The effects of a change in exchange fees charged by the JSE on overall market quality in South Africa.

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8 June 2015

Declaration

I, Keith Thompson, declare that this research report is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Management in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

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Abstract.

This study investigates how a change in the fees charged by the JSE onto members to trade stocks affects various metrics of market quality. This topic falls within the broader subject of market microstructure, which considers how frictions in trading can affect both the costs and behaviour of investors. It primarily relates to the issues of market structure and design, along with the issues of price discovery and price formation. Work in related areas has shown that changes in market design can affect market efficiency and integrity. The overall result of this work does seem to partially corroborate with those previous studies in finding there are some identifiable changes in a subset of the metrics of market quality that are examined. The most striking result is a reduction in incidents of market manipulation post the change in exchange fees. Overall instability in bid/ask spreads makes drawing any conclusions around implicit transaction costs difficult. However, there is some evidence of lower transaction costs amongst the largest market capitalisation stocks.

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CHAPTER 1 INTRODUCTION

1.1 Introduction

For a long time, the issue of frictions in financial markets had been 'largely ignored' (Stoll, 2000) with many models simply assuming the presence of a 'Walrasian auctioneer' that ensured competitive markets automatically cleared at their equilibrium price and quantity. However, over the past 30-odd years, there has been a growing interest in the process by which prices are determined in markets – a subject that has taken on the name of market microstructure (Madhavan, 2000). Work in the field of market microstructure has shown how the design, structure and rules of a stock exchange can affect topics as diverse and important in finance as the level of asset returns (Jones, 2002), market efficiency in disseminating information (Chordia, Roll & Subrahmanyam, 2008) and price volatility. The fees that a stock exchange charges market participants to trade are an example of a possible friction in the process of price formation. This study investigates the impact of a change in the fees that the Johannesburg Stock Exchange Limited (JSE) charges its members to trade on various metrics of market quality.

This chapter is organised as follows. Section 1.2 provides a background to the study by discussing the study of market microstructure and the operations of the South African equity trading environment. This is then followed by a formal problem statement, the research questions and the research objectives that the study seeks to address in section 1.3, 1.4 and 1.5 respectively. A short discussion of the data and proposed methodology follows in section 1.6. Section 1.7 presents the outline of the thesis and the chapter summary concludes the chapter.

1.2 Background to the study

The change in JSE fees charged to members to trade in equities represents a potential friction that is studied within the field of market microstructure. This section provides background on both the broad field of market microstructure in sub-section 1.2.1, as well as more detail on the JSE itself and how it fits into the broader South African trading environment in sub-section 1.2.2.

1.2.1 Market Microstructure

The study of market microstructure covers a fairly broad range of topics and areas. Two key areas of research include both matters of market structure, as well as matters relating to price formation and price discovery. Market structure focuses on the design, trading rules and protocols of a market and how these factors affect the process of price determination. The area of price formation and price discovery considers aspects like transaction costs and also how prices change over time to convey new private and public information. Other matters that fall within the ambit of market microstructure include both market transparency and the linkages between market microstructure and other areas of finance (Madhavan, 2000).

Decisions around how to structure and organize markets are not immaterial. For example, a study of a phased-in change in market type on the Tel-Aviv Stock exchange found a positive market-adjusted additional return of ~5.5% in the 30 days after the change (Amihud, Mendelson & Lauterbach, 1997). The most common structure used to conduct trading in equity markets is a continuous auction market (de Jong & Rindi, 2009), which may also be complimented with call auction markets at set points during the day. Crossing networks have grown in importance, with a study of the US market in 2008 finding that nearly 30% of all equity volumes occurred away from traditional exchanges (O'Hara & Ye, 2011). The potential lack of transparency in crossing networks has created some regulatory concerns (Michaels, 2014), but it has also been suggested that the crossing networks may help reduce trading costs by making it easier to locate uninformed traders (Madhavan, 2000).

The investigation and study of the issues of price formation and price discovery has tended to focus around issues of inventory management and asymmetric information. Early inventory management models involved looking at how market makers adjust their pricing and spreads in response to deviations of current inventory levels away from their optimal levels (Biais, Glosten & Spatt, 2005). Later models moved on to focus on matters of asymmetric information. These later models, such as that of Kyle (1985), are normally based around the interactions of informed traders, noise traders and market makers. Informed traders are held to have some level of better information about the real value of the share and can use this to earn a profit by trading with market makers. These models often focus on the process by which private and new information is transmitted and incorporated into the market price.

