662	0.95%
	Kuala Lum	47869	56722	91471	219759	190163	213757	306165	93174	95561	139908	113155	118981	122892	0.54%
	Mumbai	-	-	-	-	-	-	-	-	-	-	-	109243	130390	0.57%
	National St	-	-	-	-	-	-	-	-	-	-	-	112403	112454	0.49%
	New Zealar	8824	14285	14680	24595	27118	31950	36879	29889	24458	27827	18490	17736	21715	0.10%
	Philippine	6632	10835	15335	40148	56648	58780	80464	31211	34911	41536	25261	20606	18183	0.08%
	Shanghai	-	-	-	-	-	-	-	-	-	-	-	333356	306444	1.35%
	Shenzhen	-	-	-	-	-	-	-	-	-	-	-	192490	156648	0.69%
	Singapore	34269	47594	48934	135050	136303	150959	153107	106317	96473	198040	155126	117338	101554	0.45%
	Taiwan	98927	123460	100166	193252	247325	187206	273776	287813	260498	376508	247597	292872	261311	1.15%
	Thailand	20777	37526	57278	127474	125599	135774	95901	22792	34118	57177	29217	35950	45406	0.20%

* Following the Canadian market reorganization, Montreal Exchange now concentrates on derivatives products but maintains a small share market business

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NA : Not Available - : Not Applicable

Table 2.2

Important Notice : When using these data, please always mention World Federation of Exchanges as the source of information.

TOTAL VALUE OF SHARE TRADING
(Domestic & Foreign, including Investment Funds)

(000.000 of US$)

Time zone	Exchange	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
North America	Amex	37715	40919	42236	42236	58511	72717	91330	143230	287929	477822	945391	817042	642181
	Bermuda	NA	NA	NA	NA	NA	NA	3410	11170	27934	87151	252850	436474	413744
	Chicago	71304	74504	84356	99623	91198	105686	124958	198325	298912	580865	1190087	723900	532040
	Mexico	12169	39551	51398	63740	86334	35037	43584	54962	31192	35172	45768	38469	32286
	Nasdaq	452430	693852	891055	1350104	1449301	2398213	3301776	4481682	5518946	10467369	19798799	10934573	7254594
	NYSE	1325332	1520164	1745466	2283390	2454242	3082916	4063655	5777602	7317949	8945205	11060046	10489031	10311156
	TSX Toront	54776	59132	62735	113795	133421	151559	221216	305155	331848	357443	636533	461557	408165
South America	Buenos Air	780	4584	15846	49690	112987	31933	31326	38424	26056	11875	9701	7564	1277
	Lima	99	130	417	1672	3091	3812	3830	4279	3050	2729	2518	934	1187
	Santiago	759	1880	2055	2809	5370	11412	8488	7444	4412	6859	6083	4450	3011
	Sao Paulo	3967	6941	14782	27081	66360	57025	97510	190657	139583	83772	101537	63475	46300
Europe, Afr	Athens	3840	2401	1612	2779	5187	6077	8234	21137	50020	189280	94163	37812	23462
Middle Eas	Budapest	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	12162	4815	5908
	Copenhage	11349	10499	22435	23675	27405	28336	36440	46732	64954	66605	102636	70772	53262
	Deutsche E	508707	404649	454206	563962	592104	593936	811626	1067688	1491796	1551467	2119785	1423371	1212302
	Euronext	-	-	-	-	-	-	-	-	-	-	-	2092540	1988359
	Euronext A	40823	38916	45728	66368	85263	124324	191102	279688	409520	471226	678764	-	-
	Euronext B	9110	8226	9754	13961	16113	18343	25415	33867	60928	58629	43787	-	-
	Euronext L	-	-	-	2439	5177	4241	7245	20808	50077	40479	54897	27602	-
	Euronext P	121064	116649	124879	170362	202070	213161	282014	414321	587854	770076	1064866	-	-
	Helsinki	3975	1553	2182	7859	13298	19207	21961	36252	61117	109902	208326	180927	178202
	Irish	-	-	-	-	-	-	11794	17301	39865	47611	14381	22789	33270
	Istanbul	5870	8277	8346	21126	21667	50889	36233	56088	68485	81099	178998	74530	69937
	Italy	42172	23448	27660	66040	119389	87118	102568	203280	486507	539449	1019625	633937	634635
	JSE South	10469	8703	7754	10363	17631	17425	26998	44696	61837	86838	77446	69278	78392
	Ljubljana	-	-	-	-	417	348	494	544	852	1203	925	1197	1527
	London	543393	553922	662991	865907	1029278	1153221	1413236	1989489	2887990	3399381	4558663	4520183	4001340
	Luxembour	108	236	292	1101	1031	487	786	1048	1673	1421	1661	703	496
	Malta	-	-	-	-	-	131	12	21	354	53	188	46	48
	Oslo	14065	11639	10133	17576	17694	24926	36346	49601	42944	56719	69239	62829	56127
	Spanish Ex	-	-	-	-	-	-	-	-	-	-	-	-	653221
	Stockholms	15738	20568	28650	42746	86087	94210	136741	175822	229961	313678	485288	384396	279944
	Swiss Exch	NA	83080	117752	209885	261608	340114	443031	568882	689170	561894	638707	591065	599749
	Tehran	-	5659	6332	243	454	742	2616	1212	1362	2273	1043	1087	2071
	Tel-Aviv	3358	8221	14380	29980	25136	9159	8100	14158	15079	20958	28539	15674	12676
	Vienna	11223	7233	5155	7297	8742	13357	10692	12724	18677	12734	9642	7693	6109
	Warsaw	-	26	163	1975	5207	2761	5544	7953	8913	11139	19305	9876	7811
Asia, Pacifi	Australian	40186	46697	45577	67792	94909	98310	146236	168999	161001	198195	226485	244463	295399
	Colombo	39	104	114	378	695	210	130	309	282	209	143	156	319
	Hong Kong	34676	38597	78645	132287	126057	95832	166429	453657	206153	230032	376664	241013	194004
	Jakarta	3967	2963	3918	9088	11788	14403	32452	42605	10637	17241	15109	9410	13050
	Korea	75625	85092	116138	211968	286829	185428	177506	170826	145061	733423	556246	379623	596632
	Kuala Lump	10698	10714	19732	148556	120859	60792	178011	145688	26840	42431	52869	23880	32923
	Mumbai	-	-	-	-	-	-	-	-	-	-	-	100638	68539
	National St	-	-	-	-	-	-	-	-	-	-	-	147244	128535
	New Zealar	2072	3107	3276	6802	7188	8719	10139	10725	14274	13687	12315	9933	8878
	Osaka	243823	138549	120936	131999	191183	262054	253119	221990	182093	216029	325566	174510	124017
	Philippine	1175	1434	3019	9853	13934	14667	25510	20350	10148	19950	8187	3129	3093
	Shanghai	-	-	-	-	-	-	-	-	-	-	-	290658	211644
	Shenzhen	-	-	-	-	-	-	-	-	-	-	-	203073	140661
	Singapore	21070	18084	18906	83529	84822	63983	60255	74137	58510	107407	95153	71094	63048
	Taiwan	711737	386031	250331	352624	736708	389273	478356	1308633	895985	913610	985864	541902	633632
	Thailand	15737	19678	72104	88798	81961	59303	51397	24599	20976	37246	21117	30811	41289
	Tokyo	1287694	822974	476977	792977	859896	884000	938822	896055	750825	1675641	2315502	1659909	1564244

Since the market capitalisation figures make no allowance for new issues and the layering of returns through collective investment vehicles, we have included a record of the index levels for each of the major markets in Table 2.3. Note that the construction of indices vary around the world, and so are not directly comparable (although this doesn't stop analysts from comparing them). For instance, the Dow Jones Industrial Average is an un-weighted arithmetic index based on 30 companies set back in 1928, while the FTSE 100 is a weighted arithmetic index based on the largest 100 UK companies, which frequently changes. These two figures are frequently compared, despite the availability of a more appropriate American index: the Standard and Poor's 500.

For ease of comparison of market performance, the table is repeated with a ratio of the end of year prices, to show the annual performance (Table 2.4). The correlation between the American markets and the large European markets is clear. In general we find that the larger markets are more stable, although this comparison is hard to make, without knowing the constituents of each index. However, we find that Nasdaq is far more volatile than LSE, which is surprising since these are (for most of the period) similar market structures.

Table 2.3

otice : When using these figures, please always mention World Federation of Exchanges the :

STOCK PRICE INDEX LEVELS AT YEAR-END

Time zone	Exchange	Name of Ind	End 1990	End 1991	End 1992	End 1993	End 1994	End 1995	End 1996	End 1997	End 1998	End 1999	End 2000	End 2001	End 2002
North America	Amex	Amex Comp	308.11	395.05	399.23	477.15	433.67	548.23	572.34	684.61	688.99	876.97	897.75	847.61	824.38
	Bermuda	BSX Index	NA	NA	NA	NA	NA	978.58	918.39	1,403.02	1,524.19	1,506.54	2,293.25	2,689.28	2,220.44
	Chicago	Dow Jones I	2,633.66	3,168.83	3,301.10	3,754.09	3,834.44	5,117.12	6,448.27	7,908.25	9,181.43	11,497.12	10,786.85	10,021.50	8,341.63
	Mexico	Price & Quo	628.79	1,431.46	1,759.44	2,602.63	2,375.66	2,778.47	3,361.03	5,229.35	3,959.66	7,129.88	5,652.19	6,372.28	6,127.09
	Nasdaq	Composite	373.84	586.34	676.95	776.80	751.96	1,052.13	1,291.03	1,570.35	2,192.69	4,069.31	2,470.52	1,950.40	1,335.51
	NYSE *	NYSE Comp	1,908.45	2,426.04	2,539.92	2,739.44	2,653.37	3,484.15	4,148.07	5,405.19	6,299.93	6,876.10	6,945.57	6,236.39	5,000.00
	TSX Toront	TSE 300 Co	3,256.75	3,512.36	3,350.44	4,321.43	4,213.61	4,713.54	5,927.03	6,699.44	6,485.94	8,413.75	8,933.68	7,688.41	6,614.54
South America	Buenos Air	General Ind	2,202.87	17,856.02	13,427.51	20,607.23	15,855.62	16,237.81	18,494.87	23,071.71	17,408.76	21,227.75	16,331.21	13,341.51	25,509.41
	Lima	General Ind	-	100.00	372.90	930.47	1,414.92	1,243.37	1,429.02	1,792.71	1,335.88	1,835.57	1,208.41	1,176.45	1,391.97
	Santiago	IGPA	1,166.70	2,483.70	2,733.46	3,915.49	5,425.17	5,739.97	4,902.59	4,794.41	3,594.75	5,167.72	4,869.04	5,397.69	5,019.64
	Sao Paulo *	Bovespa	25.16	607.77	6,780.50	3,754.53	4,353.93	4,299.00	7,039.90	10,196.00	6,784.00	17,091.00	15,259.00	13,577.00	11,268.00
Europe, Afr	Athens	ASE Compo	932.00	809.71	672.31	877.26	868.91	914.15	933.50	1,479.63	2,737.55	5,535.09	3,388.86	2,591.56	1,748.42
Middle East	Budapest	BUX	-	-	-	-	-	-	-	-	-	-	7,849.75	7,131.13	7,798.29
	Copenhage	Total Share	314.80	352.56	261.59	367.40	349.10	366.33	471.95	675.98	637.52	774.66	906.82	NA	NA
	Copenhage	KAX Totalin	-	-	-	-	-	-	-	-	-	-	247.62	211.84	166.56
	Deutsche B	DAX Return	1,398.23	1,577.98	1,545.05	2,266.68	2,106.58	2,253.88	2,888.69	4,249.69	5,002.39	6,958.14	6,433.61	5,160.10	2,892.63
	Euronext A	CBS All Sha	168.30	191.40	198.00	280.80	278.00	321.50	437.30	618.80	734.70	933.10	897.00	708.00	462.10
	Euronext A	AAX All Sha	-	-	-	-	378.84	439.04	598.31	838.57	1,000.00	1,296.75	1,222.09	966.11	631.40
	Euronext B	Spot Return	4,963.81	5,481.43	5,568.08	7,543.12	7,248.67	8,401.68	10,520.94	14,329.21	20,556.03	19,075.97	18,119.31	17,229.62	13,352.97
	Euronext L	PSI General	638.30	623.63	553.71	848.54	919.95	877.69	1,163.54	1,922.72	2,427.33	2,732.36	2,507.90	2,030.50	1,611.15
	Euronext P	SBF 250	1,000.00	1,126.41	1,140.14	1,511.73	1,250.66	1,232.86	1,561.66	1,944.91	2,500.01	3,810.86	3,771.25	2,981.35	2,053.26
	Helsinki	HEX All Sha	1,000.00	781.84	829.00	1,582.12	1,846.59	1,704.20	2,495.93	3,302.26	5,564.87	14,578.68	13,033.74	8,805.01	5,775.37
	Irish	ISEQ Overa	1,201.77	1,380.23	1,227.35	1,888.94	1,850.76	2,232.45	2,725.63	4,053.80	4,995.82	5,071.54	5,722.53	5,707.00	3,995.03
	Istanbul	ISE Nationa	32.56	43.69	40.04	206.83	272.57	400.25	975.89	3,451.00	2,575.82	15,208.78	9,437.21	13,782.76	10,369.92
	Italy	MIB Index	8,007.00	7,830.00	6,916.00	9,500.00	9,813.00	9,138.00	10,332.00	16,341.00	23,035.00	28,169.00	29,681.00	22,232.00	16,954.00
	Johannesb	JSE Actuari	2,720.00	3,440.00	3,259.00	4,893.00	5,866.91	6,228.42	6,657.53	6,202.31	5,430.48	8,542.78	8,326.19	10,441.68	9,277.22
	Ljubljana	SBI	-	-	-	1,000.00	1,396.80	1,448.75	1,183.26	1,404.70	1,705.77	1,806.26	1,807.94	2,151.59	3,340.20
	London	FT SE 100	2,143.50	2,493.10	2,846.50	3,418.40	3,065.50	3,689.30	4,118.50	5,135.50	5,882.60	6,930.20	6,222.50	5,217.35	3,940.36
	Luxembour	Shares Price	2,566.38	2,713.26	2,551.40	5,207.96	4,301.38	4,325.44	5,622.99	7,009.24	7,593.24	10,227.11	NA	NA	NA
	Luxembour	LuxX Price I	-	-	-	-	-	-	-	-	1,000.00	1,397.25	1,174.11	805.32	606.82
	Malta	MSE Ordina	-	-	-	-	-	1,000.00	991.39	1,057.39	1,210.79	3,278.49	3,375.72	2,200.13	1,870.91
	Oslo	Oslo SE Tot	456.54	413.55	372.12	613.08	656.78	732.96	968.37	1,273.61	934.16	1,359.60	1,336.82	-	-
	Oslo	Oslo Børs B	-	-	-	-	-	100.00	128.88	166.63	119.27	174.10	175.94	147.38	99.14
	Spanish Ex	BCN Global	216.07	213.50	162.32	263.01	234.55	265.28	378.95	530.36	703.02	865.85	806.73	729.57	502.06
	Spanish Ex	Bolsa Bilbac	299.16	334.04	308.33	415.04	379.26	456.67	665.02	968.17	1,344.08	1,631.27	1,628.24	1,466.72	1,090.10
	Spanish Ex	General Ind	223.25	246.24	214.25	322.77	285.01	320.07	444.77	632.55	867.80	1,008.57	880.71	824.40	633.99
	Spanish Ex	IGBV Index	NA	NA	NA	NA	224.41	257.06	370.61	521.45	693.20	821.07	721.29	666.55	481.30
	Stockholm	SX General	865.00	912.00	912.07	1,387.70	1,451.00	1,716.00	2,371.00	2,936.00	3,235.00	5,382.00	4,735.00		
	Stockholm	All Share In	-	-	-	-	-	-	-	-	-	-	287.61	239.06	149.60
	Swiss Exch	Swiss Perfo	908.30	1,052.80	1,238.60	1,867.80	1,725.00	2,123.40	2,515.60	3,898.10	4,497.10	5,022.90	5,621.13	4,382.94	3,245.50
	Tehran	TEPIX	NA	NA	445.09	382.78	570.53	1,288.13	1,972.08	1,631.41	1,531.05	1,989.73	2,880.68	3,554.35	5,044.06
	Tel-Aviv	General Sha	224.33	363.03	191.64	270.15	163.77	186.66	184.84	249.87	257.49	423.44	424.71	396.49	317.68
	Vienna	Wiener Börs	502.26	418.98	348.46	270.15	429.64	387.36	429.20	486.96	464.32	493.32	456.86	464.81	479.21
	Warsaw	WIG		919.10	1,040.70	12,439.00	7,473.10	7,585.90	14,342.80	14,668.00	12,795.60	18,083.60	18,981.70	13,922.16	14,366.65
Asia, Pacifi	Australian	ASX/S&P Al	1,279.80	1,651.40	1,549.90	2,173.60	1,912.70	2,203.00	2,424.60	2,616.50	2,813.40	3,152.50	3,154.70	3,359.90	2,975.50
	Colombo	All Share Pr	NA	NA	NA	986.73	978.97	663.70	603.00	702.20	597.30	572.50	447.60	621.00	815.10
	Hong Kong	All Ordinarie	1,982.88	2,806.97	2,951.06	6,075.18	4,074.52	4,770.57	6,539.64	5,284.23	4,319.20	7,134.79	6,107.89	4,885.63	4,113.06
	Jakarta	JSX Compo	417.78	247.39	274.33	588.77	469.64	513.85	637.43	401.71	398.04	676.92	416.32	392.04	424.95
	Korea	KOSPI	696.11	610.92	678.44	866.18	1,027.37	882.94	651.22	376.31	562.46	1,028.07	504.62	693.70	627.55
	Kuala Lum	KLSE Comp	505.92	556.22	643.96	1,275.32	971.21	995.17	1,237.96	594.44	586.13	812.33	679.64	696.09	646.32
	Mumbai	BSE-500	-	-	-	-	-	-	-	-	-	-	-	1,005.82	1,176.73
	National St	Nifty Fifty	-	-	-	-	-	-	-	-	-	-	-	1,059.05	1,093.50
	New Zealan	NZSE Gross	514.02	671.67	761.71	1,155.60	1,075.94	1,273.29	1,527.08	1,571.59	1,520.10	1,777.83	1,616.31	1,886.46	1,965.61
	Osaka	300 Commo	1,464.82	1,415.57	1,122.96	1,215.20	1,339.80	1,365.51	1,314.00	1,104.87	1,020.48	1,378.72	1,238.57	985.55	800.99
	Philippine	PSE Compo	653.11	1,154.26	1,272.40	3,241.86	2,785.81	2,594.18	3,170.56	1,869.23	1,968.78	2,142.97	1,494.50	1,168.08	1,018.41
	Shanghai	SSE Compo	-	-	-	-	-	-	-	-	-	-	-	1,645.97	1,357.65
	Shenzhen	SSE Compo	-	-	-	-	-	-	-	-	-	-	-	2,073.48	2,759.30
	Singapore	All Sing Equ	323.28	404.50	394.63	628.66	533.57	555.39	536.12	425.94	380.51	668.79	502.38	426.33	348.80
	Taiwan	TSE Weight	4,503.16	4,600.67	3,377.06	6,070.56	7,124.66	5,173.73	6,933.94	8,187.27	6,418.43	8,448.84	4,739.09	5,551.24	4,452.45
	Thailand	SET	612.86	711.36	893.42	1,682.85	1,360.69	1,280.81	831.57	372.69	355.81	481.92	269.19	303.85	356.48
	Tokyo	TOPIX	1,733.83	1,714.68	1,322.10	1,439.31	1,559.09	1,577.70	1,470.94	1,175.03	1,086.99	1,722.20	1,283.67	1,032.14	843.29

NA : Not Available - Not Applicable

** NYSE New Composite index launched in 2002, and recalculated retrospectively*

*** Indexes for Sao Paulo has been rebased several times due to inflation*

**** AAX was launched in 1998, and recalculated retrospectively*

***** LuxX price index was launched at the beginning of 1999*

Table 2.4

otice : When using these figures, please always mention World Federation of Exchanges the source of data.

RATIO OF STOCK PRICE INDEX LEVELS AT YEAR-END

Time zone	Exchange	Name of In	End 1991 / End 1990	End 1992 / End 1991	End 1993 / End 1992	End 1994 / End 1993	End 1995 / End 1994	End 1996 / End 1995	End 1997 / End 1996	End 1998 / End 1997	End 1999 / End 1998	End 2000 / End 1999	End 2001 / End 2000	End 2002 / End 2001
North America	Amex	Amex Comp	1.282	1.011	1.195	0.909	1.264	1.044	1.196	1.006	1.273	1.024	0.944	0.973
	Bermuda	BSX Index						0.938	1.528	1.086	0.988	1.522	1.173	0.826
	Chicago	Dow Jones	1.203	1.042	1.137	1.021	1.335	1.260	1.226	1.161	1.252	0.938	0.929	0.832
	Mexico	Price & Quo	2.277	1.229	1.479	0.913	1.170	1.210	1.556	0.757	1.801	0.793	1.127	0.962
	Nasdaq	Composite	1.568	1.155	1.147	0.968	1.399	1.227	1.216	1.396	1.856	0.607	0.789	0.685
	NYSE *	NYSE Comp	1.271	1.047	1.079	0.969	1.313	1.191	1.303	1.166	1.091	1.010	0.898	0.802
	TSX Toront	TSE 300 Co	1.078	0.954	1.290	0.975	1.119	1.257	1.130	0.968	1.297	1.062	0.861	0.860
South America	Buenos Air	General Ind	8.106	0.752	1.535	0.769	1.024	1.139	1.247	0.755	1.219	0.769	0.817	1.912
	Lima	General Ind		3.729	2.495	1.521	0.879	1.149	1.255	0.745	1.374	0.658	0.974	1.183
	Santiago	IGPA	2.129	1.101	1.432	1.386	1.058	0.854	0.978	0.750	1.438	0.942	1.109	0.930
	Sao Paulo **	Bovespa	24.160	11.156	0.554	1.160	0.987	1.638	1.448	0.665	2.519	0.893	0.890	0.830
Europe, Afr	Athens	ASE Compo	0.869	0.830	1.305	0.990	1.052	1.021	1.585	1.850	2.022	0.612	0.765	0.675
Middle East	Budapest	BUX											0.908	1.094
	Copenhage	Total Share	1.120	0.742	1.404	0.950	1.049	1.288	1.432	0.943	1.215	1.171		
	Copenhage	KAX Totalin											0.856	0.786
	Deutsche B	DAX Return	1.129	0.979	1.467	0.929	1.070	1.282	1.471	1.177	1.391	0.925	0.802	0.561
	Euronext A	CBS All Sha	1.137	1.034	1.418	0.990	1.156	1.360	1.415	1.187	1.270	0.961	0.789	0.653
	Euronext A	AAX All Sha					1.159	1.363	1.402	1.193	1.297	0.942	0.791	0.654
	Euronext B	Spot Return	1.104	1.016	1.355	0.961	1.159	1.252	1.362	1.435	0.928	0.950	0.951	0.775
	Euronext L	PSI General	0.977	0.888	1.532	1.084	0.954	1.326	1.652	1.262	1.126	0.918	0.810	0.793
	Euronext P	SBF 250	1.126	1.012	1.326	0.827	0.986	1.267	1.245	1.285	1.524	0.990	0.791	0.689
	Helsinki	HEX All Sha	0.782	1.060	1.908	1.167	0.923	1.465	1.323	1.685	2.620	0.894	0.676	0.656
	Irish	ISEQ Overa	1.148	0.889	1.539	0.980	1.206	1.221	1.487	1.232	1.015	1.128	0.997	0.700
	Istanbul	ISE Nationa	1.342	0.916	5.165	1.318	1.468	2.438	3.536	0.746	5.904	0.621	1.460	0.752
	Italy	MIB Index	0.978	0.883	1.374	1.033	0.931	1.131	1.582	1.410	1.223	1.054	0.749	0.763
	Johannesb	JSE Actuari	1.265	0.947	1.501	1.199	1.062	1.069	0.932	0.876	1.573	0.975	1.254	0.888
	Ljubljana	SBI				1.397	1.037	0.817	1.187	1.214	1.059	1.001	1.190	1.552
	London	FT SE 100	1.163	1.142	1.201	0.897	1.203	1.116	1.247	1.145	1.178	0.898	0.838	0.755
	Luxembour	Shares Pric	1.057	0.940	2.041	0.826	1.006	1.300	1.247	1.083	1.347			
	Luxembour	LuxX Price I									1.397	0.840	0.686	0.754
	Malta	MSE Ordina						0.991	1.067	1.145	2.708	1.030	0.652	0.850
	Oslo	Oslo SE Tot	0.906	0.900	1.648	1.071	1.116	1.321	1.315	0.733	1.455	0.983		
	Oslo	Oslo Børs B						1.289	1.293	0.716	1.460	1.011	0.838	0.673
	Spanish Ex	BCN Global	0.988	0.760	1.620	0.892	1.131	1.428	1.400	1.326	1.232	0.932	0.904	0.688
	Spanish Ex	Bolsa Bilbac	1.117	0.923	1.346	0.914	1.204	1.456	1.456	1.388	1.214	0.998	0.901	0.743
	Spanish Ex	General Ind	1.103	0.870	1.507	0.883	1.123	1.390	1.422	1.372	1.162	0.873	0.936	0.769
	Spanish Ex	IGBV Index					1.145	1.442	1.407	1.329	1.184	0.878	0.924	0.722
	Stockholm	SX General	1.054	1.000	1.521	1.046	1.183	1.382	1.238	1.102	1.664	0.880	0.000	
	Stockholm	All Share In											0.831	0.626
	Swiss Exch	Swiss Perfo	1.159	1.176	1.508	0.924	1.231	1.185	1.550	1.154	1.117	1.119	0.780	0.740
	Tehran	TEPIX			0.860	1.490	2.258	1.531	0.827	0.938	1.300	1.448	1.234	1.419
	Tel-Aviv	General Sha	1.618	0.528	1.410	0.606	1.140	0.990	1.352	1.030	1.644	1.003	0.934	0.801
	Vienna	Wiener Börs	0.834	0.832	0.775	1.590	0.902	1.108	1.135	0.954	1.062	0.926	1.017	1.031
	Warsaw	WIG		1.132	11.953	0.601	1.015	1.891	1.023	0.872	1.413	1.050	0.733	1.032
Asia, Pacifi	Australian	ASX/S&P Al	1.290	0.939	1.402	0.880	1.152	1.101	1.079	1.075	1.121	1.001	1.065	0.886
	Colombo	All Share Price Index				0.992	0.678	0.909	1.165	0.851	0.958	0.782	1.387	1.313
	Hong Kong	All Ordinarie	1.416	1.051	2.059	0.671	1.171	1.371	0.808	0.817	1.652	0.856	0.800	0.842
	Jakarta	JSX Compo	0.592	1.109	2.146	0.798	1.094	1.241	0.630	0.991	1.701	0.615	0.942	1.084
	Korea	KOSPI	0.878	1.111	1.277	1.186	0.859	0.738	0.578	1.495	1.828	0.491	1.375	0.905
	Kuala Lum	KLSE Comp	1.099	1.158	1.980	0.762	1.025	1.244	0.480	0.986	1.386	0.837	1.024	0.929
	Mumbai	BSE-500												1.170
	National St	Nifty Fifty												1.033
	New Zealan	NZSE Gross	1.307	1.134	1.517	0.931	1.183	1.199	1.029	0.967	1.170	0.909	1.167	1.042
	Osaka	300 Commo	0.966	0.793	1.082	1.103	1.019	0.962	0.841	0.924	1.351	0.898	0.796	0.813
	Philippine	PSE Compo	1.767	1.102	2.548	0.859	0.931	1.222	0.590	1.053	1.088	0.697	0.782	0.872
	Shanghai	SSE Compo												0.825
	Shenzhen	SSE Compo												1.331
	Singapore	All Sing Equ	1.251	0.976	1.593	0.849	1.041	0.965	0.794	0.893	1.758	0.751	0.849	0.818
	Taiwan	TSE Weight	1.022	0.734	1.798	1.174	0.726	1.340	1.181	0.784	1.316	0.561	1.171	0.802
	Thailand	SET	1.161	1.256	1.884	0.809	0.941	0.649	0.448	0.955	1.354	0.559	1.129	1.173
	Tokyo	TOPIX	0.989	0.771	1.089	1.083	1.012	0.932	0.799	0.925	1.584	0.745	0.804	0.817

NA : Not Available - : Not Applicable

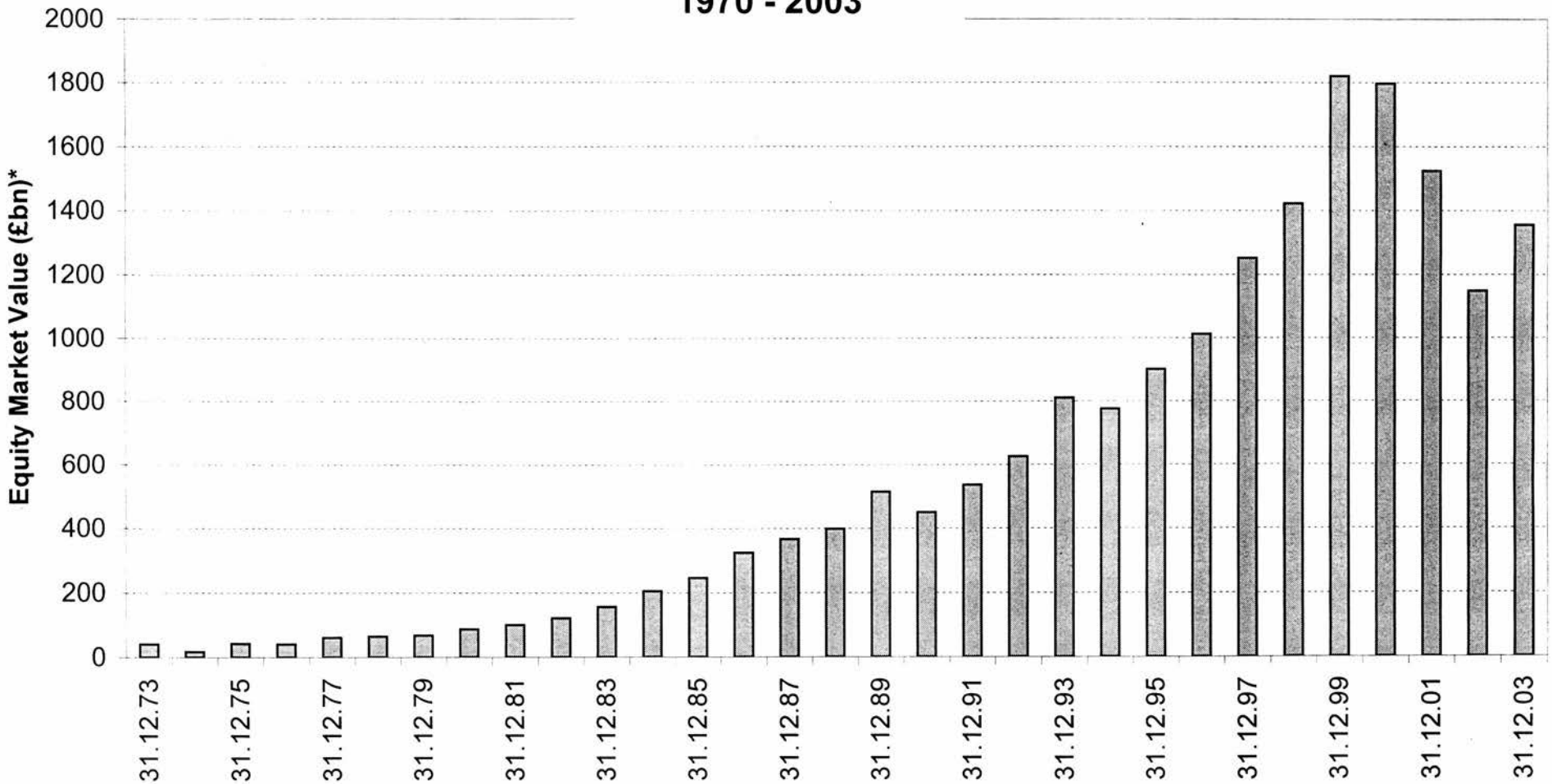
** NYSE New Composite index launched in 2002, and recalculated retrospectively*

*** Indexes for Sao Paulo has been rebased several times due to inflation*

**** AAX was launched in 1998, and recalculated retrospectively*

***** LuxX price index was launched at the beginning of 1999*

Table 2.5
UK Equity Market Value
1970 - 2003



* 1970 - 1994 incl. equity values are for UK & Irish companies

3 LITERATURE REVIEW

3.1 Introduction

3.1.1 Efficient Markets

The efficient markets hypothesis (EMH) comes in three forms. In its strongest form prices reflect all information. Semi-strong form efficiency implies that prices reflect all publicly available information. Weak-form efficiency states that the current price reflects all information implied by previous prices. Although there is no consensus as to the most appropriate form, if any, of the EMH, the hypothesis is frequently used a starting point or benchmark for any financial markets research. The important conclusion of each form of the EMH is that without superior information, it is impossible to outperform the market systematically.

The Capital Asset Pricing Model (CAPM) builds on the EMH to show that the optimum portfolio for a risk averse investor, is a combination of the market portfolio and a risk free asset. While tracker funds account for a significant proportion of the market (roughly a third on the NYSE), the remainder of the market continue to trade actively, whether speculating, rebalancing portfolios or trading with some other motivation. While many papers state that greater trading volume is a sign of market efficiency and investor welfare, it also implies that fewer investors believe in the conclusions of the CAPM. The financial markets are a "nil-sum" game: for every winner there is a loser. And the volume of trading activity stands counter to the rational behaviour predicted by the EMH.

3.1.2 Behavioural Finance

Hirshliefer (2001) offers an alternative to EMH and CAPM, based on "imperfectly rational behaviour": DMH (Deficient Markets Hypothesis) and DAPM (Deranged Anticipation and Perception Model). While the hypothesis may be delivered with tongue in cheek, he goes on to define many of the psychological theories that may be relevant to pricing and trading activity in the financial markets.

Kahneman and Tversky (1971) introduced the idea of prospect theory, which makes subtle differences to the standard utility theory. While standard utility theory states that utility is increasing but convex with wealth, prospect theory states that when faced with uncertainty, an individual will apply a function of the probability rather than the probability itself. They find that individuals over estimate large probabilities but under estimate small probabilities. An exception is for very small probabilities (e.g. lottery odds) which investors over estimate. Furthermore, they state that the utility curve is kinked at the point of current wealth, and it is convex below, and concave above this point.

Read *et al* (1999) explain the idea of "Narrow Framing", where problems are solved with a subset of information. Shefrin and Statman (1985) explain "mental accounting" and the "disposition effect" whereby investors put gains and losses into separate mental compartments, and become less inclined to realize the losses. This unwillingness to realize losses is an example of a "self deception theory". Other examples are "anchoring", where investors are influenced by information irrelevant to the decision process, "omission bias", where regret is felt more strongly following an active decision rather than a passive one, and the "endowment effect" or "status quo bias" where people prefer to keep what they have rather than trade for a better option. Two of the most commonly quoted self deception theories are "overconfidence" and "biased self-attribution" (Odean (1998)) where people are

overly optimistic. Furthermore, when results do go well, they take credit for it, and when they go badly, they blame it on external forces.

A fundamental conclusion of the above theories is that "if arbitrage is costly and noise traders are active, asset prices may deviate from fundamental values for long periods of time." (Gemmill and Thomas (2002)) This means that static price models such as CAPM have no chance of encapsulating the behavioural issues. DeLong *et al* (1990) introduced a model of noise trader behaviour to show that arbitrageurs could not drive the prices towards the underlying value in the presence of noise traders, and use this model to justify the discount on investment trusts. Daniel *et al* (2001) and Barberis and Haung (2000) also offer models to explain the short term miss-pricing effects. One of the biggest problems with testing the suitability of such models is the quantification of the behavioural attributes. If the results are taken from a controlled experiment, then the conclusion will be distorted by the design of the experiment, and the differences between it and the real money markets. If the results are taken from the observed stock price movements, then there is the risk of spurious correlation and the potential accusation of fitting the theory to the data.

To date, there have been very few empirical studies applying behavioural finance. The difficulty is in translating the theories into expected and testable price effects on the financial markets. Bridging the gap between "imperfectly rational" investor behaviour and stock price movements, and offering a suitable canvas for testing these theories is "market microstructure".

3.1.3 Market Microstructure

O'Hara (1995) defines market microstructure as "the study of the process of outcomes of exchanging assets under explicit trading rules". Microstructure is important to various parties e.g. investors, brokers, market makers, regulators and the

owners of the exchange. Each stakeholder will have a different opinion about the best market design, but there are some common goals. While the microstructure theory does not contradict the efficient markets hypothesis in equilibrium, Madhavan (2000) notes that "asset prices need not equal full-information expectations of value because of a variety of frictions" and it is this friction that is relevant to the efficiency of prices and the transaction costs of trading. As mentioned in the introduction, the definition of "efficiency" varies and much of the market microstructure literature uses the stronger definition of prices fully reflecting information. Irrespective of the definition, efficient prices are more than a theoretical pursuit. Market designers are keen to ensure efficient prices, to avoid market crashes, and encourage the population to invest in the economy.

Madhavan (2000) provides a comprehensive summary of the microstructure literature. He focuses on 4 main areas: price discovery, market structure and design, information and disclosure, and the interface of market microstructure with other areas of finance. In this chapter, we will look in detail at the price formation theory and models, how the structure affects this process and the interpretation of information. We will also look at specific areas of the market design such as the role of the market maker, the limit order book, alternative methods of trading, and a summary of the microstructure comparisons. Although we will not go into any great depth regarding the applications of the theory and how it relates to the other areas of finance theory, we will take a look at some of the well established results (e.g. size effects, seasonal and intraday patterns, volume volatility relationship).

3.2 Price Formation Models and Theory

3.2.1 Introduction

Early papers on efficient markets used an assumption like "all investors make an informed decision about what the underlying value of the security is, and if the current price is above the underlying value they sell, and if the current price is below the underlying value, they buy." Over the years it became apparent that in the real world, investors didn't always know the underlying value, and in some cases, they didn't even care. Investors have many different reasons for trading, and these will be discussed later, but it is clear that while equity shares are viewed as a long term investment, many investors hold them for very short periods of time in an attempt to beat the market. So the question of how the price reflects the views of the market participants has become a popular one. One of the surprising things is that convergence of prices towards a theoretical equilibrium is almost always assumed, rather than proved.

3.2.2 Inventory Risk

One of the first popular theories used the risks faced by the market intermediary to justify the existence of a bid-offer spread and explain the method by which prices begin to reflect information. Garman (1976) explained how the supply and demand are stochastic processes, and how the market coped with a temporary order imbalance. Garman's model had a single market maker who sets a price he is willing to buy and a price he is willing to sell. Order arrival follows two independent Poisson processes for buy and sell orders. The fact that the two order arrival processes are asynchronous leads to the market maker's problem.

The Garman (1976) model assumes that the market maker is not allowed to borrow stock or money and so the sole aim is to maximise trading profits while mitigating the risk of running out of stock or money. O'Hara (1997) notes that the assumption regarding the order arrival process implies that no subset of traders can dominate the market, which in turn implies that traders don't act on private information or any "synchronized order strategies (such as portfolio insurance)". These assumptions are far from realistic and hide many of the features of the market microstructure.

Stoll (1978) extends the theory by stating that the market maker, like any other trader, is risk averse and therefore demands compensation for bearing the risk of holding an inventory away from his desired level. Amihud and Mendelson (1980) extend the model in a different way, giving the market maker the ability to change his prices in response to changes in his inventory. While the earlier models explained how prices were set for a one period model, Amihud and Mendelson (1980) suggested how prices may move as a response to the change in the market maker's inventory.

Cohen *et al* (1981) address the issue of multiple liquidity suppliers. They find that because markets are discrete and have transaction costs, there is always a chance of non-execution by placing a limit order, however close to the opposing side of the spread. Their model makes some significant assumptions e.g. trades occur at one time period, and limit orders are cancelled immediately afterwards. Again these assumptions have a non trivial impact on the conclusions. Ho and Stoll (1983) extended the theory to allow for the inventory levels of competing dealers. Rather than thinking of the collection of investors with a choice of market orders and limit orders, they create a model of two competing dealers who were given the choice of what prices to offer liquidity at, and whether to trade at another dealer's price. Their assumptions were far more realistic, but still these models did not yield results about the ability of prices to reflect the underlying value.

3.2.3 Information Based Models

Bagehot (1971) first introduced the idea that some investors trade with better private information than others, and that this information asymmetry has an impact on the prices set by a market maker, or any other market structure. Stoll (1978) mentioned the risk of trading against investors who know more than the market maker, but it was not until Copeland and Galai (1983) that the concept was built into a market microstructure model.

Copeland and Galai (1983) think of the bid-offer spread in two separate ways. First, it can be thought of as the profit that the market maker gains as a reward for providing the liquidity. Second, it can be thought of as the price of a call and put option given to the traders. Copeland and Galai (1983) found that the mathematics implied by the latter approach was not tractable, but that it did highlight the importance of the risk of information asymmetry, and volatility. While the early inventory models explained that a spread should exist as a result of the transaction costs, the information based models explained that a spread should exist as a result of the risk of private information, and the volatility of the stock.

Glosten and Milgrom (1985) use the Copeland and Galai (1983) model to explore the impact of asymmetric information on the price formation process. They ignore all of the existing theory about inventory models, assuming that market makers are risk neutral and have infinite resources. While this provides an opportunity to look at the issue of "information" in isolation, it does not then lead to a complete picture that could be used in empirical analysis. Another important assumption that has remained in much of the literature is that uninformed investors will never speculate. Uninformed traders, it is argued, will always lose money to the informed traders in this situation, and so it is irrational for them to speculate, and so they won't. In

response to this, the issue of different perceptions of information, and seemingly irrational behaviour will be addressed later.

The Glosten and Milgrom (1985) model is based around a tree structure. Firstly, there may be good or bad news held as private information. Secondly, traders may have this information or they may not. Lastly, they may decide to buy or sell. Clearly, an informed trader with good news will not sell and an informed trader with bad news will not sell, but all other potential outcomes have a positive probability. Their model leads to several important results. Firstly, they showed how the spread depended on the arrival of orders through time. Secondly, they showed that prices form a martingale, and so the price reflects all of the information available to the market maker. Since, prices and public information is within the market maker's information set, this means that the prices are semi-strong-form efficient, but not necessarily strong-form efficient. It should be noted that introducing the concept of inventory risk, and assuming that this has a non-negligible effect on the behaviour of the market maker in setting prices, we might conclude that the market is not semi-strong form efficient.

The idea that market makers revise their beliefs after every trade, as per the Glosten and Milgrom model, implies that prices move following a trade with even an uninformed trader. It is clear that market makers must have some way of determining which trades were more likely to be informed and which were less likely. The first candidate for differentiation was the size of the trade. The catalyst for this was the empirical work of Dann *et al* (1977), Holthausen *et al* (1987), who found greater price movements following larger (particularly block) trades.

Easley *et al* (1997) present a similar model, but introduce a fourth level to the decision tree, which determines whether an information event has occurred or not. Both the Glosten and Milgrom model and the Easley and O'Hara model suffer from

some very restrictive assumptions. For instance, they assume that traders queue up and trade sequentially, or that investors are chosen at random to trade at a specific time. Both of these approaches ignore the fact that an informed trader may trade and then wish to trade again immediately.

Having established two different models to explain the price discovery process, which is the more appropriate? Hasbrouk (1988) finds evidence that the "information effect dominates inventory control effects." Madhavan (2000) suggest that this "may be due to inventory effects being spread over a longer period than information effects." This casts some doubt over Hasbrouk's conclusion. Madhavan's comment further implies that the information effect may not be permanent, as so many papers seem to assume.

3.2.4 Price Discovery in an Order Book Market

Parlour (1998) defines a dynamic model of investor behaviour, in an environment where the price doesn't change in a 1 tick market. She shows that if the bid price in a limit order book market drops, the offer price is more likely to drop than it is to stay constant or increase. Foucault (1999) use a dynamic model that allows for price movements, but simplifies the detail of the order book. Goettler *et al* (2003) use a "dynamic pure limit order market" to show the real costs of trading for the investors. The conclusions drawn from each model vary, and we can only conclude that the artificial aspects of the model design play an important part.

Madhavan (2000) states "in a hybrid market, where some trades are between public investors without dealer intervention... We cannot estimate a structural model... without actual market maker inventory data." Using a solution put forward by Hasbrouk (1988) we implicitly assume that "the information effect has a permanent effect on prices... while the inventory effect is transitory" and that these two effects

sum to the total. By varying the level of dealer intervention, we could then expect to see a change in the transient volatility. In the limit, we would expect a market without dealers to have no transient volatility. This seems unlikely. Not all assumptions can be extended to the limit, but the validity of this one should at least be questioned. Hasbrouk (1991) offers support to this argument, saying that "in the formal models of asymmetric information, the trade is driven partially by private information, and partially by liquidity needs, but in no part is the trade driven by public information which is relevant to forecasting the value of the security."

Easley (1997) counters by saying that an "important aspect of the sequential trade approach is that it is possible to demonstrate that prices do indeed converge to full information values." She then points out that this only occurs in the limit, and that the models make no comment about how long the price process may take to reach efficiency. The models also ignore the complication of new information being introduced while the market is still adjusting to the previous information event.

Adding to this debate, Goetzmann and Massa (2001) introduce an extra explanatory factor into the CAPM model. This reflects the "dispersion of opinions" or "heterogeneity of trade among investors". They split traders into positive and negative feedback traders; dependent on how they react the day after a market rise or fall. They find that the impact of these two groups does not cancel out, which leads to a departure from CAPM. They find that this explanatory factor works very well, when CAPM does not.

3.2.5 Price Discovery in a Non Continuous Market

There are various methods employed for the opening of a financial market. The LSE allows limit order and market orders to be placed before opening for SETS stocks. Investors can't see the orders, but they can see the crossing price, which is set by

specific rules, with the aim of maximising the volume traded. All committed parties trade at the crossing price when the market opens. On the NYSE, a similar process occurs, except the crossing price is not visible before the open, which the specialist, rather than simple rules, is responsible for setting. Madhavan and Panchapagesam (2000) study the opening procedure on the NYSE and find several important results. Firstly "the opening price reflects specialist information and price-continuity requirements" which "induces staleness, by tying the opening price to the previous day's close". Secondly, "inventory effects at the open are very weak" despite the monetary incentive for such actions. Thirdly, "the NYSE's designated dealer (specialist) sets a more efficient price than the price that would prevail in a pure call market using only public orders." The pure call market they refer to is a blind auction, and they concede that a fully transparent call market may set more efficient prices.

The Paris Bourse "tatonnement process" is similar to the opening of the LSE. Investors place orders on the order book, but can only see the price and volume that would trade if the market opened immediately, and the 4 next best orders. This is a halfway house between the open and closed auction process that Madhavan and Panchapagesam (2000) referred to above. Biais *et al* (1999) find a "very active order placement during the preopening period" showing the importance of the "price discovery phase". They cannot reject the hypothesis that a large degree of noise exists early in the process, but orders placed closer to the opening are very informative.

3.3 Asymmetric Information

3.3.1 What is Information?

The fact that everyone is using a subset of the total market knowledge and that some may have a more useful subset than others is central to the concept of efficient markets. The distinction of informed and uninformed traders is also an important assumption, despite being an abstract idea. Whether it is the actual presence of informed traders or simply the perceived risk of their presence, the evidence and the arguments regarding asymmetric information, stand up to scrutiny. The question that follows is, in what circumstances should the affect of asymmetric information be largest? Should smaller stocks have a greater risk, because the larger information gathering companies have a lower profit margin, and so devote less time on them? Should newer companies have a greater risk? Are initial share offers a lesser or greater risk?

Hasbrouk (1991) suggests that investors are basing their estimates on "past performance, in house analysis, rumour and market analyst companies, gut reaction, inappropriate models." We might add to the list with, personal experience, internal or external performance measures, guess work, mood, confidence, liquidity requirements or inside information. It should be noted that "insider trading" is illegal in most markets, but this is not to say that the definitions are strict enough or that every market participant is ethical enough to ignore this as a possible motivation to trade. Easley *et al* (1997) talk of "valuation-relevant information" as the fundamental driver of prices. It should be noted that a small proportion of the reasons to trade listed above could be described as "valuation-relevant information". A good example of this is the "internet bubble", in which the majority of market participants believed that the technology sector was over priced, but still bought up the shares for fear of missing out on the short term gains.

3.3.2 An Example of Information

The interpretation of the term "information" is fundamental to this thesis and market microstructure research in general. To demonstrate how vague the definition can be, and the pitfalls that result, this section provides a detailed example. The aim is to highlight how different parties (academics or practitioners) perceive information. For example, the "information" that behavioural scientists perceive is not the same as the "information" used in the market microstructure literature, and yet the two fields seem to have been combined without addressing the issue.

Suppose company X has nearly completed a merger with another company. The management of company X believes that this will be beneficial for both companies, and that the stock price will go up. They have information, but this is insider information and so they cannot trade on it. At this point, we may assume that the stock is under priced.

A document is leaked about the merger and trader Y obtains this. Trader Y believes he is the first person outside the company to see this, and so decides to buy shares in company X. They have information, by most people's definition. We may assume that the action of buying the stock will drive up the price towards or possibly beyond its underlying value.

Trader Y decides that he may obtain a larger share of company X at a lower price if he asks brokerage firm Z to execute the large buy order. Firm Z agrees and they start to execute the order with their clients and contacts. Firm Z has information but again, cannot act on it, as this would breach insider trading rules.

Firm Z, trading on behalf of trader Y, places some orders with clients, and some orders are placed on the automated order book, as limit or market orders. These combined actions drive the price up.

One technical analyst observes the buying activity and decides that this is indicative of asymmetric information, and so decides to buy. Another technical analyst, using an alternative model believes that the price movements are an overreaction to a previous information event and so decides to sell. Do either of these analysts have information? We may argue that they do not have private information as they are simply looking at the price movements, which are available to the whole market. However, they each have a unique model, which they use to analyse the price data. If you ask the analysts the answer may well be yes, but if you determine the answer from the implications of previous academic research, the answers may vary. Some papers implicitly assume that only the analysts who gets it right is the informed one. Either way, the price formation models described earlier, require participants to analyse price and trade information in order for prices to reflect the aggregate information available to the market.

Lets say another trader A hears some bad news about one of company X's products. They already own shares in company X and decide that now is a good time to sell them. They sell them quickly and drive down the price. What trader A didn't know is that company X was withdrawing its product as part of the lead up to the merger, which all concerned believe to be a good thing. Trader A is using incomplete information, but information none the less. This type of information does not fit into the pricing model assumptions, but it does fit into the behavioural finance models. In other words, the trader may well trade in the same way as an informed trader (e.g. aggressively and with large trades), but if we are to assume that prices are efficient, somehow the market would not react to this in the same way as it would to the information implied by the trades of trader Y (who knows about the merger).

At this point, the share price has declined, Trader A has sold his complete stake, trader Y has bought as much as he is willing to buy, (as he is bound by limits on exposure to individual stocks), and now another trader (trader B) stumbles upon the information about the withdrawn product. He too decides that he is the first to hear this information, and had better trade before the markets find out and the price declines. They sell, and the price declines. Does he have information? His information set is (like that of any other trader) incomplete, and (like trader A) is misleading. The literature ignores the impact of this situation once again, and the market has now overreacted to what will turn out to be false information.

Meanwhile, the brokerage firm Z has observed this trading activity, and noted that the price has gone in the opposite direction from that implied by trader Y. They have fulfilled their obligation to trader Y and so are not restricted in their trading of this stock. They believe that trader Y was informed and so trade on their own account. Does brokerage firm Z have information? They may or may not believe that they do. They may trade cautiously, because they are less sure of the "information". As a result, prices move upwards but very slowly, as the brokerage firm spreads their trades over time. It turns out that they are trading on the right side, on second hand information, but the market, and the models of price formation, do not react fully to reflect the underlying information.

The information about the impending merger of Company X leaks out further. Traders around the city, hear this information second or third hand. They decide to buy the stock and as a result drive the price up. Do they have information? Yes, but it is not first hand, and they cannot assume that they are the first to hear it and react to it. They approach the market cautiously. They observe a recent drop in the share price (as a result of traders A and B) and assume that no one else has traded on the information. The price goes up, and the market closes on the efficient price.

At this point a financial journalist spots the trend and discovers the information. He prints it in a national publication, and thousands of private investors decide that company X is a good buy, and do exactly that. The price far surpasses its theoretical value. Are these investors trading on information? Well, their information is not private information, and we would not expect the market to react to this trading activity in the same way that it did to the actions of trader Y. However, according to the efficient markets hypothesis, market prices should reflect all market wide information. When the information was published, it became market information. At what point did the market react to the information efficiently? Before or after? Although the information was published to everyone, the history of price movements can be interpreted in different ways, and so it is not obvious from the point of view of the outsider, what prices should do as a result of this information.

Although this example seems convoluted and confusing, it is still a gross simplification of the activity on the actual stock exchange. What we can draw from this simple example is that it is implausible that the price always reflects market information. Furthermore, it is not clear that it converges on a price that reflects market wide information. And finally, it highlights the difference in the interpretation of the term "information" in price setting theory, in trader behaviour models and in practice.

3.3.3 Implications for the Market

The risk of asymmetric information is important to all market participants, including the directors of the listed companies themselves. Some companies disclose more information in their annual reports than is required by law, in an attempt to convince the shareholders that there is nothing to hide, and so there is a lower risk of private information. Easley *et al* (2000) create a model that shows "a difference of 10

percentage points in the probability of information-based trading between two stocks leads to a difference in their expected returns of 2.5 percent per year." They use the PIN (Probability of information-based trading) as a measure of information. It should be noted that this measure is calculated with reference to the price impact of trades, and so linking this with higher returns is not surprising.

If the risk of private information exists, there is clearly a motivation to gather information, to ensure that you are one of the "informed investors". But this information gathering takes time and money. Easley *et al* (1998) state "there remains the conundrum that if markets are already efficient, then it is hard to justify either the information-gathering activities of analysts or the expense." Also, given that the investment markets are a nil sum game, then greater information gathering leads to a greater (net of expenses) expected loss from trading. This is similar to the conundrum of why investors don't just hold the market portfolio. For some reason, whether rational or otherwise, the majority of investors believe that they have the upper hand.

A final question to ask is how the implication of information affects the long term stock values. If investors see a large upward swing, resulting from an uninformed trade, are their expectations altered? The price formation models would suggest that this is the case, and so we have to ask how the long term equilibrium is affected. It has been assumed for so long that Ahn *et al* (2001) state as a matter of fact, "an important difference between informed trading and liquidity trading is that the former triggers permanent price changes, but the latter results in temporary price changes." Isn't it more likely that all trades have a short term and a long term impact based on the likelihood of them being informative, and that we implicitly assume that these errors (understating the impact of informed trades and overstating the uninformed trades) roughly cancel out?