The analysis of transaction costs is subsumed within the topic of price formation and price discovery. Transaction cost analysis in equity markets has traditionally focused on the costs faced by investors. These costs are normally divided in two parts, with the early literature establishing a clear line between explicit and implicit transaction costs (Demsetz, 1968). Explicit costs are made up of all the various taxes, fees and commissions that an investors faces when buying or selling shares. These costs are normally easy to identify and, if the data is available, simple to measure. Implicit costs are more contentious. They consist of all other costs that are not included in the final invoiced price paid by the investor. In line with the original work by Demsetz (1968), the use of bid/ask spreads in measuring implicit costs remains popular (Pollin & Heintz, 2011). The literature splits this spread into three distinct components of cost. The components are order processing costs, inventory management and asymmetric information (de Jong, Nijman & Roell, 1995). It should be noted that an exclusive focus on bid/ask spreads to measure implicit costs is not without controversy. One of the key problems with bid/ask spreads is the increased importance of institutional investors in equity markets. This class of investor has been a major driver of the growth in trading volumes in US markets (Chordia, Roll & Subrahmanyam, 2010). Institutional investors typically trade in large size, with orders that can take several days to complete (Chan & Lakonishok, 1995). With such large orders, the bid/ask spread is not a precise measure of the cost of trading immediately (Grossman & Miller, 1988). Alternative measures of implicit costs that have been suggested include implementation shortfall (Bessembinder, 2003; Anand, Irvine, Puckett & Venkataraman, 2012) as well as VWAP and the mean of the open/high/low/close (Domowitz, Glen & Madhavan 2001). A significant problem with these other measures is that they generally require access to the private order data of investors. Such data is very often not available, or only available with a long lag.

Algorithmic trading and high-frequency trading (HFT) has attracted growing interest from the academic community, as computer-based trading systems have taken on an ever more prominent role in financial markets. This ‘rise of the machines’ has been a key change in the market structure in recent years, with one estimate finding that as much as 73% of the volume that traded in US markets in 2009 originated from computers (Hendershott, Jones & Menkveld, 2011). HFT on its own is now thought to be anywhere from 40% to 85% of daily trade in the US (Huh, 2014). These developments have not been without controversy, as events such as the Flash Crash of 2010 and the fall of Knight Capital after a computer system error show. Michael Lewis’s recent book ‘Flash Boys’ has also not helped the public image of the HFT industry. A central theme of the book is that HFT firms receive an unfair advantage over regular traders. This advantage reportedly comes from some stock exchanges that provide HFT firms with preferential access to systems and order types that allow them the ‘skip the queue’ (Sukumar, 2014).

The academic literature around algorithmic trading and HFT continues to struggle towards consensus. Hendershott and Moulton (2011) found that a dramatic increase in the speed and automation of trade in the New York Stock Exchange (NYSE) raised effective bid-ask spreads through higher risks of asymmetric information, although it did improve price efficiency. A separate study of the London and Paris Stock Exchanges found that algorithmic trading caused average trade size, value and bid/ask spreads to fall. It also found that the market was more informationally efficient (Aitken, Aspris, Foley & Harris, 2014). HFT strategies can be divided into liquidity-taking (aggressive) strategies and liquidity-provision (passive) strategies. Liquidity-taking strategies revolve around speed, attempting to react before others to a profitable event. Studies on aggressive strategies have generally found that they increase the adverse selection and trading costs of others. Liquidity-provision strategies operate more like high-speed market makers, and studies of these strategies have mainly found that they result in narrower bid/ask spreads and more informationally-efficient prices (Baron, M., Brogaard, J. & Kirilenko, A., 2014). A study of the NASDAQ market found that HFT increased market quality in periods of both normal and falling markets (Hasbrouck & Saar, 2013). However, the study could not discount the possibility that HFT could worsen a crisis during periods of severe market dislocation. Huh (2014) comes to a similar conclusion, highlighting that liquidity-providing strategies provide less market making activities when markets are volatile. In essence, liquidity-providing HFT's have seemingly taken on much of the role of traditional market-makers. But in times of crisis, they may withdraw from the market and weaken the process of price formation - right at the time when they are needed the most.

1.2.2 The South African Equity Trading Environment

The South African equity market is structured along the same lines as most global equity markets. It is important to distinguish between the roles played by investors and brokers as it is relevant to the question of who bears the costs and benefits of a change in exchange fees. After this, key aspects of the JSE are discussed. This is followed by a short description of how trading in equities is conducted on the exchange.

Investors are responsible for making specific decisions about which asset classes and specific instruments to buy and sell. This is done with the goal of maximizing their return for a given level of risk that they are willing to assume. Institutional investors are typically dominant in this process in South Africa, pooling assets from individuals, corporates and governments and making investment decisions on their behalf. The Association for Savings and Investment SA (2013) identifies a value of R 1,373 billion worth of assets under professional management by South African funds (as of 31 December 2013). These assets are fairly heavily concentrated, with the 7 biggest fund managers representing ~56% of total assets in the industry (Cairns, 2013). It is relevant to note that South African fund managers are subject to exchange controls, which were designed and implemented to limit capital outflows from the country. The nature and extent of these controls have been gradually relaxed over time. But they still limit the amount that a fund manager can invest outside of South Africa to no more than 25%-30% of total assets. The exact levels allowed to be invested in foreign assets largely depends on how the fund is classified (Leape & Thomas, 2011).