3.3.4 Measures of Information

Harris and Hasbrouk (1996) measure the information content of a trade using the price impact over a 5 minute time interval. It is measured as the quoted mid price 5 minutes after the trade, divided by the quoted mid price at the time of the trade. Several studies (Venkataraman (2001), Haung and Stoll (1996), Griffiths *et al* (2000)) use this measure with a 30 minute time interval, but usually test for longer periods as well.

The time interval seems arbitrary, but is a compromise between a time long enough for the market to adjust to the new information, but not so long to be affected by the introduction of subsequent information. As Hasbrouk (1991) points out, "inventory control effects are inherently transient, while the information inferred from a trade due to asymmetric information is permanently impounded in the stock price". The question is whether 5 or even 30 minutes is an appropriate period to exclude the inventory effect, but include the asymmetric information effect? Hasbrouk (1991) also states that "the full impact of a trade in the security price is not felt instantaneously but with a protracted lag", so even if the period is long enough to have excluded the inventory effect, it may still understate the full price impact.

Easley *et al* (1997) define "information content... as the revision induced in the market maker's beliefs." Easley *et al* (1998) refine this model of price informativeness, to take into account their constructed decision tree. But still, the parameters are estimated from the trade data, in which they are testing. The reasoning seems quite circular, but without explicit data to identify the motivation (whether informed or not) of a trade, it is impossible to test these measures accurately.

3.3.5 Selection

Many papers talk about the risk that uninformed traders face when placing limit orders and being picked off by informed traders. We can assume that an informed trader will keep trading until he has reached his desired volume, or his actions have pushed the price too far away from the original trade price. There is also a theory that, market makers who can see the identity of the trader before they trade have a greater ability to distinguish informed and uninformed traders. If this is the case, then it poses the question of what happens to the short term price movements on each market? If informed traders can trade more profitably through an anonymous order book market, then it implies that the price is slower to react there than with a market maker: if the market maker was slower to react then the informed trader would keep trading with him. This questions the selection issue: given the choice in a hybrid market, should an informed trader use a market maker or an automated order book? And does the answer depend on which definition of "information" is being used for this informed trader?

Measuring this is problematic, since a market maker's quotes are often improved upon. We cannot simply compare the quoted spread on each market. Neither can we compare the size of the effective spread, since the activity on the other side of the spread affects the measure. What we need to compare is the speed (measured in consecutive trades) with which a trade moves in the direction implied by an informed trade, or a sequence of informed trades.

3.4 Classification of Investors

Many papers use a simplified categorization of investors. Below is a summary of a few of the investor classifications commonly used, along with the assumptions and

conclusions found for that group. The different classes of investor are not mutually exclusive.

3.4.1 Informed Traders

As explained above, "information" is usually assumed to be perfect private information. Specifically, every informed investor knows which direction to trade in and is certain that nobody else possesses this information. The former condition ensures that informed traders only ever trade with uninformed traders, and the latter ensures that the market price reflects the information.

Theory rarely addresses the question regarding the relative proportions of informed and uninformed investors. If we assume that informed traders only trade with uninformed traders, we cannot assume that uninformed traders are equally likely to buy and sell, since they must be on the "wrong side" of the market more often than not. We must assume that uninformed traders come to the market in equal proportions of buyers and sellers, but are then selected against, as some uninformed traders on the "right side" fail to execute.

3.4.2 Uninformed Liquidity Traders

Extant literature describes the liquidity trader as someone who trades because they need to trade e.g. a unit trust fund manager has to sell shares when a large proportion of unit holders cash in their units. Liquidity traders are assumed to have no private information, and so the market influence of their trades should be small. They are also assumed to trade passively, and with equal probability of arriving at the market with a buy or a sell order. We stated in the previous section that uninformed traders must fail to execute in order to maintain the equilibrium between informed and

uninformed traders, but if they really do "need to trade" then this assumption seems inappropriate.

Presenting a more balanced view, Grossman and Miller (1998) tell us "a liquidity event... leads them to perceive a gap at the current prices between their desired holdings of a particular asset and their current holdings of the asset". This is a very different picture. First of all, it states that a rise in prices could be seen as a liquidity event; giving a shareholder a reason to sell and realise his gains. The same rise in prices viewed by a technical analyst may be perceived as "information", but for the liquidity trader, it is simply a "liquidity event". Secondly, the definition highlights the asymmetry of liquidity events. If the market is in equilibrium, liquidity traders may be equally likely to buy or sell. If the price then goes up, any liquidity trader would be less likely to buy and more likely to sell. This means that whenever the prices move, the assumption that liquidity traders are equally likely to buy and sell is inappropriate. Irrespective of the price movements, this assumption is hard to accept. We could argue that there are many events that lead an investor to have to sell his holding in something quickly (e.g. the unit trust manager described above), but fewer that would lead to a buy order. We might then expect the asymmetry concerning the reasons for liquidity trading to manifest itself as an asymmetry in liquidity trading activity.

Another assumption regarding liquidity traders is that they adopt passive trading strategies. The rationale is that they do not expect the price to move in any particular direction in the short term, so they are willing to wait to execute the order, relying on the transient volatility to swing in their direction.

De Long *et al* (1990) used this classification of investors to establish the "noise trader" theory. They show that informed investors cannot exploit their position completely, because there is a risk that the noise traders may drive the price away

from the "informed value". They use this to show that uninformed investors can survive in the long run, as sell as proposing explanations to other market anomalies such as the closed end fund puzzle.

3.4.3 Institutional investors

Keim and Madhavan (1995) examine "the behaviour of institutional traders", which account for 72% of the US share volume. Schwarz and Shapiro (1992) give a similar statistic that 73% of the share volume on the LSE relates to institutional investors. Institutional investors may be clearly defined as those who trade with money that belongs to another party. Although these investors do not own the underlying asset, they usually have a financial incentive (annual management charge or a performance bonus) to ensure the best possible prices for the trade, so there is no reason to believe that they trade with split priorities or with any less diligence than an individual trading with his own savings. Motivations behind trade decisions are easier to collect for a single large institution than a collection of individual investors. As such papers like Conrad et al (2002) use the behaviour of institutions to approximate the decisions made by the market as a whole.

3.4.4 Individual Investors

It is fair to say that an individual investor is assumed to be everything that an institutional investor is not, and so a description here would simply repeat the previous paragraph. But it is worth thinking about how individuals trade. Individuals are, as the name suggests, a far from homogenous set. They are likely to have vastly varying wealth and technical experience concerning financial markets. We would not expect a fund manager to trade on the stock market in the same way as an individual with no knowledge of markets, who was given a number of shares when his building society demutualised. The two main differences are the motivations for

trade, and the method of trading. An uninformed individual would usually employ the services of a brokerage firm. The investors may not know the difference between a market order and a limit order. The broker may ask the investor or he may make the decision to sell immediately with a market order, or enter a limit order and try to trade at a better price before the end of the day. Either way, the instructions given by the individual would lead to a relatively aggressive trading strategy, from an uninformed starting point. This contradicts the generally accepted view that uninformed traders, trade passively.

3.4.5 Foreign Investors

Very few papers draw the distinction between domestic and foreign investors, despite being important, for a variety of reasons. Demand from foreign investors is constantly changing, and more volatile than domestic demand. The needs of foreign investors, along with their information set and list of alternative investments are very different to domestic investors. According to economic theory, the reshuffling of domestic stocks between domestic investors has a smaller impact than the "hot money" flow of foreign investors who transfer money in and out of the market.

One paper that does address this issue is Grinblatt and Keloharju (2001). They study the Finnish stock market, where foreign investors may play a more important role in the market than in the UK, but it is clear that they may trade in different ways to domestic traders. They find that "domestic investors – particularly the less sophisticated investor categories – tend to be contrarians and foreign investors tend to be momentum investors." It seems sensible that traders further away from the physical market place may be less well informed and so their trading occurs later after the information has been impacted into the prices (although a link between information asymmetry and momentum traders has not been found empirically).

3.5 Market Maker Behaviour

Another important type of investor is the market maker or specialist. Although a simple category to define, there are a few distinct kinds of market maker. Much of the research looks at a single market maker who takes part in every trade on the market. The monopolistic NYSE specialist, however, takes part in only a fraction of trades, although he is obliged to offer liquidity when it is required. The competing market makers of NASDAQ or LSE's SEAQ are also obliged to quote prices they are willing to trade, but the competitive aspect leads to a difference in their behaviour. Some recent papers even refer to those traders placing limit orders on an automated order book as the market maker. This loose definition of the market maker as the "liquidity provider" will not be used here, in preference for the official definition (on the LSE) of a member firm that is obliged to offer liquidity whenever the market is open.

3.5.1 The Inside Trader

In some markets (such as the NYSE) the market maker, or specialist, sits in the middle of the automated order book. Investors can place market orders or limit orders with the specialist. The specialist is obliged to maintain liquidity in the market, but does this by adding his limit orders to the book. Limit orders are ranked by price and time as usual, but the specialist always ranks last at a given price. Chung *et al* (1999) find that "a large proportion of posted bid-ask quotes originates from the limit order book without direct participation by specialists, and that competition between traders and specialists has a significant impact on the bid-ask spread". Given the conflicting demands for a specialist to maintain liquidity at all times and earn a profit from trading, it is not easy to see whether the specialist is using his position to judge when offering liquidity is profitable or when it is required by regulation.

Many of the models (Glosten and Milgrom (1985), Easley *et al* (1997)) assume that the market maker is uninformed, and that he trades purely for liquidity reasons, to control his own inventory whilst minimising the risk of asymmetric information. This is a difficult assumption to swallow, but even more so when considering a market like that on the NYSE. This leads us back to the question of what information actually is. Is the limit order book informative? If so, then studying the actions of a specialist who possesses this private information seems to be a fruitful area. The NYSE specialist has since lost his monopoly on the order book. Boehmer *et al* (2003) study this event and conclude that liquidity in the order book is improved, transaction costs are lower, and cumulative abnormal returns are positive as a result of this. But this does not answer the question of how much the specialist is driven by profits and how much by regulatory requirements, and how efficient are prices as a result of this conflict.

3.5.2 Conflicting Aims of the Market Maker

It is easy to read the literature and come to the conclusion that market makers are all identical, rational and predictable, despite having been given woolly instructions like "ensuring prices aren't too discontinuous". In response to this, Corwin (1999) examines the differences in behaviour between different NYSE specialist firms. He discovers different styles, whereby specialists who have more frequent trading halts "are associated with lower effective spreads, more frequent price movement, and lower transitory volatility". This relationship is not surprising. Glosten (1994) showed that a market with lower effective spreads will, ceteris paribus, cope less well with extreme conditions, and so require more frequent trading halts. But the important point is that specialist behaviour is heterogeneous.

3.5.3 Price Efficiency

Having established that market maker behaviour varies, we find ourselves asking questions about the efficiency of the market, given this variation in behaviour. If a market maker decides to follow the price more closely to facilitate the control of his inventory, what impact will it have on investor expectations? Using the models of O'Hara (1995), where orders are sent to the market maker one at a time, a large uninformed market buy order would drive the market makers price up. If the next order was a large uninformed sell order the market maker may not revise the price, as his inventory objectives have been met. In practice, the higher price may attract more sellers, and so the aggregate demand would drive the price back down. But that is the issue; is the market maker setting the price, or is it just a product of market demand? If investors use the quoted price as information, then the market maker must be in part responsible for affecting the price. This is a simplified example of how market maker behaviour may affect the long term value of shares. Harris and Hasbrouk (1996) find results that suggest "specialists believe buy market orders convey more information than do sell market orders." That is, the price impact of buy orders is greater than the price impact of sell orders. But couldn't this simply reflect the fact that a market maker with a positive inventory (usually required by regulation) has a greater gain from seeing prices go up?

3.5.4 Multiple Market Makers

Many markets employ a single specialist to sit between the buyers and sellers. It is not a coincidence that the NYE still have a single specialist and most of the previous research looks at this case. However, both the NASDAQ and SEAQ operate a system of competing market makers. Grossman and Miller (1988) show that increasing the number of market makers increases the depth of the market and so increases the liquidity, particularly around crashes and other anomalies. Similarly,

Biais *et al* (2000) state that "competition among market-makers leads to a deeper market, and a larger trading volume than in the monopoly case." However, Chan and Fong (2000) state "NASDAQ dealers operate in a decentralized market, which may make it difficult to identify the presence of informed dealers." These two viewpoints do not necessarily contradict each other. While increasing the number of market makers may lead to a more competitive market, with smaller spreads, it doesn't imply that prices should reflect information any more efficiently. Simaan *et al* (2003) add to issue of efficiency by linking pre-trade transparency to market maker quotation behaviour.

Christie and Schultz (1994) ask, "why Nasdaq market makers avoid odd-eighth quotes". On Nasdaq, market makers known as "preference traders" can attract order flow by promising to trade at the best quoted price. In this way, market makers have less incentive to offer the best price: if they do then they would lose money on the trades they would have made anyway, and if a large proportion of the market trading is routed to preference orders, the price improvement may not attract much new business. In this way, the spreads may be kept higher than in a market without preference trading rules.

While Corwin (1999) found heterogeneity between specialist on the NYSE, does this affect the overall behaviour with multiple market makers? It may be that the competition between market makers leads to a common equilibrium between stocks. It is also possible that certain market makers dominate the market using something other than price and depth (e.g. preference arrangements), and so the efficiency of the market in different stocks varies. This issue has not been addressed in the literature, and will not be quantified in this thesis, but it should be noted as an explanation for the variability in measures of efficiency between stocks.

Naik and Yadav (2002) examine the difference in market maker behaviour after the LSE switched from a dealer market to an order book market with voluntary market makers. They find that "dealers in a trading system with obligatory market-making contracts fulfil an important and useful price stabilisation function even though these contract are difficult to monitor or enforce". They also find that "obligatory market-makers posting firm quotes face adverse selection losses (due to trading with informed traders) that are not different from those faced by voluntary market-makers who... only display quotes on request".

3.6 Trader Behaviour – Rational and Behavioural Issues

Allen and Gorton (1992) ask "is it possible for an uninformed trader to buy a stock, drive the price up and then sell the stock at this higher price, thereby earning a profit?" If we are to assume any of the existing theories for anonymous markets then, this should be possible. This is one example of rational trading activity that is not in the best interests of the market as a whole. Deliberate market manipulation is illegal in most markets. For example, trading heavily in the last 10 minutes of trading on the LSE to distort the volume weighted average price (VWAP) and so alter the position of a stock in an index is a known problem. However, there may be other, less detectable ways of manipulating the market. The fact that we have laws to stop this kind of activity is proof enough that there are traders willing to do this.

3.6.1 Hiding Information

The size effect, whereby large trades move the prices more than smaller trades summing to the same value, is one of the oldest identified anomalies. Barclay and Warner (1993) find that "informed investors... attempt to camouflage their trades by spreading them over time, or by trading when liquidity volume is high." The ideas of informed investors "trading when liquidity volume is high" and using market

orders to gain immediacy before the information gets old, do not sit well together (i.e. do they wait for liquidity volume is low, and then place market orders?). However, Lee and Radhakrishna (2000), find that "few (6%) of the total market orders are split up in execution." This seems to imply that stealth trading is not such a prevalent activity, or at least not on the NYSE. Lee and Radhakrishna (2000) also find that "a much larger proportion (24%) of total market orders is batched in execution." This type of behaviour seems to contradict the conventional knowledge of minimising the price impact of a trade. Perhaps then, they are trying to move the market?

It seems likely that stealth trading would vary between markets. Chan and Fong (2000) state "adverse information associated with large trades seems to be more substantial on the NYSE than Nasdaq". They justify this as a result of the professional relationships built up on the NYSE, but it seems possible that it actually reflects a difference in trading strategy.

Finally, assume that institutional traders are more likely to be informed, as in Lee *et al* (1991) and assume that institutional traders are more adept at stealth trading as in Barclay and Werner (1993). Wouldn't we expect the effect of the information to be understated by the trades of the informed institutional investor? Lee and Radhakrishna (2000) find that "trade size is still highly effective in separating institutional trades and individual investor activities", but this does not rule out the possibility of a small proportion of stealth traders affecting the equilibrium of the market. It is possible that the stealthily executed institutional trades are larger than the individual trades on average, but this type of trading behaviour would still have an impact on the market equilibrium.

3.6.2 Contrarian and Momentum Investors

A "contrarian" investor trades in the opposite direction to the market. Note that the "opposite direction" is usually interpreted in terms of recent performance, i.e. buy the losers and sell the winners (rather than in relation to a measure of current demand for buying and selling). In contrast, a "momentum investor" buys the stocks that have recently gone up, and sells those that have recently gone down.

Chordia *et al* (2002) find that "order imbalance increases following market declines and vice versa, which reveals that investors are contrarian on a aggregate." To avoid confusion it should be noted that Chordia *et al* refer to "orders" in a market where all orders execute and so we should interpret "orders" as "trades". Griffiths *et al* (2001) find that domestic investors tend to be contrarian while foreign investors are momentum traders, and so Chordia *et al*'s statement should be read the context of the NYSE investor profile.

Many papers have shown that both momentum and contrarian investment strategies can be profitable. Jegadeesh and Titman (2001) and Jegadeesh and Titman (1993) examine the profitability of momentum strategies. In each paper, they find similar levels of profit from the momentum strategy. What is interesting about these two results is that having published an article in 1993, the market has not learned from the result and exploited the theory, thus closing out the result. They state that "the behavioural models imply that the holding period abnormal returns arise because of delayed overreaction to information" but then apply a warning to this interpretation as only some of the stocks they invest in experience post holding period reversals.

DeBondt and Thaler (1987) explain the overreaction phenomenon whereby companies with good earnings announcements continue to do well in subsequent years, despite poorer results, and vice versa. They maintain that this is due to

irrational behaviour, rather than the size effect[1]. Zarowin (1989) studies the same result, but finds that by matching the winners and losers by size, we find no evidence of overreaction and so can attribute the result solely to the size effect. Jegadeesh and Titman (2001) also find greater reversals in small firms than large firms.

It seems confusing that, seemingly opposing trading strategies can both make profits. There are a number of possible explanations. Firstly the results could be a product of data mining, or at least dependant on the sample period chosen. It seems plausible that contrarian investors might do well in a bear market, while momentum investors do better in a bull market. Another possibility is the difference in return intervals used. If stocks do follow regular patterns of ups an downs, then each strategy could be profitable: the contrarians have to judge the peaks just before they happen, and momentum investors must judge the start of a trend very quickly. Although timing rules can be set easily in retrospect, it is difficult to do so in real time. It is worth noting that the existence of such stock price patterns exist because other investors fail to identify the trends accurately.

3.6.3 Other Types of Investor

Many conclusions have been drawn about the trading behaviour of other investor subgroups. Grinblatt and Keloharju (2001) find that "domestic investors – particularly the less sophisticated investors categories – tend to be contrarians and foreign investors tend to be momentum investors." Keim and Madhavan (1995) examine the behaviour of institutional investors. They find that different institutions trade with different strategies, and that these are as important as the market conditions when determining whether to place a limit order or a market order. Milgrom and Stokey (1982) state that uninformed traders who speculate will lose out in the long run, and so uninformed traders must trade for other reasons. This last

[1] where smaller firms outperform larger firms

classification has one of the most serious implications. Many papers since 1982 have used this rationale to justify the actions of uninformed traders as liquidity motivated. Isn't it possible that the uninformed traders don't know they are uninformed?

3.6.4 Behavioural Issues

Grinblatt and Keloharju (2001) ask, "What makes investors trade?" They conclude "past returns, reference price effects, the size of the holding period capital gain or loss, tax-loss selling, and, to a small extent, the smoothing of consumption over the life cycle... are determinants of trading."

Gray and Gray (1997) liken the NFL spread betting market with the financial markets. They find that "the market overreacts to a team's recent performance and discounts the overall performance of the team over the season to date". In the sports world this is referred to as the "hot hands" effect, where recent form is taken as a better indicator than it should, but perhaps this is not caused by the individuals, but the information providers, who choose to present the data with emphasis on the most recent news. Information providers want to show that they are up to date, so it seems logical that they would put more emphasis on the most recent information. This leads to the "narrow framing" problem that Read *et al* (1999) talk of, whereby investors make decisions based on a subset of information.

Grinblatt and Keloharju (2001) state that sophisticated investors ignore past returns, but unsophisticated investors take good returns as a signal to sell. It is not clear that sophisticated investors should ignore past returns (although the EMH states that the return history contains no information), but it is clear that the unsophisticated are acting in a less than optimal way. Shefrin and Statman (1985) explain the "disposition effect" whereby investors have a tendency to hold on to losers too long and sell winners to soon. Lakonishok and Smidt (1986) suggest that investors may

sell winners to rebalance their portfolio and those who buy with short term information may sell when the price goes up as they believe this to reflect the true price. Harris (1988) also suggests that investors may hold on to losers as they perceive the transaction costs prohibitively high (since the losers will, on average, be smaller than winners, and costs are higher for smaller companies). Odean (1998) tests these theories for individuals trading through a discount brokerage house, and finds that rebalancing portfolios and avoiding high trading costs are unlikely to justify the result. Furthermore, he shows that the disposition effect is not present in December, when the tax advantages of selling losers, and holding onto winners, is a greater motivation than the unexplained behavioural bias.

3.7 Alternative Methods of Trading

3.7.1 Where Else Can You Trade?

With a few exceptions (e.g. Conrad et al (2002)), much of the empirical finance research ignores the issue of alternative methods of trading, and even when it is addressed, it is always a subset of the trading methods. It is possible for a given stock to be traded on a formal domestic market, on the informal upstairs or block market, or as a cross listed security on a foreign market. Within the formal market (dependent on which market it is), an order may be routed to the order book as a limit order or market order, or to a floor broker, or to one of a set of competing market makers. The stock may also be traded as an option in the derivatives market, although few individual stock options are exchange traded. Understanding the choices available to an investor, including the relative merits and costs, is vital in determining the aggregate behaviour of the markets.

3.7.2 Selection Issues

Traditional wisdom tells us that large trades convey more information, but when there are alternative ways of trading this may not be the case. In addition to the competing market makers, NASDAQ offers a Small Order Execution System (SOES). This is an automated order book, for trades of up to 1000 shares. Chan and Fong (2000) find that SOES trades of 1000 shares convey more information than the large institutional trades on the main market. (Their measurement of information is the permanent price affect of the trade). The result may be because informed traders are selecting against the other participants on the anonymous SOES market. However, if they are splitting their trades between platforms then Chan and Fong's result suggests that SOES should be used to finish off the order if at all (since this trade moves the market). In fact, it seems likely that SOES may be used by institutions wishing to move the market price. A final alternative is that the SOES is used by the private individuals that it was designed for, and the market misinterprets the signals as information. Either way, it is of interest for two reasons. What trades really hide private information? And how is the market price set with two alternative trading mechanisms.

3.7.3 Competition

Glosten (1992) explained that different markets cannot coexist, if competing on price alone. Pagano and Roell (1992) state that "if agents can choose between two competing auction markets, in the absence of a transaction cost differential all trade will concentrate on a single market". One common assumption is that a market maker has greater ability to identify informed traders, than an anonymous order book, and this selection issue is sufficient to justify the existence of both markets. However, Chan and Fong (2000) argue that "Nasdaq dealers operate in a decentralized market, which may make it difficult to identify the presence of

informed traders." Pagano and Roell (1992) suggest that markets compete by "thickness... trading technology, taxes and other processing costs", and that these factors "may separate out specific clienteles". The problem then is to identify and quantify all of the factors that investors use to differentiate between markets. Only then will the theory begin to match the real world.

There are many examples of aggregate investor behaviour that seems to contradict the theory. Blume and Goldstein (1997) show that markets that compete with the NYSE for a given stock, "attract a significant portion of their volume when they are posting inferior bids and offers". Admati and Pfleiderer (1988) show that theoretically, trading activity should gravitate to the time of day with the most liquidity. But while we have found daily patterns, it is certainly not true that all trading activity gravitates to one time of day.

3.7.4 Efficiency

A further question is whether the existence of alternative trading platforms adds to the efficiency of the overall market. Cohen *et al* (1981) find that "consolidating the currently fragmented system (by e.g. instituting a consolidated limit order book) will reduce search costs and further shrink spreads by increasing the effective thickness of the market. Although the spread is synonymous with liquidity and liquidity is synonymous with efficiency, Cohen *et al* are not saying the prices are more efficient. Neither is it the case that lowering the spread is desirable. Madhavan (2001) points out that minimising the spread is not desirable from the point of view of the traders who use a limit order strategy on the automated order book.

Pagano and Roell (1992) state that "prices are quicker to adjust to order flow information in a centralised market". They assume that the prices are adjusting to a true underlying value, but this is not necessarily the case. Furthermore, it raises the

question regarding the efficiency of prices on different markets. Are cross listed stock prices consistent? There are rational explanations for prices to be different e.g. stock price is lower on the less liquid market to reflect this risk. But is the relationship between the prices constant, or does it follow a pattern, or does it experience inefficiencies?

3.8 Trading Activity, Liquidity, Volatility and Returns

3.8.1 Liquidity

Grossman and Miller (1988) define liquidity as "the demand and supply of immediacy". This could be interpreted as a mixture of the price and depth at the best price and the size of all market orders. Chordia *et al* (2001) use dollar trading volume as a proxy for liquidity. Countless other articles use the quoted spread or the effective spread as a measure of liquidity. Perhaps the only consistent opinion regarding liquidity, is that "more of it is better". In this chapter we will introduce some of the reasons liquidity changes, and how this affects the price movements.

3.8.2 Volume and Returns

The adage of "it takes volume to move prices" is likely older than the theories that support it. Mahieu and Bauer (1998) discuss the Mixture of Distribution Hypothesis, which posits that "stock returns and trading volumes are jointly dependent on the same underlying, latent information flow variable." But it would be naïve to assume that volume alone was the explanation, rather than the underlying reasons why volume changes.

The EMH implies that returns reflect information, and so, if volume increases when there is a greater asymmetry in information, then returns would in turn reflect this

information. Hasbrouk (1991) confirms that the impact on prices, and so, the information asymmetry appear more significant for smaller firms. This is often sited as proof of the information asymmetry / prices relationship, although it is also possible that the price impact is simply measuring the immediate impact of a large trade in an illiquid market for the smaller stocks.

A wide spread is also an indicator of asymmetric information and Hasbrouk (1991) finds that "trades which occur in the face of a relatively wide spread have a larger price impact than those which occur when the spreads are narrow." However, it is not clear how the asymmetry of the order book or the behaviour of buyers and sellers would affect the returns. This will be addressed in chapter 6.

3.8.3 Daily Variations

Trading strategies designed to exploit the inefficiencies of the market microstructure are very short term. During the internet price bubble, a new breed of day traders emerged, who speculated in the morning and tried to close their position by the end of the day. With this length of time horizon it is vital that the investor knows if and how the market regularly varies throughout the day.

Most of the papers that talk of daily trading patterns are based on the NYSE. (One exception is Yadav and Pope (1992) who look at the intraday patterns in the stock market risk premia, but concentrate on the cash and futures markets, so are not directly comparable). The NYSE opens at 9am and closes at 4pm. Trades can be arranged upstairs at any other time. On the LSE there is a very different pattern. Not only is there a longer trading day (8am to after 4:30pm) but there is an opening call option to consider. How do these differences affect the daily patterns?

Madhavan and Panchepagesan (2000) and Biais *et al* (1999) show the importance of the opening procedure in setting prices, and the opening accounts for a sizable proportion of the day's trading. Biais *et al* (1999) state that "because of considerable overnight valuation uncertainty, price discovery is important and difficult at the opening of the market".

Jain and Joh (1988) find that average trading volume is "highest during the first hour, declines monotonically until the fourth hour, but increases again on the fifth and the sixth hours." They also find that "on average, the largest stock returns occur during the first (except on Monday) and the last trading hours". Jain and Joh (1998) also state that "hourly trading volume is found to be caused (in the Granger-Sims sense) by returns".

Chordia *et al* (2002) find that the "change in number of transactions has a separate... (from the order imbalance) ... and very significant positive impact on spreads". They explain this by the "sheer volume of trading... making it more difficult for market makers to control inventory and induce them to respond by quoting large spreads." This is a rational explanation, but one that would not exist in an order book market. Many studies have found the relationship between volume and price movements, but not necessarily a relationship with the number of trades and price movements. It is possible that splitting up large informed trades could be a driver behind this result, but correcting for volume, it would be interesting to see if the number of trades is an indicator of price movements. There are also observable weekly and monthly patterns in trade data. Jain and Joh (1988) show that Mondays have lower returns, and the hourly pattern of trading is different on this day. Chodia *et al* (2001) find that "liquidity and trading activity fall on Fridays" and "Tuesday tends to be accompanied by increased trading activity and increased liquidity". Jegadeesh and Titman (2001) find that momentum profits are positive for all months except January, due to the tax incentives for selling on the NYSE in December.

Lynch (1996) sheds some light on seasonal patterns by exploring the effect of infrequent and non-synchronous trading activity, demonstrating that the change in traders behaviour contributes to the stock price volatility.

Cai *et al* (2004) compare the daily variations in spread, volume and volatility for 5 of the major trading platforms: NYSE, Nasdaq, SEAQ, SETS and the LSE before SETS was introduced. They find that the dealer markets have decreasing spread, while the others have a U-shaped daily pattern. They also show that the pattern of intraday volume changed on SEAQ, when SETS was introduced. In particular, the mid afternoon peak in volume disappeared, leaving just the late morning and end of the day peaks.

3.8.4 Variability in Trading Volume

Chordia *et al* (2001) find a "negative and surprisingly strong cross-sectional relationship between stock returns and the variability of dollar trading volume and share turnover, after controlling for size, book to market ratio, momentum and the level of dollar volume or share turnover". This contradicts their expectation, based on the fact that risk associated with greater variability in liquidity (proxied by trading volume) should lead to investors demanding a higher expected return. Perhaps this is just a timing issue, in that an increase in variability of liquidity does lead to a demand for a greater return, but since the present value of future dividends does not change, the only way to have a higher expected return in the future is to have a lower price now. Another explanation might be that the trading volume varies a lot more when the stock price is going down. If there is a market wide fear of bad news for a given stock, then the traders who make profits by offering liquidity may decide not to offer as much liquidity. And so, investors are left with fewer options over the strategic timing of their trades.

Chordia *et al* (2002) state that "while order imbalance appears to have no forecasting ability, there is evidence that both the number of trades and the market return can predict changes in liquidity". (note "order" refers to "trade") If, as stated in the previous paragraph, there is a strong result linking variability of liquidity with stock prices, then it would seem possible to forecast stock prices using some function of trade imbalance.

3.8.5 Volatility

French and Roll (1986) separate the effect of public and private information by studying the weekday exchange holidays. They suggest that the variance of returns over the two day period starting at the close of trading before the holiday, should be roughly double that of a normal day. They find only a 14% increase in variance and so "most of the volatility of stock returns is caused by informed traders whose private information is impounded in prices when exchanges are open" (Madhavan (2000))

Gallo and Pacini (2000) use a GARCH process to explain the clustering of volatility in prices. They look at days with "beginning-of-the-day surprises", where the opening price is significantly different from the previous day closing price. They find that the volatility during those days are highest and that prices overreact to perceived information in the short term. They also find that lagged information has little impact on the result.

Chan and Fong (2000) emphasise the significance of the "size of trades beyond that of the number of trades in the volatility-volume relation." This may reflect the relationship between asymmetric information and size of trade, but it may also indicate that the market cannot cope well with large trades, leading to greater volatility and less efficient prices.

Grinblatt and Keloharju (2001) find that "high volatility increases the propensity of households to buy rather than sell a stock", but find it hard to "concoct a rational story". Their results allows for the magnitude and direction of the return.

3.9 The Automated Order Book

Glosten (1992) asks the question, "is the automated limit order book inevitable?" The automated order book was relatively new in 1992, and Glosten would have been unaware of just how many markets have now switched to this design. Glosten (1992) finds that in order to compete with an automated order book, a rival market must compete on something other than price, but the interpretation of the evidence is far from conclusive. While most of the research ignores the issues surrounding the automated order book, the papers that have addressed the issues (Venkataraman (2001), Haung and Stoll (1996)), use what some feel to be inappropriate measures, such as the bid ask spread.

3.9.1 Interpretation of the Spread

In the market maker paradigm, a low effective spread is good: investors trade with lower costs, and so prices will reflect a more diverse set of opinions and this attracts more investors. From the point of view of the investor, there is no down side to a small effective spread. With regard to an automated order book, Madhavan (2001) discusses the use of the effective spread as a measure of transaction costs, drawing attention to the fact that many of the traders who would previously have paid a spread to the market marker, now gain the spread from those who demand liquidity.

Goettler *et al* (2003) discuss the interpretation of the effective spread on an automated order book, and state that it is not a good measure of "welfare". Having

defined a model, which explicitly allows for an investor's choice between a market order and a limit order, they conclude that reducing the effective spread may not be in the interest of the investing population. They reject the effective spread as a measure of welfare in favour of volume. But is volume such a good thing? Greater volume would seem to imply that more traders are willing to trade because of lower overall transaction costs, but this may not be the cause.

3.9.2 Order Flow

The automated order book is such a different market because investors have the choice of whether to take or provide liquidity in the market to achieve their investment goals. Previously the job of providing liquidity was performed by an expert. Their aim was to provide a continuous (i.e. prices don't jump, volatility is low) and liquid market. But now, liquidity is supplied by individuals, with no explicit aims regarding the overall welfare of the market. Naik and Yadav (2002) find that "public investors supplying liquidity face adverse selection losses that are significantly higher than those faced by (voluntary) market intermediaries." What impact does this have on the efficiency or liquidity of the market? The automated order book has only been introduced to markets with sufficient depth of trading interest. Beber and Caglio (2003) show that liquidity is supplied (limit orders placed) when liquidity is low (spreads are wide) and so there is a natural equilibrium that ensures that markets are liquid. However, there is no such justification for investors to keep the markets continuous. This leads us to a very different situation; one in which prices may be manipulated. Clearly the behaviour of order book investors, and in particular the choice of market orders and limit orders, is of primary concern in understanding the automated order book market.

3.10 Aggressiveness of Orders

"Aggressiveness" (not "aggression" for some reason) is a term that reflects an investor's demand for immediacy. A market order that executes immediately is aggressive, while a limit order is passive. The further away from the spread the limit order is, the more passive it is. Size also plays a part in measuring the aggressiveness of orders. A large market order is considered more aggressive than a small market order, particularly where the large order "walks the book" or eats up the depth at best price, thus increasing the spread. The size of a limit order is harder to interpret. If a large order is placed inside the spread, it is neither more aggressive nor more passive than a smaller order at the same price.

3.10.1 Information

The relationship between aggressiveness and information has been used for so long that it is now treated as a fact. Beber and Caglio (2003) ask "do order submission strategies change around periods when traders are likely to be asymmetrically informed?" Griffiths *et al* (2000) find that "aggressive buyers tend to be more informed on average than other buyers, whereas aggressive sellers tend to be motivated by liquidity". But what other factors would imply a greater asymmetry of information? We will look at investor type, spread, depth, previous order activity and volatility.

3.10.2 Investor Type

Studies have been carried out on trader behaviour around the world: Harris and Hasbrouk (1996) on the NYSE, Griffiths *et al* (2000) in Toronto, Grinblatt and Keloharju (2001) in Finland, Biais *et al* (1995) in Paris. In each market it is generally assumed that informed institutional investors trade aggressively and

uninformed individual investors trade passively. Observing that this simplification is non trivial, Keim and Madhavan (1995) look at institutional investment styles. They differentiate between classes of institutional investors such as, (informed) momentum investors, who may use market orders to exploit short term information, (informed) value managers, who may not require quick execution and so use limit orders and (uninformed) benchmark fund managers who may use market orders for closer matching to the index.

3.10.3 Gravitational Pull Effect

Cohen *et al* (1981) first referred to the "probability jump" or "gravitational pull effect" to "explain why market spreads may be substantial even in markets composed of many traders". They show that investors faced with a bid-offer spread may choose to place a limit order inside the spread to gain priority in the queue. For a buy order, the limit price would typically be one tick ahead of the existing best bid price, but it could be anywhere in the spread. Given the choice of placing a limit order closer to the best offer price, we reach a point where the investor would rather gain the certainty of execution, than gain the difference between the best offer price and the posted limit price. In markets with discrete prices, this explains why a spread exists. It is useful to think of this "gravitational pull" to determine the factors that may affect the decision between an aggressive market order and a limit order. Beber and Caglio (2003) split the determinants into two main groups: microstructure variables such as spread and depth, and market condition variables such as performance of the market, performance of the stock, volatility of the stock.

3.10.4 Size of Spread

Ellul *et al* (2003) find that "wider (narrower) quoted spreads increase the probability of limit (market) orders." This is consistent with findings from Biais *et al* (1995),

and Beber and Caglio (2003). It is clear that, holding everything else constant, a wider spread can be viewed as a greater gain for limit orders or a greater cost for market orders.

On the opposing side of this argument, Harris and Hasbrouk (1996) look at the "stopped orders that are subsequently executed at better prices" on the NYSE. This is where a broker (usually the specialist) guarantees to fill the order, but attempts to find a better price for the trader. When the NYSE spread is wider, there is a greater opportunity for this to happen. They find that "the price improvement is greatest for small orders and for orders placed into markets with wide spreads." This price improvement mitigates some of the cost of trading in a wide market, although, it is not clear when the specialist chooses to stop the order, and so there may be issues regarding anti-selection risk.

3.10.5 Depth

Ellul *et al* (2003) find that "larger quoted depth elicits net demand for that liquidity". Biais *et al* (1995) also note that limit orders are more common when the order book is thin. As we discussed above, the spread indicates the relative gains to be made from the choice of market or limit order. Depth is also an indicator, for markets that use time priority. If an investor places a limit order at the spread, there is a greater probability of execution, so this strategy is more likely to be profitable.

To ensure price stability on the Tokyo Stock Exchange, a large market order, which would otherwise move the stock price by more than a fixed limit, is held as an "indicative order". This order is effectively held as a limit order at the threshold, and other investors are invited to fill the order. Hamao and Hasbrouk (1995) state that "holding order size constant, an order that is held with an indicative quote has a larger cumulative price impact than one that is immediately executed in full." They

interpret this as an indication that "price limits do not merely smooth transient liquidity effects, but are also associated with changes in market depth". The latter reflects the cancellation of limit orders as they are repriced to match the price limit. But the selection issue of when the indicative quote is held (when prices would move too much) that makes this result unsurprising. It also provokes questions about the behaviour of those who place limit orders at prices that can't fully execute (in the short term at least).

3.10.6 Previous Orders

Sandas (2001) suggests that "the market order flow distribution and the price impact function changes with market conditions" and "in particular, the variance of the market order flow distribution is positively correlated with the past trading volume." However, not only is the overall variance and volume predictable, but the choice of orders is as well. Parlour (1998) proposes that order type follows certain patterns. For instance, observing a limit sell order is most likely after a market buy order. The next most probable preceding order type is a limit buy order. The next is a market sell order. And finally, we are least likely to see two consecutive limit orders. However, in empirical tests, Ellul *et al* (2003) state that "positive first-order auto correlation exists for order type", but that "negative autocorrelation exists for order type over longer horizons". Chordia and Subrahmanyam (2000) find that trade "imbalances are strongly positively auto-correlated for up to five lags". Parlour (1998) argues that this may be due to stealth trading. This issue was discussed earlier, and we may conclude that this is not an adequate explanation of what seems to be less the optimal behaviour. Or perhaps we have just not found the correct indicators?

3.10.7 Volatility

Griffiths *et al* (2000) state that "stock price volatility is expensive for the aggressive trader but beneficial to the trader with passive executed orders." Beber and Caglio (2003) use the volatility of a stock price as an explanatory variable for the aggressiveness of orders. They calculate volatility as a moment of the exponential moving average of past returns over a 20 day period. They argue that an investor's decision concerning if and how to trade depends on not only the expected liquidity, but the volatility of the liquidity. Chordia *et al* (2001) also posit that "agents are risk averse and dislike variability in liquidity, so that stocks with greater variability should command higher expected returns." The scientific rational is sound, but it relies on investors actually calculating the "variability of liquidity", rather than using the present or average level of liquidity. An investors faced with trading in a volatile stock may change his strategy, but it would also depend on their prior expectation of the performance of the stock. If they believe that the stock is going up, and so they want to buy, they are unlikely to decide on a very passive limit order strategy to benefit from the volatility.

3.10.8 Time Remaining in the Day / Daily Patterns

Abhyanker *et al* (1997) and Ellul *et al* (2003) suggest that the "time remaining in the trading day is a factor in order choice". They add that "order activity exhibit a U-shaped intraday pattern" and that sellers become "more aggressive later in the day". Beber and Caglio (2003) on the other hand, find that the "time of the day is more important in affecting buy order aggressiveness than sell order aggressiveness".

3.10.9 Which Strategies Make Profits?

Knez and Ready (1996) state that "limit orders may be inappropriate for implementing a particular trading strategy because of the risk that the strategy's potential profit will evaporate while waiting for the order to be hit." This argument clearly has merit, but the overall cost and potential profit needs to be measured for a more balanced view.

Griffiths *et al* (2002) state that the "optimal strategy to minimize overall costs in filling an order is to buy (sell) at the bid (ask) price" on the Toronto Stock Exchange. Harris and Hasbrouk (1996) find similar results on the NYSE, with the most profitable strategy involving limit orders at or better than the prevailing quote. Harris and Hasbrouk (1996), who ignore many of the explanatory variables, qualify their conclusion by saying that only when we know the information or liquidity motivations for trade, can we really determine what a profitable trading strategy is, and so the Knez and Ready (1992) theory may still be appropriate for informed traders.

The result that limit order strategies are more profitable is even more surprising for Harris and Hasbrouk (1996) who look at the NYSE, where there is frequently a market order price improvement by the specialist. They also make an overstatement of the cost of not transacting, by assuming that these orders are immediately replaced by a market order at the time of cancellation. Interestingly, they also state that the "best limit order strategies were the ones most commonly used".

Griffiths *et al* (2000) find that aggressive orders have a positive price impact, and this price impact is increasing with order size and price volatility and negatively related to firm size. On the flip side, limit orders have a negative impact, but the

variables listed above have little or no effect on the price impact. This asymmetry implies that most profitable order strategies are most likely asymmetrical as well.

3.10.10 What Happens to Cancelled Orders?

Although Harris and Hasbrouk (1996) assume that all limit orders are immediately replaced with market orders at cancellation for the empirical tests, they find that "only a fraction of all cancelled orders are actually resubmitted". This means that the traders were only willing to trade at that price and they were not bound by any fixed requirement to trade. This further blurs the line between informed and uninformed traders. The observation also implies a problem in measuring the profits made from different trading strategies. In response to this problem, Lo *et al* (2002) use a model of survival analysis to measure the time to execution of limit orders.

3.11 Asymmetry of the Order Book

There is no reason to believe that, given a finite number of traders with imperfect information, there should be as many people willing to sell as those willing to buy. There is also no reason to believe that those buyers and sellers would behave in the same way, submit the same types of orders for similar sized trades or have the same motivations to trade. Identifying the ways in which they differ and measuring the difference is the vital step in understanding how these behavioural traits affect the market equilibrium.

Ellul (2003), Parlour (1998), Goettler *et al* (2003) and Keim and Madhavan (1996) discuss the equilibrium. They show that sellers are more likely to use market orders than buyers. This indicates either a more sophisticated trading strategy for buying, or that a sell is more likely to be informed than a buyl. Although the overall picture may show sellers using more market orders, Harris and Hasbrouk (1996) state that

"sell limit orders generally have higher fill rates than do buy limit orders placed equally far from the market". Note that this is not surprising in a rising market. Given that the bull markets have lasted longer than bear periods, the bias is unavoidable, but it should be offered as a possible explanation.

3.11.1 Brokerage

Chan and Lakonishok (1993) state that in the USA "institutional sales are more likely than purchases to involve an intermediary broker". They state this as an explanation for the asymmetry of short term price movements, but it may also have implications to the behaviour of traders on the order book. Intermediary brokers may be given different or incomplete information that an in house dealer. If a firm has information, they may not disclose it to the broker, but rather an instruction to sell 10,000 shares by the end of the day for instance. The broker's performance may also be measured in different ways: execution price compared to the price at open, or the price at close, or average price for the day. If they are measured against the price at the end of the day, then playing the spread in the morning, and if unsuccessful then placing a large market sell near the end of the day, thus driving the price down, will lead to favourable performance figure for the broker.

3.11.2 Short Selling Constraints

Allen and Gorton (1992) state that "short sale constraints which make it easier to exploit good news than bad news" imply that "if there is a different probability of a buyer being informed than a seller, the effects of purchases and sales on prices will again be asymmetrical (even if liquidity trading is symmetric)." It is not clear what they mean by the phrase "even if liquidity trading is symmetric". If there are an equal quantity of liquidity buyers as liquidity sellers, then there must be an equal amount of informed buyers and sellers. Allen and Gorton (1992) admit that "in the

long run the number of sales and purchases must usually balance" but that this is not the case in the short term. If we are to believe that liquidity trading is symmetrical in the long run, then there must be as many informed buyers and sellers in the long run. If this is the case, then we can not have " a different probability of a buyer being informed than a seller".

While short selling constraints may limit the ability of an investor to exploit some very good information, it is not clear that this will limit the possibility of everyone else using it. If the information is regarding an impending bad news event, it only takes one of the stock holders to trade and exploit the information. According to market microstructure theory (Glosten and Milgrom (1985), Easley *et al* (1997)), an informed investor will trade until the price reflects the true value, and so even a single investor, with sufficient inventory could move the price to fully reflect the information. This is a strong assumption, and so we can not discount the issue that Allen and Gorton (1992) highlighted, but we should note that although short selling constraints may not restrict the volume of sell initiated trades, it certainly restricts the number of traders behind these. It is possible that the extreme price movements (whether justified or not) reflect the competition of many traders on the same side of the market. Perhaps it is this competition that drives the prices, rather than the information?

3.11.3 Implications of Asymmetry

Chordia *et al* (2002) state that "order imbalances in either direction, excess buy or sell orders, reduce liquidity." They go on to explain that the drop in liquidity reflects the greater risk of private information, and the practical constraints of a market maker controlling his inventory. It should be noted that when they refer to "orders", they are talking about transactions on a market maker driven market, where, since the market maker is obliged to trade at all times, these terms are interchangeable.

This does not mean that the result cannot be interpreted from the point of view of an automated order book. Chordia and Subrahmanyam (2000) point out that order imbalance is only important for the "paradigm of an intermediated market... otherwise one could use the time-honoured statement 'for every buyer there is a seller' to argue that order imbalances are irrelevant". But this is not the case when you extend the definition of orders to include those orders that don't execute.

Another question that their result poses concerns the effect on prices of removing the intermediary. If we consider a situation in which an order imbalance arises on an intermediated market and then, holding constant the desires to trade of all investors concerned, we replace the market maker with an automated order book, what would happen? Would the prices move more dramatically? Would some of the trades choose not to trade given the problems of moving the market price? Would some of the traders adopt limit strategies? And if so, which category of investors?

Griffiths *et al* (2000) extend the analysis from short term fluctuations to "longer-term returns". They support previous results, stating "aggressive buyers tend to be more informed on average than other buyers, whereas aggressive sellers tend to be motivated by liquidity." Given that returns are a direct consequence of the trading interest, it is hard to accept this as a conclusive result, but it does offer support to the asymmetry theory.

3.12 Microstructure Comparisons

The problem with experiments in the social sciences is the selection of suitable test subjects and the lack of control on other variables. Given so few financial markets, and even fewer sufficiently liquid to warrant a comparison, results have been scarce. Nevertheless, making a comparison between different markets or the same market at

different times is still one of the best methods for measuring the effects of market design.

3.12.1 Theoretical Results

Academic results have not as yet converged on the "ideal market microstructure". Each of the empirical studies described below discuss the theories that support their findings. In addition, Glosten (1994) presents a theoretical paper, asking the question "is the electronic order book inevitable?" While exchanges are, in general, making the switch to an automated order book, it has never been proven that this is a superior market design, or even what criterion they should be compared by.

Glosten (1994) finds that in the long term, no intermediated market structure could compete with the automated order book by competing on price alone. This conclusion leaves the door open for many possible alternatives. For instance, if a market maker thought that they could differentiate between informed and uninformed traders, they could compete with an anonymous order book market. Other methods of competing with an order book might involve additional services (information or administrative), trading at different times or opening the market to a greater number of participants. There is also the possibility that traders are loyal to a market structure due to behavioural biases, in the same way that consumers are loyal to their favourite brands.

Glosten (1994) also finds that the order book performs as well as any other microstructure during times of "extreme adverse selection problems". This is set in the concept of competing exchanges. It should be noted that a monopolistic market maker who has the ability to make greater profits in times of stability, could provide more liquidity during times of low or unbalanced market activity.

Pagano and Roell (1992) also look at the theoretical differences between microstructure types, concentrating on the issue of transparency. Their definition of transparency concerns the speed that trading information is communicated with all market participants, and the level of detail that is supplied, and information regarding the best prices available at any time. This definition encompasses post trade transparency and visibility of the orders awaiting execution, but it does not include the identity of a trader in the order queue. This is an important difference, because it excludes the effect of a market maker's ability to differentiate between informed and uninformed traders. So the focus is on the ability of market participants to trade on an equal basis with, or instead of having, a market maker.

Pagano and Roell (1992) look at 4 market types:

1. Transparent Auction – one off trade at a single price. Traders can see every order willing to trade before execution.
2. Batch Auction – as above, but traders see limited data e.g. the implied market price and the volume that would trade (no information on individual trades).
3. Continuous Auction – market orders are executed immediately, and limit orders sit on a book that is visible to market participants.
4. Dealership – Monopolistic dealer, who publishes trade information after a delay.

The main finding is that "market liquidity goes hand in hand with transparency", and so the most transparent market structure would be the most liquid, and have the smallest spread. This is because uninformed traders can better guard themselves to insiders. They do admit that "in a more transparent market, prices are less favourable over some range of order sizes" as traders adapt their strategy to the market mechanism. However, the idea that transparency leads to more liquid markets, along with the ability of automated order books to publish trading data in

real time, implies that the most efficient market microstructure is an automated order book.

3.12.2 Trading at Different Times of the Day

Madhavan (1992) demonstrates that "a periodic trading mechanism can function where a continuous market would fail." Admati and Pfleiderer (1988) show that even in a continuous market, trading activity should gravitate to the time of day with the most liquidity. So why do we have continuous markets? The easy answer is that investors and other market participants demand this. The relative merits of a one off market are often discussed, and it explains in part, why most continuous markets have a pre-opening auction process. It is this combination of a continuous dealer or order book market, with a one off auction that makes for a popular comparison.

Biais *et al* (1999) point out that "because a large number of traders are batched at the opening and because the opening is structured as a uniform-price auction, market impact and adverse selection problems are likely to be less pronounced than during the trading day". They use this as a rationale for large traders to use the opening procedure more than the smaller traders. This is yet another example of selection problems experienced in competing markets: if large traders are informed traders, we would expect a greater proportion of information to be derived form the opening procedure, than the proportion of trading would suggest. For example, if 10% of trading occurs in the batched process (as claimed by Biais *et al* (1999), then we might expect more than 10% of the informed trades to be present.

The main conclusion of Biais *et al* (1999) is that order activity during the early stages of the opening procedure (8:30am to 9am) they cannot reject the noise hypothesis (i.e. no information content), but as the opening procedure progresses, the prices become informationally efficient. They suggest that the initial period of noise

may reflect the difficulty in pricing the stocks given the many uncertainties, or it may reflect gaming procedures from investors trying to manipulate the market. However, if the latter is true, someone is mistaken. Either the market manipulators are wasting their time or the Biais *et al* (1999) conclusion of prices reflecting information is misleading.

Camerer (1998) tests a similar situation by placing bets at a horse race and then cancelling them before the race. He finds that his actions did have an impact on other betters, particularly when he placed a bet and cancelled the bet close to the start of the race. Both Camerer (1998) and Biais *et al* (1999) find that the activity closer to the end of the procedure, to be more informative. However, Biais *et al* (1999) point out that as the race time approaches, there is a real chance that a gambler will not be able to cancel the bet in time due to physical restraints such as queues, and that this was a rational justification for prices to react to this bet as being informed rather than deliberately misleading. This threat does not exist on the Paris Bourse opening auction, and so the influence of manipulative orders cancelled before the opening is mitigated. Furthermore, the two situations are far from comparable. A gambler wishing to cancel his bet will not necessarily get the same odds as when he placed the bet. Unless the odds are fixed for the entire period, this situation is closer to a continuous market than the opening auction.

One alternative explanation for this noisy order activity is that the market participants are either disguising their own orders or are trying to find out what other orders are being placed. The Paris Bourse does not publish details of every order, but simply the strike price and the volume that would trade if the market were to open immediately. By repeatedly entering large orders to move the strike price in that direction, you could take the difference in the volume that would trade and the change in the strike price and solve the simultaneous equations to determine what other orders were on the book. This theory has not been explored. It would be

difficult to prove from the order data, and it is unlikely that traders using this strategy would admit to it and lose their informational advantage. So this suggestion seems likely to remain as an unproven theory.

Amihud and Mendelson (1987) take a different approach to the same problem. They compare the opening and closing price data for the NYSE. They argue that the opening price is a result of the opening call auction process and that the closing price is a result of the continuous dealership market. They fit an ARMA (1,1)[1] model to the data, which implies that prices follow a lagged partial-adjustment process with noise. They find that "open to open" market returns are more variable than the "close to close" market returns, and so traders in the opening procedure are subjected to greater variability in returns. The downside of this comparison is that there are so many differences between the opening and continuous markets, that it is difficult to associate this result with a particular characteristic of the microstructure. Biais *et al* (1999) suggested that more informed traders would choose to trade in the opening market. This would support the results found by Amihud and Mendelson (1987). However, Pagano and Roell (1992) state that transparency would lead to a more liquid market, which would in turn lead to a more stable market. This contradicts the results found by Amihud and Mendelson (1987).

The problem with all of the comparisons between opening procedures and the continuous market is that there are too many differences. There are selection problems regarding when informed traders wish to trade. There is greater uncertainty regarding information at the open, as there are up to 18 hours between the closing and opening. There are different ways of carrying out market manipulation in the two markets, and different rewards. There are different risks faced by the market participants (e.g. market maker inventory risk). There are even behavioural issues to explain why investors react differently in the afternoon, given

[1] Auto Regressive Moving Average model.

good or bad performance in the morning. So academics decided to take an alternative approach, and compare cross listed stocks.

3.12.3 Cross Listed Stocks

Many stocks have a primary listing on one stock market but are also traded on other markets. Lee (1993) and Petersen and Fialkowski (1994) find that execution costs are slightly higher on NASDAQ and the regional exchanges, compared to the main listing on the NYSE. There are several reasons for this result. First, the liquidity of the market and the proportion of the trading in a stock on a single market will affect the transaction costs. Arguably, the "liquidity" is what we are trying to measure here and so we may conclude that the NYSE is more liquid than the NASDAQ. But we cannot say that this is solely due to the design of the market. The NYSE currently attracts such a large proportion of the world market capitalization and trading volume, that it is unsurprising to find that the NYSE is more liquid than the regional exchanges.

De Jong *et al* (1995) and Schmidt and Iversen (1993) find that spreads are greater on the LSE SEAQ international compared to the spreads on the domestic markets for French and German listed stocks respectively. This is a similar result to the American studies, in that the main listing has lower transaction costs. It also shows that the dealer market in each comparison has the higher transaction costs. One important difference is that the argument regarding the volume differential that we used to justify the American result can not be used here. However, the fact that the dealer market appears to be the less efficient in all cases raises the question as to whether we are comparing consistent measures of execution cost? De Jong *et al* (1995) compare the quoted spread and the effective spread on each market. They look at the case of a trade at the smallest amount. Trades on SEAQ international can and do receive price improvements, but the quoted spread on the Paris Bourse

represents the price you actually pay, so the "equivalent" or "realistic" spread on SEAQ international is being overstated. Comparing the effective spreads also has pitfalls. While De Jong *et al* (1995) categorize trades by size, they also note that trades on SEAQ international tend to be much bigger, and so the average size of trade in each category will not be equal, nor will the relative frequency of occurrence. This however, is not sufficient to explain the large difference in average effective spread (0.3% in Paris, and 1.3% in London). De Jong *et al* (1992) go on to explain that the differences in tax and that fact that many SEAQ International trades are shown net of commission, have a significant impact on the results. For some trade sizes (above normal market size) the transactions appear to be cheaper on SEAQ International, net of all charges.

A further problem with trading in stocks away from the domestic or centralized market is that of information. While modern electronic methods of communication mitigate the issue, there is a belief that being physically near to the market aids with the speed and quality of information retrieval. Even if this does not happen, the perceived risk could have an impact on the market. If it was the case that SEAQ International lagged behind the Paris Bourse in terms of prices reflecting information, then it would be a valid strategy for informed French traders to exploit the availability of trading in London. That would increase the asymmetry of information and so lead to a higher spread to compensate the market makers for the risk.

Finally, Venkataraman (2001) quotes an unpublished paper by Mike Piwowar studying the transaction costs of securities listed on the Paris Bourse and the NYSE. Piwowar finds that French stocks have lower transaction costs on the Paris Bourse, and American stocks have lower transaction costs on the NYSE. It may be that domestic stocks attract greater order flow through familiarity or national pride or

prejudice, or for any number of practical reasons, but the result suggests that there is a domestic stock bias, and so studies of cross listed stocks are of limited use.

3.12.4 Matched Samples

Having established the limitations of cross listed stock comparison, Haung and Stoll (1996) proposed another method of comparing exchanges. They created matched samples of stocks on the NYSE and NASDAQ. They chose the 175 largest NASDAQ stocks and matched them to NYSE stocks with the same industry classification using stock price, leverage, the ratio of book to market value, and market value of equity. They state that "some of these variables are also correlated with factors that have been found to determine bid-ask spreads" but go no further in justifying the choice of matching variables. Stock price is used as a proxy for the tick size as a proportion of the share price. Market value of the equity is used as larger companies typically have a more liquid market. Leverage may be thought of as a proxy for volatility, which would also affect the spread. It is not clear what the ratio of book to market value adds to the matching strategy.

Having matched the stocks, Haung and Stoll (1996) calculate the average spread for the whole of 1991. They calculate the spread in several ways. The quoted half spread, which is the difference between the quoted ask and the quoted bid, divided by two, was found to be much larger on NASDAQ than NYSE. Even correcting for trade size they find that the NASDAQ quoted half spread is nearly double that on the NYSE. One explanation might be the potential for price improvements on the NASDAQ dealer market, as explained in the previous section. However, the effective half spread, calculated as the difference between the trade price and the quoted midpoint, shows similar results. They both demonstrate that the price improvements available on the NYSE are even better than those on NASDAQ. Price improvements cannot occur on the order book unless market orders are stopped by

the specialist and traded elsewhere. This implies that most of the price improvement on NYSE is due to the floor traders. There are two explanations for this. It is possible that floor traders can trade with a much smaller spread than the limit order book. However, it is also possible that the floor trader spread is not centred around the same price as the order book. Since the measure of effective half spread is calculated as the difference between the trade price and the quoted mid point (on the order book), this will overstate or understate a realistic measure of effective half spread for each trade through the floor brokers. So would the over and understatements cancel out? Well, if two competing mechanisms in a common value environment are in price disequilibrium then one (or both) will tend to move towards the other. The net result may depend on which is the dominant price setting market, but if the order book midpoint was higher than the price at which the floor traders were trading we might expect there to be more buy orders sent through the floor traders. These purchases would be below the order book midpoint, and actually produce a negative value for the effective half spread. Clearly, this would bias the results.

The above argument assumes that all trades are correctly classified as buyer or seller initiated. This data was not recorded on either market during 1991, and so Haung and Stoll (1996) used the Lee and Ready algorithm. Roughly speaking, this algorithm compares the trade price with the last trade price and the prevailing spread and determines whether it was more likely to be a buy or a sell. Lee and Rashakrishna (2000) revisit the Lee and Ready algorithm, and find that for a sample of trades processed by SuperDOT, it predicts the direction of the trade 93% of the time. When broken down slightly, they also state that it has a 76% success rate when the trade occurs within the spread, and only a 60% success rate if it occurs at the same price as the previous trade. These statistics support the use of the Lee and Ready algorithm, but they do not address the issue of trades on the floor, which are

excluded from the empirical results. This issue was also ignored in Haung and Stoll's results, which did include the trades from the floor.

If a market maker adjusts the spread to keep it smaller when they believe trading is going to occur in one direction, does this mean it's cheaper to trade on this platform? They often say that market makers widen the spread when they perceive a risk of information asymmetry, but if they think they know what direction this is (due to past trading) there is no need to widen the spread, but rather to move it. By moving it, you are more likely to get traders on the other side.

Venkataraman (2001) mentions the "higher commissions of the floor broker" compared with routing the order through the SuperDOT order book, but ignored this for most of the study. Near the end of the paper he goes on to mention evidence from the consultants Elkins McSherry Co. that the commissions on large transactions, (likely to trade on the upstairs market at the Paris Bourse, and so excluded from the sample) are larger than the average commissions for institutional trades on the NYSE (included in the sample). The average commission was 22.84 basis points in France and 13.4 basis points in the USA. Venkataraman (2001) also states that "the brokerage commission for small trades in the United States and France has been dramatically reduced with the entry of online brokerage houses, and are comparable across the two markets." In the note attached to this comment, he admits that the online brokerage houses in the USA send orders to regional exchanges (excluded from the sample) while the online brokerage houses in France send the orders to the limit order book (included in the sample).

The effective spread that Venkataraman (2001) uses, is twice the difference between trade price on the trading floor and the midpoint of the quotes on SuperDOT. This is theoretically a common value environment, but results that show significant price improvements indicate that it is not. There is no appropriate spread to use in this

case, but we could put an upper and lower bound on it. Choosing a buy order, without loss of generality, a realistic spread would be bound on the offer side by the transaction price, and on the bid side by the SuperDOT bid quote. Using figures from Venkataraman (2001), the NYSE quoted spread was 32.39 basis points, and the effective spread was 21.22. This means that the average transaction price was 21.22/2 = 10.61 away from the midpoint, and an average quote that was 32.39/2 = 16.20. Using out alternative bound for the other side of the spread we would calculate a re-centred effective spread of 26.81 (16.20 + 10.61). And so, we conclude that the effective spread is somewhere between 21.22 and 26.81 basis points, which is significant since the effective spread on the Paris Bourse is 24.45.

In a working paper, Naik and Yadav (2002) show an alternative means of comparison, exploiting the fact that LSE switched from a dealer market to an automated order book. Looking at transaction costs in the exchange before, shortly after and 2 years after the change in trading platform, they make several conjectures. They find that "the arguably increased competition arising from the introduction of a limit order book into the London dealer market did not drive down transaction costs in competing trade-size segments". This ignored many of the issues regarding investor behaviour and how to compare the spread measures for these two market types. These issues will be addressed in subsequent chapters. Nailk and Yadav (2002) also state that "the introduction of a competing limit order book increased the relative proportion of informed trading and liquidity trading through the dealer network in London". This stands contrary to the belief that the anonymous order book market would attract the informed order flow. Perhaps, the ability to hide trading intentions by keeping them away from the order book is more efficient than the ability of dealers to detect informed trades.

Throughout the literature of market microstructure comparisons, we use the transaction costs incurred by market orders, ignoring the limit order strategy that

many investors employ. Madhavan (2001) comments that "it is unclear how to interpret effective spreads or a mixed hybrid market like the NYSE where the dealer has a small, but significant, participation rate". The aim of these studies is to measure the "cost of immediacy". This is not clear cut on the NYSE. A market order can be submitted to the SuperDOT order book, but remain unexecuted for a while. According to Bacidore *et al* (1999), 5% of the number and 45% of the volume of market orders are routed to the floor brokers. The rules of the exchange dictate that a market order can not execute at a worse price than if it had been immediately executed and so the specialist effectively underwrites the risk. But once the order is in the hands of the floor brokers, the trades are matched (like limit orders and market orders) with some winners and some losers. Whether the floor trading market is centred around the same price as the order book or not, we might expect these trades to have a net average efficient spread close to zero.

4 MARKET MAKER V AUTOMATED ORDER BOOK

4.1 Introduction

Market structures vary in many ways. Madhavan (1992) demonstrates that "a periodic trading mechanism can function where a continuous market would fail". Perhaps this structure is superior, but the physical constraints and demands of investors make this impractical. Glosten (1994) and Seppi (1997) both conclude that, of the major market types in existence, there is no clearly superior structure.

There has been a worldwide trend for exchanges to switch from dealer markets to automated order books. Automated order books are not bound by physical restriction, so they appeal to international investors. The transparency is also appealing to private investors, who can trade on an equal footing with professionals. However, the practice of designing the market microstructure depends heavily on who owns the exchange, and what they gain from it. The NYSE is owned by the member firms that gain from the commission that they generate from their floor trading services. This may be a reason for the NYSE being slow to follow the trend of automated order book markets. Despite pressure exerted by market makers, in 1996, the London Stock Exchange introduced SETS (Stock Exchange Trading System), an automated order book, to replace SEAQ (Stock Exchange Automated Quotation), a multiple dealer market, for the most liquid stocks.

There have been different approaches to comparing aspects of market microstructure. Amihud and Mendelson (1987), Biais *et al* (1999), and Madhavan and Panchagesan (2000) compare trading activity during the opening procedure and the continuous daily market. They find that prices set during the auction process are very informative, but they cannot conclude much about other aspects of the market

structure. Schmidt and Iversen (1993), Lee (1993), Petersen and Fialkowski (1994), DeJong *et al* (1995) and Bessembinder and Kaufman (1997) compare the execution costs for cross listed stocks. Their results vary, but they all note that trading activity for the primary listing or domestic market, is greater than on the alternative platform. The importance of this relationship is hard to quantify, and so attributing results to other aspects of the market design is difficult. Haung and Stoll (1996) and Venkataraman (2001) compare matched samples of stocks on different stock exchanges. These samples are matched in terms of size, price, trading activity and market sector. Haung and Stoll (1996) compare the NYSE with Nasdaq. They conclude that recorded execution costs are lower in the NYSE auction market than in the Nasdaq dealer market. Venkataraman (2001) finds that the NYSE has lower execution costs than the Paris Bourse, thus concluding that the floor traders add value to the trading process. Conrad et al (2002) look directly at the decisions made by institutional investors faced with a choice of trading platform. While many of the conclusions differ in the microstructure literature there is a consensus that the professional relationships built up on a trading floor (or a telephone based market with competing market makers), add value to the process of price discovery and reduce transaction costs.

The problems that cloud the conclusions of these studies vary. For example, comparisons of NYSE and Nasdaq ignore the issue of commission. Haung and Stoll (1996) explain that trades on the NYSE larger than £10,000 shares incur commission, while Nasdaq spreads include the full cost of trading. Each market has alternative methods of trading. Nasdaq offers a Small Order Execution Service (SOES) for trades of less than 1000 shares. These trades are ignored in the calculations of market efficiency, even though Chan and Fong (2000) highlighted the importance of these trades as they convey more information than even the largest orders sent to the market makers.

Comparisons across international markets have even greater limitations. The demand for trading can come from different sources. The SEAQ International market (superseded by SEATS international) on the LSE attracts institutional investors worldwide, while the Paris Bourse has a largely domestic investor profile, including many individuals. Given that different groups of investors have different investment needs (liquidity requirements, tax mitigation, time horizon of matched liabilities, risk aversion) and a different economic and political environment, along with access to different information, and understanding of the foreign market, it is not surprising that transaction costs differ.

An important assumption regarding trader behaviour is that large traders tend to be better informed than small traders. This is partly attributed to the gulf, in terms of relevant knowledge, between institutional investors and individuals and also to the fact that an investor is more likely to want to trade in large volumes to exploit good information. Another assumption is that informed traders trade quickly, for fear of the information leaking out before it can be exploited. Keim and Madhavan (1995) recognise that this classification may be too simplistic e.g. a tracker fund must buy a stock as it enters the index, and so would become a large aggressive uninformed trader. Barclay and Warner (1993) also look at the possibility of stealth trading, where informed traders use many small trades to fill their order. It is this recognition that the order strategy may depend on the microstructure that is particularly important. If informed traders trade small on an order book, and large through a trading floor, measures of information should reflect this.

When discussing investor behaviour it is important to define the alternatives available. Uninformed traders on the Paris Bourse may decide to take their orders to the upstairs market, or send a market order to the order book, or place a limit order inside, outside or at the spread. They may also decide to split the order to minimise

the market impact or hide their intentions. Uninformed traders in a SEAQ stock have far less choice.

This chapter explores the importance of human intermediation, by comparing the execution costs incurred on SETS and SEAQ. The chapter is arranged as follows: Section 2 describes the efficiency measures and Sections 3 and 4 cover the data and research design. In Section 5 we discuss the results of the comparison, Section 6 presents the results of an alternative methodology, Section 7 discusses asymmetric information risk, and we conclude in Section 8.

4.2 Measures of Efficiency

We calculate the statistics using a similar method to Venkataraman (2001) for ease of comparison. These four measures are also used in previous studies (Haung and Stoll (1996), Bessembinder and Kaufman (1997)), although different names have been used on occasion. There are three measures of efficiency, and an indicator of asymmetric information. The first measure is the Quoted Spread:

$$\text{Percentage Quoted Spread}_{it} = 100 * (\text{Offer}_{it}-\text{Bid}_{it}) / \text{Mid}_{it}$$

Offer_{it} and Bid_{it} are the best offer and bid prices quoted by market makers on SEAQ or the best bid and offer prices shown on the SETS limit order book for a given stock (i) and trade (t). Mid_{it} is the midpoint of the offer and bid prices.

The quoted spread is averaged without weighting. The rationale behind this method is that we only care about the spread when trades take place. Other arguments could be made, and Venkataraman (2001) uses a time weighted average. The time weighted average makes no allowance of how many trades were placed in a given period. Furthermore, erroneous results may creep in as a result of calculating the

spread during a trading halt, or when the market is closed (e.g. days closed early). The only clear advantage of calculating a time weighted average is to maitain consistency with Venkataraman (2001). The limitations of the time weighted average, and the computational cost outweigh this gain. This issue is discussed further in the next section.

The Effective Spread represents the cost of immediacy:

$$\text{Percentage Effective Spread}_{it} = 200 * D_{it} * (\text{Price}_{it} - \text{Mid}_{it}) / \text{Mid}_{it}$$

D_{it} is a dummy variable that equals 1 for a buy order and –1 for a sell order. Price_{it} is the transaction price.

The Price impact is used as an indicator of the likelihood of a trade containing information. It represents the permanent affect on prices of a trade.

$$\text{Percentage Price Impact}_{it} = 200 * D_{it} * (V_{i,t+n} - \text{Mid}_{it}) / \text{Mid}_{it}$$

$V_{i,t+n}$ is the mid price at the time of the first trade more than n minutes after the original trade. For this comparison, we have taken n to be 30 minutes.

Finally we calculate the Percentage Realized Spread. This represents the total cost of trading, including the immediate execution cost and the gain due to moving the market. Note that the realized spread is simply the effective spread less the price impact, as defined above.

$$\text{Percentage Realized Spread}_{it} = 200 * D_{it} * (\text{Price}_{it} - V_{i,t+n}) / \text{Mid}_{it}$$

4.3 Data

The data set was obtained from the London Stock Exchange. It includes details of the best bid and offer prices quoted by SEAQ market makers and every limit order placed onto the SETS order book. Each quote is time stamped to the nearest second. A separate data set records every trade with a time stamp to the nearest second, along with the quantity, price, participant codes, and whether it was reported by the buyer or the seller. For certain trade types (e.g. the ordinary trades in SEAQ stocks and the automated trades in SETS stocks) we can say with certainty whether the trade was initiated by the buyer or the seller. These two data sets have been combined to show the quoted spreads at the time of each trade. SETS market orders may be matched against several limit orders. Each transaction is recorded separately, but the combined details of the trade can be collated through the unique order code.

Timing of trades is vital for the comparison and so trades reported late are excluded from the sample. Inspection of the data also highlighted errors. Occasionally prices were typed with the decimal point in the wrong place, or the figures were reversed, or the figures were simply implausible. The incidence of obvious errors in the data were small (less than 1%), and so they were simply deleted from the sample if:

1. The Bid or Offer prices were non positive
2. The effective spread was greater than 20% of the quoted spread
3. The quoted spread was less than zero or greater than £10
4. The trade occurred out of hours.
5. The trade was reported and then corrected
6. The mid price 30 minutes after the trade was zero

While there is no official dealer market for SETS stocks, a significant proportion of trades occur away from the order book. These are trades organised with retail

brokers or transactions between brokerage firms. Proportions of trade types are shown in Table 4.1. This paper compares the market makers and an automated order book, so only the trades on the order book have been included in the SETS sample.

Venkataraman (2001) addresses this issue for the NYSE, stating that only 5% of trades and 42% of the share volume go through the trading floor. Venkataraman includes every trade in the sample, and not just those occurring on the trading floor. It could be argued that this dilutes the impact of the trading floor in the statistics, but data limitations and the hybrid nature of the NYSE led him to make this decision. Here, we are interested in the automated trades only as these represent all of the trades on the formally defined exchange.

SEAQ trades were matched up with the transaction reports, to identify the presence of a market maker in the trade. All trades with a market maker on one and only one side of the trade were included.

4.4 Research Design

All FTSE 250 stocks trading on SETS at 1 September 1998 were matched with FTSE 250 stocks trading on SEAQ. Certain stocks were excluded from the list of potential matches. Companies that changed trading platform were excluded. Companies that delisted, went bankrupt, were taken over or merged during the period were excluded. This was done to simplify calculations. There is no reason to believe that this introduces a bias.

While the FTSE 250 constituents trading on SETS tend to be the larger companies, it is possible to match pairs of companies using the same method as Venkataraman (2001). Table 4.2 shows the sample of matched stocks. We use 4 different algorithms:

1. Price and Market Capitalisation.
2. Price and Trading Volume.
3. Industry, Price and Market Capitalisation.
4. Industry, Price and Trading Volume.

Trading Volume is calculated as the total trading volume reported to the exchange throughout the period of review. This includes the trades that occurred away from the SETS order book, or the SEAQ market makers. Trading volume in this context is a proxy for liquidity, so it is sensible to look at all methods of trading rather than the subset of trades that we are concentrating on in this paper.

Market Capitalisation is calculated at the start of the period of study. Perhaps it would be more appropriate to average market capitalisation over the period but the opening figure is used to be consistent with Venkataraman (2001). This is unlikely to make any significant difference to the results.

Price is used to ensure that the tick size as a relative proportion of the stock price is consistent. Although price is proportional to market capitalisation for a given stock, the same cannot be said when comparing stocks. This is why both price and market capitalisation may be used together.

Matching by industry is harder for FTSE stocks than many other markets, as the subdivision is much finer (by the FTSE Actuaries All Share classification). Where possible, we have matched stocks by sub-sector, but if no stock was available, we have used stocks from the same sector. In a few cases, this has meant matching the likes of a tobacco company with a health company. The purpose of matching by industry is to account for trends in demand. While stocks in the same sector have similar characteristics, there are reasons why share prices would move together, e.g.

TABLE 4.1 BREAKDOWN OF TYPES OF TRADE EXECUTED IN EACH MARKET

FTSE 250 SEAQ

September 1998			July 2002	
Number of Trades	Trading Volume		Number of Trades	Trading Volume
52.75	87.42	Ordinary Trades	54.70	88.69
11.07	1.82	Protected Transactions	16.35	1.86
15.98	2.07	Single Protected Transaction	12.03	2.09
7.04	4.61	Market Maker to Market Maker	4.52	3.30
6.06	0.91	Cross at same price	6.56	0.76
4.85	2.69	Non Protected Portfolio	4.32	2.77
2.25	0.49	Other Trades	1.50	0.53

FTSE 250 SETS

September 1998			July 2002	
Number of Trades	Trading Volume		Number of Trades	Trading Volume
18.22	31.20	Automatically Executed Trades	23.94	52.08
61.89	64.50	Ordinary Trades	58.07	44.18
9.22	0.89	Cross at same price	6.20	0.42
4.57	0.17	Worked Principal Trade	2.44	0.06
3.82	2.71	Non Protected Portfolio	5.05	1.41
1.38	0.15	Protected Portfolio	0.77	0.11
0.43	0.17	Volume Weighted Average Price	2.49	0.17
0.46	0.21	Other Trades	1.04	1.57

FTSE 100 SETS

September 1998			July 2002	
Number of Trades	Trading Volume		Number of Trades	Trading Volume
27.31	53.26	Automatically Executed Trades	36.41	65.23
56.95	44.59	Ordinary Trades	47.88	30.95
3.56	0.29	Cross at same price	1.58	0.17
4.26	0.09	Worked Principal Trade	0.68	0.01
5.60	1.55	Non Protected Portfolio	3.57	0.75
1.22	0.05	Protected Portfolio	0.72	0.05
0.86	0.10	Volume Weighted Average Price	6.99	0.31
0.25	0.06	Other Trades	2.18	2.53

Transactions were summed for the calender months shown above.
Samples included all stocks on the appropriate index and platform for the whole month.
Figures shown are percentages of the total number or volume of trading in that month.

TABLE 4.2A MATCHED SAMPLE: MATCHED BY PRICE AND MARKET CAPITALISATION

Stock	Sub Sector	Sector	Price	Market Capitalization	Deviation	Price	Market Capitalization	Stock	Sub sector	Sector
BPB	Building & Construction Materials	Basic Industries	2.3	1486.69	0.121	2.525	1281.07	AVIS EUROPE	Transport	C Services
BR.STEEL	Steel & other metals	Basic Industries	0.895	2080.05	0.224	1.055	1563.17	COCA-COLA BEV.	Food Producers & Processors	NC Consumer Goods
CMG	Software & Computer Services	Information Technology	16	2146.01	0.596	11.15	882.82	NAT.EXPRESS	Transport	C Services
ELECTROCOMPS.	Distribution	C Services	3.935	1610.93	0.018	3.86	1585.41	AIRTOURS		C Services
EMAP	Media & Photography	C Services	11.33	2128.53	0.222	11.625	1393.34	PENNON GROUP	Utilities Other	Utilities
GALLAHER GRP.	Tobacco	NC Consumer Goods	4.0875	2508.15	0.438	4.795	1183.71	SMITH(WH)GRP.	General Retailers	C Services
LONRHO	Diversified Industries	General Industries	3.25	79.57	0.589	5.05	173.87	WILSON BOWDEN	Construction & Building Materials	Basic Industries
MEPC	Real Estate	Financials	4	1733.97	0.092	3.95	1459.31	FIRSTGROUP	Transport	C Services
NEXT	General Retailers	C Services	4.825	1673.63	0.174	3.71	1533.42	BBA GRP.	Transport	C Services
NTHN.ROCK	Banks	Financials	5.55	2255.52	0.044	5.525	2454.04	YORK.WATER	Water	Utilities
PROVIDENT FIN.	Speciality & Other Finance	Financials	8.7	2307.36	0.574	5.225	1177.14	LOGICA	Software & Computer Services	Information Technology
RANK GRP.	Leisure Entertainment & Hotels	C Services	2.275	2101.29	0.358	2.355	1033.56	BUNZL	Support Services	C Services
RMC GRP.	Construction & Building Materials	Basic Industries	8.2	2049.12	0.479	8.375	742	SETON SCHOLL	Health	NC Consumer Goods
SMITH&NEPHEW	Health	NC Consumer Goods	1.8	1569.66	0.324	1.405	1044.99	NTHN.FOODS	Food Producers & Processors	NC Consumer Goods
TARMAC	Construction & Building Materials	Basic Industries	1.135	733.74	0.081	1.02	693.66	CARADON		
TATE & LYLE	Food Producers & Processors	NC Consumer Goods	3.4	2005.86	0.254	3.575	1258.07	DEBENHAMS	General Retailers	C Services
TI GRP.	Engineering & Machinery	General Industries	3.175	1823.58	0.083	2.79	1891.25	MORRISON (WM)	Food & Drug Retailers	NC Services
UTD.BISCUITS	Food Producers & Processors	NC Consumer Goods	2.385	943.44	0.033	2.375	1003.19	IMI	Engineering & Machinery	General Industries
WOLSELEY	Construction & Building Materials	Basic Industries	3.7	3695.38	0.164	2.66	3695.38	VAUX GRP.	Brewing	NC Consumer Goods
IMP.TOBACCO GRP	Tobacco	NC Consumer Goods	6.3	2750.13	0.399	5.66	1337.82	ALLIANCE UNICHM	Health	NC Consumer Goods
		sum	89.7275	14798.29	1.605	92.765	14368.9			
		average	3.901195652	643.403913	0.070	4.0332609	624.7347826			

FTSE 250 SETS stocks are shown on the left, matched FTSE SEAQ stocks on the right.

Sector and Sub Sector are as per FTSE All Share classification.

Price is shown in pounds

Market Capitalisation shown in millions

Deviation is the average deviation statistic, calculated as half the difference in price over the sum of prices.

plus half the difference in market capitalisation divided by the sum of market capitalisation, all divided by two.

TABLE 4.2B MATCHED SAMPLE: MATCHED BY PRICE AND TRADING VOLUME

Stock	Sub Sector	Sector	Price	Trading Volume	Deviation	Price	Trading Volume	Stock	Sub sector	Sector
BPB	Building & Construction Materials	Basic Industries	2.3	1.074462891	0.114	2.355	0.87456086	BUNZL	Support Services	C Services
BR.STEEL	Steel & other metals	Basic Industries	0.895	3.27053492	0.601	0.8775	0.841124999	AEGIS GRP.	Media & Photography	C Services
CMG	Software & Computer Services	Information Technology	16	0.987446064	0.188	11.625	0.929927233	PENNON GROUP	Utilities Other	Utilities
ELECTROCOMPS.	Distribution	C Services	3.935	0.995467407	0.214	3.78	0.672449439	ARRIVA	Transport	C Services
EMAP	Media & Photography	C Services	11.33	1.782674771	0.616	11.515	0.434605934	SERCO GRP.	Support Services	C Services
GALLAHER GRP.	Tobacco	NC Consumer Goods	4.0875	1.845213228	0.080	3.71	1.733375261	BBA GRP.	Transport	C Services
LASMO ORD.	Oil Exploration & Production	Resources	1.035	1.803715584	0.331	1.345	1.200772151	FKI	Engineering & Machinery	General Industries
LONRHO	Diversified Industries	General Industries	3.25	0.614323893	0.103	3.49	0.703307395	BOWTHORPE		
MEPC	Real Estate	Financials	4	0.832739705	0.050	4.055	0.907551422	JOHNSON,MATTH.	Chemicals	Basic Industries
NEXT	General Retailers	C Services	4.825	2.808143842	0.105	5.225	2.464911923	LOGICA	Software & Computer Services	Information Technology
NTHN.ROCK	Banks	Financials	5.55	1.66634426	0.138	5.525	1.268148292	YORK.WATER	Water	Utilities
PROVIDENT FIN.	Speciality & Other Finance	Financials	8.7	1.038403059	0.080	8.375	0.919071376	SETON SCHOLL	Health	NC Consumer Goods
RANK GRP.	Leisure Entertainment & Hotels	C Services	2.275	1.207253629	0.036	2.375	1.173304286	IMI	Engineering & Machinery	General Industries
RMC GRP.	Construction & Building Materials	Basic Industries	8.2	1.422795141	0.263	4.795	1.424812627	SMITH(WH)GRP.	General Retailers	C Services
SMITH&NEPHEW	Health	NC Consumer Goods	1.8	0.979000484	0.200	2.32	759580787.4	BARRATT DEVEL.	Construction & Building Materials	Basic Industries
TARMAC	Construction & Building Materials	Basic Industries	1.135	0.668789343	0.050	1.055	0.651108284	COCA-COLA BEV.	Food Producers & Processors	NC Consumer Goods
TATE & LYLE	Food Producers & Processors	NC Consumer Goods	3.4	0.855021038	0.062	3.475	0.771227843	HAMMERSON	Real Estate	Financials
TI GRP.	Engineering & Machinery	General Industries	3.175	1.556880441	0.110	3.575	1.407857109	DEBENHAMS	General Retailers	C Services
UTD.BISCUITS	Food Producers & Processors	NC Consumer Goods	2.385	0.57584338	0.060	2.235	0.544441737	MANCHESTER UTD.	Leisure Entertainment & Hotels	C Services
WOLSELEY	Construction & Building Materials	Basic Industries	3.7	1.290995809	0.039	3.95	1.274752853	FIRSTGROUP	Transport	C Services
BLUE CIRCLE	Construction & Building Materials	Basic Industries	3.1	1.987107112	0.142	3.86	2.12276373	AIRTOURS		C Services
BURMAH CAST.	Oil & Gas	Resources	8.77	0.885525522	0.167	11.15	0.805694851	NAT.EXPRESS	Transport	C Services
DAILY MAIL'A'	Media & Photography	C Services	28.05	0.876719746	0.729	5.8	0.759868139	PSION	Electronic & Electrical Equipment	General Industries
ENTERPRISE OIL	Oil Exploration & Production	Resources	3.05	1.779422415	0.390	2.83	0.851649447	ASS.BR.PORTS	Transport	C Services
IMP.TOBACCO GRP	Tobacco	NC Consumer Goods	6.3	2.860974176	0.612	5.525	0.838895439	CAPITA GROUP	Support Services	C Services
		sum	153.7275	36.13438712	5.601	125.8325	26.83554357			
		average	5.912596154	1.38978412	0.215	4.8397115	1.032136291			

FTSE 250 SETS stocks are shown on the left, matched FTSE SEAQ stocks on the right.

Sector and Sub Sector are as per FTSE All Share classification.

Price is shown in pounds

Trading volume shown in millions of pounds.

Deviation is the average deviation statistic, calculated as half the difference in price over the sum of prices.

plus half the difference in trading volume divided by the sum of trading volume, all divided by two.

TABLE 4.2C MATCHED SAMPLE: MATCHED BY INDUSTRY, PRICE AND MARKET CAPITALISATION

Stock	Sub Sector	Sector	Price	Market Capitalization	Deviation	Price	Market Capitalization	Stock	Sub sector	Sector
BPB	Building & Construction Materials	Basic Industries	2.3	1486.69	0.607	2.32	368.18	BARRATT DEVEL.	Construction & Building Materials	Basic Industries
BR.STEEL	Metals	Basic Industries	0.895	2080.05	0.638	0.6925	674.86	AGGREGATE IND.	Construction & Building Materials	Basic Industries
ELECTROCOMPS.	Distribution	C Services	3.935	1610.93	0.018	3.86	1585.41	AIRTOURS		C Services
EMAP	Media & Photography	C Services	11.33	2128.53	0.730	6.055	855.41	FLEXTECH	Media & Photography	C Services
GALLAHER GRP.	Tobacco	NC Consumer Goods	4.0875	2508.15	0.403	2.66	3695.38	VAUX GRP.	Brewing	NC Consumer Goods
LONRHO	Diversified Industries	General Industries	3.25	79.57	0.650	1.815	171.58	VICKERS	Engineering & Machinery	General Industries
MEPC	Real Estate	Financials	4	1733.97	0.271	3.475	1154.24	HAMMERSON	Real Estate	Financials
NEXT	General Retailers	C Services	4.825	1673.63	0.175	4.795	1183.71	SMITH(WH)GRP.	General Retailers	C Services
NTHN.ROCK	Banks	Financials	5.55	2255.52	0.537	5.475	693.2	CLOSE BROS.	Speciality & Other Finance	Financials
PROVIDENT FIN.	Speciality & Other Finance	Financials	8.7	2307.36	0.671	6.4	730.55	CATTLES	Speciality & Other Finance	Financials
RANK GRP.	Leisure Entertainment & Hotels	C Services	2.275	2101.29	0.682	2.235	410.44	MANCHESTER UTD.	Leisure Entertainment & Hotels	C Services
SMITH&NEPHEW	Health	NC Consumer Goods	1.8	1569.66	0.263	1.055	1563.17	COCA-COLA BEV.	Food Producers & Processors	NC Consumer Goods
TARMAC	Construction & Building Materials	Basic Industries	1.135	733.74	0.220	1.38	573.43	ASHTEAD GRP.	Construction & Building Materials	Basic Industries
TATE & LYLE	Food Producers & Processors	NC Consumer Goods	3.4	2005.86	0.418	2.66	3695.38	VAUX GRP.	Brewing	NC Consumer Goods
TI GRP.	Engineering & Machinery	General Industries	3.175	1823.58	0.434	2.375	1003.19	IMI	Engineering & Machinery	General Industries
UTD.BISCUITS	Food Producers & Processors	NC Consumer Goods	2.385	943.44	0.310	1.405	1044.99	NTHN.FOODS	Food Producers & Processors	NC Consumer Goods
WOLSELEY	Construction & Building Materials	Basic Industries	3.7	3695.38	0.685	4.055	813.84	JOHNSON,MATTH.	Chemicals	Basic Industries
IMP.TOBACCO GRP	Tobacco	NC Consumer Goods	6.3	2750.13	0.399	5.66	1337.82	ALLIANCE UNICHM	Health	NC Consumer Goods
		sum	73.0425	33487.48	8.110	58.3725	21554.78			
		average	4.057916667	1860.415556	0.451	3.2429167	1197.487778			

FTSE 250 SETS stocks are shown on the left, matched FTSE SEAQ stocks on the right.

Sector and Sub Sector are as per FTSE All Share classification.

Price is shown in pounds

Market Capitalisation shown in millions

Deviation is the average deviation statistic, calculated as half the difference in price over the sum of prices.

plus half the difference in market capitalisation divided by the sum of market capitalisation, all divided by two.

TABLE 4.2D MATCHED SAMPLE: MATCHED BY INDUSTRY, PRICE AND TRADING VOLUME

Stock	Sub Sector	Sector	Price	Trading Volume	Deviation	Price	Trading Volume	Stock	Sub sector	Sector
BPB	Building & Construction Materials	Basic Industries	2.3	1.074462891	0.176	2.32	0.759580787	BARRATT DEVEL.	Construction & Building Materials	Basic Industries
BR.STEEL	Steel & other metals	Basic Industries	0.895	3.27053492	0.705	0.6	1.069231268	PILKINGTON	Construction & Building Materials	Basic Industries
ELECTROCOMPS.	Distribution	C Services	3.935	0.995467407	0.125	3.95	1.274752853	FIRSTGROUP	Transport	C Services
EMAP	Media & Photography	C Services	11.33	1.782674771	0.385	11.15	0.805694851	NAT.EXPRESS	Transport	C Services
GALLAHER GRP.	Tobacco	NC Consumer Goods	4.0875	1.845213228	0.679	8.375	0.919071376	SETON SCHOLL	Health	NC Consumer Goods
LASMO ORD.	Oil Exploration & Production	Resources	1.035	1.803715584	0.483	1	0.657741832	BR.BORNEO OIL	Oil & Gas	Resources
LONRHO	Diversified Industries	General Industries	3.25	0.614323893	0.081	2.78	0.610650224	MORGAN CR.	Engineering & Machinery	General Industries
MEPC	Real Estate	Financials	4	0.832739705	0.109	3.475	0.771227843	HAMMERSON	Real Estate	Financials
NEXT	General Retailers	C Services	4.825	2.808143842	0.330	4.795	1.424812627	SMITH(WH)GRP.	General Retailers	C Services
NTHN.ROCK	Banks	Financials	5.55	1.66634426	0.534	5.48	0.515916628	ELECTRA INV.TST	Investment Companies	Financials
PROVIDENT FIN.	Speciality & Other Finance	Financials	8.7	1.038403059	0.483	6.4	0.522863795	CATTLES	Speciality & Other Finance	Financials
RANK GRP.	Leisure Entertainment & Hotels	C Services	2.275	1.207253629	0.387	2.235	0.544441737	MANCHESTER UTD.	Leisure Entertainment & Hotels	C Services
RMC GRP.	Construction & Building Materials	Basic Industries	8.2	1.422795141	0.559	4.055	0.907551422	JOHNSON,MATTH.	Chemicals	Basic Industries
SMITH&NEPHEW	Health	NC Consumer Goods	1.8	0.979000484	0.678	8.375	0.919071376	SETON SCHOLL	Health	NC Consumer Goods
TARMAC	Construction & Building Materials	Basic Industries	1.135	0.668789343	0.122	1.1	0.540320807	WIMPEY(GEO)	Construction & Building Materials	Basic Industries
TATE & LYLE	Food Producers & Processors	NC Consumer Goods	3.4	0.855021038	0.485	1.405	0.74288043	NTHN.FOODS	Food Producers & Processors	NC Consumer Goods
TI GRP.	Engineering & Machinery	General Industries	3.175	1.556880441	0.285	2.375	1.173304286	IMI	Engineering & Machinery	General Industries
UTD.BISCUITS	Food Producers & Processors	NC Consumer Goods	2.385	0.57584338	0.216	1.665	0.533005635	GLYNWED INTL.	Food Producers & Processors	NC Consumer Goods
WOLSELEY	Construction & Building Materials	Basic Industries	3.7	1.290995809	0.482	4.38	0.555619158	BERKELEY GRP.	Construction & Building Materials	Basic Industries
BLUE CIRCLE	Construction & Building Materials	Basic Industries	3.1	1.987107112	0.506	4.055	0.907551422	JOHNSON,MATTH.	Chemicals	Basic Industries
DAILY MAIL'A'	Media & Photography	C Services	28.05	0.876719746	0.635	11.65	0.558228903	ADMIRAL	Support Services	C Services
IMP.TOBACCO GRP	Tobacco	NC Consumer Goods	6.3	2.860974176	0.734	5.66	0.544573592	ALLIANCE UNICHM	Health	NC Consumer Goods
		sum	125.9075	32.48199312	9.555	103.68	17.78095665			
		average	5.47423913	1.41226057	0.415	4.5078261	0.773085072			

FTSE 250 SETS stocks are shown on the left, matched FTSE SEAQ stocks on the right.

Sector and Sub Sector are as per FTSE All Share classification.

Price is shown in pounds

Trading volume shown in millions of pounds.

Deviation is the average deviation statistic, calculated as half the difference in price over the sum of prices.

plus half the difference in trading volume divided by the sum of trading volume, all divided by two.

change in raw material cost, but also apart, e.g. one company signs an important contract. Given the matching errors already introduced, it is reasonable to allow this slight deviation from the original research design. One exception to this rule is that of financials: investment trusts were not matched against other financials, as these have very different performance characteristics.

An Average Deviation statistic was calculated for each pair of stocks. For the first comparison, the average deviation is calculated as:

$$[[(Price_Q - Price_T) / (Price_Q + Price_T)] /2 + [(MC_Q - MC_T) / (MC_Q + MC_T)] /2]/2$$

where MC is the market capitalisation and the subscripts Q and T refer to SEAQ and SETS respectively. Each pair with an average deviation greater than 0.75, was excluded. Haung and Stoll (1996) sum over the square of the characteristic deviation, rather than simply sum, but we have used the method of Venkataraman (2001) for consistency.

Having matched the stocks into appropriate pairs, we collate the two samples: SEAQ and SETS. Each of the efficiency measures is averaged over each month in the sample. Each of the trade dependent measures is subdivided into the size of the trade:

£50,000 <	Very large	
£10,000 <	Large	< £50,000
£5,000 <	Medium	< £10,000
£1,000 <	Small	< £5,000
	Very small	< £1,000

These data points were then averaged over the year, and averaged over each stock and each sample.

A sample period of two years, starting from 1st of September 1998 was chosen. As companies move up and down the index, and switch trading platforms, it becomes more difficult to match the samples appropriately for the whole period. Two years was chosen as a compromise between this limitation, and the need for statistically significant results.

4.5 Comparison of Matched Stocks

Table 4.3 presents the results in the same format as Venkataraman (2001) for ease of comparison. Given that our sample relates to the less liquid stocks on the LSE, it is not surprising that the efficiency measures are higher (less efficient) than the NYSE and the Paris Bourse. Our results appear to contradict those of Naik and Yadav (2002), who use a different methodology.

4.5.1 Quoted Spread

The results show significantly higher quoted spreads on SEAQ than SETS. This agrees with the theoretical results of Glosten (1994), but contradicts the empirical findings of Venkataraman (2001). However, there are several reasons why the quoted spread should not be used to compare SEAQ with SETS (or any two markets with different structure). First, there are always opportunities for price improvement from SEAQ market makers, but what you see is what you get on the limit order book. Secondly, the quoted spread on SEAQ is usually quoted for normal market size, while the spread on the limit order book could be quoted for any quantity. For example, it is not uncommon for traders to front run the spread with small volume

TABLE 4.3 TRANSACTION COST MEASURES, BROKEN DOWN BY SIZE OF TRADE

		Industry, Price and Trading Volume			Industry, Price and Market Capitalization			Price and Trading Volume			Price and Market Capitalization		
		SETS	SEAQ	difference	SETS	SEAQ	difference	SETS	SEAQ	difference	SETS	SEAQ	difference
Quoted Spread	OVERALL	**65.90**	**173.63**	**107.73**	**65.41**	**157.33**	**91.92**	**67.27**	**127.85**	**60.59**	**66.16**	**134.60**	**68.44**
Effective Spread	very small	84.05	159.80	75.74	83.45	130.87	47.42	89.35	106.50	17.15	85.67	114.77	29.10
	small	74.87	140.12	65.25	72.79	122.88	50.09	76.43	99.17	22.73	73.58	101.05	27.47
	medium	68.47	117.69	49.22	66.90	113.46	46.56	69.47	90.68	21.20	67.57	87.95	20.38
	large	66.83	113.25	46.43	67.58	110.19	42.61	67.23	90.76	23.53	67.25	91.08	23.83
	very large	63.50	66.55	3.05	62.66	59.86	-2.80	68.77	56.06	-12.70	68.79	56.10	-12.68
	OVERALL	**67.66**	**127.93**	**60.26**	**67.09**	**113.34**	**46.26**	**70.03**	**91.58**	**21.55**	**69.30**	**93.65**	**24.36**
Price Impact	very small	26.97	5.67	-21.30	22.95	3.18	-19.77	27.77	3.64	-24.13	21.79	2.90	-18.89
	small	21.59	8.66	-12.93	20.32	7.75	-12.57	21.68	6.91	-14.77	20.84	5.42	-15.42
	medium	31.97	12.94	-19.02	31.57	14.76	-16.81	32.27	11.51	-20.76	31.05	9.71	-21.34
	large	48.36	33.10	-15.27	48.73	36.05	-12.68	48.56	28.20	-20.36	48.74	25.38	-23.35
	very large	56.67	27.43	-29.24	54.78	26.22	-28.56	57.71	26.32	-31.40	55.49	24.80	-30.70
	OVERALL	**44.47**	**14.53**	**-29.94**	**43.85**	**14.29**	**-29.55**	**45.24**	**13.20**	**-32.05**	**44.17**	**11.24**	**-32.93**
Realized Spread	very small	57.09	154.13	97.04	60.51	127.69	67.19	61.58	102.86	41.28	63.88	111.87	47.98
	small	53.28	131.46	78.19	52.47	115.13	62.66	54.76	92.26	37.50	52.74	95.63	42.88
	medium	36.50	104.75	68.24	35.33	98.70	63.37	37.20	79.17	41.97	36.52	78.24	41.72
	large	18.46	80.16	61.69	18.85	74.14	55.29	18.67	62.56	43.89	18.51	65.70	47.18
	very large	6.83	39.12	32.29	7.88	33.65	25.77	11.05	29.75	18.69	13.29	31.31	18.02
	OVERALL	**23.19**	**113.40**	**90.20**	**23.24**	**99.05**	**75.81**	**24.79**	**78.38**	**53.60**	**25.12**	**82.41**	**57.29**

Data set includes all trades between 1/9/98 and 1/9/99. Trades were excluded if reported late or if the trade price was outside of the spread by more than 10%. Trading volume was averaged over the year. Price and market cap figures were taken as at 1/9/98. Industry specific stocks were matched by sub sector if possible, and by sector if not. Duplicates were removed (keeping the pair with the lowest "average deviation"). Figures are quoted in basis points.
very small < £1000 < small < £5000 < medium < £10000 < large < £50000 < very large
Quoted spread is the difference between the offer and bid price divided by the mid price
Effective Spread is two times the difference between the trade price and the mid price divided by the mid price
Price Impact is two times the difference between the mid price 30 minutes after the trade and the prevailing mid price, divided by the prevailingmid price.
Realised Spread is two times the difference between the trade price and the mid price 30 minutes after the trade, divided by the prevailing mid price.

quotes. This would understate the "realistic" spread. Thirdly, there is no generally accepted method to cope with the fact that trades occur at different times than quote revisions. Is it appropriate to evaluate the efficiency of trading with a measure that doesn't involve any aspect of a trade?

4.5.2 Effective Spread

Overall, the effective spreads are larger on SEAQ than on SETS, for each matching algorithm. Extrapolating the results from Venkataraman (2001), we would expect SETS to have larger spreads, but based on these figures it would appear that on the LSE, the order book is a more efficient trading platform.

The difference is largest for small trades (£1,000 - £4,999) and decreases with size. The decreasing transaction cost could be rationalised by the proportion of investors trading through the order book. For SETS stocks, uninformed traders of large volume may take their business to brokers off the market. This means that on average, we might expect large trades on the order book to contain more information than large trades on SEAQ. However the size related decrease in transaction cost is even more pronounced for SEAQ than it is for SETS, suggesting that other factors are involved. In fact, for very large trades (> £50,000), the overall result is reversed and transactions on SEAQ have a lower incurred cost than those on SETS. One possible explanation is time selection. On SEAQ, market makers may offer beneficial terms when they are certain of finding a counter party for the other side of the trade, thus reducing their own inventory risk. This can occur when large trades are offered to a market maker with a time restriction, much like an option or a limit order. The market maker can then try to find counter parties to this trade and earn (almost) risk free profits. There is no legally binding mechanism for this type of "offer to trade", but traders know that future trading terms would be jeopardised by reneging on an agreement. The equivalent time selection issue for SETS, is that

traders are only willing or able to place large market orders when liquidity is high (spreads are narrow and depth is high).

We observe a significant relationship between size of trade and transaction cost. This relationship has been long established, based on the idea that large trades convey more information or demand greater depth and so the execution costs are bigger. But in this case, we find the opposite result. Transaction costs decrease significantly with size for both SEAQ and SETS stocks. It would seem that while transaction costs increase with trade size for the larger stocks on the more liquid markets such as the NYSE or the Paris Bourse, the issues of time selection for SETS (orders are affected by the order book, rather than the other way round) and SEAQ (traders are willing to take the liquidity offered by market makers trying to control their inventory risk), becomes a more pertinent issue for less liquid markets like the mid cap stocks on the FTSE250. Any comparison of market types should therefore allow for the fact that the results may not hold for markets with fewer market participants or smaller company stocks.

We have used the absolute size to categorise trades. It could be argued that the relative size is more important, i.e. we should compare the percentage of a company being traded in any given transaction. However, two out of the four samples are matched using market capitalisation and this makes an approximate allowance for the relative size of trades. Nevertheless, the results will be weighted unevenly between stocks.

The figures vary between matching algorithms, particularly those that ignore the industry of each firm. However, the differences all have the same sign, and the trend by size is observed for each method.

4.5.3 Price Impact

Overall the price impact is higher on SETS than SEAQ. Previous research (Haung and Stoll (1996), Venkataraman (2001), interpret this statistic as a measure of information asymmetry. Given the alternative methods of trading available for SETS stocks, we might expect a greater proportion of the informed trades to go through the order book, and this is consistent with our result. However, the difference between the SETS and SEAQ values is too great to justify with this argument alone. Even if the off market trades had the equivalent of a zero price impact (there is no reason to justify a negative value), the weighted average would still be larger on SETS than SEAQ.

Another interesting result, is the relationship between Price Impact and size of trade. The relationship is roughly increasing with two exceptions. Very small trades on SETS have a larger price impact than small trades. This may be a result of deliberate market manipulation, whereby investors take advantage of the lack of depth to move the spread. It may also be explained by selection. If the markets are thin, some traders will be dissuaded from trading because of the transaction expenses (including the effect of moving the market). The traders who are not dissuaded by the thin markets would be those best informed. In this case we would expect the Price Impact to be greater. Another explanation is that the smallest trades represent the actions of private investors who are distanced from the exchange. They apply their trading strategy with less allowance for the state of the order book, and are less aware of the impact that the trade may have on the market.

The second exception to the rule of monotonically increasing Price Impact by trade size, is that very large trades on SEAQ have a lower price impact than large trades. When comparing the volume weighted Price Impact, the largest SEAQ trades have a smaller Price Impact than almost all other trade size categories. This can again be

explained within the asymmetric information paradigm. The uninformed traders in SEAQ stocks will try to justify to the market maker that they are uninformed in order to achieve a better price.

It is difficult to choose a time scale for this measure. The shorter the time scale, the bigger the impact of the size of the trade (informed trade or not), and the longer the time scale the more information from other sources and trades. I have used 30 minutes, to be consistent with Venkataraman (2001). Given that Venkataraman studies the most liquid stocks on the Paris Bourse and the NYSE, and I am studying the less liquid FTSE 250 stocks, it may be appropriate to use a longer time scale. A market maker in a SEAQ stock may decide not to change the spread for several hours. However, repeating the analysis with longer and shorter time scales produced consistent results.

Also, there is no reason to believe that an order book market and a market maker market would react to information at the same rate, e.g. 30 minutes may be appropriate for an automated order book, but much longer may be appropriate for a market maker market. It is possible that market makers are less concerned about updating quoted prices, since most trades occur within the spread. This would bias the result, as price improvements would be so long after the event that they would be more likely to include information from other sources. On the other side, market orders, which take liquidity from the market, may automatically change the spread. A large enough buy order (larger than the quoted depth) will increase the spread immediately. This does not dictate how other investors will react, but it explains what the observed prices will do in the short term. Supporting this view, Venkataraman (2001) states that the order book of the Paris Bourse "has a higher number of quote updates per day (1,055) than the New York Sample (427)". Given that we are trying to measure the efficiency of the two markets, it seems

inappropriate to implicitly assume that the two markets are equally efficient for the purpose of setting the time scale. However, there is no suitable alternative.

4.5.4 Realized Spread

This measure confirms what was discussed above. Interpreting the realized spread as the total cost of trading, we find that SEAQ is more expensive than SETS. Using the unweighted average, SEAQ trades are more than 4 times as expensive.

A negative realized spread occurs where a large trade moves the price to such an extent that the mid price passes the original weighted average price of the trade. This happens in two stages. The immediate impact is to widen the spread at the opposite side. If there was great depth close to the spread, but very little behind the best price, the immediate impact could produce a negative realized spread alone. But it is more likely that other market participants react to the large trade by moving both sides of the spread in the same direction as the trade, and this contributes to the negative realized spread. Note that the negative realized spreads are relatively small (compared to the spread) and so it does not seem possible to place a large buy order, wait for the market to react and then reverse the transaction for a profit.

4.5.5 Trading Strategy

Table 4.4 shows the number, volume and average size of the trades in each sample, and in each trade size category. There are more small trades on SEAQ than any other trade size category, while SETS has more large and very large trades than any other category. Comparing the samples by volume, the very large trades make up the lion's share of the trading as expected. Within this trade size group, the SEAQ trades are far larger (more than double) the size of the SETS trades. Overall it

TABLE 4.4 TRADE STATISTICS WITHIN CATEGORIES

		Industry, Price and Trading Volume			Industry, Price and Market Capitalization			Price and Trading Volume			Price and Market Capitalization		
		SETS	SEAQ	SETS/SEAQ	SETS	SEAQ	SETS/SEAQ	SETS	SEAQ	SETS/SEAQ	SETS	SEAQ	SETS/SEAQ
num	very small	5969	47997	0.12	4599	32726	0.14	6386	41240	0.15	4926	35006	0.14
	small	24512	113345	0.22	18313	60885	0.30	26291	117478	0.22	19602	90137	0.22
	medium	22716	41542	0.55	16843	20245	0.83	24117	46118	0.52	18091	35145	0.51
	large	63790	40993	1.56	48551	23511	2.07	70324	45520	1.54	52847	32892	1.61
	very large	57484	30704	1.87	45414	20243	2.24	64991	40191	1.62	49798	29857	1.67
	OVERALL	**174471**	**274581**	**0.64**	**133720**	**157610**	**0.85**	**192109**	**290547**	**0.66**	**145264**	**223037**	**0.65**
volume	very small	2816	26661	0.11	2181	16282	0.13	2973	22464	0.13	2314	18469	0.13
	small	75464	293278	0.26	55583	156140	0.36	81201	315163	0.26	59491	238975	0.25
	medium	165204	292806	0.56	121986	142511	0.86	175387	325197	0.54	130748	245058	0.53
	large	1701816	919131	1.85	1298035	539536	2.41	1890103	1036321	1.82	1416136	735766	1.92
	very large	7001555	8754699	0.80	5691639	6283112	0.91	7879201	13137820	0.60	6196794	9976967	0.62
	OVERALL	**8946855**	**10286576**	**0.87**	**7169425**	**7137581**	**1.00**	**10028865**	**14836964**	**0.68**	**7805482**	**11215235**	**0.70**
trade size	very small	472	555	0.85	474	498	0.95	466	545	0.85	470	528	0.89
	small	3079	2587	1.19	3035	2565	1.18	3089	2683	1.15	3035	2651	1.14
	medium	7273	7048	1.03	7243	7039	1.03	7272	7051	1.03	7227	6973	1.04
	large	26678	22422	1.19	26735	22948	1.17	26877	22766	1.18	26797	22369	1.20
	very large	121800	285132	0.43	125328	310384	0.40	121235	326885	0.37	124439	334158	0.37
	OVERALL	**51280**	**37463**	**1.37**	**53615**	**45286**	**1.18**	**52204**	**51066**	**1.02**	**53733**	**50284**	**1.07**
propn num	very small	0.034	0.175		0.034	0.208		0.033	0.142		0.034	0.157	
	small	0.140	0.413		0.137	0.386		0.137	0.404		0.135	0.404	
	medium	0.130	0.151		0.126	0.128		0.126	0.159		0.125	0.158	
	large	0.366	0.149		0.363	0.149		0.366	0.157		0.364	0.147	
	very large	0.329	0.112		0.340	0.128		0.338	0.138		0.343	0.134	
propn vol	very small	0.000	0.003		0.000	0.002		0.000	0.002		0.000	0.002	
	small	0.008	0.029		0.008	0.022		0.008	0.021		0.008	0.021	
	medium	0.018	0.028		0.017	0.020		0.017	0.022		0.017	0.022	
	large	0.190	0.089		0.181	0.076		0.188	0.070		0.181	0.066	
	very large	0.783	0.851		0.794	0.880		0.786	0.885		0.794	0.890	

Data set includes all trades between 1/9/98 and 1/9/99. Trades were excluded if reported late or if the trade price was outside of the spread by more than 10%. Trading volume was averaged over the year. Price and market cap figures were taken as at 1/9/98. Industry specific stocks were matched by sub sector if possible, and by sector if not. Duplicates were removed (keeping the pair with the lowest "average deviation"). Figures are quoted in basis points.
number of trades is a simple sum, volume of trades in pounds sterling, trade size averaged over individual trade sizes. "Propn" figures are the number or volume in that size category expressed as a percentage of the total number or volume of trades.
very small < £1000 < small < £5000 < medium < £10000 < large < £50000 < very large

appears that SEAQ trades are concentrated on small trades, and a few very large trades, while SETS trades are more evenly spread, but up to a lower limit.