Both retail and institutional investors typically rely on brokers to help them to buy/sell shares on a stock exchange. Brokers are private firms that provide investors with research and trading services. They are normally members of the major stock exchanges in the countries in which they operate. They use their exchange membership to trade on behalf of investors in return for commission payments. Brokers may also choose to provide formal or informal market making services. There is a growing trend for brokers to provide their clients with electronic systems to enable them to trade for themselves onto the exchange (this is called direct market access or DMA). Irrespective, as it is always the broker's system that interfaces directly with the exchange, any fees and charges from the exchange are levied onto the broker. The commission between investor and broker is established separately in a private contract. These fees are generally set in a long-term contract rather than being negotiated on a transaction-by-transaction basis (Goldstein, Irvine, Kandel & Wiener, 2009).

For investors in South Africa, the JSE is the only venue available for executing equity transactions in most listed stocks. This stands in sharp contrast to the trend in developed markets such as Europe and the U.S. In these markets, regulatory changes driven by policies such as the EU's Markets in Financial Instruments Directive (MiFID) has led to the establishment of multiple execution venues for a single stock ('A bigger bang', 2014). This market fragmentation has been the subject of several studies, with findings that it may compress bid-ask spreads, lower trading fees and improve execution speeds (O'Hara & Ye, 2011). One important finding from a JSE perspective is that having a single central order book for a stock typically raises transaction costs (Colliard & Foucault, 2012). While the situation of a single central order book does characterise trading in many South African stocks, it should be noted that several of the larger and more liquid stocks listed on the JSE are fully fungible with listings on exchanges in other countries. The presence of these dual-listed counters (DLCs) is an important feature of the JSE equity market. Additionally, a number of JSE-listed companies also have actively traded American Depositary Receipt programs in the US (notably the gold miners). Nonetheless, the existence of only a single trading venue in South Africa means that investors often do not have a choice between competing trading venues with differing cost schedules. Even in the case where a stock is also listed on a foreign market, there are a number of frictional impediments to trading in another venue. These include the explicit costs of transacting in these markets, along with potential foreign exchange risk, ADR conversion costs (which are typically material) and any costs arising from the mismatched settlement cycles (such as financing and borrowing costs).

The JSE is a fully electronic, order-driven market. The rules of the JSE state that they only accept orders from the electronic systems maintained by members of the exchange, but they do allow broker/members to offer investors a DMA service. The trading day is divided up into auction phases and periods of continuous trading. Exact statistics are difficult to determine, but volume during all the auction phases is generally no more than 20% of the total volume on the day. During the periods of continuous trading, traders can submit electronic buy and sell orders into a central order book. These orders can specify a limit price, or can be entered 'at market'. If a buy order with a limit is entered (called a limit buy or limit sell from here), the trading system will match them against any limit sell orders that have been previously placed with a sell limit below or equal to the buy limit. The total number of shares that will trade in this matching process depends on the number of shares requested on both the buy and sell order, with the system seeking to maximise the total number of shares that trade in each transaction. Any residual amounts that are left over after the matching process will stay in the central order book at their respective limits. They will remain in the order book until they either get completed in a subsequent transaction, expire, or are cancelled by the trader. In the event that a limit buy (or sell) order matches against several sell (or buy) limit orders, the JSE trading system will match them in order of price-time-visibility. Hence, in the case of sell orders, the sell order with the lowest limit will be filled first, followed by the second lowest limit price and so forth. Should there be two or more sell orders entered with the same limit price in the central order book, the orders will be filled based on time – with the order entered first being filled first and so on.

Market orders work in slightly different fashion. A market buy order entered into the system will immediately match with each existing limit sell order in the system until the total volume in the market order has been satisfied. In general, a market order will execute the full number of shares placed in the order and so potentially limit any opportunity costs of trading. However, the market impact costs of these orders can be high as they do not set a maximum price limit. There are two scenarios in which a market order may not execute in full on the JSE. This first is when there is an insufficient total volume available across all the opposing limit orders. For example, if a buyer wants 10,000 shares total at market, but the total volume of limit sell orders for the stock is only 5,000. The second possibility is when the price impact of the market order is sufficiently large enough to trigger the JSE's circuit breakers. In this case, the market order will buy (or sell) as much as possible up to the price that triggers the circuit breaker.

On the JSE, circuit-breakers are triggered when the price moves more than a certain pre-defined percentage amount from either the previous traded price or from the previous day's closing price. These percentage levels are based on JSE's size classification of the share.

Auctions are conducted at the start (between 08:30 to 09:00) and end (between 16:50 to 17:00) of each trading day. Stocks with a small market capitalisation (designated as ZA03 by the JSE) also have an additional auction at midday (between 12:00 to 12:15). The stated goal of the midday auctions is to improve liquidity in these stocks. Auctions are also conducted whenever there is a move in a share price that triggers one of the JSE's circuit breakers. These auctions are designed to reduce volatility and find a fair price at which to continue trading in the stock. During an auction period, traders can enter both limit and market orders, but nothing trades until the end of the auction period or the 'uncrossing'. When the auction closes, the trading system makes use of a volume maximising calculation to determine the final price and volume of shares that trades in the auction. The sequence in which orders are filled continues to be based on the rules of price-time-visibility priority, with market orders considered to have price priority over limit orders. Throughout the auction, the JSE publishes an indication of the expected price and volume at which the share will uncross to market participants. This is based on the existing orders entered into the system at that point in time.