We have demonstrated that the trading behaviour differs between platforms, and that this may distort the results. But we have said nothing about the efficiency of the trading strategies employed. If traders are unable to glean information from the order book, and so do not adjust their trading strategy over time accordingly, the efficiency measures would be far higher than in a theoretical equilibrium. We stated earlier, that the proportion of trading going through the book had increased, as traders showed a reluctance to use it. This may be an indicator of investors' inability to use the order book as efficiently as is possible. Efficiency should increase as investors gain the relevant knowledge and experience from trading on SETS.

4.6 Changing from SEAQ to SETS

4.6.1 Introduction

From Venkataraman (2001), we can see that the NYSE is more efficient than the Paris Bourse, and from the above results we find that SETS is more efficient than SEAQ. These results suggest opposite conclusions as to whether human intermediation adds value to the market. However, both results agree that the larger of the two markets (or the market with the larger company stocks) is the more efficient. Although stocks were matched using various criteria, it is possible that transaction costs are biased by the other stocks trading on that platform e.g. the larger stocks on the NYSE ensure a more efficient market for the smaller stocks traded on the NYSE, as a result of attracting more investors to the market.

The size effects described above, together with the issue of order strategy, and questions regarding the appropriateness of the matching algorithm, suggest that there is sufficient doubt to motivate an alternative research design. We have therefore carried out a comparison of stocks that have been traded on each of the two FTSE platforms. Following a LSE review, it was decided to allow more FTSE 250 stocks to switch from SEAQ to SETS on 6 September 1999. SETS was intended for the more liquid stocks, and there was an element of status associated with stocks added to this trading platform. Amihud *et al* (1997) showed how stock prices jumped when introduced to a more liquid market structure. In our comparison, we wish to evaluate whether the switch from SEAQ to SETS added liquidity or not. This is similar to the approach used by Naik and Yadav (2002).

4.6.2 Research Design

We look at the two year period 1 September 1998 to 31 August 2000. The efficiency measures for each stock are first calculated for each year. We then split stocks into three groups: those that switched on 6 September 1999, those that traded on SEAQ for the two year period, and those that traded on SETS for the two year period. The remaining stocks, which switched to SETS at some other date, were excluded from the sample. There is no need to match stocks in terms of market characteristics, as we are only comparing the change from year one to year two, for each group. The un-weighted transaction costs are presented in Table 4.5. For an alternative comparison, Table 4.6 presents the transaction costs weighted by the size of trade.

4.6.3 Results

Despite the changes in market conditions, in particular the beginning of the bear period in year two, we see that the efficiency measures for those stocks that did not switch platform are relatively stable. In contrast, the spreads calculated for those that

TABLE 4.5 TRADING COST MEASURES FOR FTSE 250 STOCKS, SPLIT BY TRADING PLATFORM AND SIZE OF TRADE

Size of Trade	Trading Platform	Quoted Spread			Effective Spread			Price Impact			Realized Spread		
		year 1	year 2	y2 / y1	year 1	year 2	y2 / y1	year 1	year 2	y2 / y1	year 1	year 2	y2 / y1
	SETS SETS	66.44	62.84	0.95	69.43	63.56	0.92	44.71	47.48	1.06	24.72	16.09	0.65
OVERALL	SEAQ SETS	161.58	87.93	0.54	119.77	88.10	0.74	13.62	71.12	5.22	106.15	16.98	0.16
	SEAQ SEAQ	171.87	164.42	0.96	125.89	116.23	0.92	15.07	12.79	0.85	110.82	103.44	0.93
	SETS SETS				88.28	74.12	0.84	26.83	27.89	1.04	61.45	46.23	0.75
Very Small	SEAQ SETS				148.13	106.04	0.72	5.10	39.30	7.70	143.02	66.75	0.47
	SEAQ SEAQ				170.92	152.66	0.89	4.99	3.70	0.74	165.93	148.96	0.90
	SETS SETS				75.88	64.07	0.84	20.70	28.84	1.39	55.18	35.24	0.64
Small	SEAQ SETS				129.73	96.57	0.74	8.15	46.58	5.71	121.57	49.99	0.41
	SEAQ SEAQ				136.67	126.10	0.92	9.16	6.29	0.69	127.51	119.81	0.94
	SETS SETS				69.08	64.10	0.93	30.95	31.67	1.02	38.12	32.43	0.85
Medium	SEAQ SETS				111.92	93.57	0.84	12.68	55.36	4.37	99.23	38.21	0.39
	SEAQ SEAQ				114.73	109.54	0.95	13.65	10.96	0.80	101.08	98.58	0.98
	SETS SETS				66.44	64.43	0.97	48.31	51.27	1.06	18.13	13.17	0.73
Large	SEAQ SETS				107.90	88.67	0.82	29.33	74.77	2.55	78.57	13.90	0.18
	SEAQ SEAQ				111.45	108.67	0.98	33.80	29.56	0.87	77.65	79.12	1.02
	SETS SETS				68.34	60.97	0.89	57.26	62.15	1.09	11.08	-1.19	-0.11
Very Large	SEAQ SETS				63.44	78.51	1.24	29.22	89.69	3.07	34.21	-11.18	-0.33
	SEAQ SEAQ				63.94	61.76	0.97	21.45	20.53	0.96	42.48	41.23	0.97

Each efficiency measure has been calculated for year 1 (Sept 98 to Aug 99) and year 2 (Sept 99 to Aug 00). A ratio of year 2 over year one is shown for ease of comparison.
Samples are split into those that remained on SEAQ (SEAQ SEAQ), those that remained on SETS (SETS SETS) and those that switched from SEAQ to SETS (SEAQ SETS)
very small < £1000 < small < £5000 < medium < £10000 < large < £50000 < very large
Quoted spread is the difference between the offer and bid price divided by the mid price
Effective Spread is two times the difference between the trade price and the mid price divided by the mid price
Price Impact is two times the difference between the mid price 30 minutes after the trade and the prevailing mid price, divided by the prevailing mid price.
Realised Spread is two times the difference between the trade price and the mid price 30 minutes after the trade, divided by the prevailing mid price.

TABLE 4.6 VOLUME WEIGHTED TRADING COST MEASURES FOR FTSE 250 STOCKS, SPLIT BY TRADING PLATFORM AND SIZE OF TRADE

Size of Trade	Trading Platform	Quoted Spread			Effective Spread			Price Impact			Realized Spread		
		year 1	year 2	y2 / y1	year 1	year 2	y2 / y1	year 1	year 2	y2 / y1	year 1	year 2	y2 / y1
OVERALL	SETS SETS	59.87	59.88	1.00	81.85	73.32	0.90	21.41	28.87	1.35	60.44	44.45	0.74
	SEAQ SETS	130.73	75.63	0.58	49.22	80.76	1.64	11.26	93.72	8.33	37.97	-12.97	-0.34
	SEAQ SEAQ	152.62	156.89	1.03	43.49	41.51	0.95	5.78	5.68	0.98	37.71	35.82	0.95
Very Small	SETS SETS				76.10	66.00	0.87	21.27	30.89	1.45	54.83	35.12	0.64
	SEAQ SETS				150.94	102.50	0.68	6.38	37.83	5.93	144.57	64.67	0.45
	SEAQ SEAQ				168.64	151.12	0.90	5.93	4.36	0.74	162.71	146.75	0.90
Small	SETS SETS				70.04	65.74	0.94	32.34	34.60	1.07	37.70	31.14	0.83
	SEAQ SETS				126.42	95.13	0.75	8.81	49.03	5.57	117.61	46.09	0.39
	SEAQ SEAQ				132.39	122.75	0.93	9.45	6.68	0.71	122.93	116.07	0.94
Medium	SETS SETS				66.84	68.31	1.02	51.35	55.22	1.08	15.49	13.09	0.85
	SEAQ SETS				112.44	93.23	0.83	13.06	56.33	4.31	99.37	36.90	0.37
	SEAQ SEAQ				114.11	109.35	0.96	13.65	11.36	0.83	100.46	97.99	0.98
Large	SETS SETS				52.21	51.83	0.99	58.22	60.12	1.03	-6.01	-8.29	1.38
	SEAQ SETS				105.63	88.21	0.84	32.02	77.40	2.42	73.61	10.81	0.15
	SEAQ SEAQ				109.45	107.71	0.98	37.73	33.03	0.88	71.72	74.68	1.04
Very Large	SETS SETS				55.44	55.77	1.01	58.90	60.51	1.03	41.40	-9.99	-0.24
	SEAQ SETS				39.31	78.42	2.00	9.40	99.22	10.56	29.91	-20.81	-0.70
	SEAQ SEAQ				28.96	29.26	1.01	56.18	58.21	1.04	-0.74	-2.44	3.30

Each efficiency measure has been calculated for year 1 (Sept 98 to Aug 99) and year 2 (Sept 99 to Aug 00). A ratio of year 2 over year one is shown for ease of comparison.
Samples are split into those that remained on SEAQ (SEAQ SEAQ), those that remained on SETS (SETS SETS) and those that switched from SEAQ to SETS (SEAQ SETS)
very small < £1000 < small < £5000 < medium < £10000 < large < £50000 < very large
Quoted spread is the difference between the offer and bid price divided by the mid price
Effective Spread is two times the difference between the trade price and the mid price divided by the mid price
Price Impact is two times the difference between the mid price 30 minutes after the trade and the prevailing mid price, divided by the prevailing mid price.
Realised Spread is two times the difference between the trade price and the mid price 30 minutes after the trade, divided by the prevailing mid price.

did switch, do change significantly. The quoted spread decreases considerably, but this is unlikely to be a good indicator of efficiency. The problems of interpreting the quoted spread, price impact and realized spread apply equally to this situation as in Section 4.5. However, the increase in effective spread from year one to year two cannot be explained by data manipulation problems.

The effective spreads for the two samples that did not involve a change in trading platform, decrease slightly (8%) from year one to year two. In contrast, the effective spread for those that switched decreases by a significant 26%. This difference is experienced at all trade sizes other than the largest, for which the sample that switched platforms increases by 24%. This is consistent with the theory that the automated order book offers greater liquidity in general but trading in large volumes can be costly. Given the differences in possible trading strategy, it may be more informative to look at the total weighted transaction cost. We repeat the table, weighting by trading volume, and find a very different story. The overall effective spread for the control samples again reduces, but the sample that switched increases by 64%. This means that after allowing for the differences in trading strategies between the two markets, it is more costly to trade on SETS. There are two important points to address here. Firstly, the trades that would previously have been passed to a SEAQ market maker are split between market orders and limit orders on SETS. Harris and Hasbrouk (1996) state that informed traders tend to use market orders while uninformed traders usually use limit orders. Even if this is just partly true, we could say that the demanders of immediacy (market orders) on SETS would contain a higher proportion of information than the demanders of immediacy (all traders) on SEAQ. This would suggest that a higher effective spread is appropriate for the order book.

The second point to note is that SETS traders have the option of arranging their trade through other dealers. These off market SETS transactions reflect two things. First,

large traders may benefit from the human intermediation, and second, uninformed traders may benefit from being able to bargain better terms. Considering the traditional wisdom that larger traders are informed traders, these opposing forces may explain the fact that off-market trades are smaller than on-market trades. A significant proportion of the total trading volume takes place off the market (between 30% and 40% of the total volume), so it is possible that the off-market trades have lower transaction costs and so the cost of immediacy on SETS is less than those for SEAQ. If this were the case, the volume-weighted transaction cost off the market would have to be negative.

In Table 4.7, we present a comparison of number, volume and average trade size for the samples in this test. The control samples show a fairly consistent pattern in all three variables. Interestingly, the SETS stocks had a fall in trading volume, while the SEAQ stocks had an increase. This may be due to preference for smaller companies (which would trade on SEAQ), or more trading off the market for the SETS sample. Evidence suggests that the latter is unlikely. For the sample that switched, we find the change in order size as before, as SETS traders use large and very large trades more, but only up to a limit, while SEAQ trades are dominated by many small trades and a few extremely large trades.

The trading volume roughly halves from year 1 to year 2. This is expected since the removal of the intermediary would cut the reported trades in half. In addition, there is a significant proportion of trading off the market (between 30% and 40% of the total volume), which actually shows an aggregate increase in trading volume. This supports the theory that more investors are attracted to the level playing field found on an order book market.

TABLE 4.7 TRADE STATISTICS WITHIN TRADING PLATFORM CATEGORIES

		SEAQ - SETS		SETS-SETS		SEAQ-SEAQ	
num	very small	56823	5723	5961	7516	114218	121627
	small	141118	25099	24764	39649	300481	326888
	medium	49479	17516	22770	25841	123783	143118
	large	46240	57975	64592	72618	138035	162041
	very large	36896	46403	60722	61419	80850	100545
	OVERALL	**330556**	**152716**	**178809**	**207043**	**757367**	**854219**
volume	very small	31536	2835	2755	3692	64226	69164
	small	368495	69662	76895	104610	791020	874903
	medium	348862	128272	165515	175370	878061	1024949
	large	1030196	1512316	1738610	1851873	3025485	3565978
	very large	11275156	5954137	7407349	6629166	23408410	31380819
	OVERALL	**13054244**	**7667221**	**9391125**	**8764712**	**28167202**	**36915814**
trade size	very small	0.55	0.50	0.46	0.49	0.56	0.57
	small	2.61	2.78	3.11	2.64	2.63	2.68
	medium	7.05	7.32	7.27	6.79	7.09	7.16
	large	22.28	26.09	26.92	25.50	21.92	22.01
	very large	305.59	128.31	121.99	107.93	289.53	312.11
	OVERALL	**39.49**	**50.21**	**52.52**	**42.33**	**37.19**	**43.22**
Propn Num	very small	0.172	0.037	0.033	0.036	0.151	0.142
	small	0.427	0.164	0.138	0.192	0.397	0.383
	medium	0.150	0.115	0.127	0.125	0.163	0.168
	large	0.140	0.380	0.361	0.351	0.182	0.190
	very large	0.112	0.304	0.340	0.297	0.107	0.118
Propn Vol	very small	0.002	0.000	0.000	0.000	0.002	0.002
	small	0.028	0.009	0.008	0.012	0.028	0.024
	medium	0.027	0.017	0.018	0.020	0.031	0.028
	large	0.079	0.197	0.185	0.211	0.107	0.097
	very large	0.864	0.777	0.789	0.756	0.831	0.850

Number of trades is a simple sum, volume of trades in pounds sterling, trade size averaged over individual trade sizes. "Propn" figures are the number or volume in that size category expressed as a percentage of the total number or volume of trades.
Samples are split into those that remained on SEAQ (SEAQ-SEAQ), those that remained on SETS (SETS SETS) and those that switched from SEAQ to SETS (SEAQ SETS).
very small < £1000 < small < £5000 < medium < £10000 < large < £50000 < very large

4.7 A Measure of Information Content: Investment Trusts

4.7.1 Introduction

Earlier in this paper, we cast doubt over the interpretation of the Price Impact measure, as a proxy for asymmetric information. The rationale behind this interpretation is that informed trades have a permanent impact on prices, while other trades lead to only transient volatility or noise. The price change over a suitable time period (typically 30 minutes), should measure only the permanent impact, as the transient component has since dissipated. How this process occurs is rarely defined explicitly, and the differences between the process for alternative exchanges has not yet been addressed. O'Hara (1995) assumes that the market maker can learn to distinguish between the orders it receives, through professional relationships, but it is not clear how the many liquidity suppliers on an anonymous order book, collectively manage to filter out the effects of informed and uninformed trades. Ignoring this issue for the moment, we address the question of how well the Price Impact measure proxies for information in the intermediated market, SEAQ.

Harris (2002) notes that "spreads ... should be widest for instruments that most traders cannot easily value", and also that, traders are more likely to have useful information about a given stock than a diversified portfolio of stocks. Therefore, the information content of trades in a diversified portfolio, such as investment trust shares, should be lower than for individual stocks. If this is the case, we can test the suitability of the price impact measure as a proxy for information asymmetry, by comparing a sample of investment trusts with a suitable sample of ordinary equity shares.

4.7.2 Research Design

We repeat the process described earlier, matching the investment trust shares with other FTSE 250 companies. All of the investment trusts trade on SEAQ, and so the matched sample also trades on SEAQ. We chose the Price and Market Capitalisation algorithm. Matching was easier for the investment trust stocks, and so the maximum average deviation was reduced from 0.75 to 0.375. The matched sample is shown in Table 4.8, and the comparison of transaction costs is presented in Table 4.9.

4.7.3 Results

The Price Impact measure for the investment trust sample is lower than the matched sample. The direction of this result conforms to expectation, and so we cannot reject the hypothesis that Price Impact is a good measure of asymmetric information. Also worth noting is that the Quoted Spread and the Effective Spread for the investment trust sample is roughly half the matched sample. This is a good indication of how information affects the transaction costs.

It is interesting that the Price Impact for the investment trust sample increases with trade size, particularly at the large end of the scale, while the matched sample sees a decrease in Price Impact for the very large trades. This may be explained by the transient volatility. There is no reason to believe that transient volatility is constant with trade size. The transient component of the market impact may last longer for large trades. This means that when comparing the Price Impact of different markets, even if the mechanisms reacted to trades in a similar way (which we argued against earlier), a difference in the average trade size would bias the comparison.

TABLE 4.8 MATCHED SAMPLE FOR INVESTMENT TRUST STOCKS

Stock	Sub Sector	Sector	Price	Market Capitalization	Deviation	Price	Market Capitalization	Name	Sub sector	Sector
BANKERS INV.TST	Investment Companies	Financials	2.39	2018.37	0.110	2.79	1891.25	MORRISON (WM)	Food & Drug Retailers	NC Services
CALEDONIA INV.	Investment Companies	Financials	7.65	617.16	0.137	8.375	742	SETON SCHOLL	Health	NC Consumer Goods
CHARTER EURO.	Investment Companies	Financials	4.805	324.47	0.049	5.175	317.1	GREENE KING	Leisure Entertainment & Hotels	C Services
EDIN.INV.TST.	Investment Companies	Financials	4.43	1181.14	0.041	4.795	1183.71	SMITH(WH)GRP.	General Retailers	C Services
EDIN.US TRACKER	Investment Companies	Financials	5.485	370.97	0.087	5.205	328.56	SPIRAX-SARCO	Engineering & Machinery	General Industries
ELECTRA INV.TST	Investment Companies	Financials	5.48	933.87	0.038	5.525	1000.13	CAPITA GROUP	Support Services	C Services
FLEM.AMER.I.T.	Investment Companies	Financials	6.075	362.09	0.104	7.29	352.41	VIRIDIAN GRP.	Electricity	Utilities
FLEM.O'SEAS	Investment Companies	Financials	4.005	448.33	0.065	3.97	397.02	TRAVIS PERKINS	Construction & Building Materials	Basic Industries
FLEMING CONTL.	Investment Companies	Financials	5.935	345	0.013	5.8	345.95	PSION	Electronic & Electrical Equipment	General Industries
FLEMING MERCTLE	Investment Companies	Financials	3.175	456.65	0.051	3.285	488.47	F.I.GROUP	Support Services	C Services
FOR.&COL.IV.TST	Investment Companies	Financials	1.8775	1679.05	0.282	2.525	1281.07	AVIS EUROPE	Transport	C Services
GOVETT STRAT.IT	Investment Companies	Financials	3.71	340.61	0.023	3.66	351.94	MCKECHNIE	Aerospace & Defence	General Industries
HEND.SMALL COS.	Investment Companies	Financials	2.265	373.33	0.019	2.32	368.18	BARRATT DEVEL.	Construction & Building Materials	Basic Industries
INVEST.CAP.GWTH	Investment Companies	Financials	1.7	353.78	0.031	1.605	355.56	HEPWORTH	Construction & Building Materials	Basic Industries
MERC.EURO.PRIV.	Investment Companies	Financials	1.465	610.79	0.061	1.38	573.43	ASHTEAD GRP.	Construction & Building Mater	Basic Industries
MERCHANTS TST	Investment Companies	Financials	4.11	344.34	0.137	4.635	295.1	RM	Support Services	C Services
MURRAY INC.TST.	Investment Companies	Financials	4.585	344.59	0.047	4.66	372.21	POWELL DUFFRYN	Diversified Industries	General Industries
MURRAY INTL.TST	Investment Companies	Financials	4.35	450.73	0.077	3.825	462.54	LEX SERVICE		
RIT CAPITAL	Investment Companies	Financials	3.295	540.42	0.032	3.26	512.8	CHARTER	Engineering & Machinery	General Industries
SCOT.AMER.INV.	Investment Companies	Financials	2.1	416.47	0.021	2.125	404	CRODA INTL.	Chemicals	Basic Industries
SCOT.INV.TST.	Investment Companies	Financials	3.605	860.25	0.051	3.495	801.51	MAN(ED&F)	Speciality & Other Finance	Financials
SCOT.MORTGAGE	Investment Companies	Financials	3.58	1092.98	0.042	3.475	1154.24	HAMMERSON	Real Estate	Financials
WITAN INV.	Investment Companies	Financials	3.655	332.9	0.088	3.59	389.72	ST.IVES	Media & Photography	C Services
		sum	89.7275	14798.29	1.605	92.765	14368.9			
		average	3.90119565	643.403913	0.070	4.033261	624.7347826			

FTSE 250 SETS stocks are shown on the left, matched FTSE SEAQ stocks on the right. Price is shown in pounds Deviation is the average deviation statistic, calculated as half the difference in price over the sum of prices.

Sector and Sub Sector are as per FTSE All Share classification. Trading volume shown in millions of pounds. plus half the difference in trading volume divided by the sum of trading volume, all divided by two.

TABLE 4.9 TRADING COST MEASURES FOR INVESTMENT TRUSTS AND MATCHED COMPANIES

	Size of Trade	Investment Trusts	Matched Stocks	Difference
Quoted Spread	OVERALL	**64.00**	**156.27**	**92.27**
Effective Spread	very small	56.82	117.93	61.11
	small	54.76	120.19	65.44
	medium	51.23	122.01	70.78
	large	48.80	111.45	62.65
	very large	41.94	59.14	17.20
	OVERALL	**52.07**	**110.47**	**58.40**
Price Impact	very small	1.08	4.66	3.58
	small	1.44	8.70	7.26
	medium	1.51	15.36	13.85
	large	2.50	39.45	36.94
	very large	9.23	23.48	14.24
	OVERALL	**2.14**	**16.38**	**14.24**
Realized Spread	very small	55.74	113.27	57.53
	small	53.32	111.49	58.17
	medium	49.73	106.66	56.93
	large	46.30	72.00	25.71
	very large	32.71	35.66	2.95
	OVERALL	**49.93**	**94.10**	**44.16**

Data set includes all trades between 1/9/98 and 1/9/99. Trades were excluded if reported late or if the trade price was outside of the spread by more than 10%. Price and Market Capitalization figures were taken as at 1/9/98. Investment trust stocks were matched against other stocks by Market Capitalization and Price. Pairs were excluded if the average deviation was greater than 0.375. Figures are quoted in basis points. Difference a simple dubtraction of the value for the investment trust sample from the value for the matched sample.

very small < £1000 < small < £5000 < medium < £10000 < large < £50000 < very large

Quoted spread is the difference between the offer and bid price divided by the mid price

Effective Spread is two times the difference between the trade price and the mid price divided by the mid price

Price Impact is two times the difference between the mid price 30 minutes after the trade and the prevailing mid price, divided by the prevailing mid price.

Realised Spread is two times the difference between the trade price and the mid price 30 minutes after the trade, divided by the prevailing mid price.

4.8 Summary

There are several aspects to the design of a market. Given the limited number of comparable exchanges, it is difficult to evaluate the effect of just one aspect. Comparisons of cross listed securities ignore the differences in the amount traded on each market. Comparisons of matched stocks on different markets ignore the investor profile, tax and information flow. Comparisons of market opening with normal trading on the same market are distorted by the time lags in information flow and quote revision. The comparison in this paper improves on all of these issues, by comparing different trading platforms in the same country, in the same market, with the same investors and that trade at the same time.

Using the methodology described by Haung and Stoll (1996) and Venkataraman (2001) we find that SETS has much lower transaction costs. This result suggests that the dealer market is less efficient than the automated order book, and contradicts the conclusions of Venkataraman (2001). However, having raised questions about the validity of the comparison, given the physical differences between the exchanges, we revise the methodology and find a very different picture. On exchange transaction costs increased dramatically for those stocks that switched from SEAQ to SETS. This is attributed to the inability of the order book to cope well with large trades and the relative inexperience of London traders with regard to order strategy in an order book market. The former explanation raises a question over the suitability of the order book for the FTSE 250 stocks.

We also demonstrate that transaction costs, against expectation, decrease with size on both markets. This result is attributed to the time selection properties of each market, and it is suggested that for the less liquid markets and stocks (like the FTSE 250), this issue has a greater influence than the inventory risk or asymmetric information risk theories, that lead to the opposite result in the largest exchanges.

Finally, we compare investment trust stocks with a matched sample, to show the extent of the asymmetric information risk on the efficiency of the market. We support the use of Price Impact as a suitable proxy for informed trading, and also show that the effective spread and the realized spread are significantly larger for the matched sample.

5 THE ORDER BOOK

5.1 Introduction

Having established some of the differences between the SETS order book and its market maker predecessor SEAQ, we now analyse the order book in isolation. Earlier we showed limitations in the use of theories established for other market types, for an automated order book. The fact that traders now have the choice to offer liquidity rather than demand it, makes the order book a fundamentally different platform.

Another exciting aspect of the SETS order book is that it is relatively new. This means that little empirical work has been carried out on SETS data. It also means that market participants are acting without relevant collated data regarding the efficiency of the market, the most profitable trading strategies or investor behaviour. This offers an ideal area of study, with an untouched data set.

In this chapter we look at spread, depth, order size and the proportion traded on and off the market, and determine how these statistics depend on the relative size of the stock, seasonal variations and the likelihood of asymmetric information.

Chan and Lakonishok (1993) state that on the NYSE "institutional sales are more likely than purchases to involve an intermediary broker", and use this to justify the asymmetry of buyer and seller behaviour. The use of intermediary brokers on the NYSE is justified by their access to other floor traders and the upstairs market. The SETS order book offers no such advantage, so the presence of asymmetry in our sample would reject this explanation, and add weight to alternative explanations, such as short selling constraints and behavioural issues. As well as identifying

asymmetries between LSE buyers and sellers, section 5.2 identifies which liquidity measures (e.g. spread, depth at best, total depth) best reflect the differences in trader behaviour.

Intraday patterns are studied in section 5.3. Admati and Pfliederer (1988) state that traders gravitate towards the times of greatest liquidity. In Chapter 6 we test this hypothesis, but first we must ascertain when the most liquid times of day are, and if they differ for buyers and sellers. Abhyankar *et al* (1997) find a U-shaped intraday pattern to liquidity. Ellul et al (2003) use this theory to justify why the NYSE has a "U-shaped intraday pattern", so we might expect the liquidity provided by the order book to follow a similar pattern. But liquidity can be measured in several ways. We should determine which of our liquidity measures (e.g. same side depth at best, quoted spread, weighted quoted spread, ratio of opposite side depth over same side depth at best) follow the U-shaped pattern. If a measure does not follow this pattern, then we may assume that the theories of Admati and Pfliederer (1988) and Ellul et al (2003) are flawed, or that the measures of liquidity are given little importance by traders.

Section 5.4 discusses how the order book changes over a two year period. Although the age of a market is rarely discussed in the literature, we might expect a period of adjustment after a major change in the market microstructure. Our sample period starts just 2 years after the introduction of the SETS order book, so we may expect to find that the efficiency of the market improves throughout the period. Many papers in this area (Abhyankar *et al* (1997), Ellul *et al* (2003), Beber and Caglio (2003), Chordia *et al* (2002), Griffiths *et al* (2001)) choose bull markets for the sample period. Our sample gives a more balanced view of market conditions. Beber and Caglio (2003) show that investor behaviour differs as a result of stock performance but ignore the importance of market performance. Ellul *et al* (2003) show that positive market returns imply a greater likelihood of buy orders at or better than the

best price, and a corresponding decrease of sell orders. However, they do not explain how the choice of order type is affected for buyers and sellers. For example, if a buyer is most likely to place a limit order inside the spread during a bull market, what kind of order would he use during a bear market? Would the answer change if "buyer" was replaced by "seller"?

Another important issue concerns how prices are set on the LSE, which has an opening call auction, a continuous order book, and an unofficial dealer market. Are any one of these markets more informative? And does this change with market conditions? Glosten and Milgrom (1985), Easley et al (1997), and Parlour (1998) define models for price formation in a continuous market, while Biais et al (1999) and Madhavan and Panchapagesam (2000) address the issue of price setting in a non-continuous market, but no one as yet, has addressed the issue of price formation in the presence of both. Although we cannot determine what the price would have been, if not for the presence of one of the trading platforms, we can measure the performance during the trading day, and determine whether the continuous order book market adds value to the price setting process. Panchapagesam (2000) finds that specialist intervention induces "staleness, by tying the opening price to the previous day's close". The LSE opening procedure is automated, so unless collusion is present, the opening price should more freely match market expectations. This will be determined in section 5.5

5.1.1 Data

Our data set is largely untapped, despite offering a greater level of detail than many of the other world exchanges. One possible reasons why so little empirical research has been carried out with the order book data is the computational effort required to present it in a useful way. To give an indication of some of the problems, we describe the basic approach to recreating the order book.

The ViewOHe shows details of all orders placed, executed or removed from the SETS order book for each stock. The individual stocks are identified by an IMAS code. A stock's IMAS code can change for a number of reasons such as in the event of a stock leaving a market segment (e.g. dropping from the FTSE 100 to the FTSE 250). Once the IMAS code has been married up with the "tradable investment code" field by linking a specific order code in the ViewOHe and the ViewTNe table, we can match the stocks in the sample to the IMAS code for that month. We match each order on the ViewOHe table with an order on the ViewSOe table using the "order code". This means that the limit price can be linked with the rest of the details describing the order event.

We step through the order events on the ViewOHe table and take a snapshot of the order book before each event. If more than one event occurs in a second (the SETS order book can cope with up to ten order events per second), the snapshot is taken at the start of the second only. This ensures that the details of the spread are appropriate at the time of placing the order, which is what we need in order to determine the trading strategy. In the event of an order being so large that it is matched against several counter parties and so takes longer than a second to execute, the details of the spread for the later parts of the trade will be incorrect. In the two year sample for Vodafone, which comprised over 2,000,000 order events, there was no such occurrence.

One problem with compiling aggregate information from time series data is the persistent effect of data errors e.g. if an order was entered, but the record that showed how the order was removed is missing, we might otherwise assume that the order is still sitting on the order book. This kind of data error is rare (less than 0.1%), but not to the extent that we could ignore it. Some of these erroneous orders can be removed when the market price passes through the limit price, showing that it couldn't

possibly still exist on the order book. The order book recreation program produces a list of all outstanding orders at the end of the month. Inspection of these tables shows some of the persistent problems that could be removed manually. The data problems in the other direction (orders execute, when there is no record of it being placed) are harder to solve. This will introduce a small bias to the result, and there is no way around it. There is however, some effort required in identifying these orders, and ensuring that the order book is not affected thereafter. Validation regarding the size of orders and matching of order codes at various stages ensures that this error is not persistent.

There are other data problems, where fields have been entered incorrectly. This is usually the result of a missing decimal point, or other formatting problems. Some trades are also reported incorrectly, before a "correction", and a "correct" trade is added to the data set. Many of these problems are solved with validation at the results compilation stage, rather than the order book construction stage. This is not ideal, but filtering out erroneous data is prohibitively time consuming at this point.

5.1.2 Sample Selection

The LSE operates an automated order book for the FTSE 100 and the most liquid FTSE 250 stocks. To study how efficient markets operate, it is important to look at the largest and most frequently traded stocks. We therefore chose a selection of stocks that remained in the FTSE 100 for the entire period of study. This had the added bonus that each stock had a unique IMAS code for the entire period, which simplified the programming. The list of stocks is shown in Table 5.1. The stocks are listed in order of the average market capitalization. Market Capitalization was obtained from Datastream, for the 1st trading day of each quarter in the sample period, and averaged over these 8 dates. Of the 53 stocks that satisfied the criteria, three groups of 10 stocks were chosen. In order to draw comparisons between the

TABLE 5.1 SAMPLE OF FTSE 100 STOCKS

Rank	Name	Market Capitalisation 1999 Jan	Apr	Jul	Oct	2000 Jan	Apr	Jul	Oct	Average	Sample
1	Vodafone	30195	36626	78780	85332	95418	205149	180306	154675	108310	1
2	Glaxo	74903	78378	67299	56540	63714	69035	73669	73764	69663	1
3	BT Group	58513	66501	72221	58968	98437	74307	58878	47528	66919	1
4	Shell Transport	36716	41458	49533	45382	51148	51099	56716	55374	48428	1
5	Smithkline Beecham	46864	50933	48401	38569	44368	49054	51047	51737	47622	1
6	Astrazaneca	24861	28849	43906	45009	45584	47259	54745	60485	43837	1
7	Lloyds TSB	46469	51752	47821	41630	42405	37506	34005	35029	42077	1
8	Barclays	19570	28074	28711	26327	26623	26385	24387	27313	25924	1
9	Cable & Wireless	17780	18108	19141	15989	25529	27157	32329	27388	22928	1
10	Diageo	24492	23133	23410	20705	17026	17267	20594	20697	20915	1
11	Prudential	17640	15454	18437	18105	23818	19120	19571	18117	18783	
12	Royal Bank of Scotland	8405	11828	11815	11421	9794	22912	28930	37987	17886	
13	British Sky Broadcasting	7873	9159	10231	9981	17216	26523	23921	19034	15492	
14	CGU / Aviva	12316	12203	12063	12083	13090	12008	24189	21514	14933	
15	Abbey National	18201	18214	17238	15324	14072	12193	10736	12721	14837	
16	Reuters	8970	12871	11894	9911	12085	16393	16955	18611	13461	
17	Tesco	11398	11074	11243	12301	12803	14706	13752	16612	12986	
18	Colt Telecom	5308	7129	8546	9037	21137	19729	16763	13641	12661	
19	Rio Tinto	7426	9064	11648	11120	15808	11439	12132	10524	11145	
20	Pearson	7264	8570	7857	7980	12271	13545	12483	14946	10615	
21	BAE Systems	8984	7408	7434	7142	12054	10964	12648	11265	9737	
22	Standard Chartered	6965	9413	11437	8975	10194	9482	8850	10838	9519	2
23	British American Tobacco	8301	8045	13230	11174	7654	7098	9706	9736	9368	2
24	Siebe / Invensys	4991	10630	11601	10612	12486	9220	8748	5144	9179	2
25	Bank of Scotland	8869	10757	10951	8887	8957	8707	7692	7482	9038	2
26	Marks & Spencers	11804	11612	10533	9039	8465	7504	6864	5786	8951	2
27	Kingfisher	8847	10619	10080	8722	9399	6940	8738	6033	8672	2
28	National Grid / Transco	7074	6902	6573	6200	6993	8046	7765	8833	7298	2
29	Sainsburys (J)	9216	7361	7892	7123	6708	5762	6061	7177	7163	2
30	Rentokil Initial	12974	11003	6942	6170	6471	4795	3613	3504	6934	2
31	Bass / Six Continents	6969	6807	7414	5902	6763	7018	6364	5911	6643	2
32	GKN	5672	6703	7886	6968	6971	5655	6237	4777	6358	
33	Hays	4526	5503	5756	5512	8500	7163	6278	6795	6254	
34	Boots Group	9355	7996	7033	6072	5441	4744	4649	4586	6235	
35	Telewest Communications	3722	5936	6325	4873	7547	10211	6585	3874	6134	
36	3I Group	3451	3736	4360	4478	6608	7973	8203	9987	6099	
37	RT Group	7969	6904	6792	6745	5314	3995	5310	5554	6073	
38	BAA	7429	7258	6589	5405	4635	4236	5501	5778	5854	
39	Reed Elsevier	5377	6372	5126	4226	5312	5186	6406	6366	5546	
40	WPP Group	2803	4074	4153	4397	7575	7657	7363	6200	5528	
41	Amvescap	3098	4160	3929	3346	4854	5803	7301	10230	5340	
42	BOC Group	4204	4258	6096	6172	6531	5987	4621	4242	5264	
43	BHP Billiton	2550	3212	4891	5361	7809	6243	5848	5751	5208	
44	GUS	6372	6794	7040	4948	3641	3777	4335	4300	5151	3
45	Scottish Hydro / Scottish & Southern Energy	5924	4915	5755	4854	4257	4236	4973	4774	4961	3
46	Alliance and Leicester	5165	5004	5063	4675	4418	3713	3127	2911	4260	3
47	Land Securities	4288	4496	4796	4542	3876	3770	4092	4006	4233	3
48	EMI Group	3165	3617	4096	3428	4786	5202	5360	4084	4217	3
49	British Airways	4269	4504	4686	3641	4369	3693	4099	3051	4039	3
50	Imperial Chemicals Industries	3790	4005	4838	4685	4770	3701	3665	2657	4014	3
51	United Utilities	4689	4190	4263	3575	3293	3572	3554	3753	3861	3
52	Carlton Communications	3376	3704	3338	2754	3787	4461	5333	3397	3769	3
53	Reckitt Benckiser	3245	2769	2744	3019	3622	3820	4694	5101	3627	3

FTSE 100 stocks are ranked by average market capitalisation. Simple average is calculated from the market capitalisation at the start of each quarter in the two year period.
Sample designates the large (1), medium (2) and small (3) stock sample used in the remainder of the thesis. Market capitalisation measured in millions of pounds.

groups and attribute the differences to size, we chose the 3 groups to be as different (in terms of average market capitalization) as possible. Sample 1 is the top ten stocks, sample 2 contains stocks 22 to 31, and sample 3 contains stocks 44 to 53.

The period of study was chosen as 1 January 1999 to 31 December 2000 for several reasons. Firstly, a whole number of calendar years avoids any seasonal biases, and gives the opportunity for any seasonal trends to be investigated. The period starts at the 1st of January (the 4th of January 1999 was actually the first trading day) because limit orders that are left on the order book overnight are fewer for this day than any other, which made the construction of the order book easier. Finally, the two year period was chosen to avoid the bias of studying the order book during a bull period, as so many other papers do. The FTSE 100 rose from 5882.6 to 6930.2 in 1999 and was generally considered to be a bull period. The FTSE 100 fell from 6930.2 to 6222.5 in 2000 and for the purpose of this thesis we will consider it to be a bear period. Although 2000 started positively, and many market participants may not have considered it a bear market at the time, the 10% drop in the index value is sufficiently different to the performance in 1999, to draw comparisons between bull and bear markets.

5.1.3 Bid-offer Spread

The Bid-offer spread is the most common, and one of the most easily calculated measures of liquidity. The problems and limitations of this measure are frequently discussed in the academic literature, but rarely is an alternative suggested or calculated. Before embarking on a study of the SETS order book, we first define an alternative spread measure.

One important limitation of the bid-offer spread is that it ignores the issue of depth. While more traditional market structures may require market makers to post bid and

offer quotes for a designated Normal Market Size (NMS), modern markets, and in particular automated order books, may have a widely varying depth at either side of the spread. The use of NMS is a broad-brush solution to the issue of depth. NMS is typically calculated as the average trade size on the market, and so when the market spread is quoted at NMS, it makes for an appropriate comparison. On an automated order book, the depth is determined by the investors who place limit orders. The variation in depth makes comparison of the spread at different times difficult to analyse. One solution might be to calculate the NMS for the stocks trading on the automated order book, and recalculate a weighted average price at either side. We could then analyse the characteristics of the spread using this alternative definition. This method allows for a secondary issue of the asymmetry of the depth on an automated order book.

Another alternative is to calculate the effective spread (two times the distance from the execution price to the mid price). This makes an explicit allowance for the amount actually traded. It is worth noting that the amount actually traded may be smaller than the amount that the investor wishes to trade, as trading decisions depend on the state of the market. Another issue is that the mid price used in the calculation is simply the midpoint of the quoted spread, and so some of the issues surrounding the bid-offer spread can be found here as well.

An ideal measure of liquidity would allow for the asymmetry in demand, the difference in trading strategy, and the changing market conditions. The last two factors are hard enough to define, never mind measure, but an adjustment can be made for the asymmetry of the order book. We could define the Weighted Quoted Spread as the difference between the best offer price or best bid price (whichever has the greater depth) and the weighted average price on the opposite side of the market to fill a trade of the same depth. This measure is designed specifically to cope with

situations where traders consistently front run (place order just inside the spread) on one side of the market.

The calculation of this measure is limited by the data we have available. Only summary data is collated for the order book, including the price and depth at the best and next best prices, on either side of the market. If the depth at best price on one side is greater than the depth at the best two prices on the other. This measure will understate the asymmetry of the order book. However, even in this case, some allowance has been made, and so the measure fulfils its objective. But we should refine the definition to reflect this. The "Weighted Quoted Spread" is defined as the difference between the immediate buying and selling price for a trade equal to the "Current Market Size". The Current Market Size is defined as the depth on the side with the greatest depth at best price, or the depth at the best two prices on the other side, whichever is lower.

5.2 Volume, Spread and Depth

To put the results in subsequent sections in perspective, it is important to describe the sub-samples. Many of the tables in this section are presented for the individual stocks, to give an indication of variability and to expose any outliers, and then summarised for each of the three sub-samples for comparison of the size related phenomena. The tables are presented for buy and sell orders separately and as a ratio of buy orders over sell orders where applicable. Providing such detail comes at the cost of brevity, but the emphasis here is on exposing the data to scrutiny, rather than hiding behind aggregate statistics. This pattern of tables (buy, sell and buy/sell) is prevalent throughout the remainder of the thesis. Table 5.2 shows some of the order book characteristics.

TABLE 5.2A SPREAD BY MARKET CAPITALISATION, WEIGHTED BY BUY ORDERS

Rank	QS	QS weighted	QS st dev	QS weighted st dev	number	volume
1	0.236	0.630	0.264	1.469	620.27	42944
2	0.271	0.664	0.375	0.879	417.65	4942
3	0.323	0.824	0.403	3.224	436.94	5968
4	0.279	0.932	0.533	35.950	334.89	11678
5	0.346	0.913	0.585	20.311	346.25	4482
6	0.272	0.668	0.428	1.179	290.75	1516
7	0.332	0.883	0.538	17.355	317.24	4321
8	0.333	0.827	0.517	1.271	273.90	1980
9	0.398	1.002	0.549	2.637	277.68	4266
10	0.390	1.116	0.618	21.473	220.24	3315
avg	**0.318**	**0.846**	**0.481**	**10.575**	**353.58**	**8541**
22	0.647	2.148	1.443	43.291	142.63	1222
23	0.666	2.990	1.435	85.579	123.13	1675
24	0.511	1.870	0.876	56.540	189.16	5174
25	0.669	2.672	1.382	83.154	142.54	1499
26	0.491	1.231	0.718	2.129	194.09	3660
27	0.543	3.447	0.927	148.738	178.40	2080
28	0.507	2.440	0.780	118.552	120.97	1565
29	0.662	4.436	1.302	176.595	127.56	1937
30	0.637	1.778	1.055	12.669	134.59	3604
31	0.719	4.209	1.209	110.387	125.61	891
avg	**0.605**	**2.722**	**1.113**	**83.763**	**147.87**	**2331**
44	0.761	3.673	1.514	91.734	113.94	1118
45	0.918	6.689	1.454	144.449	98.28	868
46	0.922	5.365	1.665	147.920	93.29	596
47	0.620	7.826	1.416	213.143	98.96	600
48	0.951	7.384	1.588	201.019	98.38	916
49	0.623	1.694	1.197	13.928	134.71	1938
50	0.781	2.662	1.627	43.310	108.86	950
51	0.858	6.651	1.524	151.403	93.30	581
52	0.758	7.920	1.496	203.014	115.48	1087
53	0.791	3.794	1.493	114.442	100.91	805
avg	**0.798**	**5.366**	**1.497**	**132.436**	**105.61**	**946**
avg tot	**0.574**	**2.978**	**1.030**	**75.591**	**202.35**	**3939**

Rank refers to the size, measured as the average market capitalisation over the two year sample

QS: Quoted bid offer spread expressed as a percentage

QS Weighted: "Assymetry Adjusted" quoted spread expressed as a percentage

QS st dev: Standard Deviation of Quoted Spread

QS weighted st dev: Standard Deviation of weighted quoted spread

Number: Number of orders placed in thousands

Volume: Volume of orders placed in millions of pounds

TABLE 5.2B SPREAD BY MARKET CAPITALISATION WEIGHTED BY SELL ORDERS

Rank	QS	QS weighted	QS st dev	QS weighted st dev	number	volume
1	0.235	0.626	0.248	1.045	566.20	44403
2	0.273	0.667	0.423	0.930	404.46	3431
3	0.322	0.822	0.388	3.243	411.37	6509
4	0.274	0.742	0.425	15.380	336.28	11480
5	0.356	1.320	0.633	45.490	337.72	4634
6	0.271	0.663	0.448	1.164	299.23	1491
7	0.326	0.851	0.513	13.051	306.67	4260
8	0.326	0.809	0.478	1.152	271.70	2334
9	0.402	1.006	0.553	1.349	270.04	4497
10	0.384	1.077	0.590	26.236	217.17	3156
avg	**0.317**	**0.858**	**0.470**	**10.904**	**342.08**	**8620**
22	0.627	2.053	1.428	76.062	139.83	1174
23	0.674	3.060	1.543	85.368	124.82	1622
24	0.531	2.056	1.023	75.649	191.86	5213
25	0.660	2.343	1.159	77.949	139.18	1439
26	0.484	1.212	0.651	1.744	189.82	3635
27	0.533	2.558	0.834	107.628	167.43	1920
28	0.500	1.486	1.245	31.773	120.97	1555
29	0.634	2.626	1.210	84.181	130.19	1837
30	0.618	1.631	1.049	2.890	137.74	3548
31	0.695	2.709	1.115	59.230	126.85	875
avg	**0.596**	**2.173**	**1.126**	**60.247**	**146.87**	**2282**
44	0.735	2.195	1.437	20.988	112.63	1093
45	0.881	4.173	1.404	96.436	102.63	913
46	0.874	4.802	1.559	149.515	100.35	593
47	0.632	5.024	1.939	137.218	100.91	752
48	0.922	6.016	1.485	208.672	97.10	1488
49	0.631	1.809	1.102	34.460	138.35	1871
50	0.754	2.035	1.748	19.118	112.25	920
51	0.833	3.452	1.221	64.121	95.30	588
52	0.732	4.124	1.421	119.003	113.02	1044
53	0.730	2.556	1.184	49.010	102.68	751
avg	**0.772**	**3.619**	**1.450**	**89.854**	**107.52**	**1001**
avg tot	**0.562**	**2.217**	**1.015**	**53.669**	**198.83**	**3968**

Rank refers to the size, measured as the average market capitalisation over the two year sample

QS: Quoted bid offer spread expressed as a percentage

QS Weighted: "Assymetry Adjusted" quoted spread expressed as a percentage

QS st dev: Standard Deviation of Quoted Spread

QS weighted st dev: Standard Deviation of weighted quoted spread

Number: Number of orders placed in thousands

Volume: Volume of orders placed in millions of pounds

TABLE 5.3A DEPTH BY MARKET CAPITALISATION, WEIGHTED BY BUY ORDERS

Rank	Propn BD	Propn ND	Propn TD	BTD	BBD	OBD	OTD
1	29.41	2.42	1.40	3891	135	121	4110
2	7.97	1.84	0.97	349	15	11	414
3	8.92	2.06	1.36	564	22	23	641
4	13.84	1.83	1.24	707	55	53	881
5	21.44	2.20	0.92	355	18	19	467
6	7.85	1.92	1.65	122	8	7	104
7	8.30	1.68	1.06	339	20	20	445
8	9.51	2.61	1.38	160	10	10	167
9	9.35	2.05	1.38	361	18	21	403
10	10.54	1.82	1.32	331	23	22	332
avg	**12.71**	**2.04**	**1.27**	**718**	**32**	**31**	**796**
22	7.50	1.92	1.39	153	12	12	160
23	8.61	2.04	1.22	219	31	30	278
24	11.77	1.91	1.04	524	42	40	778
25	6.66	1.85	1.10	161	15	15	216
26	7.77	1.91	1.23	563	29	28	663
27	9.69	1.82	1.16	206	16	16	263
28	14.11	1.90	1.54	349	20	21	285
29	8.99	1.93	1.31	256	22	21	282
30	13.52	2.13	1.17	497	45	39	650
31	9.01	2.06	1.27	104	11	11	141
avg	**9.77**	**1.95**	**1.24**	**303**	**24**	**23**	**372**
44	10.53	2.02	1.75	177	15	15	158
45	8.66	2.15	1.87	118	14	14	101
46	18.65	2.16	1.61	92	11	10	87
47	9.29	2.12	1.45	97	11	11	101
48	12.71	2.28	1.52	143	15	14	152
49	13.84	2.32	1.10	252	21	20	334
50	10.72	2.16	1.21	140	22	19	399
51	10.00	2.24	1.54	84	11	11	89
52	12.14	2.15	1.48	150	14	14	189
53	9.94	2.08	2.18	157	12	11	170
avg	**11.65**	**2.17**	**1.57**	**141**	**15**	**14**	**178**
avg tot	**11.38**	**2.05**	**1.36**	**387**	**24**	**23**	**449**

Rank refers to the size, measured as the average market capitalisation over the two year sample

Propⁿ BD: Ratio at depth of best bid price over depth at best offer price

Propn ND: Ratio of depth at best two prices on bid side over the depth at best two prices on the offer side

Propⁿ TD: Ratio of total bid side depth over total offer side depth

BTD: total depth on the bid side of the market

BBD: depth at best bid price

OBD: depth at best offer price

OTD: total depth on the offer side of the market

TABLE 5.3B DEPTH BY MARKET CAPITALISATION, WEIGHTED BY SELL ORDERS

Rank	Propn BD	Propn ND	Propn TD	BTD	BBD	OBD	OTD
1	31.15	2.28	1.46	3965	125	128	4002
2	6.65	2.00	0.99	360	19	11	409
3	6.63	1.99	1.41	581	21	23	636
4	12.11	1.75	1.34	733	51	56	857
5	11.05	2.03	0.93	359	17	20	465
6	5.59	1.84	1.65	123	8	8	104
7	5.82	1.65	1.07	343	19	20	447
8	7.08	1.99	1.35	158	10	12	170
9	5.86	1.99	1.41	368	18	19	401
10	8.93	1.80	1.36	335	22	23	328
avg	**10.09**	**1.93**	**1.30**	**733**	**31**	**32**	**782**
22	6.71	2.02	1.38	151	12	12	161
23	7.50	2.16	1.23	220	30	30	274
24	8.56	1.83	1.15	534	39	42	766
25	6.86	2.01	1.15	163	15	15	211
26	5.95	1.86	1.28	568	28	29	636
27	7.14	1.86	1.22	212	16	17	261
28	10.37	2.13	1.63	352	21	21	286
29	7.48	2.09	1.38	264	22	21	279
30	9.97	2.32	1.21	511	47	40	648
31	8.78	2.29	1.39	108	11	11	138
avg	**7.93**	**2.06**	**1.30**	**308**	**24**	**24**	**366**
44	7.79	2.32	1.79	176	15	15	158
45	9.84	2.64	2.14	125	15	14	99
46	8.92	2.52	1.69	95	11	10	86
47	9.57	2.56	1.57	100	11	11	99
48	10.53	2.84	1.66	147	16	13	149
49	9.58	2.44	1.17	258	21	20	336
50	16.55	2.43	1.33	146	22	18	395
51	8.30	2.70	1.62	87	11	11	89
52	10.69	2.45	1.50	151	14	14	193
53	8.65	2.52	1.77	158	12	11	177
avg	**10.04**	**2.54**	**1.62**	**144**	**15**	**14**	**178**
avg tot	**9.35**	**2.18**	**1.41**	**395**	**23**	**23**	**442**

Rank refers to the size, measured as the average market capitalisation over the two year sample

Propⁿ BD: Ratio at depth of best bid price over depth at best offer price

Propn ND: Ratio of depth at best two prices on bid side over the depth at best two prices on the offer side

Propⁿ TD: Ratio of total bid side depth over total offer side depth

BTD: total depth on the bid side of the market

BBD: depth at best bid price

OBD: depth at best offer price

5.2.1 Volume

The first sample has over three times the order volume of the next sample, which has over three times the order volume of the last sample. The samples were chosen on the basis of market capitalization, so it was not certain that the order volume would follow this pattern from large to small. This gives us a suitable platform to compare the size related results. Note that, within each sample, there is considerable variation in the order volume. This may be an indication of other stock attributes, which lead to greater speculative interest and stock price volatility.

We find a less extreme relationship for the number of trades, which implies that the average trade size is larger for the larger companies. It is not clear whether this larger trade size reflects greater demand from large institutional traders, or simply that their order strategy is less compromised in the more liquid markets.

5.2.2 Spread

The quoted spread and the weighted average quoted spread are both wider for smaller stocks. Many studies find such a relationship, but it is still difficult to explain the extent of this phenomenon. The quoted spread for the middle sample is almost double that of the large stock sample. Even though these are all FTSE 100 companies, and so receive similar levels of media speculation and attention from information gathering services, this statistic states that compared to the risk of asymmetric information in the larger sample, risk for the smaller sample is twice as great. Part of the explanation may be due to stock prices. Although we haven't plotted the stock price here, it is reasonable to assume that larger companies have a

higher stock price and so the tick size is smaller as a percentage of the price. However, this is unlikely to explain the result in full.

The difference between the quoted spread and the depth weighted quoted spread is larger for the small stocks (in real and proportional terms). This suggests that the order book for the smaller stocks is more likely to be lopsided. The weighted quoted spread is more than 6 times the size of the quoted spread for the smaller stock sample, which suggests that the order placed behind the best price on one side, could be more than 6 times the spread behind it. This suggests a very thin market, particularly at the time of buy orders. The asymmetry of the order book will be studied in greater detail later on, but it is worth noting here that the weighted quoted spread is much smaller when totalled over the market sell orders.

We also find that the spreads are more variable for the smaller stocks. This reflects the lower level of liquidity, and the lumpiness in demand for buying and selling. If the greater demand for trading in the larger stocks is at least partly due to a greater number of investors, we might expect the aggregate response rate to a change in the spread to be quicker. A large trade in a smaller stock is also more likely to have a larger impact, which would add to this result.

5.2.3 Depth

As expected, depth at best price, and total depth, increase with the size of company. The total depth increases at a steeper gradient than the best price depth. This may be explained by the behaviour of competitive limit order traders, which will be investigated later. We can also see that the ratio of depth at the best price and in total is always positive, and in some cases extremely positive: Stock 1 (Vodafone) has a ratio of 29.41:1, which implies a huge asymmetry in demand, or at least trading strategy. It is not clear from these statistics, why there is such an asymmetry in

behaviour. Allen and Gorton (1992) noted that investors are more likely to use market orders for sells, than they are for buys. Parlour (1998) however states that the choice of limit order or market order depends on the state of the market, and so a huge asymmetry in depth as experienced, would make it more likely for sellers to use limit orders. Perhaps there is a greater propensity to front run on the offer side? It is not clear why investors may choose to do this, or whether it is a worthwhile strategy, but it would explain the observed results.

The proportion of total depth has the same sign as described above, but is far lower. This confirms the result that buyers are more likely to use limit orders, but the difference in this proportion and the proportion at best prices, highlights the issues of investor behaviour, game playing and order strategy. For two stocks out of the 30 stock sample we find the total depth to be larger on the offer side than the bid side. It is not surprising to see this for a fraction of the sample, as this most likely reflects poor performance. However, it is interesting that stock 5 (SmithKline Beecham) has the second largest ratio at best prices, but the lowest ratio in total. This may suggest game playing, as people try to indicate trading interest in the opposite direction than they are posting their real orders. This may also be due to the performance of the stock or a different cross section of investors. For example, if the small proportion of informed traders are net sellers, and informed traders use market orders rather thän competitive limit orders, the offer side depth at best may be lower, with only a small impact on the total depth.

Given that buyers and sellers trade the same volume, the fact that the order book is deeper on the bid side indicates a preference for sellers to take liquidity. This supports the theory of Allen and Gorton (1992) which suggests that sellers are less patient, but perhaps the effect is exaggerated since the greater bid side depth gives greater incentive to place a market sell order. While this highlights the importance of the order book in the investor's decision making process, it does not tell us

whether the buyers and the sellers use this information equally or at all. It is possible that the buyers structure their trades systematically, placing limit and market orders and observing the impact, while sellers have a much simpler approach that ignores or under-weights the significance of the standing orders.

There is no clear pattern to the ratio of bid side depth to offer side depth, with size of company. The middle group seems to have a lower ratio than the larger or smaller stocks. It is possible that there is a relationship present, but more likely that the ratio of buyers and sellers depends on the performance and volatility of the stock and the types of investor who are trading in the stock, which are only loosely related to size.

5.3 Daily Trading Patterns

Table 5.4 shows how the spread and depth changes throughout the trading day. The statistics are averaged over each trade within each quarter hour. This introduces a bias towards the stocks and periods with the highest trading volume. As we are looking for a general picture, and have not yet established what biases these factors might introduce, this is adequate for our purposes.

5.3.1 Depth

Overall the depth figures vary considerably. The depth at best starts high, drops until about 9:30, when it recovers and stays fairly consistent for the rest of the day. The number of investors at best price starts low and increases until 10:30 and then remains roughly constant throughout the rest of the day. This reflects the uncertainty at the start of the trading day. Investors may set the limit price without reference to the order book until it stabilises in the mid morning. At this point they are more likely to follow the lead of another investor, and post an order at the best price. One of the reasons the market is less stable at the start of the day, is the larger than

TABLE 5.4A BUY ORDER DEPTH AND SPREAD BY TIME OF DAY

hour	15 min int	Propn BD	Propn ND	Propn TD	BTD	BTN	BND	BNN	BBD	BBN	OBN	OBD	ONN	OND	OTN	OTD	QS	QS weighted	QS st dev	QS weighted st dev	15R-1	(15R-1) / avg
8	1	17.257	2.478	1.180	193	15.47	20	1.13	19	1.14	1.14	19	1.18	20	26.54	310	0.0207	0.1719	0.0341	2.8227	0.484	2.360
8	2	10.226	4.124	1.216	261	18.37	23	1.18	20	1.19	1.19	20	1.18	23	29.12	362	0.0103	0.0654	0.0161	1.5139	0.163	0.793
8	3	10.634	1.942	1.209	292	19.70	23	1.20	20	1.24	1.24	20	1.21	23	30.58	403	0.0077	0.0269	0.0105	0.6404	0.188	0.916
8	4	18.826	2.300	1.681	257	17.09	21	1.19	20	1.26	1.24	19	1.19	21	24.45	306	0.0164	0.2045	0.0368	3.6623	0.838	4.087
9	1	9.593	1.904	1.534	279	18.60	22	1.23	21	1.30	1.26	20	1.21	22	25.34	319	0.0080	0.0320	0.0115	0.8123	0.003	0.013
9	2	11.442	2.064	1.358	308	19.89	23	1.26	22	1.34	1.29	20	1.23	22	26.83	342	0.0057	0.0156	0.0068	0.1587	0.165	0.805
9	3	11.238	1.956	1.308	326	20.65	24	1.28	22	1.34	1.32	22	1.25	23	27.66	366	0.0050	0.0156	0.0062	0.4172	0.189	0.923
9	4	9.527	1.904	1.261	335	21.05	24	1.29	22	1.36	1.34	21	1.26	23	28.49	383	0.0046	0.0145	0.0053	0.3063	0.182	0.888
10	1	9.615	2.141	1.275	361	21.90	25	1.31	22	1.37	1.33	21	1.27	24	29.54	406	0.0043	0.0143	0.0051	0.4169	0.181	0.882
10	2	12.756	2.162	1.243	391	23.01	25	1.35	23	1.42	1.39	22	1.33	24	30.85	431	0.0039	0.0141	0.0082	0.5143	0.214	1.041
10	3	18.231	1.958	1.275	374	22.35	26	1.32	24	1.38	1.33	22	1.29	25	30.11	416	0.0040	0.0116	0.0052	0.2193	0.174	0.848
10	4	12.083	1.952	1.266	381	22.54	26	1.32	23	1.39	1.35	22	1.29	25	30.32	423	0.0039	0.0126	0.0053	0.4318	0.164	0.801
11	1	13.365	1.918	1.288	389	22.91	26	1.32	24	1.36	1.34	22	1.29	26	30.62	435	0.0038	0.0145	0.0048	0.7159	0.156	0.762
11	2	13.754	2.209	1.325	403	23.07	27	1.32	29	1.37	1.33	22	1.30	26	30.74	439	0.0037	0.0108	0.0048	0.1846	0.190	0.925
11	3	14.744	1.944	1.320	401	23.15	27	1.32	24	1.38	1.34	22	1.30	26	30.79	441	0.0037	0.0115	0.0043	0.2006	0.179	0.874
11	4	11.320	2.520	1.300	411	23.40	27	1.31	25	1.37	1.34	23	1.29	26	31.35	453	0.0037	0.0117	0.0047	0.3692	0.191	0.929
12	1	10.431	1.885	1.273	409	23.41	27	1.31	24	1.36	1.33	23	1.28	27	31.28	455	0.0037	0.0106	0.0041	0.1332	0.185	0.904
12	2	13.245	1.939	1.296	416	23.57	27	1.32	25	1.37	1.33	23	1.29	27	31.77	471	0.0037	0.0154	0.0059	0.6030	0.165	0.803
12	3	10.264	1.945	1.276	415	23.54	27	1.32	25	1.38	1.34	24	1.29	26	31.78	477	0.0036	0.0130	0.0041	0.4361	0.196	0.955
12	4	12.353	2.456	1.278	410	23.48	27	1.32	25	1.37	1.32	23	1.29	27	32.03	478	0.0037	0.0100	0.0048	0.0732	0.192	0.935
13	1	9.925	2.051	1.305	413	23.61	27	1.31	25	1.37	1.32	23	1.29	27	31.92	478	0.0036	0.0102	0.0042	0.1603	0.194	0.946
13	2	9.593	1.929	1.303	416	23.86	27	1.31	25	1.40	1.34	23	1.29	27	31.95	477	0.0036	0.0133	0.0043	0.7099	0.159	0.773
13	3	14.433	1.795	1.295	419	23.93	26	1.30	23	1.36	1.31	23	1.28	27	31.93	472	0.0039	0.0139	0.0045	0.6453	0.172	0.836
13	4	16.013	1.831	1.299	416	23.96	27	1.30	24	1.37	1.32	23	1.28	27	31.86	475	0.0037	0.0104	0.0043	0.1438	0.208	1.015
14	1	25.019	1.917	1.294	418	23.99	27	1.30	24	1.37	1.33	24	1.28	27	32.05	480	0.0037	0.0098	0.0039	0.0693	0.187	0.911
14	2	12.906	1.917	1.309	419	24.11	27	1.31	25	1.38	1.32	23	1.28	27	32.32	484	0.0036	0.0097	0.0039	0.0899	0.195	0.952
14	3	9.485	1.897	1.250	417	24.22	27	1.31	24	1.37	1.31	23	1.28	27	32.66	484	0.0036	0.0104	0.0039	0.1472	0.184	0.897
14	4	8.729	1.908	1.231	420	24.15	27	1.31	25	1.37	1.32	24	1.28	27	32.80	497	0.0036	0.0101	0.0040	0.1198	0.170	0.829
15	1	9.981	1.916	1.270	424	24.11	28	1.32	25	1.38	1.33	24	1.28	27	32.69	499	0.0036	0.0099	0.0040	0.1582	0.181	0.881
15	2	11.236	1.906	1.309	432	24.41	28	1.33	25	1.38	1.33	24	1.28	28	32.92	508	0.0035	0.0139	0.0040	0.7695	0.173	0.843
15	3	13.717	1.928	1.316	435	24.53	28	1.32	26	1.39	1.34	25	1.28	28	32.92	507	0.0036	0.0111	0.0054	0.2563	0.178	0.870
15	4	11.724	1.963	1.324	445	24.54	28	1.32	25	1.38	1.33	25	1.29	28	33.02	513	0.0035	0.0102	0.0043	0.2154	0.180	0.878
16	1	12.516	2.053	1.336	458	24.57	29	1.32	26	1.39	1.33	25	1.28	28	32.96	521	0.0035	0.0109	0.0042	0.3046	0.197	0.961
16	2	13.720	2.120	1.334	462	24.28	30	1.30	27	1.38	1.33	29	1.27	29	32.76	533	0.0036	0.0119	0.0044	0.3912	0.198	0.963
avg		**12.644**	**2.083**	**1.304**	**383**	**22.51**	**26**	**1.29**	**24**	**1.35**	**1.31**	**23**	**1.27**	**26**	**30.73**	**442**	**0.005**	**0.025**	**0.007**	**0.553**	**0.205**	

Prop^n BD: Ratio at depth of best bid price over depth at best offer price

Propn ND: Ratio of depth at best two prices on bid side over the depth at best two prices on the offer side

Prop^n TD: Ratio of total bid side depth over total offer side depth

BTD: Total depth on the bid side

BTN: Total number of orders on the bid side

BND: Depth at the second best bid price

BNN: Number of orders at the second best bid price

BBD: Depth at the best bid price

BBN: Number of orders at the best bid price

OTD: Total depth on the offer side

OTN: Total number of orders on the offer side

OND: Depth at the second best offer price

ONN: Number of orders at the second best offer price

OBD: Depth at the best sell price

OBN: Number of orders at the best offer price

QS: Quoted bid offer spread expressed as a percentage

QS Weighted: "Assymetry Adjusted" quoted spread expressed as a percentage

QS st dev: Standard Deviation of Quoted Spread

QS weighted st dev: Standard Deviation of weighted quoted spread

15R - 1: percentage gain over 15 minute period

(15R-1)/avg: the above measure expressed as a proportion of the average

avg exc: average excluding the last quarter hour

TABLE 5.4B SELL ORDER DEPTH AND SPREAD BY TIME OF DAY

hour	15 min int	Propn BD	Propn ND	Propn TD	BTD	BTN	BND	BNN	BBD	BBN	OBN	OBD	ONN	OND	OTN	OTD	QS	QS weighted	QS st dev	QS weighted st dev	15R-1	(15R-1) / avg
8	1	14.383	2.546	1.232	193	15.44	20	1.14	19	1.13	1.15	19	1.18	20	26.68	312	0.0200	0.1385	0.0348	2.8753	0.562	2.402
8	2	8.210	2.188	1.207	261	18.34	23	1.17	20	1.19	1.21	20	1.19	22	29.39	363	0.0100	0.0410	0.0160	0.8361	0.171	0.729
8	3	10.904	2.090	1.251	292	19.62	24	1.20	20	1.22	1.25	19	1.23	23	30.73	403	0.0074	0.0237	0.0103	0.5790	0.194	0.828
8	4	7.752	2.382	1.635	264	17.18	22	1.19	20	1.23	1.25	19	1.19	20	24.46	309	0.0163	0.1270	0.0349	2.2304	1.369	5.853
9	1	9.783	2.031	1.455	281	18.64	23	1.22	20	1.28	1.27	20	1.22	21	25.46	317	0.0079	0.0258	0.0114	0.5373	0.069	0.295
9	2	14.790	2.020	1.382	306	19.78	24	1.24	21	1.31	1.31	20	1.24	22	26.83	339	0.0056	0.0147	0.0067	0.1196	0.208	0.891
9	3	8.930	1.920	1.337	328	20.63	24	1.26	21	1.32	1.34	21	1.26	22	27.72	361	0.0050	0.0155	0.0061	0.4297	0.190	0.812
9	4	7.997	1.953	1.307	342	21.19	25	1.28	22	1.34	1.36	21	1.27	23	28.68	381	0.0045	0.0126	0.0052	0.1606	0.191	0.815
10	1	7.690	2.012	1.322	360	21.81	25	1.29	22	1.34	1.36	21	1.28	23	29.42	395	0.0043	0.0125	0.0099	0.2369	0.191	0.817
10	2	8.836	2.091	1.289	393	23.00	26	1.34	23	1.41	1.42	22	1.34	24	30.77	423	0.0039	0.0112	0.0104	0.2558	0.198	0.848
10	3	7.564	1.966	1.319	383	22.51	27	1.31	23	1.35	1.36	22	1.30	24	30.22	413	0.0039	0.0106	0.0049	0.0962	0.181	0.776
10	4	7.672	1.916	1.343	389	22.72	26	1.31	22	1.35	1.37	23	1.31	25	30.30	418	0.0038	0.0101	0.0051	0.0937	0.170	0.727
11	1	8.235	1.868	1.332	394	22.91	27	1.31	23	1.33	1.37	23	1.30	25	30.35	424	0.0038	0.0103	0.0044	0.1319	0.157	0.673
11	2	8.586	2.833	1.418	417	23.12	33	1.31	34	1.34	1.36	23	1.31	25	30.75	432	0.0037	0.0097	0.0041	0.0475	0.206	0.880
11	3	9.724	1.877	1.364	411	23.36	27	1.31	23	1.35	1.37	23	1.31	26	31.05	436	0.0037	0.0101	0.0044	0.1389	0.197	0.844
11	4	7.954	2.503	1.365	417	23.46	27	1.30	23	1.33	1.35	24	1.30	25	31.24	441	0.0037	0.0105	0.0048	0.1108	0.196	0.839
12	1	6.582	1.878	1.328	417	23.55	28	1.31	23	1.34	1.36	24	1.30	26	31.31	447	0.0037	0.0098	0.0045	0.0797	0.175	0.747
12	2	8.276	1.942	1.355	427	23.83	28	1.31	25	1.34	1.36	24	1.30	26	31.77	465	0.0037	0.0102	0.0048	0.0819	0.191	0.816
12	3	8.099	1.919	1.338	430	23.67	28	1.31	24	1.34	1.38	26	1.29	26	31.67	476	0.0037	0.0103	0.0044	0.1202	0.217	0.930
12	4	12.813	2.398	1.329	416	23.67	28	1.31	24	1.35	1.37	24	1.29	26	31.82	469	0.0036	0.0094	0.0041	0.0450	0.214	0.914
13	1	6.787	2.006	1.376	424	23.86	28	1.30	24	1.34	1.36	24	1.30	26	31.84	469	0.0036	0.0094	0.0039	0.0510	0.185	0.791
13	2	7.290	1.874	1.363	424	23.97	27	1.29	23	1.35	1.37	24	1.29	26	31.54	464	0.0036	0.0095	0.0045	0.0615	0.194	0.828
13	3	12.740	1.863	1.328	424	24.02	27	1.29	23	1.32	1.33	23	1.29	26	32.10	468	0.0039	0.0101	0.0044	0.0508	0.186	0.797
13	4	11.587	1.897	1.341	424	24.08	28	1.29	24	1.34	1.34	24	1.29	26	31.98	469	0.0037	0.0126	0.0041	0.4710	0.208	0.887
14	1	27.053	1.852	1.321	424	24.11	27	1.29	23	1.33	1.36	24	1.30	27	31.85	468	0.0037	0.0097	0.0041	0.0688	0.196	0.836
14	2	16.179	1.857	1.355	430	24.39	28	1.30	24	1.34	1.35	24	1.29	26	32.24	474	0.0036	0.0094	0.0040	0.0230	0.201	0.859
14	3	8.883	1.913	1.296	429	24.42	28	1.30	24	1.33	1.35	24	1.29	26	32.51	476	0.0036	0.0096	0.0040	0.0624	0.184	0.786
14	4	6.605	1.979	1.278	430	24.32	28	1.30	24	1.34	1.35	24	1.29	26	32.44	484	0.0036	0.0095	0.0042	0.0444	0.157	0.673
15	1	8.616	2.044	1.301	430	24.08	28	1.31	24	1.34	1.35	24	1.29	26	32.34	488	0.0036	0.0095	0.0039	0.0964	0.199	0.849
15	2	8.112	2.006	1.351	437	24.39	29	1.31	24	1.34	1.36	25	1.29	27	32.47	493	0.0036	0.0123	0.0045	0.7111	0.200	0.853
15	3	11.255	1.984	1.377	447	24.64	29	1.31	25	1.35	1.36	25	1.29	27	32.86	500	0.0037	0.0165	0.0077	0.8778	0.181	0.774
15	4	10.839	1.987	1.397	454	24.69	29	1.30	25	1.34	1.36	27	1.30	27	32.70	503	0.0035	0.0098	0.0044	0.1780	0.202	0.863
16	1	9.633	2.129	1.413	469	24.58	30	1.29	26	1.35	1.37	27	1.30	28	32.58	510	0.0036	0.0096	0.0043	0.0699	0.210	0.899
16	2	14.931	2.429	1.405	480	24.36	32	1.28	28	1.34	1.37	26	1.29	28	32.49	520	0.0037	0.0113	0.0046	0.3513	0.204	0.871
avg		**10.156**	**2.063**	**1.347**	**390**	**22.60**	**27**	**1.28**	**23**	**1.32**	**1.34**	**23**	**1.28**	**25**	**30.66**	**436**	**0.005**	**0.020**	**0.007**	**0.363**	**0.234**	

Prop^n BD: Ratio at depth of best bid price over depth at best offer price

Propn ND: Ratio of depth at best two prices on bid side over the depth at best two prices on the offer side

Prop^n TD: Ratio of total bid side depth over total offer side depth

BTD: Total depth on the bid side

BTN: Total number of orders on the bid side

BND: Depth at the second best bid price

BNN: Number of orders at the second best bid price

BBD: Depth at the best bid price

BBN: Number of orders at the best bid price

OTD: Total depth on the offer side

OTN: Total number of orders on the offer side

OND: Depth at the second best offer price

ONN: Number of orders at the second best offer price

OBD: Depth at the best sell price

OBN: Number of orders at the best offer price

QS: Quoted bid offer spread expressed as a percentage

QS Weighted: "Assymetry Adjusted" quoted spread expressed as a percentage

QS st dev: Standard Deviation of Quoted Spread

QS weighted st dev: Standard Deviation of weighted quoted spread

15R - 1: percentage gain over 15 minute period

(15R-1)/avg: the above measure expressed as a proportion of the average

avg exc: average excluding the last quarter hour

average order size. This also explains why the number and depth at best act in opposite directions during the first couple of hours. There is one spurious figure in the table for the 11:30 BBD[1]. This represents a huge order that swamps the statistic. This trade has been left in for a number of reasons. Firstly, it is a genuine offer to trade and would be binding in the event of a counter party choosing to trade. Secondly, there is no justifiable way to adjust the volume of this order. Thirdly, it draws attention to an unusual occurrence of investor behaviour, and shows how sensitive the statistics are to such events.

The total depth follows a different pattern. Total depth peaks around 8:30, drops sharply and then increases until around 3pm when it plateaus. The number and depth statistics are fairly consistent. We will discuss the daily patterns of the orders placed later in the thesis, but for now we note that the standing orders are largest first thing in the morning, when many investors may be reacting to private information, and towards the end of the day, when trading activity picks up before the close.

The ratio of depth at the best bid price and the best sell price fluctuates a great deal with no clear pattern. We might expect this, given the possibility for front running and other order strategies, but the extent of the daily fluctuations is still surprising. The ratio of the total depth on the bid side and the depth at the sell side is more informative. The low points (when there is more demand from sellers or less demand from buyers than usual) are first thing in the morning and 14:45-15:30, and the high point is 8:45-9:15. We might expect first thing in the morning to be the time of day with the most privately informed trades, given the period of time available for information gathering. By this rationale, we might expect more buyers than sellers, using the argument that buyers are more likely to be informed. If there is truth in this argument, there appears to be a lag to this predicted behaviour. One explanation for a lag concerns the behaviour of large institutions. Some companies

[1] BBD is the depth at the best bid price.

have meetings mid morning, to discuss the news and set the trading strategy. This level of bureaucracy might explain the lagged results. But perhaps informed buyers simply wait to see how the market reacts at the open before acting. Another explanation is that the informed buyers use market orders at the opening, and then use limit orders to try to fill the rest of their requirement, once the volatility of the opening has passed.

5.3.2 Spread

The results are similar to those of Abhyankar *et al* (1997). The quoted spread (by either definition) starts the day at more than 4 times the daily average. This reflects the greater uncertainty at the start of the day. Although Madhavan and Pabchapagesan (2000) have shown the price set in the opening procedure to be very informative, it may still take time for investors to evaluate this information or at least to perceive the risk to have been mitigated. By 10am the spread has levelled off, and it remains fairly constant for the rest of the day. The weighted quoted spread varies a lot more. This suggests that the quoted spread is kept constant by the gravitational pull effect first described by Cohen *et al* (1981). They state that investors are more likely to place orders inside the spread, when it is wider. But as the spread narrows, there comes a point when the investor would benefit from placing a market order instead. As well as this rational explanation, there is the possibility of behavioural biases: If investors become used to a certain level of quoted spread they are likely to maintain this relationship. Whatever the reason, the quoted spread is kept at a steady level for most of the day, while the weighted quoted spread varies. The weighted quoted spread is not a commonly analysed variable, so investors are unlikely to base their decision on it. Furthermore, we may conjecture that the decision between a limit order or a market order may depend more on the spread than the asymmetry of the depth. This is something we will address later in chapter 6.

5.3.3 Performance

"15R –1" represents the average gain over the quarter hour. It has also been expressed as a ratio with the average fifteen minute return throughout the trading day. By 09:30 the market settles down and the market moves rises between 0.16% and 0.21%, in each 15 minute period. There is no clear pattern throughout the day. However, the returns in the first hour and a half of trading are unusual. The first and last quarters of the first hour are extremely high (0.5% and 0.8%) and the 09:00 to 09:15 period is extremely low (0.003%). The variable start to the opening of the market may affect the first quarter, but this does not explain the huge difference in returns in the 08:45-09:15 period. Perhaps there are announcements at 09:00 or perhaps this adds more weight to the idea that large institutions don't start trading when the market opens. If different types of investor choose to trade for different subsets of the day (e.g. ignoring the opening auction or the closing auction, or taking a lunch break) then the market performance might reflect that.

5.4 Seasonal Patterns / Bull to Bear

Having established the basic statistics for the order book, and how they vary throughout the day, we now investigate the seasonal variations. The primary aim of this section is to identify how the order book varies as a result of seasonal trends, the growing practical knowledge of market participants and the shift from bull to bear market. The secondary aim is to confirm the suitability of the sample choice, for the comparisons in subsequent chapters.

Table 5.5 consists of all orders placed on the SETS order book, as opposed to just those that trade. Actual trading volume will be analysed in section 5.5. The two

TABLE 5.5 SPREAD AND DEPTH BY MONTH

year	month	BTD	OTD	BBD	OBD	Propⁿ BD	Propⁿ TD	1DR	QS	QS weightec	QS st dev	QS weighted st dev	num	volume
1999	1	264367	272847	18890	19049	9.087	1.836	0.9718	0.0060	0.0119	0.0201	1.1793	374	4874
1999	2	261117	233320	18838	19756	8.850	1.743	1.0682	0.0057	0.0096	0.0119	0.2708	347	4659
1999	3	260310	255936	18529	18361	9.578	1.542	1.0002	0.0050	0.0076	0.0103	0.1055	467	5953
1999	4	274739	258148	18748	18783	8.835	1.677	1.0101	0.0050	0.0068	0.0104	0.0343	490	6022
1999	5	286524	285577	19360	18315	10.848	1.496	0.9865	0.0051	0.0074	0.0109	0.0608	435	5281
1999	6	314058	320190	21378	20528	11.056	1.602	1.0067	0.0045	0.0065	0.0113	0.0555	432	5736
1999	7	306875	321538	20500	19301	9.207	1.415	0.9992	0.0044	0.0077	0.0103	0.2105	450	5813
1999	8	330900	366164	18400	18813	5.966	1.333	1.0008	0.0043	0.0062	0.0086	0.0304	409	4739
1999	9	454164	566900	20112	19268	9.078	1.219	0.9932	0.0043	0.0060	0.0071	0.0320	462	5637
1999	10	542536	658196	25683	28517	7.316	1.068	0.9926	0.0046	0.0068	0.0081	0.0712	458	7253
1999	11	673596	737156	29284	33154	8.899	1.185	0.9981	0.0046	0.0071	0.0079	0.1247	475	8735
1999	12	532947	550339	25695	28019	8.651	1.317	0.9944	0.0058	0.0090	0.0116	0.0887	368	6418
avg		**375178**	**402193**	**21285**	**21822**	**8.947**	**1.453**	**1.0018**	**0.0049**	**0.0077**	**0.0107**	**0.1887**	**431**	**5927**
2000	1	635840	525743	33589	28378	7.007	1.678	0.9868	0.0049	0.0164	0.0097	0.5050	491	10740
2000	2	1861754	1555010	67785	53532	21.096	1.604	0.9923	0.0051	0.0170	0.0082	0.6154	623	21784
2000	3	795914	830428	38420	35753	12.903	1.430	1.0050	0.0056	0.0169	0.0091	0.3863	595	12956
2000	4	757042	1154449	33706	38613	10.545	1.043	1.0028	0.0056	0.0280	0.0118	1.0331	459	9802
2000	5	1262127	1214912	47830	39728	13.495	1.214	1.0187	0.0049	0.0188	0.0098	0.9782	517	12693
2000	6	752983	979214	37398	34368	11.578	1.080	1.0711	0.0043	0.0132	0.0079	0.2714	558	11923
2000	7	856045	1108220	35128	37506	8.604	0.987	1.0400	0.0038	0.0149	0.0065	0.4667	551	10209
2000	8	937605	1161841	52857	41682	16.508	1.151	1.0847	0.0037	0.0133	0.0056	0.4158	551	16286
2000	9	1327570	1475220	49294	51527	12.486	1.149	1.0793	0.0038	0.0143	0.0062	0.5045	617	16861
2000	10	1155215	1293921	44075	39444	12.236	1.226	1.1153	0.0039	0.0134	0.0071	0.3918	639	14113
2000	11	1217116	1570361	47217	47306	17.438	1.267	1.0822	0.0037	0.0115	0.0054	0.2722	674	15839
2000	12	976127	1149297	37985	39739	17.313	1.097	1.0956	0.0038	0.0120	0.0055	0.3138	595	12877
avg		**1044611**	**1168218**	**43774**	**40631**	**13.434**	**1.244**	**1.0478**	**0.0044**	**0.0158**	**0.0077**	**0.5129**	**572**	**13840**
avg		**709895**	**785205**	**32529**	**31227**	**11.191**	**1.348**	**1.0248**	**0.0047**	**0.0118**	**0.0092**	**0.3508**	**501**	**9883**

BTD: Total depth on bid side of the order book
OTD: Total depth on offer side of the order book
BBD: Depth at best bid price
OBD: Depth at best offer price
Propn BD: Ratio of depth at best bid price over depth at best offer price
Propn TD: Ratio of total bid side depth over total offer side depth
1DR: Daily return (from 8:00 to 16:30)

QS: Quoted bid offer spread
QS Weighted: "Assymetry Adjusted" quoted spread
QS st dev:
QS weighted st dev:
Number: Number of orders placed
Volume: Volume of orders placed

year sample has been broken up into the 24 months to highlight seasonal patterns and trends from year 1 to year 2. One of the motivations for choosing the two year sample, was to compare a bull market with a bear market. Although other trends may explain some of the results, we should consider year 1 as a bull market, and year 2 as a bear market.

5.4.1 Spread and Depth

Overall, there is much more order activity in the second year. On both sides of the spread, the depth at the best price is almost double and the total depth is approximately three times as big in the second year. The quoted spread decreases in the second year, and becomes less variable. This indicates a more competitive market during the bear period. However, we would expect the spread to narrow as the number of traders using the order book increases in preference to the market dealers. Looking at the weighted quoted spread, we find a very different picture. This spread measure more than doubled in year 2. This indicates that a realistic "symmetrical depth" spread increases during the bear market. The measure is not directional, and so we cannot conclude which side of the spread has a below average depth, but it does suggest a greater depth asymmetry.

There are two reasons for changes between the years, and they work in opposite directions. Firstly, as traders become more accustomed to the SETS order book, they are more willing to trade on it. This could be the basis for the observed results. However, the sample was chosen to illustrate the bull and bear period. We might expect that the order activity would decrease in the bull market, but this is not the case. Although the 2000 bear market is tame in comparison to the periods around market crashes, we would still expect to see the behavioural aspects of traders' behaviour to become apparent with less optimism than normal, in the media at that

time. We should note that these are orders sitting on the book and not trades. Perhaps investors trade more cautiously and thoughtfully during a bear period?

5.4.2 Proportion of Buyers and Sellers

One expected result that does materialize during the bear phase is the relative proportion of standing orders on either side of the spread. The proportion of buy orders to sell orders fell from 1.45 to 1.24. Buy orders still outweigh the sell orders in a bear market as traders tend to sell with market orders rather than leaving an order to be picked off from the book. In fact, with a pessimistic view of the market, we might expect even more sellers to trade aggressively, and so this measure may actually understate the impact of the bear market.

Curiously "Propn BD"[1] increases from year 1 to year 2. If there is a greater probability of bad news during a bear market, we might expect sellers to be better informed than normal, and so use market orders rather than competitive limit orders. Or perhaps all buyers are more cautious and are more inclined to try to win the spread. If traders have fewer buy orders to place, then they may take more time monitoring them. Also, if uninformed liquidity traders believe that the stock they have to buy will come down, this would also act as an incentive to use a limit order. There are many possible explanations for this result, but they all point to the fact that investors behave very differently during optimistic and pessimistic market conditions.

5.4.3 Up Days and Down Days

The 1DR variable was added to this table to illustrate the extent of the shift from Bull to Bear. 1DR represents the return from the market open to the market close (or

[1] Propn BD is the ratio of the depth at best bid price over the depth at best offer price

more precisely the end of the VWAP period at 16:30). We might expect this statistic to decrease in the second year as the market declined by 10%, but this is not observed. There are a number of explanations for this. Firstly, the statistic is a simple un-weighted arithmetic mean, and so if several smaller stocks outperformed a few larger stocks then the measure would be positive, despite a decline in the index, which is capitalisation-weighted. Secondly, this measure makes no allowance for trading after hours, and price changes from the end of each VWAP period, through the closing auction and the opening auction, to the start of open trading the next day. This does not debase the results. In fact, it supports the theory that the speculative nature of continuous trading drives prices above the realistic or underlying value, and that these movements are corrected during the opening auction, which reflects the aggregate supply and demand more accurately.

5.4.4 Volume

The number of orders placed increased by 35% and the volume of orders placed increased by 140%. The increase in order activity is partly attributable to the fact that SETS was attracting a greater proportion of market activity. It may also be due to a shift towards less aggressive trading strategies. Aggressive trading is discussed at length in the next chapter, but for now it may simply be interpreted as the demand for immediacy. An aggressive market order that moves the market price has a score of 1, while a passive limit order placed far away from the current spread has a score of 6. The un-weighted average of the aggressive scores shows a slight increase. This result supports the theory, but is very weak. One reason for the weakness may be the shift in the proportion of buyers and sellers. If there are more sell orders in year 2, and if sellers are indeed more aggressive, this measure would understate the impact on the expected volume of orders.

5.4.5 Sample Suitability

We have identified monthly patterns that may be attributed to investor behaviour. These theories will be investigated further in Chapter 6. We have also identified year 1 to year 2 patterns. We cannot say with certainty whether this is a result of the shift in market sentiment, due to greater knowledge, or a gloomier forecast. However, we can say that the sample selected is long enough, and over a suitably varied period of market activity, to yield results that are not biased towards a bull market.

5.5 Proportion of Trading On and Off the Market

Comparisons of market activity often ignore everything outside of the market. The comparisons in the next chapter do exactly that. So in this section we put the order book into the context of the total demand for trading in a given stock. The aim is to identify any significant patterns in the data, and conclude whether the sample is appropriate for further comparison. For this comparison we use a different data set. The total number of orders placed should not be compared with the trading activity off the market, and so we only use the orders that execute, at least in part, in this comparison.

A significant proportion of the total trading volume occurs off the market between investors, and the firms that acted as market makers before the switch from SEAQ to SETS. In chapter 4, we found that the proportion of trading activity on SETS increased for the period September 1999 to July 2001. It is important to establish if and how this relationship affects the sample for the latter part of the thesis. The following section looks at the proportion of trading on and off the market. The

results are presented for the number and volume of trades taking place on the market, off the market and for all ordinary trades. The proportion of on market trades and the ratio of automated trades over automated and ordinary trades is also shown. The importance of the comparison between automated and ordinary trades is in comparing the set of trades where the investors made a decision to trade off the market, rather than being bound by a previously agreed trade, or part of a portfolio transaction (buying a basket of stocks).

5.5.1 Market Capitalization

Table 5.6 shows the proportion of trading activity on and off the market by size of company. The number of trades occurring on the order book, expressed as a percentage of the total number of trades, decreases with the size of the company. However, this is distorted by the average order size on and off the market for each stock. We might expect the more liquid order books of the larger stocks to cope with larger orders, and that is what happens in practice. The proportion of the volume of trading increases with size of company. This supports the theory that some investors choose the trading platform based on expected liquidity.

The average order size is expressed in absolute terms, and so we would expect the average order size to increase with size of company. The increase we observe for the off market trades is much shallower than the increase for automated trades. We established in sections 4.5 and 4.6 that the transaction costs are prohibitively high on the order book for very large trades, so these trades are either broken up or routed to the unofficial market makers. This means that the off market transactions are a mixture of very big and very small orders (relative to the automated transactions). Simplifying the situation like this, we can consider the average off market trade as a weighted average of large trades and small trades. This means that for the smaller stocks, there are either more large off market trades, or the large trades are

TABLE 5.6 TRADE ACTIVITIES ON AND OFF MARKET, BY MARKET CAPITALISATION

	Number of trades						Volume of trades					
rank	AT	O	Not AT	%age (AT/AT+O)	%age (AT/Total)	Total	AT	O	Not AT	%age (AT/AT+O)	%age (AT/Total)	Total
1	631	979	1003	0.39	0.39	1634	27746	47013	57587	0.37	0.33	85333
2	326	400	414	0.45	0.44	740	1665	2036	2632	0.45	0.39	4297
3	393	1173	1191	0.25	0.25	1584	3664	5306	6550	0.41	0.36	10214
4	245	336	346	0.42	0.41	591	5657	7062	8614	0.44	0.40	14271
5	266	355	367	0.43	0.42	633	2506	3361	4216	0.43	0.37	6722
6	212	192	204	0.52	0.51	416	872	1173	1454	0.43	0.37	2326
7	287	688	701	0.29	0.29	989	2668	6830	7869	0.28	0.25	10537
8	208	347	359	0.37	0.37	568	967	1640	1993	0.37	0.33	2960
9	238	417	428	0.36	0.36	666	2061	3414	4411	0.38	0.32	6472
10	189	169	180	0.53	0.51	369	1988	3535	4782	0.36	0.29	6770
avg	**300**	**505**	**519**	**0.40**	**0.39**	**819**	**4980**	**8137**	**10011**	**0.39**	**0.34**	**14990**
22	97	82	88	0.54	0.52	185	615	1197	1487	0.34	0.29	2102
23	117	120	127	0.49	0.48	244	1123	2124	2624	0.35	0.30	3747
24	185	191	200	0.49	0.48	386	3378	6533	7979	0.34	0.30	11357
25	104	158	164	0.40	0.39	268	788	1706	2055	0.32	0.28	2843
26	169	604	611	0.22	0.22	780	2173	4150	4842	0.34	0.31	7015
27	137	173	181	0.44	0.43	317	1081	2057	2498	0.34	0.30	3579
28	91	157	163	0.37	0.36	255	884	1899	2285	0.32	0.28	3170
29	101	131	137	0.44	0.42	238	1046	1908	2419	0.35	0.30	3465
30	128	148	154	0.46	0.45	282	2248	4573	5431	0.33	0.29	7679
31	88	116	122	0.43	0.42	210	455	866	1114	0.34	0.29	1569
avg	**122**	**188**	**195**	**0.43**	**0.42**	**316**	**1379**	**2701**	**3273**	**0.34**	**0.29**	**4653**
44	80	103	109	0.44	0.42	189	599	1609	1974	0.27	0.23	2573
45	71	115	120	0.38	0.37	191	457	1248	1543	0.27	0.23	2000
46	62	215	218	0.22	0.22	281	273	720	878	0.28	0.24	1151
47	59	63	67	0.48	0.47	126	277	610	750	0.31	0.27	1027
48	67	41	46	0.62	0.59	113	475	1221	1575	0.28	0.23	2049
49	110	188	193	0.37	0.36	303	1114	1945	2360	0.36	0.32	3474
50	101	154	159	0.40	0.39	260	662	1241	1494	0.35	0.31	2156
51	61	105	110	0.37	0.36	171	292	607	781	0.32	0.27	1073
52	88	59	65	0.60	0.58	153	588	1205	1514	0.33	0.28	2102
53	72	91	96	0.44	0.43	168	426	839	1025	0.34	0.29	1451
avg	**77**	**113**	**118**	**0.43**	**0.42**	**195**	**516**	**1124**	**1389**	**0.31**	**0.27**	**1906**
avg tot	**166**	**269**	**277**	**0.42**	**0.41**	**444**	**2292**	**3988**	**4891**	**0.35**	**0.30**	**7183**

AT: automatic trades that execute on the SETS order book
O: ordinary trades that are arranged away from the central market
Not AT: all trades that occur away from the central market

%age (AT/AT+O): percentage of "normal" trades that execute on the market
%age (AT/Total): percentage of all trades that execute on the market
Rank refers to the size, measured as the average market capitalisation over the two year sample

Number measrues in thousands
Volume measured in millions of pounds

proportionately larger. If there were more large trades, this might suggest a trade size selection issue, whereby investors choose to trade through dealers for fear of moving the market. If the large trades were proportionately larger, we might attribute this to an investor size selection issue. For example, a large trader, who chooses to trade through dealers due to habit or procedure, trades his holdings with regard to the proportions of his portfolio, rather than the percentage of the market capitalization of the company share.

5.5.2 Seasonal Patterns

Table 5.7 shows the proportion of trading on and off the order book, over the two year sample period. There is a small increase in the proportion of the total trading taking place on the order book. This result holds for the unweighted and the volume weighted statistic. This is consistent with our earlier finding that traders showed a reluctance to switch from their traditional trading methods to the order book. However, it may also be a reflection of the state of the market. As we are using the year 1 to year 2 comparison to highlight differences in the bull and bear market, it is worth noting that the order book may offer better opportunities for sellers and so it becomes a more popular choice during a bear period. We have shown previously that the bid side depth is usually higher, which supports this theory.

There seems very little seasonal pattern in the proportion on and off the market. The proportion varies month to month, and the relationships between months is inconsistent when comparing year 1 and year 2. We might assume that the seasonal patterns in stock returns might be reflected in the order book, but there is no clear evidence here.

Table 5.8 shows that overall, the average trade size increases from year 1 to year 2 both on and off the market. In year 1, the trade size was roughly equal on and off the

TABLE 5.7 TRADE ACTIVITY ON AND OFF MARKET BY MONTH

		Number						Volume					
year	month	AT	O	Not AT	%age (AT/AT+O)	%age (AT/Total)	Total	AT	O	Not AT	%age (AT/AT+O)	%age (AT/Total)	Total
1999	1	149	326	335	0.314	0.308	484	1461	2916	3493	0.334	0.295	4955
1999	2	146	335	342	0.303	0.299	488	1451	2619	3182	0.357	0.313	4633
1999	3	178	410	420	0.303	0.298	599	1712	3362	4472	0.337	0.277	6183
1999	4	164	347	356	0.320	0.315	520	1612	4814	5432	0.251	0.229	7043
1999	5	147	267	274	0.355	0.349	421	1490	2665	3277	0.359	0.313	4768
1999	6	156	265	273	0.371	0.365	429	1628	2874	3535	0.362	0.315	5163
1999	7	173	287	294	0.377	0.371	468	1670	2648	3296	0.387	0.336	4967
1999	8	152	271	277	0.360	0.355	429	1389	2543	2976	0.353	0.318	4365
1999	9	182	275	283	0.399	0.392	465	1611	2746	3368	0.370	0.324	4979
1999	10	179	314	322	0.362	0.357	501	2145	3425	4235	0.385	0.336	6380
1999	11	208	418	427	0.332	0.327	635	2664	4848	6002	0.355	0.307	8666
1999	12	159	295	302	0.350	0.344	461	1914	3265	4245	0.370	0.311	6159
avg		**166**	**317**	**325**	**0.346**	**0.340**	**492**	**1729**	**3227**	**3960**	**0.351**	**0.306**	**5688**
2000	1	243	380	388	0.390	0.384	631	3213	5707	6810	0.360	0.321	10023
2000	2	309	485	498	0.389	0.383	807	7443	16928	19862	0.305	0.273	27305
2000	3	287	521	535	0.356	0.350	822	4384	8807	11512	0.332	0.276	15896
2000	4	222	340	350	0.395	0.388	572	3298	5821	6979	0.362	0.321	10277
2000	5	235	361	372	0.394	0.388	607	3683	5991	7685	0.381	0.324	11367
2000	6	231	299	313	0.436	0.425	544	3237	4654	5971	0.410	0.352	9208
2000	7	218	283	297	0.435	0.423	514	2895	4312	5403	0.402	0.349	8298
2000	8	217	323	336	0.402	0.393	554	3525	5106	6153	0.408	0.364	9678
2000	9	259	339	354	0.433	0.423	612	4375	6470	7936	0.403	0.355	12311
2000	10	270	333	348	0.447	0.436	618	4279	5833	7148	0.423	0.374	11428
2000	11	276	355	371	0.437	0.426	647	4489	6578	7739	0.406	0.367	12228
2000	12	223	241	258	0.481	0.465	481	3184	4698	6023	0.404	0.346	9206
avg		**249**	**355**	**368**	**0.416**	**0.407**	**617**	**4000**	**6742**	**8268**	**0.383**	**0.335**	**12269**
avg tot		**208**	**336**	**347**	**0.381**	**0.373**	**554**	**2865**	**4985**	**6114**	**0.367**	**0.321**	**8979**
%age inc		**150**	**112**	**113**	**120**	**120**	**126**	**231**	**209**	**209**	**109**	**109**	**216**

AT: automatic trades that execute on the SETS order book
O: ordinary trades that are arranged away from the central market
Not AT: all trades that occur away from the central market

%age (AT/AT+O): percentage of "normal" trades that execute on the market
%age (AT/Total): percentage of all trades that execute on the market

Number measrues in thousands
Volume measured in millions of pounds

TABLE 5.8 AVERAGE TRADE SIZE ON AND OFF MARKET BY MONTH

year	month	AT	O	Not AT	%age AT/(AT+O)	%age (AT/Total)	Total
1999	1	9.799	8.943	10.434	0.523	0.957	10.24
1999	2	9.936	7.813	9.293	0.560	1.048	9.49
1999	3	9.599	8.203	10.636	0.539	0.929	10.33
1999	4	9.853	13.860	15.243	0.416	0.727	13.55
1999	5	10.156	9.980	11.956	0.504	0.896	11.33
1999	6	10.408	10.858	12.965	0.489	0.865	12.03
1999	7	9.637	9.239	11.201	0.511	0.907	10.62
1999	8	9.117	9.397	10.757	0.492	0.896	10.17
1999	9	8.839	9.986	11.920	0.470	0.825	10.71
1999	10	12.004	10.900	13.151	0.524	0.942	12.74
1999	11	12.822	11.605	14.061	0.525	0.939	13.66
1999	12	12.063	11.073	14.048	0.521	0.903	13.36
avg		**10.353**	**10.155**	**12.139**	**0.506**	**0.903**	**11.52**
2000	1	13.245	15.033	17.538	0.468	0.834	15.89
2000	2	24.089	34.891	39.881	0.408	0.712	33.83
2000	3	15.252	16.907	21.534	0.474	0.789	19.34
2000	4	14.858	17.113	19.948	0.465	0.827	17.97
2000	5	15.656	16.582	20.673	0.486	0.836	18.73
2000	6	14.014	15.554	19.088	0.474	0.828	16.93
2000	7	13.289	15.250	18.218	0.466	0.824	16.13
2000	8	16.211	15.798	18.292	0.506	0.928	17.48
2000	9	16.901	19.084	22.448	0.470	0.841	20.10
2000	10	15.875	17.522	20.542	0.475	0.858	18.50
2000	11	16.291	18.521	20.855	0.468	0.861	18.91
2000	12	14.251	19.525	23.387	0.422	0.744	19.14
avg		**15.828**	**18.482**	**21.867**	**0.465**	**0.823**	**19.41**
avg tot		**13.090**	**14.318**	**17.003**	**0.486**	**0.863**	**15.47**
%age inc		**153**	**182**	**180**	**92**	**91**	**169**

AT: automatic trades that execute on the SETS order book
O: ordinary trades that are arranged away from the central market
Not AT: all trades that occur away from the central market
%age (AT/AT+O): percentage of "normal" trades that execute on the market
%age (AT/Total): percentage of all trades that execute on the market
Average trade size measured in thousands of pounds

market, but in year 2, the off market trades were bigger. The increase in trade size on the market, may reflect the greater liquidity offered by the investors as they become more accustomed to (and more efficient at) using the order book. The relative increase in size off the market may reflect the lower information asymmetry risk that the off market dealers may have experienced since the switch in trading platform. An overall increase is also expected since the prices are on average higher than the previous year.

5.5.3 Up and Down Days

An old adage states that "it takes volume to move prices". That may be true, but this says nothing about the relative proportion of volume that might occur in and away from the centralised market. Table 5.9 shows the average number and volume of trades that occurred on days with different daily returns. The daily returns are measured from opening to 16:30 (as described in section 5.4.3). The days are categorised into extreme (more than a 10% decline, or more than a 10% or 20% increase) or moderate (between 5% and 10% change in either direction) or small (between 1% and 5% in either direction or less than 1% change).

The highest proportion (38% of the number or 33% of the volume) of automatèd trading occurs during stable trading days. Although this implies that more than 50% of the trading volume occurs away from the market, we should note that if traders are acting as market makers off the market, this volume is double counted, since the market maker records two trades, rather than matching the buyer and seller directly. If all of the off market trading included a pseudo market maker (and none of the trading on the order book did), it would imply that 55% of the number or 50% of the volume occurred on the book (using the 38% and 33% figures quoted above).

TABLE 5.9 TRADE ACTIVITY ON AND OFF MARKET BY DAILY RETURN

		Number					Volume					Trade Size	
	count	AT	O	%age (AT/AT+O)	%age (AT/Total)	Total	AT	O	%age (AT/AT+O)	%age (AT/Total)	Total	AT	O
10% decline	1727	103	217	0.32	0.317	325	1362	2902	0.32	0.270	5040	13.213	13.402
5% decline	5667	386	626	0.38	0.375	1030	6587	12054	0.35	0.308	21385	17.075	19.254
1% decline	22127	1395	2208	0.39	0.380	3675	17540	29847	0.37	0.319	55046	12.575	13.520
less than 1%	21124	1280	2033	0.39	0.379	3382	15336	29458	0.34	0.302	50704	11.979	14.489
1% increase	18064	1168	1912	0.38	0.372	3138	14997	24613	0.38	0.333	45059	12.843	12.873
5% increase	4805	329	577	0.36	0.357	921	5709	10556	0.35	0.308	18536	17.342	18.301
10% increase	1227	74	134	0.36	0.351	211	850	1589	0.35	0.310	2746	11.488	11.901
20% increase	1627	199	328	0.38	0.370	537	5933	7926	0.43	0.378	15684	29.843	24.132
tot	**76368**	**4934**	**8034**	**2.90**	**2.900**	**13219**	**68314.99122**	**118944.1542**	**2.90**	**2.528**	**214200.2067**	**126**	**128**
weighted average		**1092**	**1751**	**0.37**	**0.374**	**2899**	**13890**	**24437**	**0.37**	**0.316**	**43878**	**13.472**	**14.559**

Count: number of occurances

AT: automatic trades that execute on the SETS order book

O: ordinary trades that are arranged away from the central market

Not AT: all trades that occur away from the central market

%age (AT/AT+O): percentage of "normal" trades that execute on th number in thousands

%age (AT/Total): percentage of all trades that execute on the mark QS in percentage points

Number measrues in thousands

Volume measured in millions of pounds

Trade size measured in thousands of pounds

The proportion of trading on the book decreases for the moderate and extreme days, other than days with a greater than 20% increase. This result is strongest for the number of trades. Glosten (1994) believes that the order book is less able to cope with extreme volatility than a market maker, so it makes sense that traders would take their business away from the market during volatile times (when market liquidity is lower than average). It is also possible that trading halts imposed by the market regulators force investors to take their business away from the market on the extreme days. However, neither of these theories explain why such a large proportion of trades go through the order book during the very extreme up days.

5.6 Summary

We have addressed many of the issues regarding the order book, how it varies within our sample of 30 stocks, and how it varies through time. We found that spread (using quoted spread and weighted quoted spread) and total depth increase with the size of stock, but this result does not hold for depth at best price. The asymmetry of buyers and sellers does not depend on the size of the stock. Sell side depth is larger in total. Average depth is roughly symmetrical at best price, although when weighted by buy/sell orders, the ratio of depth is always greater than average at the bid/offer side of the spread. This supports the theory that order choice depends on the prevailing market conditions.

Depth and Spread measures are highest at the start of the day, decrease for the first hour and stay roughly constant for the rest of the day. Since liquidity is greater when spread is lower and depth is higher, there is no definitive answer to "when is the market most liquid". Although investors may feel drawn to the opening and closing call auctions for many reasons, there is no clear reason why traders may choose to trade at particular times of the continuous trading day.

The order book changed considerably between year 1 and year 2. Order activity increased. Average order size increased. The weighted quoted spread doubled (although the quoted spread did not increase) implying greater asymmetry. The proportion of standing sell orders to buy orders decreased, but the proportion at best price increased. The average daytime return increased. While it is difficult to separate the effects of a developing market, and change in market-wide optimism, we may hypothesise that the unofficial dealers are important in price setting, particularly during the bear period, despite decreasing their share of the trading activity.

The unofficial dealers are used less for larger companies, since the automated order book is most efficient for the very liquid stocks. The order book also takes a greater share of the trading volume on stable days, when the theoretical cost of providing liquidity is lowest. When more limit orders are placed, market orders become more attractive and so the order book is used more. The equilibrium depends on the spread and depth of the order book, but this depends on the market conditions, which in turn seems to depend on the actions of the unofficial dealers.

Most importantly, having established what the order book looks like on average, we can measure any departures from the norm. For instance, while we may expect a market buy order to be placed when the bid side depth is high, we now have a benchmark for defining "when the bid side depth is high". The obvious direction for investigation now, is to look at the orders as they are placed, executed or removed from the order book.

6 ORDER ACTIVITY

6.1 Introduction

Having established the characteristics of the SETS order book, and how they vary through time, we now discuss how investors formulate their trading strategies. When do investors use market orders and when do they use limit orders? What happens when the spread or depth on the order book changes? Which strategies imply informed trading? Which order strategies are the most profitable?

In Chapter 5 we looked at the order book and how it varies throughout the day. Here we look at the order events throughout the day. This comparison offers greater insight into trader behaviour. For example, if all trading activity (limit orders and market orders placed and deleted) slowed down during lunchtime, the order book may not change, but the comparison in this chapter would expose this behaviour.