On the 30th of September 2013, the JSE introduced a notable change in the billing model that it uses to charge members for equity transactions. The notice of this change was originally issued by the JSE on the 1st of July 2013 and is reproduced in Appendix A. Prior to the change, the exchange charged a variable fee per transaction, based on 0.0055% of the value of the transaction with a minimum charge (floor) of R4.00 and a maximum charge (ceiling) of R20.00 per transaction. The fee was charged on each transaction (or 'hit') on the exchange, irrespective of the number of shares ordered. Hence, an order could be entered to buy 1,000 shares, but such an order could result in multiple transactions if the seller only sold a few shares at a time. This created a perverse situation where the exchange fee charged per transaction could actually be more than the value of the transaction itself (assuming the stock price was low enough). From the 30th of September 2013 onwards, the JSE removed the minimum floor per transaction and reduced the variable value to 0.0053% of the transaction. It slightly compensated for this by increasing the maximum charge to R300. Thus, it became cheaper for brokers to transact in smaller trade sizes and this could also provide liquidity. The aim of this study is to assess and analyse the impact of the 30th September 2013 change in the JSE billing model on measures of market quality.

1.3 Research Problem

Exchange fees charged to market participants are a potential source of friction to the efficient formation of market prices and can impact the overall level of market quality as measured by market efficiency and market integrity. These changes in market quality can arise as market participants respond to a change in fees by adapting their trading behaviour. Exchange fees may also affect net asset returns through the channel of implicit transaction costs. The recent change in exchange fees charged by the JSE was implemented only after extensive consultation with market participants. However, the impact of this change on the overall quality of the market remains an open question. This study provides an attempt to fill this gap by measuring for any changes in a number of traditional metrics of market quality. A deeper understanding of this topic will contribute to the existing literature on market design. This may help provide future guidance for decision makers in trying to achieve the optimal design and level of regulation of financial markets.

1.4 Research questions

Specific questions that this study will seek to answer include:

- Did the change in the JSE billing model result in any changes in implicit transaction costs faced by investors.
- Did the change in the JSE billing model cause a change in overall liquidity.
- Did the change in the JSE billing model result in a change in the level of market integrity.

1.5 Objectives of the study

The aim of this study is to determine whether the change in exchange fees resulted in any impact on measures of market quality. The specific objectives are as follows:

- To investigate whether the new JSE billing model has resulted in a change in implicit transaction costs to investors.
- To establish whether the new JSE billing system had an impact on measures of overall liquidity; on the level of market integrity, and on overall market quality.

- To investigate whether the change has affected the general behaviour of market participants and the impact of the change on their returns.

1.6 Data and Methodology

The data required for this study is based on public information generated by trading activity on the JSE. The frequency of the data is on both a daily and intraday basis and it is sourced primarily from the *Bloomberg Professional* service. The general method of analysis used is a trend analysis to examine various measures of market quality before and after the change in the JSE's billing model. Where possible, the results for the JSE will be compared to those of another market over the same period to attempt to isolate the impact of the change in JSE exchange fees. To better capture any potential changes in market quality, the stocks will be segmented in two separate ways – firstly by share price and then also by market capitalization.

Market quality will be examined within a framework of market efficiency and market integrity (Harris & DiMarco, 2012). Market efficiency considers the areas of transaction costs and price efficiency and will be measured using specific metrics of realized spreads, price efficiency and liquidity measures.

Market integrity is measured by looking at the incidence of market manipulation of closing prices. Potential incidents are identified by using methods developed by the surveillance industry. These events are then evaluated against the stock exchange announcements over the same period to determine if there is evidence of market manipulation.

1.7 Chapter Outline

The thesis is structured into five chapters shown here.

Chapter 1: Introduction. This section provides a short introduction, along with key background information and the objectives of the study.

Chapter 2: Literature review. This focuses on current and historical literature around market microstructure, with a focus on the topics of transaction costs and algorithmic trading.

Chapter 3: Data and methodology. This chapter will discuss the methods and data used to conduct the study.

Chapter 4: Results. This chapter presents the results of the statistical analysis, highlighting key facets.

Chapter 5: Discussion and conclusion. The final chapter uses the empirical results to draw out a set of responses to the research questions above. It will finish with suggestions for future studies.