Abhyankar *et al* (1997) and Ellul *et al* (2003) find that order activity on the LSE and NYSE has a roughly "U-shaped intraday pattern" and that sellers become "more aggressive later in the day". Jain and Joh (1988) find that trading volume is "highest during the first hour, declines monotonically until the fourth hour, but increases again in the fifth and sixth hours." First we must check that a similar result holds for the LSE during our sample period, then determine whether the pattern arises as a result of more orders in total, or more aggressive orders, or a change in the behaviour of buyers and sellers. In Chapter 2 we discussed the differences between the LSE and the NYSE. In particular, the opening procedure, implies a different pattern of trading activity at the start of the day. While traders on the NYSE are subject to the discretion of the specialist during the opening procedure, the LSE order book is

automated, so we might expect a greater proportion of investors using the LSE opening call auction, and a smaller proportion immediately after the opening.

Beber and Caglio (2003) and Ellul *et al* (2003) make significant contributions to the body of empirical analysis of aggressiveness of orders. These papers are as yet unpublished, and were first presented after the empirical work for this thesis had been started. As such, there is a reasonable overlap of content. Both Beber and Caglio (2003) and Ellul *et al* (2003) papers study the NYSE, which operates an order book/specialist/floor trader hybrid market. Our data set offers a comparison of aggressive behaviour between the NYSE (described in Beber and Caglio (2003) and Ellul *et al* (2003)) and the LSE, and a greater insight into a pure order book market. Although the aforementioned papers study the most liquid market in the world, Beber and Caglio (2003) use a sample of 10 stocks over 3 months in 1991 and Ellul *et al* (2003) use 50 stocks over 1 week in 2001. Our data set of 30 stocks over a diverse 2 year period provides a more complete picture, and one less prone to data mining accusations.

Cohen et al (1981) refer to the "gravitational pull effect" which explains why investors choose between market orders and limit orders. Beber and Caglio (2003) suggest determinants for aggressiveness: spread, depth, market performance, stock performance, volatility of stock. Section 6.4 assesses the importance of some of these, and goes on to show how aggressiveness depends on other aspects of the market, such as the size of stock and time of day. Keim and Madhavan (1995) state that informed traders are more aggressive, so we test whether the aggressive traders are larger than average. We also test the price impact of aggressive and passive orders. Although the price impact measure is usually used for trades rather than orders, we justify this interpretation and test to see if aggressive orders have a greater price impact. Furthermore, we look for asymmetry in the market reaction to buy and sell orders.

While large orders are often indicative of information, autocorrelated order types may also forecast price movements. Parlour (1988) explained that placing an order on the order book, makes a subsequent order of a certain type, more or less likely. For example, after a market buy order, the most likely order type would be a limit sell order, thus rebalancing the equilibrium of liquidity. The least likely order to follow in this example, is another market buy order. However, Ellul et al (2003) and Chordia and Subrahmanyam (2000) find empirical evidence to the contrary. Ellul et al (2003) state that "positive first-order autocorrelation exists for order type" but that "negative autocorrelation exists for order type over longer horizons". In section 6.5 we check that autocorrelation of order type is also common on the LSE, look at the market conditions that make this more likely, and evaluate the impact of such order events. For example, we might expect consecutive market buys to occur when the spread is small and the depth on both sides is great. We may also expect the resulting price impact to be greater than that of a single market order.

The remainder of this chapter is split into 4 main sections. After describing the research design, we look at the daily order submission and cancellation patterns in section 6.3. Section 6.4 examines the aggressive trading: how this behaviour varies for different stocks, throughout the day, when the spread or depth changes, or when the market is moving or stationary. Finally, in section 6.5, we look at patterns in consecutive orders: when orders are autocorrelated, how this depends on depth, spread and recent market movements.

6.2 Research Design

This chapter is a natural extension to Chapter 5. The rationale behind the methodology and sample selection apply equally to the comparisons made in this chapter. The tables are often produced for buy orders and sell orders separately, and

then shown as a ratio of the buy and sell order figures. A composite table could have been produced instead, but it was felt that the asymmetry of the order book has such a significant affect on the market that such a table may hide many of the results.

In this chapter, we discuss the importance of "aggressiveness" in great detail. While aggressiveness is generally described as "the demand for immediacy", there is no consistent measure adopted throughout the literature. We will use the scale used by Beber and Caglio (2003), as this is one of the most recent studies and it pools the benefits of previous designs together. Although there are differences between orders on the NYSE (as studied by Beber and Caglio (2003)) and those on the SETS order book, their classification applies equally well here. SETS market orders are frequently entered with an optional limit price attached. Attaching a limit price in this way, contradicts the definition of a market order on other exchanges. However, the distinguishing factor of a market order on SETS is that the limit price crosses the spread.

The aggressiveness scale is defined as follows:

1 A market order larger than the depth at the best price on the opposite side of the spread.
2 A market order smaller than the depth at the best price on the opposite side of the spread.
3 A limit order placed inside the spread.
4 A limit order placed at the best price on the same side of the spread.
5 A limit order placed behind the best price on the same side of the spread, by up to 4 ticks.
6 A limit order placed more than 4 ticks behind the best price on the same side of the spread.

6.3 Daily Variations

Tables 6.1 and 6.2 show the order activity throughout the trading day, measured in number of events and total volume from these events respectively. In addition, Table 6.3 plots the average order size. The day is split into whole hours. The 8am to 9am and 4pm to 5pm is further split into quarter hours. The 8am to 9am subdivision is useful to see the changing pattern at the market open and the 4pm to 5pm subdivision is important to differentiate between an open and closed market. Unfortunately, the market close is not at a fixed time, and so the second and third quarters may be a mixture of an open and closed market. The 8am to 9am is also shown as a total, for ease of comparison with the other hours. The 4pm to 4:30pm period is expressed as an hourly equivalent figure.

The data shows order activity out of hours. While orders can theoretically be added or removed from the order book at any time, they cannot execute. The only rational explanation for the trading activity between midnight and 5am, is data errors. They may have been entered in a 12 hour clock format rather than a 24 hour format. They represent around 0.3% of the total trading in terms of number and volume. We cannot say for certain what the values should be, and so they have been excluded from the sample in many of the subsequent tables.

6.3.1 Orders Placed

While Abhyankar *et al* (1997) and Ellul *et al* (2003) find a U-shaped pattern for order activity, they do not break down the data into the level of detail offered here. We find that order frequency increases for the first two hours, then dips until lunch time and rises to a peak at the end of the day. The average order size is roughly concave, with the highest peak in the first hour. One blip in this pattern concerns the large buy orders placed between 11am and 12am. It is not at all clear why this would be the case from

TABLE 6.1A NUMBER OF BUY SIDE ORDER EVENTS BY TIME OF DAY

Hour	Z	P	M	C	D	E	F
1	3.90	0.99	2.19	0.01	1.70	0.00	0.02
2	5.31	1.66	3.04	0.02	2.32	0.00	0.02
3	7.98	2.42	4.27	0.02	3.67	0.00	0.03
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	47.98	0.00	0.00	0.00	2.89	143.44	0.00
8 1	91.59	12.06	29.99	0.25	24.61	0.06	0.42
8 2	91.33	14.60	38.61	0.35	33.94	0.00	0.52
8 3	97.49	18.09	47.05	0.45	37.86	0.00	0.56
8 4	131.75	20.85	49.89	0.51	44.56	0.00	0.55
8 tot	412.16	65.60	165.53	1.56	140.98	0.07	2.05
9	703.36	150.97	345.04	3.34	292.88	0.01	3.57
10	728.86	216.77	407.72	4.02	293.01	0.01	3.74
11	617.54	167.80	349.63	3.24	252.42	0.01	2.90
12	514.01	139.51	288.66	2.78	215.94	0.01	2.23
13	561.08	147.25	312.26	3.03	238.39	0.01	2.68
14	734.75	196.16	416.28	3.75	307.90	0.00	3.60
15	1014.74	288.12	584.76	5.69	412.26	0.01	5.72
16 adj	1457.94	502.91	861.41	8.41	609.53	0.03	8.54
16 1	284.45	90.35	169.70	1.63	114.80	0.01	1.55
16 2	444.52	161.11	261.01	2.57	189.97	0.01	2.72
16 3	58.64	20.13	21.06	0.00	89.73	14.73	0.00
16 4	0.65	0.26	0.39	0.01	23.69	3.09	0.00
17	1.89	0.75	1.14	0.01	0.74	0.19	0.01
18	0.96	0.35	0.48	0.01	0.65	0.02	0.00
19	0.12	0.00	0.03	0.00	0.14	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.01	0.00
sum	**6143**	**1650**	**3333**	**32**	**2584**	**162**	**31**

Number in thousands
Z: Order placed
P: Order partially filled
M: Order completely filled
C: Remainder of market order with list price cancelled
D: Order deleted by investor
E: Order expired as per investor instruction
F: Fill or kill order failed to execute

The 0800 - 0900 hour and 1600 - 1700 hour has been split into 1/4 hours. 8 tot shows the full hourly total. 16 adj is a grossed up figure based on the last half hour of trading (1600 - 1630).

TABLE 6.1B NUMBER OF SELL SIDE ORDER EVENTS BY TIME OF DAY

Hour	Z	P	M	C	D	E	F
1	4.56	0.98	2.21	0.01	2.23	0.00	0.02
2	7.37	1.25	3.46	0.04	3.68	0.00	0.02
3	8.54	1.97	4.72	0.04	3.73	0.00	0.03
4	5.65	1.81	3.55	0.03	3.05	0.21	0.02
7	65.29	0.00	0.00	0.00	3.12	168.25	0.00
8 1	87.04	13.94	28.11	0.19	21.21	0.08	0.50
8 2	85.23	16.63	36.58	0.31	29.43	0.00	0.47
8 3	90.74	20.80	44.33	0.39	32.97	0.00	0.54
8 4	124.62	22.87	47.87	0.45	39.29	0.00	0.53
8 tot	387.63	74.24	156.89	1.33	122.89	0.08	2.04
9	708.09	158.07	337.94	3.23	299.85	0.01	3.60
10	740.96	211.56	412.93	3.68	299.84	0.01	3.93
11	610.42	175.73	341.70	3.37	251.03	0.00	3.18
12	507.31	147.21	280.96	2.56	214.47	0.03	2.18
13	532.06	163.01	296.50	2.78	227.93	0.01	2.57
14	718.50	214.06	398.37	3.90	303.32	0.01	3.91
15	982.67	308.83	564.05	5.73	404.31	0.03	5.96
16 adj	1446.38	505.97	858.35	7.78	597.40	0.03	8.96
16 1	281.35	92.61	167.44	1.52	112.48	0.00	1.69
16 2	441.84	160.38	261.74	2.37	186.22	0.01	2.79
16 3	58.20	20.88	20.31	0.00	90.98	13.50	0.01
16 4	0.70	0.21	0.44	0.01	28.91	3.69	0.01
17	1.84	0.65	1.25	0.01	0.64	0.23	0.00
18	0.86	0.24	0.59	0.00	0.51	0.05	0.00
19	0.08	0.01	0.02	0.00	0.09	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.03	0.00
sum	**6064**	**1734**	**3255**	**31**	**2559**	**186**	**32**

Number in thousands
Z: Order placed
P: Order partially filled
M: Order completely filled
C: Remainder of market order with list price cancelled
D: Order deleted by investor
E: Order expired as per investor instruction
F: Fill or kill order failed to execute

The 0800 - 0900 hour and 1600 - 1700 hour has been split into 1/4 hours. 8 tot shows the full hourly total. 16 adj is a grossed up figure based on the last half hour of trading (1600 - 1630).

TABLE 6.1C RATIO OFNUMBER OF BUY SIDE AND SELL SIDE ORDER EVE

Hour	Z	P	M	C	D	E	F
1	0.86	1.01	0.99	0.43	0.76		1.00
2	0.72	1.33	0.88	0.53	0.63		0.82
3	0.93	1.23	0.90	0.64	0.98		0.82
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.73				0.93	0.85	
8 1	1.05	0.86	1.07	1.35	1.16	0.83	0.84
8 2	1.07	0.88	1.06	1.13	1.15		1.10
8 3	1.07	0.87	1.06	1.17	1.15	0.00	1.04
8 4	1.06	0.91	1.04	1.13	1.13	2.00	1.04
8 tot	1.06	0.88	1.06	1.17	1.15	0.85	1.00
9	0.99	0.96	1.02	1.03	0.98	1.63	0.99
10	0.98	1.02	0.99	1.09	0.98	1.38	0.95
11	1.01	0.95	1.02	0.96	1.01	2.00	0.91
12	1.01	0.95	1.03	1.09	1.01	0.37	1.02
13	1.05	0.90	1.05	1.09	1.05	1.57	1.04
14	1.02	0.92	1.04	0.96	1.02	0.38	0.92
15	1.03	0.93	1.04	0.99	1.02	0.52	0.96
16 adj	1.01	0.99	1.00	1.08	1.02	0.88	0.95
16 1	1.01	0.98	1.01	1.07	1.02	1.67	0.92
16 2	1.01	1.00	1.00	1.09	1.02	0.71	0.97
16 3	1.01	0.96	1.04	3.00	0.99	1.09	0.50
16 4	0.92	1.22	0.89	1.40	0.82	0.84	0.20
17	1.03	1.17	0.91	1.30	1.14	0.86	2.00
18	1.13	1.45	0.82	6.00	1.28	0.33	0.67
19	1.65	0.80	1.04		1.62	0.00	
20						0.38	
sum	**1.01**	**0.95**	**1.02**	**1.04**	**1.01**	**0.87**	**0.96**

Number in thousands
Z: Order placed
P: Order partially filled
M: Order completely filled
C: Remainder of market order with list price cancelled
D: Order deleted by investor
E: Order expired as per investor instruction
F: Fill or kill order failed to execute

Blank values show when no sell order events occur in that cell.

The 0800 - 0900 hour and 1600 - 1700 hour has been split into 1/4 hours. 8 tot shows the full hourly total. 16 adj is a grossed up figure based on the last half hour of trading (1600 - 1630).

TABLE 6.2A VOLUME OF BUY SIDE ORDER EVENTS BY TIME OF DAY

Hour	Z	P	M	C	D	E	F
1	48	7	22	0	17	0.00	0
2	76	13	33	0	28	0.00	0
3	101	19	44	1	35	0.00	0
4	68	13	32	0	35	4.35	0
7	856	0	0	0	132	3668.99	0
8 1	2464	255	711	30	593	2.16	18
8 2	2656	300	881	131	854	0.00	64
8 3	2330	309	912	46	763	0.00	24
8 4	2611	319	904	41	729	0.02	23
8 tot	10061	1183	3408	247	2939	2.18	128
9	13480	1790	5087	266	4898	0.17	187
10	12830	2188	5463	390	3976	0.13	210
11	12881	1920	4897	209	5406	0.03	120
12	9629	1669	4287	269	3209	0.07	103
13	10176	1750	4520	250	3395	0.28	127
14	14044	2427	6437	247	4662	0.04	150
15	19222	3468	8739	502	5857	0.26	285
16 adj	28427	5885	12125	570	8891	0.59	808
16 1	5567	1100	2505	115	1691	0.18	93
16 2	8646	1842	3558	170	2754	0.12	311
16 3	1765	278	294	0	2495	380.01	0
16 4	16	3	8	0	357	105.27	0
17	41	9	19	0	11	6.97	0
18	25	5	8	0	15	0.21	0
19	3	0	0	0	3	0.00	0
20	0	0	0	0	0	0.24	0
sum	**119536**	**19686**	**49361**	**2669**	**41915**	**4170**	**1714**

Volume in millions of pounds
Z: Order placed
P: Order partially filled
M: Order completely filled
C: Remainder of market order with list price cancelled
D: Order deleted by investor
E: Order expired as per investor instruction
F: Fill or kill order failed to execute

The 0800 - 0900 hour and 1600 - 1700 hour has been split into 1/4 hours. 8 tot shows the full hourly total. 16 adj is a grossed up figure based on the last half hour of trading (1600 - 1630).

TABLE 6.2B VOLUME OF SELL SIDE ORDER EVENTS BY TIME OF DAY

Hour	Z	P	M	C	D	E	F
1	50	8	22	0	19	0.00	0
2	78	9	37	1	28	0.00	0
3	100	15	49	1	35	0.00	1
4	69	13	32	2	36	5.36	1
7	949	0	0	0	71	3682.13	0
8 1	4456	233	732	2157	565	1.62	19
8 2	2373	295	885	22	784	0.00	19
8 3	2216	310	911	41	624	0.07	36
8 4	2587	327	896	32	783	0.00	23
8 tot	11632	1165	3426	2252	2756	1.69	96
9	12398	1798	5079	201	3949	0.07	159
10	12441	2127	5523	186	3970	0.09	127
11	11150	1916	4901	334	3455	0.07	195
12	9625	1715	4241	244	3029	0.56	139
13	10636	1804	4466	910	3178	0.17	154
14	14368	2563	6301	236	4807	0.03	145
15	19390	3567	8641	386	6314	0.38	262
16 adj	31553	5669	12342	572	12529	0.55	379
16 1	6150	1062	2544	144	2306	0.01	71
16 2	9627	1773	3627	141	3958	0.26	118
16 3	1748	291	281	0	2427	314.77	0
16 4	19	4	7	0	410	109.72	0
17	36	8	20	0	11	3.61	0
18	17	3	10	0	9	0.80	0
19	1	0	0	0	1	0.10	0
20	0	0	0	0	0	0.39	0
sum	**120483**	**19840**	**49206**	**5038**	**40769**	**4120**	**1469**

Volume in millions of pounds
Z: Order placed
P: Order partially filled
M: Order completely filled
C: Remainder of market order with list price cancelled
D: Order deleted by investor
E: Order expired as per investor instruction
F: Fill or kill order failed to execute

The 0800 - 0900 hour and 1600 - 1700 hour has been split into 1/4 hours. 8 tot shows the full hourly total. 16 adj is a grossed up figure based on the last half hour of trading (1600 - 1630).

TABLE 6.2C RATIO OF VOLUME OF BUY SIDE AND SELL SIDE ORDER EV

Hour	Z	P	M	C	D	E	F
1	0.95	0.93	1.02	0.44	0.92		0.46
2	0.97	1.40	0.90	0.64	1.03		0.65
3	1.01	1.31	0.91	1.53	1.00		0.58
4	0.99	1.05	0.98	0.13	0.96	0.81	0.32
7	0.90				1.84	1.00	
8 1	0.55	1.09	0.97	0.01	1.05	1.34	0.97
8 2	1.12	1.02	0.99	5.90	1.09		3.36
8 3	1.05	1.00	1.00	1.11	1.22	0.00	0.66
8 4	1.01	0.98	1.01	1.29	0.93	15.00	0.99
8 tot	0.86	1.02	0.99	0.11	1.07	1.29	1.33
9	1.09	1.00	1.00	1.33	1.24	2.31	1.17
10	1.03	1.03	0.99	2.10	1.00	1.37	1.65
11	1.16	1.00	1.00	0.63	1.56	0.45	0.62
12	1.00	0.97	1.01	1.10	1.06	0.13	0.74
13	0.96	0.97	1.01	0.27	1.07	1.67	0.82
14	0.98	0.95	1.02	1.05	0.97	1.20	1.03
15	0.99	0.97	1.01	1.30	0.93	0.68	1.09
16 adj	0.90	1.04	0.98	1.00	0.71	1.08	2.13
16 1	0.91	1.04	0.98	0.80	0.73	13.44	1.31
16 2	0.90	1.04	0.98	1.20	0.70	0.46	2.63
16 3	1.01	0.95	1.05	55.19	1.03	1.21	0.43
16 4	0.85	0.69	1.17	2.78	0.87	0.96	3.33
17	1.15	1.12	0.95	1.80	1.01	1.93	2.36
18	1.48	1.73	0.79	7.34	1.77	0.26	0.66
19	2.81	1.05	0.99		2.63	0.00	
20						0.62	
sum	**0.99**	**0.99**	**1.00**	**0.53**	**1.03**	**1.01**	**1.17**

Volume in millions of pounds
Z: Order placed
P: Order partially filled
M: Order completely filled
C: Remainder of market order with list price cancelled
D: Order deleted by investor
E: Order expired as per investor instruction
F: Fill or kill order failed to execute

Blank values show when no sell order events occur in that cell.

The 0800 - 0900 hour and 1600 - 1700 hour has been split into 1/4 hours. 8 tot shows the full hourly total. 16 adj is a grossed up figure based on the last half hour of trading (1600 - 1630).

TABLE 6.3A AVERAGE ORDER SIZE OF BUY SIDE ORDER EVENTS BY TIME OF DAY

Hour	Z	P	M	C	D	E	F
1	12.20	7.46	10.10	27.62	10.12		7.78
2	14.33	7.80	10.87	23.97	12.25		15.42
3	12.61	7.86	10.34	61.56	9.43		11.58
4							
7	17.85				45.56	25.58	
8 1	26.90	21.16	23.69	117.52	24.08	34.87	43.12
8 2	29.09	20.55	22.81	372.04	25.15	1.23	122.93
8 3	23.90	17.06	19.39	101.98	20.16		42.22
8 4	19.82	15.30	18.12	80.35	16.36	7.50	40.92
8 tot	24.41	18.03	20.59	158.21	20.85	32.55	62.39
9	19.16	11.86	14.74	79.49	16.72	13.19	52.21
10	17.60	10.09	13.40	97.15	13.57	11.58	56.05
11	20.86	11.44	14.01	64.59	21.42	4.99	41.34
12	18.73	11.97	14.85	96.80	14.86	7.28	46.19
13	18.14	11.89	14.47	82.60	14.24	25.44	47.17
14	19.11	12.37	15.46	65.91	15.14	13.61	41.75
15	18.94	12.04	14.94	88.16	14.21	18.64	49.81
16 adj	19.50	11.70	14.08	67.81	14.59	19.83	94.59
16 1	19.57	12.18	14.76	70.64	14.73	35.48	59.79
16 2	19.45	11.43	13.63	66.03	14.50	12.00	114.49
16 3	30.11	13.79	13.97	15.08	27.80	25.80	9.29
16 4	25.00	10.48	21.06	59.89	15.07	34.11	50.00
17	21.90	12.12	16.44	35.84	15.46	36.13	12.22
18	25.48	13.23	15.78	70.76	23.49	13.15	9.39
19	20.85	15.33	17.23		18.36		30.00
20						21.69	
sum	**19.46**	**11.93**	**14.81**	**84.21**	**16.22**	**25.80**	**55.57**

Average order size measured in thousands of pounds
Z: Order placed
P: Order partially filled
M: Order completely filled
C: Remainder of market order with list price cancelled
D: Order deleted by investor
E: Order expired as per investor instruction
F: Fill or kill order failed to execute

The 0800 - 0900 hour and 1600 - 1700 hour has been split into 1/4 hours. 8 tot shows the full hourly total. 16 adj is a grossed up figure based on the last half hour of trading (1600 - 1630).

TABLE 6.3B AVERAGE ORDER SIZE OF SELL SIDE ORDER EVENTS BY TIME OF DAY

Hour	Z	P	M	C	D	E	F
1	10.98	8.10	9.80	26.86	8.35		16.97
2	10.65	7.40	10.64	19.68	7.51		19.51
3	11.71	7.36	10.31	25.63	9.27		16.30
4	12.22	7.02	9.09	46.40	11.88	25.77	31.49
7	14.54				22.89	21.88	
8 1	51.19	16.73	26.06	11534.41	26.65	21.59	37.20
8 2	27.84	17.77	24.20	70.90	26.65		40.16
8 3	24.42	14.88	20.56	107.49	18.93	23.00	66.89
8 4	20.76	14.29	18.73	70.22	19.92	1.00	42.83
8 tot	30.01	15.69	21.84	1689.40	22.43	21.38	47.17
9	17.51	11.38	15.03	62.04	13.17	9.28	44.16
10	16.79	10.06	13.38	50.52	13.24	11.59	32.40
11	18.27	10.90	14.34	98.93	13.76	22.32	61.20
12	18.97	11.65	15.09	95.56	14.12	20.84	63.55
13	19.99	11.07	15.06	327.10	13.94	23.92	59.86
14	20.00	11.97	15.82	60.45	15.85	4.24	37.20
15	19.73	11.55	15.32	67.43	15.62	14.22	44.01
16 adj	21.81	11.20	14.38	73.48	20.97	16.24	42.29
16 1	21.86	11.46	15.19	95.25	20.51	4.40	42.07
16 2	21.79	11.05	13.86	59.56	21.26	18.78	42.42
16 3	30.03	13.95	13.82	0.82	26.68	23.31	10.80
16 4	27.07	18.41	16.06	30.15	14.19	29.76	3.00
17	19.49	12.67	15.78	25.88	17.52	16.05	10.37
18	19.35	11.07	16.20	57.84	16.91	16.25	9.47
19	12.25	11.67	18.07		11.33	100.00	
20						13.37	
sum	**19.87**	**11.44**	**15.12**	**164.59**	**15.93**	**22.14**	**45.96**

Average order size measured in thousands of pounds
Z: Order placed
P: Order partially filled
M: Order completely filled
C: Remainder of market order with list price cancelled
D: Order deleted by investor
E: Order expired as per investor instruction
F: Fill or kill order failed to execute

The 0800 - 0900 hour and 1600 - 1700 hour has been split into 1/4 hours. 8 tot shows the full hourly total. 16 adj is a grossed up figure based on the last half hour of trading (1600 - 1630).

TABLE 6.3C RATIO OF SIZE OF BUY ORDER EVENTS OVER SIZE OF SELL ORDER EVE

Hour	Z	P	M	C	D	E	F
1	1.11	0.92	1.03	1.03	1.21		0.46
2	1.34	1.05	1.02	1.22	1.63		0.79
3	1.08	1.07	1.00	2.40	1.02		0.71
4							
7	1.23				1.99	1.17	
8 1	0.53	1.27	0.91	0.01	0.90	1.62	1.16
8 2	1.04	1.16	0.94	5.25	0.94		3.06
8 3	0.98	1.15	0.94	0.95	1.06	0.00	0.63
8 4	0.95	1.07	0.97	1.14	0.82	7.50	0.96
8 tot	0.81	1.15	0.94	0.09	0.93	1.52	1.32
9	1.09	1.04	0.98	1.28	1.27	1.42	1.18
10	1.05	1.00	1.00	1.92	1.02	1.00	1.73
11	1.14	1.05	0.98	0.65	1.56	0.22	0.68
12	0.99	1.03	0.98	1.01	1.05	0.35	0.73
13	0.91	1.07	0.96	0.25	1.02	1.06	0.79
14	0.96	1.03	0.98	1.09	0.96	3.21	1.12
15	0.96	1.04	0.98	1.31	0.91	1.31	1.13
16 adj	0.89	1.04	0.98	0.92	0.70	1.22	2.24
16 1	0.90	1.06	0.97	0.74	0.72	8.06	1.42
16 2	0.89	1.03	0.98	1.11	0.68	0.64	2.70
16 3	1.00	0.99	1.01	18.40	1.04	1.11	0.86
16 4	0.92	0.57	1.31	1.99	1.06	1.15	16.65
17	1.12	0.96	1.04	1.39	0.88	2.25	1.18
18	1.32	1.20	0.97	1.22	1.39	0.81	0.99
19	1.70	1.31	0.95		1.62	0.00	
20						1.62	
sum	**0.98**	**1.04**	**0.98**	**0.51**	**1.02**	**1.17**	**1.21**

Average order size measured in thousands of pounds
Z: Order placed
P: Order partially filled
M: Order completely filled
C: Remainder of market order with list price cancelled
D: Order deleted by investor
E: Order expired as per investor instruction
F: Fill or kill order failed to execute

Blank values show when no sell order events occur in that cell.

The 0800 - 0900 hour and 1600 - 1700 hour has been split into 1/4 hours. 8 tot shows the full hourly total. 16 adj is a grossed up figure based on the last half hour of trading (1600 - 1630).

this table. Perhaps larger orders are placed because traders have instructions to fill an order by midday, or perhaps it reflects a typical time for price sensitive company announcements.

More sell orders than buy orders are placed during the 10am to 12am period. Interestingly, the volume of sell orders exceeds that of buy orders from 8am to 9am and 1pm to 4:30pm. So sellers place fewer but larger orders at the start and end of the day. This may reflect the spread and depth at the time of trade, or it may reflect behavioural issues.

The volume of orders placed increases dramatically during the last half hour of trading. The combined volume of the orders placed in the period 4:15pm to 4:30pm, is greater than the volume during the entire lunch hour. This is partly due to increased order size, but primarily due to an increase in the number of orders added to the book. This supports the theory that investors become more aggressive towards the end of the day in order to close out their position for the day, or in response to the fact that their limit order strategy hasn't satisfied their trading needs, and so a more aggressive strategy is required. This is supported by an increase in the deleted orders, which are discussed in section 6.3.3.

Another point worth noting is the period 16:10 to 16:30 is used to calculate the VWAP (Volume Weighted Average Price). VWAP is used for many things, such as the FTSE Actuaries All Share indices. There is something to be gained from manipulating the VWAP, and so there is a chance that the increased trading activity reflects this kind of trader behaviour. Also, the VWAP period may finish early in the event of a 5% change in consecutive execution prices, in which case a small bias may be present.

6.3.2 Orders Matched

More than half of the orders placed (but less than 40% of the total volume) are fully filled. The average size of those that transact is roughly 75% of the average size of those placed. Since aggressive market orders are more likely to transact than limit orders, it would seem that limit orders tend to be larger. Perhaps market orders are split up to hide their information. Perhaps there are large traders, willing to offer depth at prices far from the current spread.

The largest orders that transact occur in the first hour of trading. This is partly due to the impact of the transactions that result in the opening call option, but the trades are larger throughout the first hour of trading, so it seems that during the thin (relative to the rest of the day) trading of the first hour, traders are willing to place larger orders. We might assume that the first hour of trading is the most vulnerable to information asymmetry, as there are 15 and a half hours of information gathering leading up to it. Traders are willing to trade in larger chunks, however, which would neither disguise information nor minimise the price impact of the trade.

6.3.3 Removed Orders

Of the orders that don't execute, most are deleted by the trader. 40% of the buy orders placed (or 30% of the volume of buy orders) were cancelled during the trading day. More orders are deleted at the start and end of the day, than in the middle. This is indicative of diligent monitoring and active order management. As mentioned earlier, the increase in deleted orders towards the end of the day reflects a switching of trading strategy from passive to aggressive orders. The conditions under which orders are deleted along with the motivations is clearly an area for further research.

Cancelled orders occur when a market order with a limit price is partially filled, and failed orders occur when a market order with a limit price does not trade at all. There is no clear pattern to these events, as they are fairly evenly spread throughout the day in terms of number and volume. Expired orders occur either at the end of the trading day, or just before the open. The expiry date and time of an order are set at the time of placing the order. There is no obvious reason for trades to expire just before the opening of the market. Perhaps the traders are trying to influence the opening price, or perhaps this is simply a procedural effect implied by the LSE systems. There would be an advantage in leaving orders on the book overnight, and deciding whether to cancel them before the market opens, to gain time priority, but this does not seem to happen in practice.

The difference between the buy and sell order expiries are uninformative for all hours other than 7am to 8am and 4pm to 5pm, during which there are roughly equal volumes of buy and sell expiries. The average order size of buy orders that end in expiry is larger than the average order size of sell orders that end in expiry, by 20%. Given that buy and sell orders are roughly equal in size (buy orders are 2% bigger than sell orders) this shows a selection issue for order expiries. Do traders enter an expiry date when they think that failure to execute is likely? Orders that expire are larger than average orders. Do these orders represent the uninformed traders that offer liquidity to play the spread, which we introduced earlier.

Harris and Hasbrouk (1996) found that very few deleted orders are replaced with new orders. Our initial analysis suggests otherwise, but we need to look at the activity of individual traders to confirm this conclusion. All of the trading activity following deleted orders is potentially very informative, as deleted orders are an indication of trading intent as well an indication of the strategies that current market participants are following. Deleted orders are not summarised on the SETS order book system, so it would take some very close analysis in practice to imply what

orders were cancelled. This hindrance to the analysis may preclude traders from trying to draw conclusions from such events.

6.4 Aggressiveness

Aggressive trading represents an investor's demand for immediacy. The most widely supported theory is that aggressive trades reflect an information asymmetry. With a simple classification of market orders as aggressive, and limit orders as passive, then half of the volume of orders that execute are aggressive. But it is unreasonable to assume that half the traders are privately informed. So we must refine our definition to reflect the fact that the decision to trade aggressively is not exogenous to the state of the market. The size of the spread represents the trade off between certainty of execution and the cost of potentially losing the spread. Given a small enough spread we might expect any investor to place a market order. We must therefore first establish under what conditions traders behave most aggressively, to refine our estimation of the likelihood of asymmetric information.

6.4.1 Market Capitalization

Table 6.4 shows that the order activity for each sample differs very little. There are more market orders placed for the larger stocks but weighted by volume, this relationship all but disappears. The medium sized companies have the largest proportionate volume of type 1 buy orders. This is due to the fact that the larger companies have greater depth at best (so a type 1 order has to be significantly bigger for that sample), and the lack of depth for the smaller sample (so traders are more concerned about moving the market price). These opposing forces almost cancel out, and this is why the differences are so small.

TABLE 6.4A NUMBER AND VOLUME OF BUY ORDERS BY AGGRESSIVENESS AND MARKET CAPITALISATION

	Number								Volume							
Rank	1 & 2	1	2	3	4	5	6	Total	1 & 2	1	2	3	4	5	6	Total
1	291.28	39.58	251.71	125.99	91.00	59.19	52.82	620.27	18929	7679	11250	9502	7848	4205	2460	42944
2	150.19	23.65	126.54	114.83	53.83	26.64	72.16	417.65	1259	516	743	2812	339	110	423	4942
3	177.01	27.17	149.84	111.98	59.27	29.39	59.29	436.94	2448	917	1530	1685	784	358	693	5968
4	111.32	15.54	95.78	81.03	40.26	34.57	67.71	334.89	3884	1095	2789	3128	1235	1026	2406	11678
5	124.31	18.84	105.47	103.47	44.05	30.45	43.98	346.25	1724	546	1178	1454	518	270	516	4482
6	95.75	16.36	79.39	89.45	35.20	14.63	55.74	290.75	625	210	415	510	154	43	184	1516
7	131.26	19.95	111.31	88.45	42.29	24.89	30.36	317.24	1878	695	1183	1309	574	224	337	4321
8	96.33	14.68	81.65	78.07	37.66	18.37	43.48	273.90	705	248	457	580	207	67	421	1980
9	108.09	17.84	90.26	81.12	35.28	18.57	34.62	277.68	1371	482	888	1041	1372	139	343	4266
10	83.37	14.77	68.61	62.84	33.70	23.48	16.85	220.24	1420	551	870	975	451	220	248	3315
avg	**136.89**	**20.84**	**116.06**	**93.72**	**47.25**	**28.02**	**47.70**	**353.58**	**3424**	**1294**	**2130**	**2300**	**1348**	**666**	**803**	**8541**
prop^n	**0.39**	**0.06**	**0.33**	**0.27**	**0.13**	**0.08**	**0.13**		**0.40**	**0.15**	**0.25**	**0.27**	**0.16**	**0.08**	**0.09**	
22	46.00	7.66	38.34	53.54	19.41	10.63	13.05	142.63	458	178	280	472	128	58	107	1222
23	46.78	6.21	40.57	39.96	15.47	9.30	11.61	123.13	690	225	465	570	182	87	146	1675
24	79.67	12.64	67.03	57.56	29.67	15.49	6.78	189.16	2233	796	1438	1541	767	402	230	5174
25	49.76	7.92	41.84	51.18	19.51	10.32	11.78	142.54	570	221	349	556	180	74	119	1499
26	79.40	10.77	68.63	56.46	26.88	16.55	14.80	194.09	1488	517	971	1119	492	301	261	3660
27	65.37	9.84	55.53	58.14	23.80	14.93	16.15	178.40	901	426	475	655	219	118	187	2080
28	42.31	6.86	35.45	42.84	18.51	8.28	9.04	120.97	598	203	395	571	183	78	135	1565
29	45.88	7.44	38.44	45.81	17.79	9.53	8.56	127.56	780	310	470	663	219	120	154	1937
30	55.91	9.79	46.13	39.59	21.81	10.29	6.99	134.59	1583	734	849	995	553	261	211	3604
31	40.96	6.26	34.70	46.60	19.28	7.47	11.29	125.61	313	112	201	336	118	41	84	891
avg	**55.20**	**8.54**	**46.67**	**49.17**	**21.21**	**11.28**	**11.00**	**147.87**	**961.27**	**372**	**589**	**748**	**304**	**154**	**164**	**2331**
prop^n	**0.37**	**0.06**	**0.32**	**0.33**	**0.14**	**0.08**	**0.07**		**0.41**	**0.16**	**0.25**	**0.32**	**0.13**	**0.07**	**0.07**	
44	38.02	5.96	32.07	44.83	16.67	6.61	7.80	113.94	396	144	252	449	137	53	82	1118
45	31.68	4.52	27.16	38.84	14.96	5.54	7.26	98.28	292	96	196	368	104	35	68	868
46	28.17	4.18	23.99	35.69	14.52	5.68	9.22	93.29	201	74	126	238	73	27	58	596
47	28.71	4.35	24.36	35.92	15.79	6.70	11.84	98.96	187	64	123	229	81	30	74	600
48	30.71	5.57	25.14	39.55	15.99	4.89	7.25	98.38	333	127	206	360	113	33	78	916
49	49.11	9.32	39.79	47.77	18.91	9.49	9.43	134.71	765	289	476	670	227	118	156	1938
50	42.80	5.81	36.99	39.33	12.25	5.01	9.49	108.86	407	113	294	342	91	31	79	950
51	29.97	3.97	26.00	37.48	13.62	4.51	7.72	93.30	187	61	126	264	64	20	46	581
52	40.41	7.02	33.39	43.84	16.39	5.68	9.16	115.48	435	187	248	400	115	42	95	1087
53	31.76	5.69	26.07	40.98	15.13	4.89	8.15	100.91	308	133	175	305	92	27	72	805
avg	**35.13**	**5.64**	**29.49**	**40.42**	**15.42**	**5.90**	**8.73**	**105.61**	**351**	**129**	**222**	**363**	**110**	**42**	**81**	**946**
prop^n	**0.33**	**0.05**	**0.28**	**0.38**	**0.15**	**0.06**	**0.08**		**0.37**	**0.14**	**0.24**	**0.38**	**0.12**	**0.04**	**0.09**	
Total avg	**75.74**	**21.12**	**114.85**	**120.83**	**52.39**	**26.52**	**35.63**	**371.34**	**1579**	**932**	**1522**	**1877**	**863**	**418**	**512**	**6124**
Total prop^n	**0.20**	**0.06**	**0.31**	**0.33**	**0.14**	**0.07**	**0.10**		**0.26**	**0.15**	**0.25**	**0.31**	**0.14**	**0.07**	**0.08**	

number of orders in thousands
volume of trades in millions of pounds
Rank: Uniquely identifies the company (See Table 5.1)
1 & 2: Is a combined total for all market orders (Category 1 & 2)
1: Orders at or better than the opposite side price, larger than depth at best
2: Orders at or better than the opposite side price, smaller than depth at best
3: Limit price within the spread
4: Limit price at the same side, best price
5: Limit price behind best price, but within 1p
6: Limit price further that 1p away from the spread

TABLE 6.4B NUMBER AND VOLUME OF SELL ORDERS BY AGGRESSIVENESS AND MARKET CAPITALISATION

	Number								Volume							
Rank	1 & 2	1	2	3	4	5	6	Total	1 & 2	1	2	3	4	5	6	Total
1	256.37	41.02	215.35	120.96	82.33	54.14	52.40	566.20	22151	11098	11052	9243	6830	3687	2493	44403
2	148.67	24.70	123.97	108.35	50.54	26.11	70.80	404.46	1432	696	736	1052	347	209	392	3431
3	166.00	28.66	137.34	109.08	53.81	27.34	55.14	411.37	2665	1131	1534	2200	766	253	626	6509
4	113.17	15.66	97.51	81.12	38.38	34.11	69.51	336.28	3698	1116	2582	3153	1256	987	2386	11480
5	120.87	20.12	100.75	97.04	40.84	29.29	49.68	337.72	1712	620	1092	1432	529	288	672	4634
6	101.93	16.97	84.96	88.24	31.38	15.94	61.73	299.23	600	200	400	507	139	46	200	1491
7	131.18	21.11	110.07	85.94	37.27	23.63	28.66	306.67	1833	693	1140	1323	546	223	335	4260
8	99.51	14.80	84.71	76.22	34.50	18.47	42.99	271.70	657	223	434	1172	203	68	235	2334
9	103.02	18.68	84.34	81.67	33.42	17.77	34.16	270.04	2546	1710	836	1098	373	132	347	4497
10	86.93	14.98	71.96	60.61	29.96	22.18	17.48	217.17	1360	506	854	950	416	199	231	3156
avg	**132.77**	**21.67**	**111.10**	**90.92**	**43.24**	**26.90**	**48.25**	**342.08**	**3865.30**	**1799**	**2066**	**2213**	**1140**	**609**	**792**	**8620**
prop^n	**0.39**	**0.06**	**0.32**	**0.27**	**0.13**	**0.08**	**0.14**		**0.45**	**0.21**	**0.24**	**0.26**	**0.13**	**0.07**	**0.09**	
22	46.64	7.64	38.99	51.78	17.43	10.30	13.69	139.83	439	178	262	442	124	65	103	1174
23	51.42	6.70	44.72	40.44	14.99	7.53	10.44	124.82	712	202	510	538	171	75	125	1622
24	83.09	13.42	69.68	57.14	27.62	15.81	8.18	191.86	2341	867	1474	1495	748	389	240	5213
25	49.13	8.09	41.04	51.89	17.34	9.84	10.97	139.18	547	209	338	560	159	69	104	1439
26	75.48	11.58	63.90	59.52	25.21	15.24	14.36	189.82	1557	601	956	1106	469	268	235	3635
27	61.42	10.87	50.56	56.93	21.11	13.22	14.75	167.43	792	312	479	659	205	105	159	1920
28	44.62	7.19	37.43	41.28	16.93	9.74	8.40	120.97	604	206	398	555	180	92	124	1555
29	49.26	7.61	41.65	47.23	16.55	8.99	8.17	130.19	752	278	475	651	201	101	132	1837
30	58.46	10.23	48.23	40.46	21.10	9.91	7.82	137.74	1713	743	969	936	472	209	217	3548
31	42.89	6.82	36.08	46.60	17.85	8.11	11.40	126.85	324	120	204	326	108	41	76	875
avg	**56.24**	**9.01**	**47.23**	**49.33**	**19.61**	**10.87**	**10.82**	**146.87**	**978.09**	**372**	**606**	**727**	**284**	**142**	**152**	**2282**
prop^n	**0.38**	**0.06**	**0.32**	**0.34**	**0.13**	**0.07**	**0.07**		**0.43**	**0.16**	**0.27**	**0.32**	**0.12**	**0.06**	**0.07**	
44	38.10	6.34	31.77	44.44	15.40	7.07	7.61	112.63	410	150	260	423	132	53	75	1093
45	36.54	4.99	31.55	40.48	13.55	5.56	6.50	102.63	349	132	218	386	94	32	52	913
46	34.86	4.28	30.57	37.01	14.49	5.97	8.02	100.35	218	88	130	225	78	27	46	593
47	29.36	4.60	24.76	36.83	15.57	7.68	11.48	100.91	192	66	127	227	80	183	70	752
48	31.45	5.43	26.02	40.18	13.79	4.75	6.93	97.10	947	749	198	350	95	29	66	1488
49	51.97	9.07	42.89	49.45	17.96	9.48	9.48	138.35	761	275	485	645	220	109	136	1871
50	45.15	5.46	39.69	40.36	12.43	4.84	9.48	112.25	412	110	302	327	78	28	76	920
51	31.11	4.73	26.38	37.97	13.46	5.02	7.74	95.30	215	80	135	245	68	21	40	588
52	41.43	7.28	34.15	42.63	14.49	5.17	9.31	113.02	425	185	239	386	102	37	94	1044
53	35.03	5.79	29.24	40.81	13.39	5.27	8.18	102.68	288	113	176	288	78	28	69	751
avg	**37.50**	**5.80**	**31.70**	**41.02**	**14.45**	**6.08**	**8.47**	**107.52**	**421.72**	**195**	**227**	**350**	**103**	**54**	**72**	**1001**
prop^n	**0.35**	**0.05**	**0.29**	**0.38**	**0.13**	**0.06**	**0.08**		**0.42**	**0.19**	**0.23**	**0.35**	**0.10**	**0.05**	**0.07**	
Total avg	**75.50**	**22.03**	**115.96**	**120.65**	**48.48**	**25.92**	**35.38**	**368.42**	**1755.04**	**1166.08**	**1522.16**	**1814.68**	**766.31**	**399.09**	**487.97**	**6156.30**
Total prop^n	**0.20**	**0.06**	**0.31**	**0.33**	**0.13**	**0.07**	**0.10**		**0.29**	**0.19**	**0.25**	**0.29**	**0.12**	**0.06**	**0.08**	

number of orders in thousands
volume of trades in millions of pounds
Rank: Uniquely identifies the company (See Table 5.1)
1 & 2: Is a combined total for all market orders (Category 1 & 2)
1: Orders at or better than the opposite side price, larger than depth at best
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3: Limit price within the spread
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6: Limit price further that 1p away from the spread

TABLE 6.4C RATIO OF NUMBER AND VOLUME OF BUY ORDERS OVER SELL ORDERS BY AGGRESSIVENESS AND MARKET CAPITALISATION

	Number								Volume							
Rank	1 & 2	1	2	3	4	5	6	Total	1 & 2	1	2	3	4	5	6	Total
1	1.14	0.96	1.17	1.04	1.11	1.09	1.01	1.10	0.85	0.69	1.02	1.03	1.15	1.14	0.99	0.97
2	1.01	0.96	1.02	1.06	1.07	1.02	1.02	1.03	0.88	0.74	1.01	2.67	0.98	0.53	1.08	1.44
3	1.07	0.95	1.09	1.03	1.10	1.08	1.08	1.06	0.92	0.81	1.00	0.77	1.02	1.42	1.11	0.92
4	0.98	0.99	0.98	1.00	1.05	1.01	0.97	1.00	1.05	0.98	1.08	0.99	0.98	1.04	1.01	1.02
5	1.03	0.94	1.05	1.07	1.08	1.04	0.89	1.03	1.01	0.88	1.08	1.02	0.98	0.94	0.77	0.97
6	0.94	0.96	0.93	1.01	1.12	0.92	0.90	0.97	1.04	1.05	1.04	1.01	1.11	0.93	0.92	1.02
7	1.00	0.94	1.01	1.03	1.13	1.05	1.06	1.03	1.02	1.00	1.04	0.99	1.05	1.00	1.01	1.01
8	0.97	0.99	0.96	1.02	1.09	0.99	1.01	1.01	1.07	1.11	1.05	0.49	1.02	0.98	1.79	0.85
9	1.05	0.95	1.07	0.99	1.06	1.04	1.01	1.03	0.54	0.28	1.06	0.95	3.68	1.05	0.99	0.95
10	0.96	0.99	0.95	1.04	1.12	1.06	0.96	1.01	1.04	1.09	1.02	1.03	1.08	1.10	1.07	1.05
avg	**1.03**	**0.96**	**1.04**	**1.03**	**1.09**	**1.04**	**0.99**	**1.03**	**0.89**	**0.72**	**1.03**	**1.04**	**1.18**	**1.09**	**1.01**	**0.99**
prop^n	**1.00**	**0.93**	**1.01**	**1.00**	**1.06**	**1.01**	**0.96**		**0.89**	**0.73**	**1.04**	**1.05**	**1.19**	**1.10**	**1.02**	
22	0.99	1.00	0.98	1.03	1.11	1.03	0.95	1.02	1.04	1.00	1.07	1.07	1.03	0.89	1.04	1.04
23	0.91	0.93	0.91	0.99	1.03	1.24	1.11	0.99	0.97	1.11	0.91	1.06	1.06	1.15	1.17	1.03
24	0.96	0.94	0.96	1.01	1.07	0.98	0.83	0.99	0.95	0.92	0.98	1.03	1.02	1.03	0.96	0.99
25	1.01	0.98	1.02	0.99	1.13	1.05	1.07	1.02	1.04	1.06	1.03	0.99	1.13	1.07	1.14	1.04
26	1.05	0.93	1.07	0.95	1.07	1.09	1.03	1.02	0.96	0.86	1.02	1.01	1.05	1.12	1.11	1.01
27	1.06	0.91	1.10	1.02	1.13	1.13	1.09	1.07	1.14	1.37	0.99	0.99	1.07	1.12	1.18	1.08
28	0.95	0.95	0.95	1.04	1.09	0.85	1.08	1.00	0.99	0.99	0.99	1.03	1.02	0.85	1.08	1.01
29	0.93	0.98	0.92	0.97	1.08	1.06	1.05	0.98	1.04	1.12	0.99	1.02	1.09	1.20	1.17	1.05
30	0.96	0.96	0.96	0.98	1.03	1.04	0.89	0.98	0.92	0.99	0.88	1.06	1.17	1.25	0.97	1.02
31	0.95	0.92	0.96	1.00	1.08	0.92	0.99	0.99	0.96	0.93	0.99	1.03	1.10	0.99	1.11	1.02
avg	**0.98**	**0.95**	**0.99**	**1.00**	**1.08**	**1.04**	**1.02**	**1.01**	**0.98**	**1.00**	**0.97**	**1.03**	**1.07**	**1.09**	**1.08**	**1.02**
prop^n	**0.97**	**0.94**	**0.98**	**0.99**	**1.07**	**1.03**	**1.01**		**0.96**	**0.98**	**0.95**	**1.01**	**1.05**	**1.07**	**1.06**	
44	1.00	0.94	1.01	1.01	1.08	0.94	1.02	1.01	0.97	0.96	0.97	1.06	1.05	1.01	1.09	1.02
45	0.87	0.91	0.86	0.96	1.10	1.00	1.12	0.96	0.84	0.73	0.90	0.95	1.11	1.12	1.32	0.95
46	0.81	0.98	0.78	0.96	1.00	0.95	1.15	0.93	0.92	0.84	0.97	1.06	0.94	1.02	1.25	1.01
47	0.98	0.95	0.98	0.98	1.01	0.87	1.03	0.98	0.97	0.97	0.97	1.01	1.01	0.16	1.06	0.80
48	0.98	1.03	0.97	0.98	1.16	1.03	1.05	1.01	0.35	0.17	1.04	1.03	1.18	1.11	1.17	0.62
49	0.95	1.03	0.93	0.97	1.05	1.00	0.99	0.97	1.01	1.05	0.98	1.04	1.03	1.09	1.15	1.04
50	0.95	1.06	0.93	0.97	0.99	1.03	1.00	0.97	0.99	1.03	0.97	1.05	1.17	1.12	1.04	1.03
51	0.96	0.84	0.99	0.99	1.01	0.90	1.00	0.98	0.87	0.76	0.93	1.08	0.94	0.97	1.16	0.99
52	0.98	0.96	0.98	1.03	1.13	1.10	0.98	1.02	1.02	1.01	1.04	1.04	1.13	1.12	1.02	1.04
53	0.91	0.98	0.89	1.00	1.13	0.93	1.00	0.98	1.07	1.18	1.00	1.06	1.18	0.98	1.05	1.07
avg	**0.94**	**0.97**	**0.93**	**0.99**	**1.07**	**0.97**	**1.03**	**0.98**	**0.83**	**0.66**	**0.98**	**1.04**	**1.07**	**0.76**	**1.12**	**0.94**
prop^n	**0.95**	**0.99**	**0.95**	**1.00**	**1.09**	**0.99**	**1.05**		**0.88**	**0.70**	**1.04**	**1.10**	**1.13**	**0.81**	**1.18**	
Total avg	**1.00**	**0.96**	**0.99**	**1.00**	**1.08**	**1.02**	**1.01**	**1.01**	**0.90**	**0.80**	**1.00**	**1.03**	**1.13**	**1.05**	**1.05**	**0.99**
Total prop^n	**1.00**	**0.95**	**0.98**	**0.99**	**1.07**	**1.02**	**1.00**		**0.90**	**0.80**	**1.00**	**1.04**	**1.13**	**1.05**	**1.05**	

number of orders in thousands
volume of trades in millions of pounds
Rank: Uniquely identifies the company (See Table 5.1)
1 & 2: Is a combined total for all market orders (Category 1 & 2)
1: Orders at or better than the opposite side price, larger than depth at best
2: Orders at or better than the opposite side price, smaller than depth at best
3: Limit price within the spread
4: Limit price at the same side, best price
5: Limit price behind best price, but within 1p
6: Limit price further that 1p away from the spread

Aggressive sell orders are more common than aggressive buy orders as with Allen and Gorton (1992), but we also find the relationship between aggressiveness and market capitalization to be clearly monotonic. The proportion of aggressive orders (by both number and volume) increases with market capitalization. Given that the shares of the larger stock are likely to be spread between more investors, it is possible that this reflects a greater information asymmetry i.e. while any informed party may buy a stock, informed sellers must have the stock in the first place. However, this is also likely to be a result of the smaller spreads associated with the larger stocks.

One other noticeable difference is the proportion of type 3 orders. Since the spread is usually wider for the smaller stocks, there is a greater opportunity to post orders within the spread. So we find that the number and volume of buy orders placed within the spread decreases with market capitalization. A corollary to this is that orders at the spread are more likely for larger stocks. Although the number of buy orders at the spread is fewer, we find that the volume does indeed increase with market capitalization. This result holds for the sell orders as well.