Chapter Summary

The 'Walrasian Auctioneer' view of setting prices and quantity has been superseded in financial markets with the study of market microstructure. Market microstructure focuses on a diverse range of topics, with the goal of understanding the process by which prices are formed within markets. Key areas of research in the field include price formation and discovery, transparency, market design and linkages to other areas of finance. Market microstructure recognises that a number of potential frictions exist that can cause realised market prices to differ from the equilibrium prices that would otherwise hold. One such potential friction is the existence of fees charged by stock exchanges onto brokers to trade. Exchange fees may affect market quality, as well as investors' net asset returns through implicit transaction costs. In South Africa, the equity market has a single transaction venue, namely the JSE. On the 30th of September 2013, the JSE changed its billing model by removing the minimum charge of R4.00 per transaction, as well as marginally dropping the percentage value charged per trade.

This study investigates the change in the JSE billing model to determine if it caused a change in overall market quality. It is hoped that this will contribute towards the literature on optimal market design. The study is conducted in the form of a trend analysis with the data sourced primarily from the *Bloomberg Professional* service. Market quality will be measured by considering metrics of implicit cost, price efficiency and liquidity, as well as the incidence of market manipulation.

The next chapter provides a more thorough review of the topic of market microstructure, tackling several major areas of research. Key areas of market design and price formation are looked at closely. Transaction costs are also covered in detail before finally turning to the literature that has developed following the recent and dramatic growth in computer-based trading.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

This chapter presents the literature review related to the research topic. The chapter is organized in the following manner. Section 2.2 starts with a general discussion of market microstructure. Section 2.3 provides an overview of the topic of market structure, before section 2.4 examines the central themes in the areas of price discovery and price setting. Section 2.5 looks at the issue of transaction costs in more detail, helping to draw the distinction between these costs and exchange fees. Section 2.6 discusses the growing trend and implications of algorithmic trading systems and its offshoot, high-frequency trading. The chapter summary concludes the chapter.

2.2 Market Microstructure

Adam Smith's 'Invisible Hand' has always occupied an important place in economic thinking. Leon Walras took the concept of a natural force of self-interest bringing together buyers and sellers further, developing the idea of a 'Walrasian auctioneer'. A 'Walrasian auctioneer' is a hypothetical market maker who matches demand with supply in perfectly competitive markets to ensure they always clear at equilibrium prices and volumes. Such a 'Walrasian' view of how a financial market sets prices and volumes was common until the 1970's, with the issue of market frictions 'largely ignored' (Stoll, 2000). Since then, there has been growing scrutiny of the simplifying assumption that the observed price in the market is equivalent to a Walrasian equilibrium price (Beja & Goldman, 1980). The increasing complexity of financial markets has also helped grow academic interest and literature around the processes by which prices are formed – a subject that has taken on the name of market microstructure (Madhavan, 2000).

Market microstructure is concerned with looking inside the 'black box' of price formation, considering aspects such as the design, structure and rules of financial markets and how they influence observed market prices. The issue of transaction costs is addressed within this broader area, with market frictions resulting in prices that may diverge away from their expected behaviour (Easley & O'Hara, 2003). A key belief in the study of market microstructure is that the features of a market are relevant to the behavior of asset prices. For example, it has been shown that historic volume has predictive power over the pace at which price momentum reverses (Lee & Swaminathan, 2000). A long-run empirical analysis of transaction costs over the 20th century found that measures of market liquidity predicted stock returns one year ahead (Jones, 2002). Further, the study of microstructure can help in providing important policy suggestions for the optimal design and level of regulation in financial markets. It also has implications for many other areas of finance including corporate finance and international finance.

The study of market microstructure contains a wide and varied range of topics. Madhavan (2000) suggests grouping the existing academic research into four separate topics. These are namely: price formation and price discovery; market structure and design; information and disclosure, and informational issues around the interface of market microstructure to other areas of finance. The topic of price formation and price discovery considers both static matters like transaction costs, as well as more time dependant issues such as how prices change to incorporate new and private information over time. The area of market structure and design focuses on trading protocols and rules, and how these can change and affect the process by which prices are determined. Information and disclosure looks at market transparency and how changes in the level of information provided to market participants can influence trading behaviour. Finally, informational issues arising from the interface of market microstructure speaks to how market microstructure relates to and enriches the debate in other areas of finance. An alternative approach used to review the field of market microstructure involves evaluating the theoretical models that seek to find equilibrium outcomes within a simple framework; and then making use of these theoretical underpinnings to understand the existing empirical analysis of markets (Biais et al, 2005).

In this review, market structure and design is considered first to help 'set the scene'. This is followed by a discussion around the main themes of price discovery and price formation. A particular focus is then paid to two specific areas of potential relevance to this study. The first is the topic of transaction costs, and its linkages to other areas of study in finance. This is followed by a discussion on algorithmic trading systems, including high-frequency trading (HFT), which has been the topic of much of the recent literature. HFT is of particular interest, as it has been called a paradigm shift in financial markets, with the potential to affect the workings of even the most fundamental aspects of the market (O'Hara, 2014). Matters around information and disclosure, along with links to other areas of finance, are touched on within the discussion below.

2.3 Market Structure

Market structure is concerned with a number of factors including: who can access the market; what instruments can be traded on a market; what levels of disclosure are required from different market participants, and what are the methods and rules relating to the routing of orders and setting of execution prices (de Jong & Rindi, 2009). There are a number of important areas to consider when designing and considering market structure. This includes the market type which determines the allowable timing of trades; the need or presence of market makers, and the level of automation. Consideration needs to be given as to whether a market provides a price discovery function or if it makes use of prices that are set elsewhere. The specific rules governing trading on the market also deserves attention. These rules cover diverse aspects such as the allowable types of orders, tick size and minimum order sizes (or lots). Finally, notice should be paid to the transparency, and feedback, provided back to market participants throughout the trading process (Madhaven, 2000).

Choices around market structure are not immaterial. For example, a study by Amihud et al (1997) found that a phased-in change in the market type of the Tel-Aviv Stock exchange caused a positive market-adjusted additional return of ~5.5% in the 30 days after the change. In another study, reductions in tick size (the smallest increment by which a price can be changed in a trading system) was found to be associated with higher levels of market efficiency and lower bid-ask spreads (Chordia et al, 2008).

2.3.1 Order- and Quote-driven markets

One of the key ways to classify financial markets is to distinguish between order-driven and quote-driven markets (Madhavan, 1992). A primary difference between the two is the existence of formal market-makers in a quote-driven system. Market makers provide liquidity to other market participants, ensuring that there is always a buy (bid) and sell (ask) price at which other participants can transact. Quote driven markets are common in fixed income and foreign exchange markets. Equity exchanges that operate quote driven markets often impose requirements on market makers. These requirements may include the need to be present in the market at all times. It is also common for an exchange to require market makers to be willing to transact in at least a certain minimum number of shares, as well as place a maximum on the difference (or the 'spread') between the bid and ask prices that they quote at any time.

Order-driven markets do not have formal market makers, and are normally structured as auction markets. Auction markets can be call auctions or continuous auctions. In a call auction, all orders are entered into the call session and transparency is high, with market participants able to view each other's order during this period. At the end of the period, a ruling price is set at which all transactions take place based on the orders submitted. A continuous auction operates differently, with market participants able to send orders at any time during the auction period and these orders are immediately executed at the time of submission against any available countervailing orders. Continuous auction markets are typically electronic, with all participants able to observe previous transactions before entering their orders into a central place, which is often called a central order book or limit order book. The central order book provides a matching system. Continuous auction markets are commonly used in the trading of both derivatives and stocks globally (de Jong & Rindi, 2009). By contrast, pure call auction markets are uncommon at best. However, the literature does suggest there are some benefits to the use of call auctions, as they concentrate liquidity into a specific period. A theoretical analysis by Vayanos (1999) showed that a trader could achieve higher gains from trade if they can credibly commit to trading in a single piece in a call auction instead of having to spread out their trade to reduce market impact. An analysis of the Frankfurt Stock Exchange found that transaction costs for small trades are lower in the call market, but large trades are cheaper to execute in the continuous market (Kehr, Krahnen & Theissen, 2001). Overall, the literature suggests that while there may be welfare gains from structuring markets as call auctions, continuous auctions do provide a useful complement (Bias et all, 2005).

2.3.2 Crossing Networks

Crossing networks (sometimes called 'dark pools' or 'upstairs markets') provide an alternative venue for institutional investors to execute large trades and have taken on a growing importance in equity markets. A study of the US market in the first three months of 2008 found that nearly 30% of all equity volume occurred away from traditional exchanges (O'Hara & Ye, 2011). Crossing networks are typically set-up as privately operated trading venues and are classified as order-driven markets (de Jong & Rindi, 2009). Orders submitted to crossing networks are not visible to other market participants. These orders are then matched off against orders from other institutional traders, based on the rules of the crossing network. The specific rules used by the matching process are not always clear, but the transaction price is typically derived from prices prevailing in the primary market for the stock. As an example, the rules of ITG's Posit crossing network for US orders is to run a call auction eight times a day, with the price at which orders are executed chosen randomly from the stock's primary market in the seven minutes following the end of the call auction period. This potential lack of transparency in price setting by crossing networks is one of the reasons why the US Securities and Exchange Commission (SEC) recently recommend a change in regulation to force all crossing networks to disclose their matching rules to the SEC (Michaels, 2014). Another issue with crossing networks is that they create potential regulatory issues, such as the incentive to manipulate prices on the primary market (de Jong & Rindi, 2009). On the other side of the debate, it has been suggested that crossing networks may help reduce trading costs by helping to locate trading counterparties who do not possess private information (Madhavan, 2000). However, the economic benefit of these crossing networks may still be small for average-sized block trades (Madhavan & Cheng, 1997). There is also disagreement around the contribution of crossing networks to the process of price discovery (Ibikunle, 2014).