6.4.2 Average Order Size

We established earlier that average order size increases with market capitalization. In Table 6.5, however, we note that as a percentage of the average order size for each stock, the average order size varies by aggressiveness. We can see that the market orders (type 1 and 2) are smaller than the average order size for that stock in the largest group of companies. For the smaller companies, the aggressive orders are larger than the average for the stock. The opposite is true for the competitively prices limit orders (type 3 and 4). These orders are larger than the average order size for the large companies, and equal or smaller than the average for the smaller companies. If we interpret size of trade as an indicator of information, this might

TABLE 6.5A AVERAGE ORDER SIZE OF BUY ORDERS BY AGGRESSIVENESS AND MARKET CAPITALISATION

	Aggressiveness							
Rank	**1 & 2**	**1**	**2**	**3**	**4**	**5**	**6**	**Total**
1	64.98	194.04	44.69	75.42	86.24	71.05	46.59	69.23
2	8.38	21.81	5.87	24.49	6.29	4.12	5.86	11.83
3	13.83	33.76	10.21	15.05	13.23	12.17	11.68	13.66
4	34.89	70.47	29.12	38.60	30.68	29.67	35.53	34.87
5	13.87	28.98	11.17	14.06	11.75	8.88	11.73	12.95
6	6.53	12.85	5.23	5.70	4.37	2.92	3.30	5.21
7	14.30	34.83	10.62	14.80	13.57	8.99	11.10	13.62
8	7.32	16.90	5.60	7.43	5.50	3.64	9.68	7.23
9	12.68	27.04	9.84	12.83	38.90	7.47	9.92	15.36
10	17.03	37.29	12.68	15.52	13.39	9.37	14.72	15.05
avg	**19.38**	**47.80**	**14.50**	**22.39**	**22.39**	**15.83**	**16.01**	**19.90**
prop^n	**0.97**	**2.40**	**0.73**	**1.12**	**1.13**	**0.80**	**0.80**	**1.00**
22	9.96	23.29	7.29	8.81	6.57	5.42	8.22	8.57
23	14.74	36.19	11.46	14.26	11.76	9.34	12.62	13.60
24	28.03	62.95	21.45	26.77	25.85	25.96	33.99	27.35
25	11.45	27.87	8.35	10.86	9.22	7.20	10.11	10.51
26	18.74	48.00	14.15	19.81	18.31	18.17	17.63	18.86
27	13.79	43.35	8.55	11.26	9.19	7.88	11.58	11.66
28	14.12	29.56	11.14	13.33	9.90	9.47	14.91	12.94
29	17.00	41.69	12.22	14.47	12.31	12.65	18.05	15.18
30	28.30	74.97	18.40	25.14	25.38	25.40	30.23	26.78
31	7.63	17.84	5.79	7.21	6.13	5.45	7.43	7.10
avg	**16.38**	**40.57**	**11.88**	**15.19**	**13.46**	**12.69**	**16.48**	**15.25**
prop^n	**1.07**	**2.66**	**0.78**	**1.00**	**0.88**	**0.83**	**1.08**	**1.00**
44	10.43	24.25	7.86	10.01	8.24	8.06	10.51	9.81
45	9.23	21.27	7.22	9.47	6.97	6.37	9.36	8.83
46	7.12	17.75	5.27	6.66	5.04	4.76	6.25	6.39
47	6.51	14.69	5.05	6.38	5.10	4.45	6.24	6.07
48	10.84	22.72	8.21	9.09	7.06	6.68	10.70	9.31
49	15.58	31.02	11.96	14.03	12.03	12.48	16.58	14.38
50	9.51	19.39	7.95	8.69	7.44	6.29	8.37	8.73
51	6.24	15.36	4.84	7.06	4.67	4.39	5.97	6.23
52	10.76	26.60	7.43	9.13	7.02	7.33	10.43	9.41
53	9.69	23.31	6.72	7.45	6.10	5.59	8.86	7.98
avg	**9.59**	**21.64**	**7.25**	**8.80**	**6.97**	**6.64**	**9.32**	**8.71**
prop^n	**1.10**	**2.48**	**0.83**	**1.01**	**0.80**	**0.76**	**1.07**	**1.00**
avg	**15.12**	**36.67**	**11.21**	**15.46**	**14.27**	**11.72**	**13.94**	**14.62**
prop^n	**1.03**	**2.51**	**0.77**	**1.06**	**0.98**	**0.80**	**0.95**	**1.00**

Rank: Uniquely identifies the company (See table 5.1)
1 & 2: Is a combined total for all market orders (Category 1 & 2)
1: Orders at or better that the opposite side price, larger than depth at best
2: Orders at or better than the opposite side price, smaller than depth at best
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Average order size mesaured in thousands of pounds

TABLE 6.5B AVERAGE ORDER SIZE OF SELL ORDERS BY AGGRESSIVENESS AND MARKET CAPITALISATION

		Aggressiveness						
Rank	1 & 2	1	2	3	4	5	6	Total
1	86.40	270.55	51.32	76.41	82.96	68.11	47.57	78.42
2	9.63	28.17	5.94	9.71	6.86	8.00	5.53	8.48
3	16.05	39.45	11.17	20.17	14.23	9.24	11.35	15.82
4	32.68	71.30	26.48	38.86	32.73	28.95	34.32	34.14
5	14.16	30.83	10.84	14.76	12.96	9.83	13.53	13.72
6	5.88	11.78	4.71	5.74	4.42	2.89	3.24	4.98
7	13.98	32.83	10.36	15.40	14.64	9.42	11.69	13.89
8	6.60	15.04	5.12	15.38	5.87	3.68	5.46	8.59
9	24.72	91.54	9.92	13.44	11.17	7.44	10.17	16.65
10	15.64	33.77	11.87	15.67	13.89	8.99	13.22	14.53
avg	**22.57**	**62.53**	**14.77**	**22.56**	**19.97**	**15.65**	**15.61**	**20.92**
prop^n	**1.08**	**2.99**	**0.71**	**1.08**	**0.95**	**0.75**	**0.75**	**1.00**
22	9.42	23.27	6.71	8.54	7.09	6.30	7.55	8.39
23	13.85	30.13	11.41	13.30	11.43	10.01	12.01	13.00
24	28.17	64.62	21.15	26.16	27.09	24.58	29.35	27.17
25	11.13	25.78	8.24	10.78	9.16	7.03	9.50	10.34
26	20.63	51.93	14.96	18.58	18.61	17.59	16.35	19.15
27	12.89	28.75	9.48	11.57	9.72	7.97	10.78	11.47
28	13.53	28.60	10.63	13.44	10.62	9.48	14.80	12.85
29	15.28	36.49	11.40	13.79	12.12	11.20	16.16	14.11
30	29.30	72.67	20.10	23.14	22.38	21.13	27.80	25.76
31	7.56	17.66	5.65	7.01	6.02	5.07	6.66	6.90
avg	**16.18**	**37.99**	**11.97**	**14.63**	**13.42**	**12.04**	**15.10**	**14.91**
prop^n	**1.08**	**2.55**	**0.80**	**0.98**	**0.90**	**0.81**	**1.01**	**1.00**
44	10.76	23.64	8.18	9.52	8.54	7.44	9.92	9.70
45	9.57	26.36	6.91	9.54	6.95	5.66	7.94	8.90
46	6.24	20.54	4.24	6.08	5.39	4.45	5.73	5.91
47	6.55	14.32	5.11	6.17	5.12	23.79	6.08	7.45
48	30.12	137.98	7.62	8.71	6.92	6.16	9.58	15.33
49	14.64	30.34	11.32	13.05	12.25	11.46	14.35	13.52
50	9.12	20.11	7.61	8.09	6.28	5.80	8.02	8.20
51	6.92	16.92	5.13	6.45	5.05	4.09	5.14	6.17
52	10.25	25.44	7.01	9.06	7.05	7.22	10.08	9.24
53	8.23	19.45	6.01	7.05	5.82	5.27	8.44	7.31
avg	**11.24**	**33.51**	**6.91**	**8.37**	**6.94**	**8.13**	**8.53**	**9.17**
prop^n	**1.23**	**3.65**	**0.75**	**0.91**	**0.76**	**0.89**	**0.93**	**1.00**
avg	**16.66**	**44.68**	**11.22**	**15.19**	**13.45**	**11.94**	**13.08**	**15.00**
prop^n	**1.11**	**2.98**	**0.75**	**1.01**	**0.90**	**0.80**	**0.87**	**1.00**

Rank: Uniquely identifies the company (See table 5.1)
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Average order size mesaured in thousands of pounds

TABLE 6.5C RATIO OF AVERAGE BUY ORDER SIZE AND AVERAGE SELL ORDER SIZE BY AGGRESSIVENESS AND MARKET CAPITALISATION

		Aggressiveness						
Rank	1 & 2	1	2	3	4	5	6	Total
1	0.75	0.72	0.87	0.99	1.04	1.04	0.98	0.88
2	0.87	0.77	0.99	2.52	0.92	0.52	1.06	1.39
3	0.86	0.86	0.91	0.75	0.93	1.32	1.03	0.86
4	1.07	0.99	1.10	0.99	0.94	1.03	1.04	1.02
5	0.98	0.94	1.03	0.95	0.91	0.90	0.87	0.94
6	1.11	1.09	1.11	0.99	0.99	1.01	1.02	1.05
7	1.02	1.06	1.03	0.96	0.93	0.95	0.95	0.98
8	1.11	1.12	1.09	0.48	0.94	0.99	1.77	0.84
9	0.51	0.30	0.99	0.95	3.48	1.00	0.98	0.92
10	1.09	1.10	1.07	0.99	0.96	1.04	1.11	1.04
avg	**0.86**	**0.76**	**0.98**	**0.99**	**1.12**	**1.01**	**1.03**	**0.95**
prop^n	**0.90**	**0.80**	**1.03**	**1.04**	**1.18**	**1.06**	**1.08**	**1.00**
22	1.06	1.00	1.09	1.03	0.93	0.86	1.09	1.02
23	1.06	1.20	1.00	1.07	1.03	0.93	1.05	1.05
24	1.00	0.97	1.01	1.02	0.95	1.06	1.16	1.01
25	1.03	1.08	1.01	1.01	1.01	1.02	1.06	1.02
26	0.91	0.92	0.95	1.07	0.98	1.03	1.08	0.98
27	1.07	1.51	0.90	0.97	0.95	0.99	1.07	1.02
28	1.04	1.03	1.05	0.99	0.93	1.00	1.01	1.01
29	1.11	1.14	1.07	1.05	1.02	1.13	1.12	1.08
30	0.97	1.03	0.92	1.09	1.13	1.20	1.09	1.04
31	1.01	1.01	1.02	1.03	1.02	1.08	1.12	1.03
avg	**1.01**	**1.07**	**0.99**	**1.04**	**1.00**	**1.05**	**1.09**	**1.02**
prop^n	**0.99**	**1.04**	**0.97**	**1.02**	**0.98**	**1.03**	**1.07**	**1.00**
44	0.97	1.03	0.96	1.05	0.97	1.08	1.06	1.01
45	0.96	0.81	1.05	0.99	1.00	1.12	1.18	0.99
46	1.14	0.86	1.24	1.10	0.94	1.07	1.09	1.08
47	0.99	1.03	0.99	1.03	1.00	0.19	1.03	0.81
48	0.36	0.16	1.08	1.04	1.02	1.08	1.12	0.61
49	1.06	1.02	1.06	1.08	0.98	1.09	1.15	1.06
50	1.04	0.96	1.05	1.07	1.18	1.08	1.04	1.06
51	0.90	0.91	0.94	1.09	0.93	1.07	1.16	1.01
52	1.05	1.05	1.06	1.01	1.00	1.02	1.03	1.02
53	1.18	1.20	1.12	1.06	1.05	1.06	1.05	1.09
avg	**0.85**	**0.65**	**1.05**	**1.05**	**1.00**	**0.82**	**1.09**	**0.95**
prop^n	**0.90**	**0.68**	**1.10**	**1.11**	**1.06**	**0.86**	**1.15**	**1.00**
avg	**0.91**	**0.82**	**1.00**	**1.02**	**1.06**	**0.98**	**1.07**	**0.97**
prop^n	**0.93**	**0.84**	**1.03**	**1.04**	**1.09**	**1.01**	**1.09**	**1.00**

Rank: Uniquely identifies the company (See table 5.1)
1 & 2: Is a combined total for all market orders (Category 1 & 2)
1: Orders at or better that the opposite side price, larger than depth at best
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Average order size mesaured in thousands of pounds

suggest that informed traders are more willing to gamble on the larger stocks. Perhaps the trading volume for the larger stocks gives a greater probability of quick execution. So informed traders are willing to try a limit order and gain the spread, with a view to placing a market order quickly if the gamble doesn't pay off. When faced with the same decision for a smaller stock, they may not be willing to wait while the lumpy orders flow in, and so prefer the certainty of execution.

There may also be a behavioural bias induced by the size of the trade. Due to mental accounting, investors may gauge the size of their aggressive orders appropriate to their holding, the size of their portfolio, or the absolute value. Investors may be discouraged from sending a large aggressive order to the market for fear of how the market may react to it.

For the smaller companies in particular, we can see that orders inside the spread are bigger than orders at the spread, which are bigger than orders just behind the spread, expressed in relation to the average order size. If we again interpret size of order as an indicator of information, this would suggest that informed traders place limit orders further up the queue. This agrees with the earlier statement that informed traders are willing to use limit orders but are not willing to wait a long time. This size effect can also be rationalised by the probability of completely filling the order. After allowing for the prior ranking orders, it is more possible that a small order will fill if placed behind the best quote, but a large order would have to be placed inside the quote to fill completely against the same order.

6.4.3 Daily Patterns

Table 6.6 shows the number and volume of trades by aggressiveness, for each quarter hour during the trading day. Table 6.7 shows the average order size throughout the trading day. Finally, for ease of comparison, the number and volume

TABLE 6.6A VOLUME AND NUMBER OF BUY ORDERS BY AGGRESSIVENESS AND TIME OF DAY

		Number								Volume								Prop^n of day		Aggressiveness		Market orders as prop^n of total orders	
Hour	1/4 hour	1 & 2	1	2	3	4	5	6	Total	1 & 2	1	2	3	4	5	6	Total	Number	Volume	Number	Volume	Number	Volume
8	1	16.75	2.58	14.18	39.52	8.75	2.93	21.61	89.56	589	211	378	869	298	154	489	2399	0.015	0.020	3.671	3.530	0.187	0.246
8	2	23.64	3.36	20.28	38.06	11.97	3.44	14.22	91.33	876	372	504	779	341	177	484	2656	0.015	0.022	3.378	3.338	0.259	0.330
8	3	28.32	4.18	24.15	37.92	14.47	4.25	12.54	97.49	755	252	503	701	346	259	269	2330	0.016	0.020	3.288	3.286	0.290	0.324
8	4	35.97	5.83	30.14	47.84	17.20	5.84	24.90	131.75	855	292	563	830	365	170	391	2611	0.022	0.022	3.469	3.280	0.273	0.327
9	1	56.73	7.15	49.58	63.90	22.46	9.42	26.07	178.58	1214	447	767	1044	430	207	392	3288	0.029	0.028	3.311	3.109	0.318	0.369
9	2	56.40	7.44	48.97	57.74	23.33	11.22	23.84	172.53	1162	405	757	941	435	213	339	3090	0.028	0.026	3.310	3.101	0.327	0.376
9	3	60.18	7.87	52.30	56.63	23.87	13.18	22.65	176.50	1132	354	778	906	1417	230	308	3994	0.029	0.034	3.284	3.330	0.341	0.283
9	*4*	*61.31*	*8.29*	*53.02*	*54.76*	*24.28*	*13.44*	*21.97*	*175.75*	*1213*	*395*	*819*	*910*	*445*	*231*	*310*	*3108*	*0.029*	*0.026*	3.270	3.073	0.349	0.390
10	1	67.72	9.86	57.86	56.03	25.59	14.42	22.45	186.22	1279	447	832	912	469	250	352	3262	0.031	0.028	3.237	3.091	0.364	0.392
10	2	77.33	11.93	65.40	56.47	29.10	14.88	20.99	198.76	1418	580	838	944	498	252	286	3397	0.033	0.029	3.164	2.959	0.389	0.417
10	3	63.06	9.12	53.94	50.48	24.44	14.30	19.07	171.35	1241	441	800	858	457	240	272	3069	0.028	0.026	3.222	3.024	0.368	0.404
10	4	65.94	9.06	56.89	50.20	23.94	13.35	19.11	172.54	1272	435	836	877	454	228	272	3102	0.028	0.026	3.191	3.006	0.382	0.410
11	1	58.47	8.22	50.25	46.34	21.62	12.78	17.45	156.87	1114	378	736	796	426	218	252	2805	0.026	0.024	3.210	3.044	0.373	0.397
11	2	59.05	8.37	50.68	47.55	22.79	13.11	17.03	159.52	1139	386	753	2734	439	215	228	4755	0.026	0.040	3.205	3.006	0.370	0.239
11	3	56.85	7.69	49.15	44.34	21.59	12.02	15.91	150.71	1058	348	709	736	404	196	223	2617	0.025	0.022	3.191	3.023	0.377	0.404
11	4	57.65	8.02	49.63	45.56	19.90	11.89	15.64	150.84	1122	389	733	774	394	204	209	2704	0.025	0.023	3.166	2.970	0.383	0.415
12	1	52.49	7.18	45.31	41.62	19.56	11.46	14.76	139.88	1008	327	682	705	359	193	207	2472	0.023	0.021	3.193	3.013	0.375	0.408
12	2	47.90	6.88	41.02	37.81	18.19	10.51	13.65	128.06	978	348	630	670	379	187	207	2422	0.021	0.020	3.198	3.020	0.374	0.404
12	3	48.15	6.85	41.30	36.90	17.64	10.04	12.92	125.64	1061	380	681	682	337	172	184	2435	0.021	0.021	3.171	2.915	0.383	0.435
12	4	45.51	6.12	39.38	35.64	16.88	9.76	12.65	120.43	941	350	591	657	340	176	188	2300	0.020	0.019	3.188	2.984	0.378	0.409
13	1	46.14	6.30	39.84	35.30	16.92	9.76	12.19	120.31	892	308	584	625	335	164	182	2198	0.020	0.019	3.171	3.004	0.384	0.406
13	2	48.30	6.41	41.89	36.56	17.28	10.29	12.70	125.12	948	326	622	630	342	180	200	2300	0.021	0.019	3.170	3.012	0.386	0.412
13	3	63.73	8.74	54.99	49.48	23.43	14.04	16.27	166.95	1231	412	819	859	449	228	234	3001	0.028	0.025	3.167	2.988	0.382	0.410
13	4	56.88	7.67	49.21	44.08	20.80	11.86	15.07	148.70	1100	380	719	746	404	208	219	2676	0.024	0.023	3.169	2.999	0.383	0.411
14	1	56.39	7.62	48.78	43.95	21.04	11.89	15.12	148.39	1189	488	701	764	403	209	218	2781	0.024	0.024	3.176	2.927	0.380	0.427
14	2	58.13	7.85	50.28	45.41	20.83	11.50	14.96	150.82	1130	385	745	840	423	203	216	2813	0.025	0.024	3.151	2.987	0.385	0.402
14	3	78.40	11.27	67.13	63.60	30.64	17.56	20.58	210.77	1640	565	1075	1228	598	304	283	4054	0.035	0.034	3.179	2.963	0.372	0.405
14	4	84.26	12.13	72.13	68.10	31.64	18.82	21.97	224.78	1777	604	1174	1279	662	373	305	4397	0.037	0.037	3.173	2.987	0.375	0.404
15	1	91.78	13.51	78.27	72.62	35.03	20.03	24.27	243.73	1895	639	1256	1324	706	370	345	4642	0.040	0.039	3.175	2.989	0.377	0.408
15	2	95.26	14.52	80.74	73.10	35.73	20.27	23.69	248.05	2046	806	1241	1318	687	354	315	4720	0.041	0.040	3.151	2.891	0.384	0.434
15	3	99.83	15.57	84.26	74.87	36.14	20.75	24.13	255.71	2038	739	1299	1316	722	357	336	4771	0.042	0.040	3.135	2.930	0.390	0.427
15	4	107.50	16.88	90.61	76.75	38.00	20.75	24.26	267.25	2206	822	1384	1382	768	372	362	5090	0.044	0.043	3.104	2.916	0.402	0.433
16	1	116.47	19.86	96.61	81.67	42.09	20.58	23.64	284.45	2507	994	1513	1483	849	380	349	5567	0.047	0.047	3.063	2.848	0.409	0.450
16	2	184.07	36.00	148.07	121.54	61.10	31.10	46.71	444.52	3920	1857	2063	1962	1213	711	841	8646	0.073	0.073	3.098	2.928	0.414	0.453
16	3	45.75	19.81	25.93	0.81	0.70	0.54	9.37	57.16	1420	1089	330	16	29	35	206	1704	0.009	0.014	2.376	1.947	0.800	0.833
	sum	2272	350.11	1922.16	1833.13	838.89	451.95	674.35	6070.60	47366	17947	29418	34097	17621	8618	10474	118176						

number in thousands

volume in millions of pounds

1 & 2: is a combined total for all market orders (Category 1 & 2)

1: Orders at or better that the opposite side price, larger than depth at best

2: Orders at or better than the opposite side price, smaller than depth at best

3: Limit price within the spread

4: Limit price at the same side, best price

5: Limit price behind best price, but within 1p

6: Limit price further that 1p away from the spread

Propn of Day: proportion of day's order activity in the quarter hour period.

Aggressiveness: average aggressiveness score

Market orders as prop^n of total orders: ratio of type one and two order divided by the total orders for that 15 minute period.

TABLE 6.6B VOLUME AND NUMBER OF SELL ORDERS BY AGGRESSIVENESS AND TIME OF DAY

		Number								Volume								Prop^n of day		Aggressiveness		Market orders as prop^n of total orders	
Hour	1/4 hour	1 & 2	1	2	3	4	5	6	Total	1 & 2	1	2	3	4	5	6	Total	Number	Volume	Number	Volume	Number	Volume
8	1	15.45	2.74	12.71	35.16	8.05	2.49	23.43	84.58	2706	2357	349	804	264	137	481	4391	0.014	0.037	3.770	2.298	0.183	0.616
8	2	21.30	3.50	17.81	34.67	10.96	3.18	15.11	85.23	872	443	429	739	305	149	308	2373	0.014	0.020	3.444	3.090	0.250	0.367
8	3	26.24	4.28	21.95	35.35	12.33	3.82	13.01	90.74	782	301	482	701	311	151	271	2216	0.015	0.019	3.314	3.155	0.289	0.353
8	4	34.19	5.86	28.32	44.21	14.48	5.54	26.21	124.62	814	308	506	799	325	264	385	2587	0.021	0.022	3.515	3.342	0.274	0.315
9	1	52.61	7.11	45.50	60.36	20.25	9.52	27.73	170.47	1039	347	692	1008	375	189	370	2982	0.028	0.025	3.368	3.160	0.309	0.348
9	2	58.91	7.72	51.19	59.69	22.22	11.29	23.34	175.45	1141	370	771	936	402	191	336	3006	0.029	0.025	3.275	3.094	0.336	0.380
9	3	62.91	8.40	54.51	57.01	23.78	13.44	22.67	179.80	1455	682	773	938	418	206	298	3315	0.030	0.028	3.263	2.876	0.350	0.439
9	4	65.94	8.66	57.28	56.93	24.60	13.54	21.37	182.38	1247	421	825	925	417	208	297	3094	0.030	0.026	3.226	3.019	0.362	0.403
10	1	74.30	10.54	63.76	57.90	24.59	14.34	21.05	192.18	1274	435	839	893	440	225	318	3150	0.032	0.027	3.164	3.043	0.387	0.404
10	2	87.18	13.01	74.16	57.88	26.87	14.80	20.52	207.25	1392	504	887	904	450	224	268	3237	0.034	0.027	3.086	2.940	0.421	0.430
10	3	64.54	9.24	55.30	51.56	23.07	13.76	18.72	171.85	1245	426	818	1023	403	208	260	3139	0.028	0.027	3.192	2.977	0.376	0.397
10	4	66.00	8.93	57.06	50.84	22.31	12.84	17.90	169.88	1212	399	812	838	415	207	243	2915	0.028	0.025	3.157	2.982	0.388	0.416
11	1	59.42	8.48	50.94	48.03	21.27	12.15	16.85	157.72	1165	409	756	786	406	197	242	2795	0.026	0.024	3.179	2.983	0.377	0.417
11	2	59.55	8.77	50.78	46.69	20.44	11.81	16.60	155.09	1368	611	757	806	373	202	226	2974	0.026	0.025	3.165	2.824	0.384	0.460
11	3	56.80	8.27	48.53	44.85	20.44	11.35	15.37	148.80	1094	373	720	752	391	194	202	2633	0.025	0.022	3.162	2.969	0.382	0.415
11	4	57.50	8.62	48.88	45.81	19.17	11.37	14.96	148.81	1196	493	703	775	372	186	217	2747	0.025	0.023	3.139	2.894	0.386	0.435
12	1	52.04	7.53	44.51	40.90	18.35	10.54	14.09	135.82	1033	375	657	707	354	178	210	2481	0.022	0.021	3.163	2.972	0.383	0.416
12	2	47.84	7.04	40.80	38.28	17.25	9.91	13.29	126.57	1000	366	634	671	322	161	216	2370	0.021	0.020	3.174	2.969	0.378	0.422
12	3	48.32	7.30	41.02	38.13	16.88	9.51	12.66	125.50	1113	451	662	704	321	161	203	2502	0.021	0.021	3.146	2.876	0.385	0.445
12	4	45.54	6.68	38.86	36.38	15.94	9.78	11.69	119.32	982	382	600	640	316	156	177	2272	0.020	0.019	3.154	2.910	0.382	0.432
13	1	43.82	6.36	37.46	35.55	15.35	9.61	11.88	116.20	1546	968	577	623	300	156	175	2800	0.019	0.024	3.172	2.509	0.377	0.552
13	2	46.59	6.75	39.83	35.64	15.68	9.85	12.43	120.18	981	384	597	627	294	157	189	2248	0.020	0.019	3.161	2.915	0.388	0.436
13	3	57.09	9.09	48.01	46.65	19.54	13.00	16.08	152.37	1237	489	748	868	400	211	237	2952	0.025	0.025	3.181	2.935	0.375	0.419
13	4	53.73	7.83	45.90	43.49	18.86	12.27	14.96	143.31	1100	405	695	771	371	188	205	2635	0.024	0.022	3.186	2.946	0.375	0.417
14	1	54.79	8.25	46.54	42.51	19.35	11.99	15.25	143.88	1132	410	722	772	379	203	201	2668	0.024	0.023	3.181	2.942	0.381	0.421
14	2	55.18	8.25	46.94	42.98	18.46	11.41	14.91	142.94	1161	408	752	771	377	186	200	2695	0.024	0.023	3.158	2.919	0.386	0.431
14	3	80.39	12.57	67.81	63.09	26.86	17.51	20.99	208.83	1799	671	1128	1638	564	294	267	4562	0.034	0.039	3.153	2.887	0.385	0.394
14	4	87.01	13.59	73.42	66.86	28.60	18.70	21.67	222.84	1951	718	1233	1228	612	325	307	4424	0.037	0.037	3.136	2.890	0.390	0.441
15	1	94.49	14.83	79.66	72.31	31.28	19.88	23.81	241.76	1993	715	1278	1302	638	351	311	4598	0.040	0.039	3.137	2.905	0.391	0.434
15	2	95.17	15.42	79.75	70.59	31.38	18.97	23.39	239.50	1957	709	1249	1265	637	326	312	4496	0.039	0.038	3.121	2.901	0.397	0.435
15	3	96.93	16.40	80.53	73.60	32.49	19.28	24.42	246.72	1964	729	1234	1290	661	463	339	4716	0.041	0.040	3.126	2.981	0.393	0.416
15	4	101.44	17.32	84.12	75.17	33.95	19.16	24.97	254.69	2248	899	1349	1951	678	330	374	5581	0.042	0.047	3.112	2.877	0.398	0.403
16	1	114.69	19.61	95.08	82.00	39.28	21.20	24.18	281.35	3131	1666	1465	1473	797	386	362	6150	0.046	0.052	3.071	2.652	0.408	0.509
16	2	188.62	36.79	151.84	120.90	58.16	30.21	43.95	441.84	5049	2938	2110	1952	1157	668	802	9627	0.073	0.081	3.057	2.679	0.427	0.524
16	3	38.56	19.04	19.52	0.74	0.64	0.48	15.99	56.40	1276	1091	185	17	21	13	350	1677	0.009	0.014	2.858	2.243	0.684	0.761
	sum	2265	364.80	1900.25	1812.69	773.09	438.49	675.46	5964.77	52651	23656	28995	32900	15266	8052	10157	119027	0.983	1.007				

number in thousands

volume in millions of pounds

1 & 2: Is a combined total for all market orders (Category 1 & 2)

1: Orders at or better that the opposite side price, larger than depth at best

2: Orders at or better than the opposite side price, smaller than depth at best

3: Limit price within the spread

4: Limit price at the same side, best price

5: Limit price behind best price, but within 1p

6: Limit price furth 4: Limit price at the same side, best price

Propn of Day: prop 5: Limit price behind best price, but within 1p

Aggressiveness: a· 6: Limit price further that 1p away from the spread

Market orders as prop^n of total orders: ratio of type one and two order divided by the total orders for that 15 minute period.

TABLE 6.7A AVERAGE SIZE OF BUY ORDERS BY AGGRESSIVENESS AND TIME OF DAY

Hour 1/4 hour	1 & 2	1	2	3	4	5	6	Total
8 1	35	82	27	22	34	53	23	27
8 2	37	111	25	20	28	52	34	29
8 3	27	60	21	18	24	61	21	24
8 4	24	50	19	17	21	29	16	20
9 1	21	62	15	16	19	22	15	18
9 2	21	54	15	16	19	19	14	18
9 3	19	45	15	16	59	17	14	23
9 4	20	48	15	17	18	17	14	18
10 1	19	45	14	16	18	17	16	18
10 2	18	49	13	17	17	17	14	17
10 3	20	48	15	17	19	17	14	18
10 4	19	48	15	17	19	17	14	18
11 1	19	46	15	17	20	17	14	18
11 2	19	46	15	58	19	16	13	30
11 3	19	45	14	17	19	16	14	17
11 4	19	48	15	17	20	17	13	18
12 1	19	45	15	17	18	17	14	18
12 2	20	51	15	18	21	18	15	19
12 3	22	55	16	18	19	17	14	19
12 4	21	57	15	18	20	18	15	19
13 1	19	49	15	18	20	17	15	18
13 2	20	51	15	17	20	17	16	18
13 3	19	47	15	17	19	16	14	18
13 4	19	50	15	17	19	18	15	18
14 1	21	64	14	17	19	18	14	19
14 2	19	49	15	19	20	18	14	19
14 3	21	50	16	19	20	17	14	19
14 4	21	50	16	19	21	20	14	20
15 1	21	47	16	18	20	18	14	19
15 2	21	55	15	18	19	17	13	19
15 3	20	47	15	18	20	17	14	19
15 4	21	49	15	18	20	18	15	19
16 1	22	50	16	18	20	18	15	20
16 2	21	52	14	16	20	23	18	19
16 3	31	55	13	19	41	64	22	30
avg	**21**	**51**	**15**	**19**	**21**	**19**	**16**	**19**

average order size in thousands of pounds
1 & 2: Is a combined total for all market orders (Category 1 & 2)
1: Orders at or better that the opposite side price, larger than depth at best
2: Orders at or better than the opposite side price, smaller than depth at best
3: Limit price within the spread
4: Limit price at the same side, best price
5: Limit price behind best price, but within 1p
6: Limit price further that 1p away from the spread

TABLE 6.7B AVERAGE SIZE OF SELL ORDERS BY AGGRESSIVENESS AND TIME OF DAY

Hour	1/4 hour	1 & 2	1	2	3	4	5	6	Total
8	1	175	859	27	23	33	55	21	52
8	2	41	127	24	21	28	47	20	28
8	3	30	70	22	20	25	40	21	24
8	4	24	53	18	18	22	48	15	21
9	1	20	49	15	17	19	20	13	17
9	2	19	48	15	16	18	17	14	17
9	3	23	81	14	16	18	15	13	18
9	4	19	49	14	16	17	15	14	17
10	1	17	41	13	15	18	16	15	16
10	2	16	39	12	16	17	15	13	16
10	3	19	46	15	20	17	15	14	18
10	4	18	45	14	16	19	16	14	17
11	1	20	48	15	16	19	16	14	18
11	2	23	70	15	17	18	17	14	19
11	3	19	45	15	17	19	17	13	18
11	4	21	57	14	17	19	16	15	18
12	1	20	50	15	17	19	17	15	18
12	2	21	52	16	18	19	16	16	19
12	3	23	62	16	18	19	17	16	20
12	4	22	57	15	18	20	16	15	19
13	1	35	152	15	18	20	16	15	24
13	2	21	57	15	18	19	16	15	19
13	3	22	54	16	19	20	16	15	19
13	4	20	52	15	18	20	15	14	18
14	1	21	50	16	18	20	17	13	19
14	2	21	49	16	18	20	16	13	19
14	3	22	53	17	26	21	17	13	22
14	4	22	53	17	18	21	17	14	20
15	1	21	48	16	18	20	18	13	19
15	2	21	46	16	18	20	17	13	19
15	3	20	44	15	18	20	24	14	19
15	4	22	52	16	26	20	17	15	22
16	1	27	85	15	18	20	18	15	22
16	2	27	80	14	16	20	22	18	22
16	3	33	57	9	23	32	28	22	30
avg		**23**	**65**	**15**	**18**	**20**	**18**	**15**	**20**

average order size in thousands of pounds

1 & 2: Is a combined total for all market orders (Category 1 & 2)

1: Orders at or better that the opposite side price, larger than depth at best

2: Orders at or better than the opposite side price, smaller than depth at best

3: Limit price within the spread

4: Limit price at the same side, best price

5: Limit price behind best price, but within 1p

6: Limit price further that 1p away from the spread

TABLE 6.7C RATIO OF AVERAGE SIZE OF BUY ORDERS OVER AVERAGE SIZE OF SELL ORDERS, BY AGGRESSIVENESS AND TIME OF DAY

Hour	1/4 hour	1 & 2	1	2	3	4	5	6	Total
8	1	20	10	97	96	104	96	110	52
8	2	91	87	103	96	102	110	167	104
8	3	89	86	95	93	95	154	103	98
8	4	100	95	105	96	94	61	107	95
9	1	108	128	102	98	103	111	112	105
9	2	106	114	103	104	103	112	99	105
9	3	81	55	105	97	338	114	104	123
9	4	105	98	107	102	108	112	101	104
10	1	110	110	109	105	102	110	104	107
10	2	115	126	107	107	102	112	104	109
10	3	102	105	100	86	107	111	103	98
10	4	105	107	103	106	102	106	105	105
11	1	97	95	99	105	103	105	100	101
11	2	84	66	100	333	106	96	98	155
11	3	97	100	97	99	98	95	107	98
11	4	94	85	103	100	102	105	92	97
12	1	97	91	102	98	95	100	94	97
12	2	98	97	99	101	112	110	93	101
12	3	96	90	102	100	101	101	89	97
12	4	96	100	97	105	101	112	98	100
13	1	55	32	95	101	101	103	101	76
13	2	93	89	99	98	106	109	104	98
13	3	89	88	96	93	94	100	98	93
13	4	94	96	97	95	99	114	106	98
14	1	102	129	93	96	98	103	109	100
14	2	92	99	92	103	99	109	108	99
14	3	94	94	96	74	93	103	108	88
14	4	94	94	97	102	98	114	98	99
15	1	98	98	100	101	99	105	109	100
15	2	104	121	98	101	95	102	100	101
15	3	101	107	101	100	98	72	100	98
15	4	93	94	95	69	101	104	100	87
16	1	79	59	102	101	99	101	99	90
16	2	80	65	100	100	100	103	99	89
16	3	94	96	135	85	127	230	100	100
avg		90	79	100	102	106	104	103	98

average order size in thousands of pounds

1 & 2: Is a combined total for all market orders (Category 1 & 2)

1: Orders at or better that the opposite side price, larger than depth at best

2: Orders at or better than the opposite side price, smaller than depth at best

3: Limit price within the spread

4: Limit price at the same side, best price

5: Limit price behind best price, but within 1p

6: Limit price further that 1p away from the spread

of trades for each aggressiveness characteristic are presented as proportions of the total number or volume in that quarter hour period.

The opening procedure ensures that limit orders are already on the book when continuous trading starts at 8am. This is also the first time that investors can see the orders on the book, rather than just the crossing price at open. Trading activity in the first hour is very different to the rest of the day. Overall trading is lower, and the aggressiveness is lower. In the first 15 minutes, only 19% of the orders are market orders, compared to the daily average of 38%. This may be partly due to the risk and uncertainty of the market after open. It could also be that the aggressive traders have filled their orders with the opening procedure, or that those who offer liquidity, wait to see the state of the order book, before setting or adjusting their limit price.

The slow start to the day drags on until around 10am. The overall volume of trading is concave between 10am and 4pm, but the aggressiveness follows no clear pattern. Other than a few odd results like the dip in volume weighted market buy orders at 11am, the aggressiveness is fairly steady. Order activity in general and aggressiveness increase at the end of the day. The last half hour of trading sees the daily high in number and volume of orders and also in the proportion of market orders.

The number of type 1 orders (market orders greater than depth) fluctuates more widely than the other categories as a result of the size related definition. During the middle of the day, when depth is greater than earlier in the day, fewer market orders are larger than the opposite side depth. Type 1 orders move the market price immediately, and this may persist for the rest of the day and beyond. It is possible that traders are less inclined to move the price in the middle of the day, as they are trying to work a larger order. There is also no incentive to manipulate the price, as is the case during the VWAP period at the end of the day.

TABLE 6.8A PROPORTION OF NUMBER AND VOLUME OF BUY ORDERS BY AGGRESSIVENESS AND TIME OF DAY

		Number							Volume						
Hour	1/4 hour	1 & 2	1	2	3	4	5	6	1 & 2	1	2	3	4	5	6
8	1	18.71	2.88	15.83	44.13	9.77	3.27	24.13	24.56	8.79	15.77	36.23	12.40	6.43	20.38
8	2	25.89	3.68	22.21	41.67	13.10	3.77	15.57	32.97	14.00	18.97	29.32	12.82	6.68	18.20
8	3	29.05	4.28	24.77	38.89	14.84	4.36	12.86	32.40	10.79	21.60	30.07	14.86	11.12	11.55
8	4	27.30	4.43	22.87	36.31	13.06	4.43	18.90	32.74	11.18	21.56	31.79	13.98	6.51	14.99
9	1	31.77	4.01	27.76	35.78	12.57	5.28	14.60	36.94	13.60	23.34	31.77	13.08	6.31	11.91
9	2	32.69	4.31	28.38	33.47	13.52	6.50	13.82	37.60	13.10	24.50	30.46	14.07	6.89	10.98
9	3	34.09	4.46	29.63	32.09	13.52	7.47	12.83	28.34	8.86	19.48	22.69	35.49	5.76	7.72
9	4	34.89	4.72	30.17	31.16	13.81	7.64	12.50	39.04	12.70	26.33	29.27	14.32	7.42	9.96
10	1	36.36	5.29	31.07	30.09	13.74	7.74	12.06	39.22	13.70	25.51	27.95	14.38	7.66	10.79
10	2	38.91	6.00	32.91	28.41	14.64	7.49	10.56	41.75	17.09	24.66	27.78	14.65	7.41	8.41
10	3	36.80	5.32	31.48	29.46	14.26	8.35	11.13	40.43	14.38	26.06	27.97	14.90	7.82	8.88
10	4	38.22	5.25	32.97	29.09	13.87	7.74	11.08	40.99	14.03	26.96	28.28	14.62	7.34	8.77
11	1	37.32	5.25	32.08	29.58	13.80	8.16	11.14	39.72	13.47	26.24	28.37	15.18	7.77	8.97
11	2	37.02	5.25	31.77	29.81	14.28	8.22	10.67	23.95	8.12	15.83	57.50	9.24	4.51	4.79
11	3	37.72	5.10	32.61	29.42	14.33	7.98	10.56	40.41	13.31	27.10	28.13	15.44	7.48	8.54
11	4	38.27	5.32	32.94	30.25	13.21	7.89	10.38	41.49	14.38	27.11	28.63	14.58	7.55	7.74
12	1	37.52	5.13	32.39	29.75	13.98	8.19	10.55	40.80	13.21	27.59	28.51	14.51	7.81	8.38
12	2	37.40	5.37	32.03	29.53	14.20	8.21	10.66	40.38	14.36	26.03	27.67	15.67	7.74	8.54
12	3	38.32	5.45	32.87	29.37	14.04	7.99	10.28	43.54	15.59	27.96	27.99	13.84	7.05	7.57
12	4	37.79	5.09	32.70	29.60	14.01	8.10	10.50	40.90	15.21	25.69	28.55	14.77	7.63	8.15
13	1	38.35	5.23	33.12	29.34	14.06	8.11	10.14	40.59	14.00	26.59	28.43	15.23	7.45	8.30
13	2	38.60	5.13	33.48	29.22	13.81	8.22	10.15	41.22	14.16	27.05	27.39	14.88	7.81	8.71
13	3	38.17	5.23	32.94	29.64	14.03	8.41	9.75	41.01	13.72	27.29	28.63	14.95	7.60	7.81
13	4	38.25	5.16	33.09	29.64	13.99	7.98	10.14	41.09	14.21	26.88	27.87	15.11	7.76	8.18
14	1	38.00	5.13	32.87	29.62	14.18	8.01	10.19	42.74	17.55	25.19	27.46	14.47	7.50	7.83
14	2	38.54	5.20	33.34	30.11	13.81	7.62	9.92	40.17	13.67	26.50	29.87	15.04	7.23	7.69
14	3	37.20	5.35	31.85	30.17	14.54	8.33	9.76	40.47	13.94	26.53	30.29	14.74	7.50	6.99
14	4	37.49	5.39	32.09	30.30	14.07	8.37	9.77	40.43	13.73	26.70	29.10	15.05	8.49	6.93
15	1	37.66	5.54	32.11	29.79	14.37	8.22	9.96	40.84	13.77	27.06	28.53	15.22	7.98	7.43
15	2	38.40	5.85	32.55	29.47	14.41	8.17	9.55	43.35	17.07	26.28	27.93	14.55	7.49	6.67
15	3	39.04	6.09	32.95	29.28	14.13	8.11	9.44	42.73	15.50	27.23	27.59	15.14	7.49	7.05
15	4	40.22	6.32	33.91	28.72	14.22	7.76	9.08	43.34	16.14	27.20	27.16	15.09	7.30	7.12
16	1	40.95	6.98	33.96	28.71	14.80	7.23	8.31	45.03	17.85	27.18	26.63	15.24	6.82	6.27
16	2	41.41	8.10	33.31	27.34	13.75	7.00	10.51	45.33	21.48	23.86	22.69	14.02	8.22	9.72
16	3	80.03	34.66	45.37	1.41	1.22	0.94	16.40	83.31	63.92	19.39	0.92	1.68	2.03	12.07
	sum	1308.34	211.95	1096.39	1060.61	471.95	251.27	407.83	1409.80	540.56	869.24	999.42	513.23	253.56	324.00
	avg	37.38	6.06	31.33	30.30	13.48	7.18	11.65	40.28	15.44	24.84	28.55	14.66	7.24	9.26

number in thousands
volume in millions of pounds
prop^{n} expressed as a percentage of all trades in that 1/4 hour interval
1 & 2: is a combined total fro all market orders (Category 1 & 2)
1: Orders at or better that the opposite side price, larger than depth at best
2: Orders at or better than the opposite side price, smaller than depth at best
3: Limit price within the spread
4: Limit price at the same side, best price
5: Limit price behind best price, but within 1p
6: Limit price further that 1p away from the spread

TABLE 6.8B PROPORTION OF NUMBER AND VOLUME OF SELL ORDERS BY AGGRESSIVENESS AND TIME OF DAY

		Number							Volume						
Hour	1/4 hour	1 & 2	1	2	3	4	5	6	1 & 2	1	2	3	4	5	6
8	1	18.27	3.24	15.03	41.57	9.52	2.94	27.70	61.63	53.68	7.95	18.31	6.01	3.12	10.95
8	2	25.00	4.10	20.89	40.68	12.86	3.73	17.73	36.75	18.68	18.07	31.12	12.87	6.27	12.99
8	3	28.91	4.72	24.19	38.96	13.59	4.20	14.34	35.31	13.58	21.73	31.61	14.04	6.82	12.22
8	4	27.43	4.70	22.73	35.48	11.62	4.45	21.03	31.48	11.91	19.57	30.87	12.58	10.19	14.88
9	1	30.86	4.17	26.69	35.41	11.88	5.59	16.27	34.85	11.65	23.20	33.82	12.57	6.34	12.42
9	2	33.58	4.40	29.18	34.02	12.66	6.44	13.30	37.96	12.30	25.66	31.13	13.36	6.36	11.18
9	3	34.99	4.67	30.32	31.71	13.22	7.47	12.61	43.88	20.58	23.30	28.29	12.61	6.23	8.99
9	4	36.15	4.75	31.41	31.21	13.49	7.42	11.72	40.30	13.62	26.68	29.88	13.48	6.73	9.61
10	1	38.66	5.48	33.18	30.13	12.79	7.46	10.95	40.43	13.81	26.63	28.36	13.98	7.14	10.08
10	2	42.06	6.28	35.78	27.93	12.97	7.14	9.90	42.99	15.58	27.41	27.93	13.90	6.91	8.28
10	3	37.60	5.39	32.21	30.04	13.44	8.02	10.91	39.65	13.59	26.06	32.60	12.84	6.64	8.27
10	4	38.85	5.26	33.59	29.93	13.13	7.56	10.53	41.57	13.70	27.87	28.75	14.23	7.10	8.35
11	1	37.67	5.38	32.30	30.45	13.49	7.70	10.69	41.68	14.63	27.04	28.11	14.51	7.03	8.67
11	2	38.39	5.65	32.74	30.11	13.18	7.62	10.71	45.98	20.53	25.45	27.10	12.54	6.79	7.60
11	3	38.17	5.56	32.61	30.14	13.74	7.63	10.33	41.53	14.18	27.35	28.56	14.85	7.37	7.68
11	4	38.64	5.79	32.85	30.78	12.88	7.64	10.05	43.53	17.95	25.58	28.22	13.56	6.77	7.91
12	1	38.29	5.54	32.74	30.09	13.50	7.75	10.36	41.62	15.14	26.48	28.50	14.26	7.17	8.45
12	2	37.80	5.56	32.23	30.25	13.63	7.83	10.50	42.18	15.42	26.75	28.33	13.59	6.80	9.09
12	3	38.50	5.82	32.69	30.38	13.45	7.58	10.09	44.48	18.01	26.47	28.14	12.82	6.43	8.13
12	4	38.16	5.59	32.57	30.49	13.36	8.19	9.79	43.23	16.82	26.41	28.19	13.92	6.88	7.78
13	1	37.71	5.47	32.23	30.59	13.21	8.27	10.22	55.19	34.58	20.62	22.26	10.71	5.58	6.25
13	2	38.76	5.62	33.14	29.65	13.04	8.20	10.34	43.65	17.09	26.56	27.88	13.08	7.00	8.39
13	3	37.47	5.96	31.51	30.62	12.83	8.53	10.55	41.89	16.55	25.34	29.40	13.54	7.13	8.03
13	4	37.49	5.47	32.03	30.35	13.16	8.56	10.44	41.73	15.37	26.36	29.27	14.10	7.12	7.78
14	1	38.08	5.73	32.35	29.54	13.45	8.33	10.60	42.14	15.25	26.88	28.73	14.10	7.57	7.46
14	2	38.61	5.77	32.84	30.07	12.91	7.98	10.43	43.07	15.15	27.92	28.62	13.98	6.89	7.44
14	3	38.49	6.02	32.47	30.21	12.86	8.38	10.05	39.43	14.70	24.73	35.91	12.36	6.45	5.85
14	4	39.05	6.10	32.95	30.00	12.83	8.39	9.72	44.11	16.23	27.87	27.77	13.84	7.35	6.94
15	1	39.08	6.13	32.95	29.91	12.94	8.22	9.85	43.37	15.56	27.81	28.34	13.89	7.64	6.76
15	2	39.74	6.44	33.30	29.48	13.10	7.92	9.77	43.53	15.76	27.77	28.14	14.16	7.25	6.93
15	3	39.29	6.65	32.64	29.83	13.17	7.82	9.90	41.64	15.46	26.17	27.36	14.01	9.82	7.18
15	4	39.83	6.80	33.03	29.51	13.33	7.52	9.80	40.28	16.11	24.16	34.96	12.15	5.91	6.69
16	1	40.76	6.97	33.79	29.15	13.96	7.54	8.59	50.91	27.08	23.83	23.96	12.96	6.28	5.89
16	2	42.69	8.33	34.36	27.36	13.16	6.84	9.95	52.44	30.52	21.92	20.27	12.02	6.94	8.33
16	3	68.36	33.75	34.61	1.31	1.13	0.85	28.35	76.08	65.07	11.01	1.01	1.23	0.79	20.89
	sum	1313.40	224.28	1092.13	1070.32	447.47	252.71	434.09	1530.48	676.87	856.61	974.71	452.65	239.84	320.34
	avg	37.53	6.41	31.20	30.58	12.78	7.22	12.40	43.73	19.34	24.47	27.85	12.93	6.85	9.15

number in thousands
volume in millions of pounds
prop^{n} expressed as a percentage of all trades in that 1/4 hour interval
1 & 2: Is a combined total fro all market orders (Category 1 & 2)
1: Orders at or better that the opposite side price, larger than depth at best
2: Orders at or better than the opposite side price, smaller than depth at best
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The pattern for sells is very similar to that for buys. As expected, the sells are in general more aggressive than buys. Also, the relative change in aggressiveness at the end of the day is sharper for sells than buys. If we assume that the increase in aggressive trading at the end of the day reflects the last attempt to fill the order for the day, it would seem that sellers who were using limit order strategies have a greater need to trade. This may also reflect day traders who buy in the morning, but are forced to close out their position at the end of the day. The increase in aggressiveness is significant for the last half hour of trading and since the VWAP period is mostly contained within the last quarter, the result cannot be solely attributed to market manipulation.

There are a few spurious numbers in the buy and sell table. The large volume of type 1 sells at 8am and 1pm, type 3 buys at 11:15am and type 4 buys at 9:30am, reflect four very large orders. These orders were entered for an unrealistic volume. The market orders were also entered with a limit price at the opposite side of the spread. It is not clear why the market would accept an offer to sell like this, since the participant's ability to sell is obviously limited. An offer to buy is also limited by the market capitalization. These four figures highlight how sensitive the results are to an individual trader's actions. It is important to establish this, to put the results in context, and to show how easy it is for a single institution to manipulate the market statistics.

Average order size is largest during the first half hour of the day. This is consistent for all aggressiveness categories. Order size decreases for most of the first hour, although there are some erratic patterns for orders placed away from the spread, presumably reflecting the uncertainty over how the price will settle after the opening procedure. After the first hour of trading, the average order size of market buy orders is fairly constant for all aggressiveness classes, until a sharp rise during the closing

procedure. In contrast, market sell orders increase in size from 4pm, adding to the evidence of day traders trying to close out their position.

6.4.4 Price Impact

Table 6.9 shows the average change in price between the time the order was submitted and 5 or 30 minutes after the event. The price is measured as the mid point of the quoted spread. Traditionally, Price Impact is used to measure the information content of a trade. Combining this interpretation with the theory that informed traders trade aggressively, we would expect to see an increasing price impact with aggressiveness.

The Price Impact is usually measured for trades, but we are expanding this set to include all orders. The interpretation of the measure applies equally in this case, but there are a few points worth special mention. A trade may automatically move the mid point of the quoted spread, by taking the depth at best price (i.e. a type 1 order). In theory, the Price Impact measures the permanent impact, due to the information content of the trade. In practice, the short term price frictions and immediate price changes can affect these measures. The problem is that orders of different aggressiveness do not have the same immediate impact. For instance, a type 2 order takes some of the depth at best price, but has no immediate impact on the price. However, a type 3 order, which does not trade immediately, does have an immediate impact, shifting the mid point of the quoted spread in the same direction as the order.

Orders placed at or behind the best price have no immediate impact. If these trades are indeed uninformed, and the Price Impact is an accurate measure, we might expect to see a Price Impact of zero on average. If however, traders take these uninformed orders as a signal that the market can cope with a greater volume (in the opposite direction) we might experience a negative Price Impact.

TABLE 6.9A PRICE IMPACT OF BUY ORDERS BY AGGRESSIVENESS AND TIME OF DAY

		Price impact over 5 minutes						Price impact over 30 minutes						
Hour	1/4 hour	1	2	3	4	5	6	1	2	3	4	5	6	number
8	1	2.47	2.64	1.59	1.18	-2.38	0.88	0.77	1.82	1.40	1.01	-2.37	0.60	89562
8	2	1.21	0.92	0.51	0.30	-1.39	0.20	1.46	0.80	0.64	0.40	-1.36	0.26	91328
8	3	0.55	0.37	0.17	0.08	0.00	-0.03	0.67	0.31	0.21	0.09	0.05	-0.01	97493
8	4	1.46	0.97	0.47	-0.04	-0.03	-0.16	1.17	0.94	0.35	-0.04	-0.01	-0.17	131748
9	1	0.11	0.23	0.17	0.04	0.02	-0.08	0.16	0.15	0.18	0.02	0.02	-0.13	178577
9	2	0.64	0.19	0.17	0.03	0.27	0.07	0.53	0.12	0.11	0.14	-0.01	0.07	172534
9	3	0.31	0.16	0.14	0.04	0.01	-0.03	0.52	0.16	0.38	0.03	0.11	-0.04	176502
9	4	0.43	0.25	0.24	0.05	0.02	-0.04	0.29	0.26	0.09	0.03	0.01	-0.08	175746
10	1	0.22	0.15	0.11	0.03	0.02	0.04	0.20	0.08	0.09	0.04	0.04	-0.05	186218
10	2	0.26	0.14	0.13	0.06	0.02	-0.03	0.24	0.16	0.13	0.06	0.04	-0.06	198755
10	3	0.19	0.10	0.08	0.02	0.01	-0.04	0.27	0.10	0.11	0.07	0.03	-0.01	171351
10	4	0.35	0.25	0.09	0.03	0.02	-0.02	0.37	0.28	0.12	0.06	0.04	-0.02	172537
11	1	0.25	0.13	0.09	0.03	0.01	-0.02	0.50	0.26	0.23	0.02	0.08	0.10	156669
11	2	0.79	0.33	0.16	0.08	0.09	-0.01	0.60	0.52	0.32	0.32	0.36	0.09	159518
11	3	0.90	0.20	0.21	0.03	0.03	0.01	1.02	0.23	0.29	0.06	0.20	0.17	150710
11	4	0.78	0.12	0.16	0.03	0.16	0.28	0.60	0.28	0.40	0.22	0.03	1.06	150638
12	1	2.65	0.49	0.17	0.33	0.82	0.76	0.19	0.33	0.34	0.31	-0.11	-0.07	139883
12	2	0.33	0.15	0.08	0.09	-0.04	0.27	-0.52	-0.18	-0.14	-0.26	-0.32	-2.13	128056
12	3	4.13	0.96	0.24	0.02	0.04	-0.05	-1.16	0.11	0.33	0.10	0.12	-0.17	125636
12	4	0.19	0.19	0.10	0.03	0.02	-0.02	0.22	0.20	0.10	0.04	0.02	-0.09	120430
13	1	0.84	0.11	0.15	0.03	0.02	-0.03	0.31	0.41	0.18	0.12	0.05	-0.02	120307
13	2	0.18	0.07	0.09	0.08	0.06	-0.02	0.19	0.19	0.18	0.05	0.02	-0.01	125124
13	3	1.73	0.09	0.19	0.03	0.02	-0.02	0.20	0.17	0.16	0.04	0.02	-0.09	166949
13	4	0.31	0.11	0.16	0.02	0.33	-0.01	0.26	0.13	0.11	0.02	0.01	-0.05	148701
14	1	0.18	0.32	0.10	0.03	0.01	0.24	0.47	0.22	0.15	0.03	0.29	-0.06	148386
14	2	0.39	0.10	0.15	0.02	0.02	0.78	0.47	0.12	0.25	0.04	0.02	0.00	150822
14	3	0.26	0.10	0.11	0.04	0.02	-0.03	1.36	0.23	0.20	0.12	0.01	-0.06	210771
14	4	0.51	0.16	0.25	0.17	0.00	0.35	0.32	0.13	0.18	0.03	0.02	-0.15	224775
15	1	0.23	0.08	0.15	0.03	0.15	-0.05	7.91	0.27	1.69	0.21	0.06	-0.08	243733
15	2	0.26	0.11	0.09	0.03	0.02	0.01	0.91	0.24	0.20	0.06	0.07	0.05	248053
15	3	0.85	0.27	0.32	0.11	6.53	0.07	0.29	0.15	0.16	0.08	0.06	-0.26	255707
15	4	0.76	0.11	0.08	0.04	0.04	0.05	0.55	0.22	0.11	0.12	0.07	0.07	267248
16	1	0.43	0.12	0.09	0.04	0.04	-0.07	-3.05	-3.37	-3.51	-3.60	-3.91	-3.33	284452
16	2	-2.12	-2.51	-2.67	-2.72	-3.53	-4.91	-4.91	-4.88	-4.37	-4.85	-4.95	-4.66	444519
sum		**23.02**	**8.15**	**4.35**	**0.39**	**1.46**	**-1.65**	**13.37**	**1.15**	**1.36**	**-4.85**	**-11.20**	**-9.36**	
avg		**0.68**	**0.24**	**0.13**	**0.01**	**0.04**	**-0.05**	**0.39**	**0.03**	**0.04**	**-0.14**	**-0.33**	**-0.28**	
avg exc		**0.76**	**0.32**	**0.21**	**0.09**	**0.15**	**0.10**	**0.67**	**0.29**	**0.29**	**0.11**	**-0.07**	**-0.04**	

Price Impact is the change in quoted midpoint over a 5 or 30 minute period, measured in percentage points above 100.