2.4 Price Discovery and Price Formation

Market microstructure literature in the areas of price discovery and price formation investigates the process by which market participants are able to convert their levels of demand and supply for financial instruments into fully realized transactions. It subsumes the topic of transaction costs, and also investigates matters such as the speed and nature in which prices absorb and reflect new private and public information. A general coverage of the key themes in the area is undertaken here, before moving onto a more detailed analysis of transaction costs in the next section.

Early literature and models focused on the spread between the two-way (bid and ask) prices quoted by market makers. This followed on from the pioneering work of Demsetz (1968), who argued that such a spread was the market makers compensation for 'predictive immediacy' in execution. Empirical work has found evidence relating this spread to other market variables such as volume, risk and the number of market makers (Stoll, 1989). More recently, Barclay, Kandel and Marx (1998) found a significant negative relationship between changes in the spread and trading volumes.

Theoretical models seeking to explain the variation in spreads initially focused on inventory management costs (Madhavan, 2000). Inventory management costs relate to the costs borne by a liquidity provider in trying to maintain their inventory of stocks at an optimal level. The term liquidity provider can be used in a more general sense than market maker, although the terms are used interchangeably here. Intuitively, the role of the liquidity provider is to actively buy and sell to provide immediacy, hopefully generating a small profit with each transaction. They do not wish to accumulate positions of any significant size. For example, in the case where a liquidity provider buys a large number of shares from a seller, they are likely to end up with more shares than they wish to own. The liquidity provider in this situation now runs a risk that the price of the share drops before they are able to reduce their inventory back to their optimal level – thus generating a realized loss. This underlying idea drives many of the models of price formation that are built around inventory management costs, such as that of Stoll (1978). As the liquidity provider trades, their actual and desired levels of inventory diverge and they adjust their bid and ask prices accordingly. An interesting question that arises from this adjustment process is if the liquidity provider keeps the spread constant and simply moves the mid (the average of the bid / ask) up or down, or if they widen or narrow the spread in reaction to sub-optimal inventory levels. Theoretical models provide a somewhat conflicting view with O'Hara and Oldfield (1986) showing that inventory levels influence the market makers in setting both the width and position of their quoted spreads. An alternative approach by Ho and Stoll (1980) finds that the width of the spread does not change with inventory, but the position of the spread on the order book does move. An empirical investigation of market makers on the London Stock Exchange (LSE)'s SEAQ market finds that they almost never narrow the spread, but rather compete by moving their price around the market bid/ask levels (Reiss & Werner, 1996). An important result that flows from these models is that liquidity providers provide an economically valuable service by bringing together different buyers and sellers through time, via the use of their inventory (Madhavan, 2000). The economic value of this service is generally ignored in Walrasian markets, as it is assumed that all potential buyers and sellers arrive in the market at the exact same point in time.

More recent models in market microstructure have increasingly incorporated informational aspects, looking at the interaction of liquidity providers with traders who may possess different levels of private and public information. Such models also often incorporate rational expectations (Madhavan, 2000). These models typically distinguish between informed traders, noise traders and market makers. The idea of an informed trader was first raised by 'Bagehot' (1971), where some traders have asymmetrically better information than the market makers and use this advantage to generate profits. Informed traders are not necessarily corporate insiders, although the term 'insider' is often used in the literature. However, they are held to have access to some level of material informational advantage when making trading decisions. For example, in Glosten and Milgrom (1985) the decisions of informed traders may be based on inside information, superior analysis or they may simply be trading for liquidity reasons. An empirical analysis of the electronic limit order book of the Australian Stock Exchange found that approximately 10% of orders were from informed sources. However, these orders potentially have a greater impact on prices than those of noise traders (Brown, Thomson & Walsh, 1999). Noise traders (also often called liquidity traders) are market participants whose trading decisions are not based on market analysis or meaningful information (Jordan, Miller & Dolvin, 2012).

In a seminal note, Kyle (1985) develops a model where a single informed trader with a monopoly on material information places orders over time. The informed trader attempts to maximize their profit before the information becomes public. In this model, market makers only set a price after orders are placed and use the information on aggregate order flow to update their beliefs. Kyle (1985) shows that, in this framework, the market price will ultimately reflect all available information. An important feature of noise traders is that their presence means uninformed traders cannot just look at transaction prices to uncover the information held by informed traders; as such prices also includes the actions of noise traders (Grossman & Stiglitz, 1980).

Market makers are generally held to be uninformed and tend to lose to informed traders on average, but are able to recoup these losses on noise traders (Madhavan, 2000). The risk of losing to informed traders requires some level of compensation to be made to the market maker. This implies that the bid-ask spread can be partly explained as including payment for the asymmetric information risks faced by the market maker. Models of asymmetric information can also be used to fully explain the empirical observation that larger trades (also called block trades) are typically done at a 'worse' price than small trades. This effect arises as market makers are uncertain if they are trading a block amount with a party that holds an informational edge or not (Easley & O'Hara, 1987). More recently, Duong and Kalev (2014) looked at the effect of removing the broker ID in the Australian Stock Exchange, which removes the ability for a trader to distinguish between informed and noise traders. They found that anonymity allowed for improved liquidity, but at the expense of prices taking longer to adjust to the information contained in informed traders' order flow.