1: Orders at or better that the opposite side price, larger than depth at best
2: Orders at or better than the opposite side price, smaller than depth at best
3: Limit price within the spread
4: Limit price at the same side, best price
5: Limit price behind best price, but within 1p
6: Limit price further that 1p away from the spread

TABLE 6.9B PRICE IMPACT OF SELL ORDERS BY AGGRESSIVENESS AND TIME OF DAY

		Price impact over 5 minutes						Price impact over 30 minutes						
Hour	1/4 hour	1	2	3	4	5	6	1	2	3	4	5	6	number
8	1	-5.46	1.49	0.47	1.11	-0.79	1.80	-5.96	-0.12	0.26	1.06	-0.83	1.12	84576
8	2	-0.76	0.01	0.00	0.20	-1.47	0.33	-1.02	0.06	0.15	0.60	-1.52	0.90	85225
8	3	-0.11	0.08	0.16	0.47	-1.46	0.30	-0.10	0.13	0.09	0.26	-1.42	0.35	90741
8	4	1.37	0.37	-0.42	0.12	0.00	0.29	1.19	0.33	-0.44	-0.05	0.01	0.42	124623
9	1	-0.94	-0.18	-0.19	-0.04	0.00	0.14	-1.85	-0.25	-0.22	-0.12	-0.08	0.17	170465
9	2	-0.27	-0.09	-0.09	-0.02	0.01	0.15	-0.38	-0.19	-0.19	-0.10	-0.08	0.06	175446
9	3	-0.30	-0.11	-0.06	-0.06	-0.02	0.03	-0.36	-0.13	-0.13	-0.09	-0.06	0.03	179804
9	4	-0.24	-0.01	0.00	-0.05	0.00	0.01	-0.32	-0.01	-0.14	-0.07	-0.05	-0.01	182376
10	1	-0.18	-0.08	-0.01	0.06	0.09	0.09	-0.25	-0.11	-0.13	-0.07	-0.04	0.03	192179
10	2	-0.25	0.11	-0.02	-0.03	0.06	-0.01	-0.23	-0.08	-0.07	-0.04	0.01	0.03	207245
10	3	0.11	-0.09	-0.10	-0.05	-0.03	0.01	0.07	-0.07	-0.10	0.00	-0.05	0.00	171653
10	4	-0.04	-0.08	-0.08	-0.04	-0.01	0.30	-0.12	-0.06	-0.06	0.03	-0.04	0.38	169878
11	1	-0.18	-0.07	-0.09	-0.03	-0.02	0.14	0.13	0.13	0.35	0.59	0.85	0.16	157716
11	2	-0.08	0.08	0.10	0.08	-0.02	0.22	-0.29	0.34	0.25	0.26	-0.05	0.88	155093
11	3	-0.23	0.00	0.11	0.34	0.29	0.04	0.86	0.27	0.22	0.67	-0.01	0.35	148803
11	4	-0.22	0.12	0.28	0.15	0.17	0.81	-0.04	0.60	0.45	0.67	-0.03	0.46	148810
12	1	-0.17	0.73	0.36	0.71	0.11	0.60	-0.18	0.89	0.23	0.66	0.25	0.79	135920
12	2	0.18	-0.18	-0.16	0.27	-0.08	-0.02	-0.88	-0.85	-0.95	-0.37	-0.51	-1.55	126566
12	3	1.67	0.80	0.13	0.13	-0.02	0.47	-0.53	-0.38	0.16	-0.05	0.05	0.05	125503
12	4	-0.22	-0.05	-0.02	-0.01	0.02	0.03	-0.26	-0.06	-0.08	-0.05	-0.04	0.01	119322
13	1	-0.22	0.11	0.08	0.17	-0.01	0.19	-0.16	-0.03	0.04	0.16	0.00	0.09	116200
13	2	-0.16	-0.06	-0.06	-0.04	-0.02	0.01	-0.16	-0.02	0.05	0.18	0.22	0.53	120183
13	3	0.14	0.00	-0.06	0.13	-0.02	0.08	-0.25	-0.01	0.04	-0.07	0.11	0.07	152365
13	4	-0.20	0.03	0.10	-0.03	-0.03	0.29	-0.30	-0.08	-0.08	-0.07	-0.07	0.40	143308
14	1	-0.14	-0.02	0.21	-0.03	-0.02	0.00	-0.23	-0.04	0.00	0.11	0.17	0.00	143882
14	2	-0.23	-0.04	-0.06	-0.03	-0.04	0.04	0.49	0.02	-0.03	-0.05	0.36	0.06	142943
14	3	-0.14	0.00	-0.04	0.05	0.00	0.10	0.50	0.16	0.09	0.23	0.14	0.56	208831
14	4	0.39	0.27	0.10	0.13	0.61	0.34	-0.27	-0.07	0.06	-0.07	0.19	0.25	222842
15	1	-0.16	-0.07	-0.05	0.03	-0.03	0.13	-0.31	0.07	1.61	0.08	0.09	0.78	241762
15	2	-0.19	-0.04	0.03	0.14	-0.02	0.04	-0.14	0.09	0.16	-0.01	0.17	0.27	239495
15	3	-0.35	0.21	0.22	6.17	0.15	0.20	-0.59	0.04	0.09	-0.02	0.18	0.28	246720
15	4	-0.18	0.07	0.15	-0.01	0.33	0.02	-0.22	0.06	0.30	-0.01	0.19	0.14	254694
16	1	-0.21	0.03	0.01	0.04	0.05	0.16	-3.90	-3.18	-3.25	-4.15	-4.01	-3.86	281351
16	2	-2.94	-2.85	-2.59	-2.60	-3.19	-4.40	-5.87	-4.87	-4.25	-4.54	-4.68	-4.84	441841
sum		**-10.95**	**0.49**	**-1.61**	**7.42**	**-5.41**	**2.93**	**-21.93**	**-7.43**	**-5.49**	**-4.49**	**-10.58**	**-0.61**	
avg		**-0.32**	**0.01**	**-0.05**	**0.22**	**-0.16**	**0.09**	**-0.65**	**-0.22**	**-0.16**	**-0.13**	**-0.31**	**-0.02**	
avg exc		**-0.24**	**0.10**	**0.03**	**0.30**	**-0.07**	**0.22**	**-0.38**	**0.02**	**0.06**	**0.13**	**-0.06**	**0.25**	

Price Impact is the change in quoted midpoint over a 5 or 30 minute period, measured in percentage points above 100.

1: Orders at or better that the opposite side price, larger than depth at best
2: Orders at or better than the opposite side price, smaller than depth at best
3: Limit price within the spread
4: Limit price at the same side, best price
5: Limit price behind best price, but within 1p
6: Limit price further that 1p away from the spread

A simple arithmetic average has been calculated for all orders that are placed during open trading, and for all periods that are contained entirely within the open trading hours. (i.e. we have excluded the last quarter hour, when averaging the Price Impact over 5 minutes, and the last 2 quarter hours for the 30 minute Price Impact). The Price Impact at the very end of the day is large and negative for all aggressiveness types. This reflects the artificial spread implied by the closing procedure and so can be ignored. Unless otherwise stated, we will use the restricted average in making comparisons.

Overall, Price Impact increases with the aggressiveness of the trade. This supports the theory that aggressive trades are more informed. Over 5 minutes we observe a positive Price Impact for all buy order aggressiveness categories, while the 30 minute measure has small negative values for orders placed behind the best price. Given that these orders have no immediate price impact, we must conclude that in the very short term (less than 5 minutes) passive buy orders are followed by aggressive buy orders, but given more time (30 minutes), investors interpret the information as an indication to sell.

Note that the Price Impact is directional, and so we expect to see negative Price Impact for aggressive sell orders. This is the case for large aggressive orders (type 1), but we find that type 2 orders have a small positive Price Impact. This supports the theory that sellers are on average less informed than buyers, but it seems surprising that small aggressive sell orders wouldn't imply any information.

We also find that type 3 sell orders, which have an immediate negative impact on prices, have a positive Price Impact over 5 and 30 minutes. This means that a sell order placed within a spread is likely to lead to an increase in the mid price in the short term. We have already shown that orders placed within the spread are more

likely when the spread is wide. If the sell order reduces the spread, the next buy order is more likely to be on one side of the spread, but not in between. Given that the Price Impact is positive, large market buy orders must follow. Perhaps buyers read this offer to sell as an indication of a more liquid market and so trade more aggressively pushing the price up. And perhaps this spurs a chain reaction of buyers.

We find a curious result for type 5 sell orders (placed close to but behind the best price), when these passive sell orders have a negative Price Impact. Given the positive Price Impact for all other passive order types, we must question this result. On closer inspection, the statistic is influenced by large negative values early in the day (8:00am to 8:45am). Early in the day we might expect the results to vary, since the market is just picking up speed, and it is still ascertaining the appropriate market price. It is also likely that an indication to sell, placed behind the spread, is more informative when placed in the context of the volatile opening period, than if it were placed in the stable market conditions that apply for the majority of the day.

Other than the unusual results at the start of the day, and the distorted results at the end of the day, there is very little pattern to the daily data. This is partly due to some spurious results. For example, the 30 minute Price Impact for buy orders between 3:00pm and 3:15pm is 7.91 (way above the 0.67 daily average). In an earlier table we found that 13,500 type 1 orders were placed, with a total volume of £639million, during this time period.

Another unusual result worth noting is the 30 minute Price Impact for all buy orders placed between 12:15pm and 12:30pm. They have negative values across the board. We showed in Section 6.3 that trading activity slows down during the lunchtime period, so we might expect a change in the sensitivity of the Price Impact. Given that market sell orders are more likely than market buy orders, we might expect the market price to fall during these periods of less vigilance. Note also that there are a

few days in the year when the LSE closes early, and on these public holidays, the exchange closes at 12:30pm. For the same reason that we discarded the periods at the end of the day, we can conclude that the 12:00pm-12:15pm period will be negatively biased. This may contribute to that result, but is not great enough to explain it entirely.

6.4.5 How Does Aggressiveness Depend on Spread and Depth

The Gravitational effect suggested by Cohen *et al* (1981), and the model defined by Parlour (1998), state that investors are more likely to take liquidity when it is plentiful, and add to it when it is low. Furthermore, they explain how this depends on the depth at the same side and opposite side independently. Table 6.10 shows the orders in each aggressiveness category, against the average characteristics of the market at the time the order is placed.

The number, volume and average trade size have been included purely for context. The "Propn" columns show the average ratio of bid side depth over offer side depth. Propn BD is the ratio of depth at the best bid and offer prices, Propn ND is the ratio of depth at the best two prices in either side, and Propn TD is the ratio of total depth. The spread details are split into the same side and opposite side, and arranged symmetrically for ease of comparison. The columns are labelled with three letters. The first letter refers to which side of the spread (B = Bid, O = Offer), the second refers to what prices it refers to (B = best price, N = next best price, T = total, or all prices) and the last letter refers to the depth (D) or the number of orders that make up that depth (N). Finally, the quoted spread, and the alternative "weighted quoted spread" are displayed.

The quoted spread and the weighted quoted spread follow a similar pattern. Aggressive orders are entered when the spread is small, passive orders are entered

TABLE 6.10 ORDER BOOK SPREAD AND DEPTH BY AGGRESSIVENSS

						SAME SIDE									OPPOSITE SIDE					
Buy	Number	Volume	Avg OS	QS	QS wtd	Prop^n BD	Prop^n ND	Prop^n TD	BTN	BTD	BNN	BND	BBN	BBD	OBD	OBN	OBN	ONN	OTD	OTN
1	350	17947	51262	0.23024	0.74129	52.92	3.75	1.40	39	972	1.39	48	1.41	43	14	1.16	41	1.37	1015	53
2	1922	29418	15305	0.22447	0.72259	9.53	1.86	1.33	38	935	1.33	45	3.90	77	74	4.13	42	1.25	1036	51
3	1833	34097	18601	0.68588	3.30289	11.05	2.11	1.32	30	590	1.34	34	1.39	34	28	1.32	33	1.32	673	43
4	839	17621	21005	0.45294	1.73556	9.35	1.76	1.24	36	841	1.46	45	1.36	30	36	1.37	43	1.37	969	51
5	452	8618	19068	0.38075	1.07487	12.17	2.10	1.23	39	983	1.44	48	1.34	36	41	1.36	48	1.38	1161	56
6	674	10474	15532	0.493	2.67878	9.19	1.90	1.27	33	552	1.35	32	1.31	26	27	1.32	31	1.34	659	47

Sell	Number	Volume	Avg OS	QS	QS wtd	Prop^n BD	Prop^n ND	Prop^n TD	OTN	OTD	ONN	OBN	OBN	OBD	BBD	BBN	BND	BNN	BTD	BTN
1	365	23656	64847	0.23494	1.02099	4.05	1.53	1.18	54	1070	1.36	43	1.43	41	14	1.16	50	1.40	934	38
2	1900	28995	15259	0.22833	0.71915	9.99	2.06	1.27	49	924	1.26	38	4.25	71	74	3.88	41	1.28	836	36
3	1813	32900	18150	0.67389	2.26527	6.75	1.95	1.43	41	653	1.32	32	1.36	31	29	1.34	35	1.33	599	30
4	773	15266	19747	0.44913	1.43679	15.41	2.33	1.31	51	938	1.41	41	1.33	30	38	1.39	47	1.39	866	36
5	438	8052	18364	0.37581	1.08171	21.03	2.38	1.30	54	1068	1.42	45	1.31	36	44	1.38	52	1.40	1039	39
6	675	10157	15038	0.49769	2.54157	12.26	2.33	1.52	46	623	1.34	30	1.30	26	29	1.34	34	1.36	614	35

Buy / Sell	Number	Volume	Avg OS	QS	QS wtd	Prop^n BD	Prop^n ND	Prop^n TD	OTN	OTD	ONN	OBN	OBN	OBD	BBD	BBN	BND	BNN	BTD	BTN
1	0.960	0.759	0.791	0.980	0.726	13.066	2.461	1.186	0.725	0.908	1.019	1.099	0.991	1.054	1.018	0.997	0.829	0.982	1.087	1.388
2	1.012	1.015	1.003	0.983	1.005	0.954	0.902	1.047	0.786	1.012	1.059	1.177	0.917	1.074	0.995	1.067	1.026	0.973	1.240	1.433
3	1.011	1.036	1.025	1.018	1.458	1.637	1.083	0.920	0.727	0.904	1.016	1.076	1.021	1.100	0.956	0.987	0.933	0.987	1.124	1.415
4	1.085	1.154	1.064	1.008	1.208	0.607	0.758	0.949	0.711	0.897	1.030	1.089	1.027	1.023	0.941	0.985	0.916	0.986	1.119	1.430
5	1.031	1.070	1.038	1.013	0.994	0.579	0.882	0.949	0.716	0.920	1.018	1.079	1.020	1.001	0.936	0.981	0.915	0.981	1.118	1.443
6	0.998	1.031	1.033	0.991	1.054	0.749	0.817	0.832	0.724	0.887	1.014	1.054	1.008	1.010	0.955	0.986	0.933	0.987	1.073	1.351

depth divided by 1000
agg = number of occurances in 1000s
vol divided by 1000000
QS expressed as a percentage
alternative presentation
wtd: weighted
Prop^n BD is the ratio of the depth at best bid price over the depth at the best offer price
Prop^n ND is the ratio of the depth of best bid price and the next best bid price
Prop^n TD is the ratio of the total depth on the bid side over the total depth on the offer side

BTD: Total depth on the bid side
BTN: Total number of orders on the bid side
BND: Depth at the second best bid price
BNN: Number of orders at the second best bid price
BBD: Depth at the best bid price
BBN: Number of orders at the best bid price

OTD: Total depth on the offer side
OTN: Total number of orders on the offer side
OND: Depth at the second best offer price
ONN: Number of orders at the second best offer price
OBD: Depth at the best sell price
OBN: Number of orders at the best offer price

Same side and Opposite side refer to the spread on the same or opposite side when the order is placed
same side depth is bid side depth for buy order and offer sife depth for sell orders.

when the spread is large, and orders are placed within the spread, when the spread is very large. The result for type 3 orders may be biased by the orders placed early in the trading day, when the spread is still establishing itself, but we would still expect type 3 orders to be placed when the spread is at its widest. Another interesting result is that the spread is wider for type 4 orders than for type 5. In other words, investors who observe a narrow spread are more likely to place an order behind the best price, than at the best price. This, along with the result for type 3 orders, supports the theory that investors have a preconceived idea of what the spread should be, and so place their limit orders with reference to that.

The design of the weighted quoted spread ensures that it is wider than the quoted spread, but the ratio of the two spread measures is of interest. A larger ratio implies a greater average depth imbalance. In general we find that the passive orders are placed when the ratio is higher. This may reflect a preference for passive orders when the imbalance is greatest, but this measure is not directional, and therefore far from conclusive. Another explanation is that the depth imbalance is simply greater when the spread is wider. However, one departure from the rule is the type 1 sell orders. The weighted quoted spread is far greater than expected. This implies that although aggressive sell orders and aggressive buy orders are entered when the quoted spread is at a similar level, the sell orders are entered when the depth imbalance is greater.

The buy side Propn TD column conforms to expectation. Aggressive buy orders are submitted when there is more total depth on the buy side, with the exception of the type 6 orders, which are entered when there is a greater depth imbalance than for other orders placed at or behind the spread. This supports the theory that the orders placed further from the spread are entered without reference to the current market situation, but rather reflect private investment needs.

We find a similar result on the sell side, with aggressive sell orders being entered when the imbalance of buy to sell depth is tipped towards the sell side. The exception this time is the type 3 orders. We have already established that type 3 orders are placed when the spread is wide, and for sell orders in particular, this is likely to be a more important decision factor than the depth imbalance. It is worth noting that the bid side depth is greater than the sell side depth for all aggressiveness categories. If investors are aware that this is the norm, but have not calculated an average, they may use this to support their decision to buy or disregard this as unimportant if they wish to sell. Hirshliefer (2001) explains how individuals apply these falsely weighted logical arguments to justify their trading decisions. This may explain why sellers pay less attention to the depth imbalance than the buyers.

The proportion of depth at best price and at the best two prices (Propn BD and Propn ND respectively) vary between aggressiveness categories a lot more than the corresponding figures for proportion of total depth, and so are harder to interpret. It is easy for traders to manipulate these statistics deliberately (if there is a financial incentive to do so), and also as an indirect result of genuine trading strategies i.e. front running. One important comparison to make is the Propn BD for aggressive orders. While type 2 buy and sell orders have a similar depth at best price imbalance of around 10:1, the type 1 buy orders have a 53:1 ratio, and the type 1 sell orders have a 4:1 ratio. This implies that large aggressive orders are entered when the depth at best price is balanced heavily in the same direction, compared to the average depth imbalance. This may be expected, but it is not clear why the same is not true for smaller aggressive orders. If the most aggressive orders imply greater information, why are type 1 orders swayed so heavily by market conditions, while type 2 orders are not?

Comparing the average order book in more detail offers a greater insight. The total number of orders on either side of the market is consistently tipped in favour of the

sellers. This is in spite of the theory that sellers are on average more aggressive than buyers. The average total depth is also greater on the sell side. We can also see that type 3 and type 6 orders are placed when the total depth is at its lowest. This reflects trading at the market opening, as well as periods of less liquidity. Interestingly, when the total depth is largest on the same side, investors place either a type 1 order or a type 5 order. If the depth on both sides is at its largest, investors are most likely to enter a type 5 order. We saw earlier in the daily trading patterns that the trading activity picked up towards the end of the day, and this order choice between type 1 and type 5 orders reflects the volatility and volume during the last half hour of the market.

The depth at best price is interesting for several reasons. Most importantly is that although other depth measures are consistent for the buy side or sell side, the depth at best price is consistent for the same side and opposite side (i.e. the buy side depth for buy orders is roughly the same as the sell side depth for sell orders). We find that type 2 orders are entered when the depth is at its greatest, and the average depth on each side is roughly equal. Not surprisingly, type 1 orders are more common when the opposite side depth is smaller, but we find that the same side depth is also smaller (than when type 2 orders are placed). The same side depth is larger than when passive orders are placed, however, which supports the gravitational pull theory, whereby losing time priority is too heavy a burden to bear, and so an aggressive market order is used instead.

The depth figures for passive orders do not follow a simple linear pattern but the figures are uncannily similar for buy and sell orders. Orders are placed in the market when same side depth is quite high and opposite side depth is slightly lower. As before, this may be a reflection of the prevailing depth figures, when the spreads are largest. Orders are placed at the best price when same side depth is low and opposite side depth is quite high. This reflects the willingness to accept the fact that they are

not first in the queue, when the same side depth is low, and the opposite side depth indicates greater trading interest on the other side. Orders are placed just behind the spread when the same side depth is high and the opposite side depth is even higher. This implies that traders see the opposite side depth as an indication of further trading interest. Even though the same side depth is high, traders are willing to post a limit price just behind the best price, in the belief that the opposite side depth is forecasting opposite side market orders. Finally, orders are placed far behind the spread when the depth on either side is low. This may simply be spread betting, or it may again reflect the opening procedure when the depth is lower. There will also be a size bias, as defined in section 6.4.2, whereby investors are more willing to post orders away from the spread for smaller stocks, and so the depth figures reflect a greater proportion of small stocks in this aggressiveness category.

The results from the depth figures and the Propn figures seem to conflict, and so we should clarify exactly what these figures represent, and how they may be distorted. In particular, we find that the Propn BD figure for type 1 sell orders is 4, implying that the bid side depth is on average 4 times bigger than the offer side depth. However, the OBD figure is 3 times bigger than the BBD figure, implying that the average offer side depth is 3 times bigger than the bid side depth. This apparent contradiction is a result of when the averaging takes place. Assume there are two sell orders. At the time of the first one, the bid depth is 12 and the offer side depth is 1. At the time of the other order, the bid depth is 24 and the offer side depth is 36. In this case the Propn BD figure is ((12/1 + 24/36)/2) = 6.33. BBD is ((12+24)/2) = 18 and OBD is ((1+36)/2) = 18.5. This gives us the situation whereby the Propn BD implies greater bid side depth, and the depth figures imply that the offer side depth is greater. We can see that the depth figures are weighted towards the larger depth figures, and hence the larger stocks, but it is also far less sensitive to front running. It is this second reason that makes the depth figures particularly useful.

6.5 Is Order Activity Autocorrelated?

6.5.1 Introduction

A market buy order can have an immediate impact on the market. Given the changes in the spread and depth on the offer side, another market buy order is theoretically less likely. Parlour (1998) tells us that a limit buy order is likely, perhaps closing the spread slightly, or a limit sell may replenish the liquidity that was taken by the original order. So what happens when a market buy order is followed by another market buy order? Is this more significant than seeing one large market buy order? Does the combination of the two orders have a greater impact on the market? And under what conditions is this likely to happen? There are many questions concerning the patterns of order type, and this section aims to answer some of them.

We simplify the classification of orders by aggressiveness. An order that executes (at least in part) immediately is reclassified as a market order, and all other orders are limit orders. For simplicity, we refer to a market buy as "MB", a market sell as "MS", a limit buy as "LB" and a limit sell as "LS". For each trade, we find the next order type, and split each trade into 1 of the 16 ordered permutations. Table 6.11 shows the number and volume of each permutation.

For each trade type, the most likely trade type to follow is the same type. We might expect this for the limit orders, as investors may place limit orders at several prices at the same time, particularly in the morning. These orders may reflect genuine trading interest, or an attempt to influence the direction of the market. The case for autocorrelated market orders is less clear. On closer inspection of the data, it appears that some traders split a market order to match the orders on the other side of the spread. For example, if there were sellers at 100 and 101, the investor would enter a buy order with a limit price of 100 for the depth at that price, and another at 101. A

TABLE 6.11 AVERAGE NUMBER AND VOLUME OF GROUPED ORDER TYPES

TT	NTT	Number	Volume	Prop^{n} of total	Prop^{n} of total volume
LB	LB	1489	25830	0.1237	0.1089
LB	LS	1075	18219	0.0893	0.0768
LB	MB	625	14390	0.0520	0.0607
LB	MS	609	12372	0.0506	0.0522
sum		**3798**	**70810**	**0.3156**	**0.2985**
avg		**950**	**17703**		
LS	LB	1072	18026	0.0891	0.0760
LS	LS	1415	22954	0.1176	0.0968
LS	MB	600	13104	0.0499	0.0552
LS	MS	612	12292	0.0508	0.0518
sum		**3700**	**66376**	**0.3074**	**0.2798**
avg		**925**	**16594**		
MB	LB	621	13137	0.0516	0.0554
MB	LS	602	13354	0.0500	0.0563
MB	MB	639	11718	0.0531	0.0494
MB	MS	409	9156	0.0340	0.0386
sum		**2272**	**47365**	**0.1888**	**0.1997**
avg		**568**	**11841**		
MS	LB	615	14054	0.0511	0.0592
MS	LS	607	15624	0.0505	0.0659
MS	MB	408	11213	0.0339	0.0473
MS	MS	635	11758	0.0528	0.0496
sum		**2265**	**52650**	**0.1882**	**0.2220**
avg		**566**	**13162**		
sum tot		**12035**	**237201**		
avg tot		**752**	**14825**		

TT: First order type
NTT: second order type
Number: Number of orders placed
Volume: Volume of orders placed
LB: Limit Buy order
LS: Limit Sell order
MB: Market Buy order
MS: Market Sell order
avg: average for sub group
avg tot: average over all orders
Prop'' tot: number of occurances expressed as a proportion of the total number of ordered pairs
Prop'' vol tot: volume for each ordered pair expressed as a proportion of total volume

limit order for 101 would lead to the same transaction cost, unless of course, the limit sell order was removed between the time the market buy order was entered, and received at the market (which is less than a second). However, this behaviour is not common, and so the result cannot be attributed solely to that. Another possibility is that the market orders are grouped together, typically at the end of the day. This would suggest a strong relationship between all market orders, rather than just buys or just sells. And so, the autocorrelation of market buy orders and market sell orders, seems to be the result of herd behaviour.

6.5.2 Performance Figures

Table 6.12 shows 4 different performance measures for each of the 16 trade type combinations. "15R" is the return over the quarter hour, "1DR" is the return over the full trading day, "PI_5" and "PI_30" are the price impact of the trade over 5 minutes and 30 minutes respectively. Price Impact was defined formally in section 4.2, but is simply the change in the midpoint of the spread over the stated time horizon. The measure is usually interpreted as the level of asymmetric information implied by a trade. In this comparison, we are calculating the price impact for those orders that don't trade immediately, and so the interpretation should really be "the level of asymmetric information implied by the order"

For both time horizons, we find the same pattern in the price impact measure, based on the average of each subgroup. The groups ranked from highest to lowest are MB, MS, LS, LB. This conforms to the expectation that buy orders are more informative than sell orders. Although this exact result has never been stated formally, Allen and Gorton (1992) stated that sellers are more likely to use a market order than buyers, irrespective of information. This is partly because there is a lower chance that someone is exploiting information on that side of the market (as they need the information, and the stock to sell), and so the relative costs are lower. This means

TABLE 6.12 AVERAGE PERFORMANCE FOR GROUPED ORDER TYPES

TT	NTT	15R	1DR	PI 5	PI 30
LB	LB	1.0017	1.0234	0.9984	0.9969
LB	LS	1.0019	1.0246	0.9973	0.9959
LB	MB	1.0019	1.0332	0.9997	0.9973
LB	MS	1.0019	1.0308	0.9965	0.9944
sum		**4.0074**	**4.1120**	**3.9920**	**3.9844**
avg		**1.0019**	**1.0280**	**0.9980**	**0.9961**
LS	LB	1.0018	1.0250	0.9978	0.9959
LS	LS	1.0020	1.0219	0.9993	0.9975
LS	MB	1.0022	1.0335	1.0060	1.0032
LS	MS	1.0022	1.0262	0.9984	0.9961
sum		**4.0081**	**4.1066**	**4.0015**	**3.9927**
avg		**1.0020**	**1.0267**	**1.0004**	**0.9982**
MB	LB	1.0019	1.0357	0.9993	0.9964
MB	LS	1.0022	1.0310	1.0067	1.0048
MB	MB	1.0022	1.2829	1.0205	1.0132
MB	MS	1.0025	1.3454	1.0264	1.0169
sum		**4.0088**	**4.6950**	**4.0530**	**4.0313**
avg		**1.0022**	**1.1738**	**1.0132**	**1.0078**
MS	LB	1.0020	1.0275	0.9975	0.9952
MS	LS	1.0020	1.0294	0.9986	0.9960
MS	MB	1.0025	1.3471	1.0229	1.0138
MS	MS	1.0034	1.2627	1.0135	1.0064
sum		**4.0100**	**4.6666**	**4.0324**	**4.0114**
avg		**1.0025**	**1.1666**	**1.0081**	**1.0029**
sum tot		**16.0343**	**17.5802**	**16.0789**	**16.0199**
avg tot		**1.0021**	**1.0988**	**1.0049**	**1.0012**

TT: First order type
NTT: second order type
15R: return over the 15 minute interval
1DR: daily return (from 08:00 to 16:30)
PI 5: Price Impact over 5 minutes
PI 30: Price Impact over 30 minutes

LB: Limit Buy order
LS: Limit Sell order
MB: Market Buy order
MS: Market Sell order
avg: average for sub group
avg tot: average over all orders

that less information is implied by sell orders in general, and that the decision to choose a market or a limit order is a weaker indicator of information for sells than it is for buys.

The Price Impact measure may also be distorted by the immediate impact of moving the market. The time horizons are chosen to minimise the effect of transitory volatility, and maximise the effect of the permanent price impact. Given that no time horizon satisfies this precisely, we may expect the short term effects to be present in the results. This may contribute to the positive price impact of the market buy orders. However, the market sell orders, which could have an immediate negative impact on the midpoint, have a positive price impact over 5 and 30 minutes. Considering that limit sell orders have a negative price impact, this implies that market sell orders contain more positive information than limit sell orders. This seems counterintuitive, but it is possible that if investors are trying to buy a large holding, they may be encouraged by the presence of an aggressive seller, and so act more aggressively themselves. Clearly the market sell order cannot convey positive valuation specific information, but it may indicate a trading interest than could be exploited in the short term.

Note also that limit orders, which may have no immediate impact on the spread, lead to a negative price impact (unless an LS is followed by an MB). Limit sell orders may reduce the midpoint directly if placed within the spread. Although there are proportionately few orders placed within the spread, this may explain the result. However, limit buy orders can only increase the midpoint of the spread, and yet the price impact is negative, irrespective of the following trade. This result cannot be explained by moving the market, so we can attribute it to the information risk. Extant literature tells us that limit orders are uninformed and that they wait to be picked off by informed market orders. The negative price impact implies that, although informed sellers may be more likely to use market orders, they may be

waiting for other investors to post market buy orders before they act. This suggests that sellers adopt a more thoughtful strategy than first envisaged.

6.5.3 Spread and Depth

Table 6.13 shows the average spread and depth characteristics for each of the 16 paired order types. Although we have established relationships between the frequency of the ordered pairs, and whether they are an indication of short term performance, we must put these events into the context provided by the market spread.

As we showed earlier, the limit orders are more common when the quoted spread, and the weighted quoted spread, are larger than average. Furthermore, we find that the quoted spread measure for limit buys and limit sells is symmetrical. Using the weighted quoted spread, we find that the spread is larger when limit buys are placed. This implies that depth imbalance is greater when limit buys are placed. The one exception to this rule is that the weighted quoted spread is larger for a limit buy then a limit sell, than it is for two limit buys in a row. In this situation, the limit buy order may affect the spread in a way that makes a limit sell more likely. Perhaps it evens out the depth imbalance, or perhaps there are subtleties regarding the type of limit order (type 3,4,5 or 6) that are not picked up by this statistic.

Another relationship worth noting is that of the autocorrelation of market orders. Using either quoted spread measure, we find that the spread is larger when market buy orders are followed by market buy orders, or market sell orders are followed by market sell orders, than if a market order on one side is followed by a market order on the other side. This supports the theory that market orders and order imbalances are indicators of information. Market orders on one side of the market imply an

TABLE 6.13 SPREAD AND DEPTH BY GROUPED ORDER TYPE

TT	NTT	BTD	OTD	BBD	OBD	Propⁿ BD	Propⁿ ND	Propⁿ TD	QS	QS weighted
LB	LB	573454	691715	27944	28463	10.0038	1.9828	1.2540	0.0068	0.0326
LB	LS	635769	703910	30269	29052	9.4239	2.0628	1.3675	0.0067	0.0337
LB	MB	871772	991952	37813	34207	14.7379	1.9738	1.3077	0.0032	0.0096
LB	MS	856342	1001679	38964	38661	9.1275	1.9357	1.1764	0.0036	0.0125
sum		**2937336**	**3389256**	**134991**	**130384**	**43.2931**	**7.9551**	**5.1056**	**0.0203**	**0.0883**
avg		**734334**	**847314**	**33748**	**32596**	**10.8233**	**1.9888**	**1.2764**	**0.0051**	**0.0221**
LS	LB	638443	709972	30423	29244	10.8014	2.0116	1.3938	0.0067	0.0268
LS	LS	618660	637847	30029	26831	10.0207	2.2544	1.4848	0.0067	0.0239
LS	MB	971847	1015072	43611	36629	15.4871	2.2281	1.4155	0.0036	0.0099
LS	MS	788287	856492	32609	33926	10.7730	2.0723	1.2479	0.0033	0.0097
sum		**3017237**	**3219384**	**136673**	**126630**	**47.0823**	**8.5664**	**5.5420**	**0.0203**	**0.0703**
avg		**754309**	**804846**	**34168**	**31657**	**11.7706**	**2.1416**	**1.3855**	**0.0051**	**0.0176**
MB	LB	949421	1070115	42069	35154	19.8565	2.1512	1.3349	0.0029	0.0094
MB	LS	897526	940045	40655	31639	15.1855	2.2718	1.3846	0.0029	0.0090
MB	MB	942453	1051635	99758	95574	14.3242	2.0706	1.3214	0.0022	0.0073
MB	MS	986492	1085085	117049	110950	15.1599	2.1093	1.3190	0.0020	0.0067
sum		**3775892**	**4146881**	**299531**	**273318**	**64.5261**	**8.6029**	**5.3598**	**0.0100**	**0.0324**
avg		**943973**	**1036720**	**74883**	**68329**	**16.1315**	**2.1507**	**1.3399**	**0.0025**	**0.0081**
MS	LB	782355	917257	33131	36250	8.4511	1.8557	1.1715	0.0029	0.0110
MS	LS	869148	950603	31247	38690	10.0229	1.9508	1.2379	0.0029	0.0087
MS	MB	986729	1079088	113772	113222	10.2073	1.9326	1.3478	0.0020	0.0069
MS	MS	814050	889502	95902	92068	7.8950	2.1440	1.2987	0.0023	0.0072
sum		**3452282**	**3836450**	**274053**	**280230**	**36.5763**	**7.8831**	**5.0559**	**0.0101**	**0.0337**
avg		**863070**	**959112**	**68513**	**70058**	**9.1441**	**1.9708**	**1.2640**	**0.0025**	**0.0084**
sum tot		**13182746**	**14591970**	**845248**	**810561**	**191.4778**	**33.0074**	**21.0633**	**0.0606**	**0.2248**
avg tot		**823922**	**911998**	**52828**	**50660**	**11.9674**	**2.0630**	**1.3165**	**0.0038**	**0.0140**

TT: First order type
NTT: second order type
BTD: Total depth on bid side of the order book
OTD: Total depth on offer side of the order book
BBD: Depth at best bid price
OBD: Depth at best offer price

Propⁿ BD: Ratio at depth of best bid price over depth at best offer price
Propn ND: Ratio of depth at best two prices on bid side over the depth at best two prices on the offer side
Propⁿ TD: Ratio of total bid side depth over total offer side depth
QS: Quoted bid offer spread
QS: Weighted: "Assymetry Adjusted" quoted spread

LB: Limit Buy order
LS: Limit Sell order
MB: Market Buy order
MS: Market Sell order
avg: average for sub group
avg tot: average over all orders

information asymmetry. And the fact that traders in this situation are willing to accept the cost of a larger spread, implies that they have a greater urgency to trade.

However, even though the spread is narrower when market orders swap sides, we find that the depth is much greater on both sides of the spread. The depth is almost 20% bigger than when market orders stay on the same side of the market, and more than 200% bigger than when a limit order appears somewhere in the ordered pair.

Although the average depth at best is almost symmetrical, we find, as before, that the average proportion of depth at the bid side to depth at the opposite side is strongly positive. When Propn BD is highest, the most likely order type to follow is a market buy order, unless the original order was a market buy, in which case a limit buy order is most likely to follow. This supports our earlier theory that buy orders are far more dependent on market conditions, and a large same side depth at best price, gives greater motivation to use a market order. However, when a market buy order is placed in this situation, it may widen the spread, which makes a limit order more likely. The fact that a limit buy order follows is interesting as it indicates that the market is learning: the midpoint rises in response to the market buy order. We found earlier that a limit sell order was most likely to follow a market buy order (ceteris paribus), but now we learn that if the proportion of depth is greater on the bid side, we are more likely to see a limit buy order. The combination of the two indicate that the Propn BD measure may be an indicator for short term price movements.

When Propn TD is highest, the most likely order to follow is a limit sell order, unless the original order was a market sell, in which case a market buy order is most likely to follow. The exception may be due to buyers exploiting a new limit order placed, or they may feel that this is an indication of further demand on the opposite side of the market. However, the general rule is more than likely a reflection of sellers using

the depth imbalance as an indication that the price may be moving towards them, and so a limit order strategy is more likely to execute. One way to interpret these Propn measures is that Propn BD is an indicator of short term (minutes) order activity, and Propn TD is an indicator of longer term (hours) order activity.

6.6 Summary

Order activity follows regular patterns. While the market opening procedure was not analysed explicitly, the repercussions are felt in the early hours of the trading day. Order activity increases for the first few hours, dips at lunchtime and rises to a peak by the end of the day. The relative aggressiveness (and the average sell order size), follow a similar pattern. The exciting period during the end of the day has a much higher order volume and trading volume. As well as an increase in aggressive orders, there is an increase in orders placed behind the spread. Beber and Caglio (2003) found similar results on the NYSE. This activity reflects a combination of pressing needs to fulfil daily trading objectives and manipulation of the VWAP period.

Although size and aggressiveness are the most common indicators of informed trading, the average size of orders that actually execute is roughly three quarters of the size of the average order size. This suggests that size alone, is not a good indicator of informed trading. Aggressive trading increases with market capitalization, primarily due to the narrower spreads associated with the more liquid stocks. The results support the Allen and Gorton (1992) gravitational pull theory, that narrower spreads imply a greater proportion of market orders. But we also find that the limit price of passive orders are affected by the spread. When the spreads are narrow, orders are placed behind the spread, when they are wide, orders are placed inside the spread, and at other times they are placed at the spread. We attribute this result to a behavioural bias whereby investors assume that the spread

will revert to a "normal" size of spread. This is an extension of the "anchoring" theory described by Hirshliefer (2001). Despite offering a similar measure of liquidity, this result does not hold for the weighted quoted spread, since this measure is not readily available.

The price impact broadly increases with aggressiveness, which supports the link between aggressiveness and information. However, the price impact over 30 minutes for limit orders placed behind the spread is negative for buys and sells. We may attribute this partly due to the volatile periods at the end of the day, when investors often choose between market orders or limit orders behind the spread, as explained in Beber and Caglio (2003), to benefit from the volatility. Another anomalous result is that type 2 sell orders have a positive price impact. These results show that the aggressiveness of orders is not a strong indicator of short term price movements.

We find that orders placed behind the spread are often placed with little reference to the market conditions. This suggests an unsophisticated but not necessarily uninformed strategy. We also use a behavioural bias to explain why buyers pay more attention than sellers, to the asymmetry in depth when deciding between a market order and a limit order. The ratio of same side depth over opposite side depth may be used as a proxy for short term price movements. When the ratio is above average, a market order is often the best option. Since depth is usually greater on the bid side, traders may use this to justify the decision to place a market buy order. But when a seller is faced with the same situation, even if the ratio is above average, the bid side depth may still be greater than the sell side depth in absolute terms. Without knowing the average value, a seller would not use the depth asymmetry to justify their order choice.

Contradicting Parlour (1998), we find that the most likely order event to follow a market or limit buy or sell, is an order event of the same type. Consecutive market buy orders lead to a positive price impact as expected, but the price impact is largest when a market buy follows a market sell or vice versa. While traders may prefer to use market orders when others are trading actively, it still seems odd that the net effect of a market buy order and a market sell order is greater than two consecutive market buy orders.

7 CONCLUSION

7.1 Introduction

This thesis offers many insights into trader behaviour on the SETS order book, and puts them into the context of the LSE market and of the world exchanges. It also provides a solid base from which to build a model of order strategy. The concluding chapter is split into 3 main sections. The first two sections (8.2 and 8.3) outline many of the important results from the empirical analysis. Section 8.2 summarises the results of the comparison between SETS and SEAQ. Section 8.3 summarises the results from the two chapters on the SETS order book and the observed trading behaviour. The final section introduces an order strategy model, defining the important characteristics and suggesting areas for further research.

7.2 Microstructure Comparison

Using the methodology of Haung and Stoll (1996) and Venkataraman (2001), it is concluded that SETS has lower transaction costs than SEAQ. This implies that the automated order book is more efficient than the dealer network. The result conflicts with the result of Venkataraman (2001), that the human intermediation of the NYSE trading floor reduces the overall transaction costs. However, an alternative methodology, which compares the transaction costs of stocks that switched platforms against those that did not, suggests that the dealer market (SEAQ) is more efficient than the automated market (SETS). The likely reason for this result is that traders are inexperienced in using the order book (SETS). The alternative methodology also suggests that the order book can't cope with large orders.

Transaction costs decrease with size of trade. This is inconsistent with existing theory (O'Hara (1995)). The result is attributable to block trades in the case of SEAQ and a time selection issue for SETS. We also show that price impact is a suitable measure of the information content of trades. However, asymmetric information leads to a much higher quoted spread and effective spread, and these measures are stronger indicators of information asymmetry, than the price impact.

7.3 The SETS Order Book

We discovered many results and relationships concerning the variables of the order book, aggregate trader behaviour and individual trader behaviour. Each result adds to the bigger picture of the efficiency of the market. As well as adding depth and breadth to the empirical work carried out on automated order book markets, and SETS in particular, we draw many conclusions about the behavioural aspects of trader activity. Perhaps the most concise way of summarising the results is to say that there are clearly observable patterns of trader behaviour that highlight the frictions imposed on the efficiency of prices, and that these patterns may be exploitable in real markets. The next 2 sections cover the main points from Chapters 5 and 6.

7.3.1 The Order Book

The "typical" order book is different for each stock. Larger companies have smaller quoted spreads, and greater overall depth, although depth at best price has a much weaker correlation with the size of the company. Other relationships are consistent for all of the companies in our sample. For example, total offer side depth is usually greater than the total bid side depth, but the depth at best price is roughly symmetrical. The ratio of depth (bid side depth divided by offer side depth) fluctuates widely, due to a variety of order strategies, making the ratio a poor

indicator of short term price movements. Spread decreases during the first hour of trading, and depth increases during the first hour of trading, as the market stabilises after the opening call auction. A higher proportion of orders go through the order book on stable days, suggesting that off market traders are better informed. There is also evidence that traders were learning how to use the order book more efficiently as the sample period progressed.

We find some interesting results in comparing the bull and bear phase of the market. Both the overall order activity and the proportion of trading on the market were higher during the bear market. The quoted spread remained stable, but the weighted quoted spread doubled in the bear period, relative to the bull period. There was proportionately more sell volume on the book during the bear period. The ratio of buyers over sellers at best price was greater during the bear period. Surprisingly, the "day time" returns were higher during the bear period. This suggest that the opening procedure may set more efficient prices than the continuous market which drives prices higher than expected. And finally, the average order size was higher during the bear period (more than can be justified by the increase in prices).

7.3.2 Order Strategy

Order activity follows consistent daily patterns. For example, overall trading activity dips at lunchtime. Sellers place fewer, but larger orders at start and end of the day. Overall trading volume increases sharply at the end of the day. Trading is thinner and less aggressive at the start of the day, even though the book is thickest in the first hour. This implies that quoted spread is more important than total depth when assessing the liquidity of the market. Order activity and aggressiveness increase at the end of the day, which is attributable to the activity of day traders, VWAP manipulation and traders being drawn to times of greatest liquidity.

As expected, we find that price impact increases with the aggressiveness of orders, although there are a few exceptions. Type 4 buy orders (limit price at the best price) have a positive price impact over 5 minutes implying that these orders are quickly followed by more aggressive buy orders. Type 5 orders (limit price up to 4 ticks behind the spread) have a higher than expected price impact (in some cases they appear to be more informative than type 4 orders). Type 1 sell orders (market orders bigger than the opposite side depth) have a positive price impact. The market seems to interpret a type 1 sell orders as uninformed and as an indicator of short term offer side activity.

Market sell orders, expressed as a proportion of all sell orders, is positively correlated with the size of the company. This relationship exists, but is much weaker for market buy orders. Not all market orders execute immediately or completely. The average size of fully filled orders is three quarters of the average size of all orders. Roughly one third of orders are removed before filling and deleted orders are smaller than the average order size.

The quoted spread is similar when weighted by buy orders or sell orders, but the weighted quoted spread (defined in chapter 5) varies a great deal. This implies that order imbalance is less important than observable spread when determining order choice. Market orders are more likely when the spread is small. Depth is also an important factor for order choice. Buyers may use the depth imbalance to justify aggressive trading, but since the imbalance is usually in that direction, sellers are less likely to use this measure to justify a market order. Limit orders placed behind the spread show no relationship with the prevailing market conditions (spread and depth). The extent of the relationships described above, vary throughout the day. During the last half hour of trading, many of the relationships seem weaker as the order activity increases, and the prices become more volatile. Consecutive market orders frequently switch sides towards the end of the day.

7.4 Further Research

The results of this thesis may be extended in many directions. One obvious application of the results, is a short term price forecasting model. Section 8.4.1 describes such a model, and explains what other areas should be studied before the model could be developed. Section 8.4.2 then describes a few further areas of research.

7.4.1 Price Forecasting

Paradoxically, theory regarding the price setting ability of order book markets (O'Hara (1995), Parlour (1998)) is rarely used in the empirical analysis of the markets (Venkataraman (2001), Beber and Caglio (2003)). This may be because published empirical research generally uses the NYSE. However, another reason is that the theoretical models have been developed from market maker markets, rather than starting afresh. In some cases, the models seem to be manipulated to fit the results of the older market microstructures. Some studies ignore the issue of fitting a pricing model to an order book market, and merely state that prices are efficient (Ahn *et al* (2001)). But before we can measure the efficiency of an order book market, we must establish what factors lead to inefficiencies.

The results in this thesis could be used to develop a "black box", to determine the most profitable order strategy. This model could simply be based on a regression analysis that updates to account of changes in the market, followed by a set of simulations. The inputs would include market data such as spread, depth, asymmetry, recent price movements, time of day, recent order types, timing of trades, number of traders posting orders and overall market performance. The inputs

would also have to include the desired size of order, time restrictions, attitude to risk and the strength and longevity of private information. The output would include the preferred trading platform (if more than one is available), how to split the trade over time, the limit price (if applicable), the predicted price impact and what alternatives should be used if market conditions change during the process.

An important step in predicting short term price movements, is to determine who is interested in trading in a given stock. Keeping a list of all investors who own a specific company share is one way of narrowing the list of possible sellers. Traders are anonymous unless you are the counter party to a trade, so placing a small trade to identify the traders on either side of the market may prove useful. The data set does not allow for this study, but theoretically we may show many relationships between the size of orders, the likelihood of asymmetric information, the size of the trader, the timing of orders, autocorrelation and cancellation of orders, and other variables pertaining to order strategy. Working backwards from these results, we may use the variables observed on the market to determine the most likely "type" of investors present in the market. This may then suggest what hidden trading interest there might be.

Having established which investors are present in the market, we may predict the likelihood of asymmetric information. It was shown in Chapter 4 that price impact is a crude measure of information asymmetry. Price impact is also retrospective; we cannot wait 30 minutes to determine the level of information. A more sophisticated model might allow for the types of investor present, the time of day, recent price movements, the stability of the spread and depth, the number of traders on either side of the spread and other current market variables. The more efficient the measure of asymmetric information, the more confident traders might be of the value of their own private information, and in the stability of the market price.

Comparing the price impact of actual trades against those predicted by the model could be used to refine our estimates. The model should update constantly, to cope with all changes in the market conditions. O'Hara (1995) stresses the importance of time in the efficiency of prices. This variable has been ignored throughout this thesis due to the extra computational effort that would be required. (Applying the "time since last trade" or "number of trades in the last 5 minutes" variables would be an important extension of this work.) Since time of day and time since last order event are potentially informative, the model should update even in the absence of changes in the market. The model could also be refined after the publication of market statistics (such as those used in this thesis) that offer greater detail than the real time data.

Perhaps this section may seem to depart from the noble pursuit of knowledge. However, the success of a model (like the one described above) would indicate market inefficiency, and this is of great interest in academia. Some may argue that inefficiency cannot be proven unless a model could beat the market net of transaction costs. A natural extension would be to use the model to manipulate the market and then profit from the inefficiency (or identify existing inefficiencies and exploit them). Some may also argue that the results would be a product of data mining, exposure to risk or just luck. However, while there exists a difficulty in modelling the real world, the above accusations remain an inescapable burden.

7.4.2 Other Areas for Further Research

Results in Chapter 6 suggest that the opening auction is more efficient than the continuous trading day. This was not tested explicitly, but it is possible to analyse the orders placed during the opening auction. It is also possible to identify trades placed during the closing auction or any trading halts. Madhavan and Panchapagesam (2000) study the opening auction on the NYSE, but little has been

done to show how the two distinct microstructures (the opening auction and the continuous market) interact. It may also be fruitful to study which types of investor (categorised by size or investment style) use the opening auction, and under what market conditions. Do more investors use the opening auction to fill their orders when the markets are volatile? And if so, which investors? Since trading halts are usually called when prices are volatile, we may expect the aggregate trader behaviour to be different during the trading halt auction and the opening auction. There are many aspects of trader behaviour that may be uncovered by an analysis of the activity during the call auction process.

A further study could address the issue of conflicting trading interests, by collating data for investors rather than traders. The aggregate data on the LSE does not include this level of detail, but brokerage houses should have this information. Grinblatt and Keloharju (2001) use data from the Finnish Stock Exchange to show how the holding period and returns over that period affect the decision to trade. Given a similar data set, it would be possible to show how holding period and returns affect the method of execution of a trade. It would also provide a more detailed cross section of investors, to refine the relationship between size and aggressiveness of orders.

Although survey based research is rare within published market microstructure literature, there are many areas in which this may aid our understanding of trader behaviour. First, we could collate information regarding actual decisions to trade along with the reasons for choosing the method of execution. Second, we could provide hypothetical questions to test for behavioural aspects such as anchoring, biased self-attribution and regret theory, and evaluate how these affect the aggressiveness of orders. A study of finance students, active practitioners and retired traders may highlight the importance of knowledge and experience as well as the susceptibility to be misled by market data.

One of the criticisms of the SETS order book is that it cannot cope with large orders (Chapter 4). Instead of working a large order through the book, block trades may be negotiated by off-market traders. The statistics in this thesis make no explicit allowance for block trades. Identifying block trades, how they affect the market price, the information they imply and the overall cost of execution would aid the understanding of how the two market structures (the formal order book and the informal dealers) interact. It could also be used to refine the results of Chapter 4 and the comparison of trade activity on and off the market in Chapter 6.

Testing behavioural aspects on the financial markets is difficult because the "efficient price" is never known (unless declared bankrupt). An area with many similarities to the financial markets (and as long a tradition) is poker. Texas Hold 'em poker involves four rounds of betting, with two cards dealt to each player and five community cards laid on the table as the betting continues. When all five cards are on the table, the omniscient observer knows with certainty, which player has the best hand. Each player makes an assessment of the value of their own hand against the value of their opponents' hands, based on the bets their opponents have made, the positions they are sitting, their current chip levels and their "betting styles". The analogy with the financial markets is clear; a player has private information (the two cards in his hand), and market information (five cards on the table, and the actions of other players), and the only way to make money is to take it from other players. The advantage of studying poker is that it is mathematically tractable.

There are many other ways in which the results of this thesis could be refined or extended. In Chapter 6 we concluded that investors were learning to use the order book more efficiently. This could be tested more thoroughly given a data set stretching from the order book inception (1997) to the present day. Also in Chapter 6, we defined an alternative spread measure. This could be tested against other

measures of liquidity allowing for depth and asymmetry of depth, to determine the most informative measures. In Chapter 6 we analysed how market performance and trade activity depends on the volume of trading on and off the market. One way to refine this study would be to match up the actions of investors trading on and off the market, to determine how the two markets interact. Many of the suggestions in this section rely on having sufficient data. While the LSE data set analysed in this thesis offers a huge volume of detailed data, there are many limitations imposed. Further studies would benefit greatly if the LSE (or another market) were to provide data in a more appropriate format for quantitative research.

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