Finally, it should be noted that the assumption of noise traders in a market is not without its detractors. Some researchers have raised the question as to why noise traders are seemingly always willing to lose money to market makers and informed traders (Bias et al, 2005). Introducing elements of bias from the field of behavioral finance may hold the answer to this question. In an analysis based on Kyle's model discussed above, Benos (1998) finds that the actions of overconfident informed traders closely follows the behavior patterns of noise traders, although the model still requires some noise traders to be present. In this scenario, prices become more volatile but information is more quickly transmitted into prices. This finding is somewhat at odds with Odean (1998), who notes that the presence of overconfident traders can cause markets to limit their reaction to the information contained in the behavior of rational traders. He also finds that overconfidence in traders has been found to increase trading volumes.

2.5 Transaction costs

The topic of transaction costs fits within the broader area of price formation in market microstructure, with the literature normally exclusively focused on costs at the level of the investor. Transaction costs are important in financial markets as they may have considerable impact on asset prices and investment decisions. There are models linking higher transaction costs to both higher expected returns and lower trading volumes (Barclay et al, 1998). The higher expected return arises as investors will require increased compensation for investing in stocks with larger transaction costs. And lower trading volumes come about as stocks with high transaction costs are likely to attract investors with longer holding periods who can effectively amortise such costs (a clientele effect). While Barclay et al (1998) find evidence that costs have a greater impact on volumes than expected returns, Amihud and Mendleson (1986) provide support for the view that expected returns are a positive function of costs (as measured by bid-ask spreads). They suggest that this may encourage firms to engage in liquidity-enhancing actions to bring down transaction costs in an effort to lower the cost of capital to the firm. Vayanos (1998) suggests a general equilibrium model of transaction costs which shows that higher transaction costs can have two opposing effects on an investors demand for shares, causing them to buy fewer shares but also to hold on to existing shares for longer.

More directly, high trading costs affect overall portfolio returns negatively and may lead to significant underperformance versus a benchmark. Perold (1988) called this the 'implementation shortfall', although the term has subsequently taken on a separate specific meaning in the evaluation of trading performance. He compared a paper portfolio based on the Value Line ranking system with the real Value Line fund. He found the paper portfolio was able to outperform the market by 20% a year from 1965 to 1986, but the real fund was only able to manage a 2.5% outperformance. More recently, an analysis of trading costs across a number of markets and time found that transaction costs are economically significant when related to realised returns (Domowitz et al, 2001). A link has also often been made between trading costs and price discovery. By creating frictions in the market, trading costs can potentially slow down the process of price discovery. In their investigation of the Hong Kong market, Choy and Zhang (2010) found strong support for the view that the market with lower trading costs will play a bigger role in price discovery.

In attempting to measure transaction costs, Demsetz (1968) classic article has informed much of the subsequent literature. He investigated transaction costs on the NYSE, dividing up the total cost into two distinct elements – brokerage fees and the bid/ask spread. Subsequent work on transaction costs has expanded and refined on the original ideas set out by Demsetz (1968). However, his proposed fundamental framework of viewing transaction costs in terms of explicit costs (normally brokerage fees) and implicit costs (bid-ask spreads amongst other measures) remains very much intact. We discuss each separately below.

2.5.1 Explicit Costs

Explicit costs are normally easily categorised and understood, but can vary greatly from equity market to equity market. Explicit costs include: charges levied by brokers for trading services (brokerage charges / commission); additional market fees levied on the investor; clearing and settlement costs, and any taxes. The majority of these costs can be easily identified and measured. For example, within South Africa, any order to buy shares which results in a change of beneficial ownership will attract a Securities Transfer Tax of 0.25% of the value of the trade. Orders to sell shares are not subject to this tax. Brokerage charges are trickier to measure as they are agreed in private contracts between the investor and broker and thus are not in the public domain. Helping to overcome this limitation, a number of private firms collect information on financial market trades directly from institutional investors and provide estimates of explicit trading costs for various markets. A commonly cited source for this data is Elkins McSherry (for example, see Pollin & Heintz, 2011 and Domowitz et al, 2001). According to the company's website in May 2014, they hold information on over 24 million transactions covering $7.2 Trillion worth of trading activity sourced from 1,500 investment manager and 2,000 brokers. Given all this, it could be argued that the measurement of explicit transaction costs in equity markets at a point in time is largely an empirical matter. But researchers still face a number of challenges including access to strictly controlled private data and appropriate analysis. Over longer periods of time, these explicit costs are likely to change significantly as a result of changes to aspects like the tax regime and market regulations. Jones (2002) provides an example of how NYSE commission rates were dramatically reduced following deregulation of minimum charges in 1975. However, such changes do not generally pass without notice and it would seem reasonable to assume explicit costs are likely to be stable over shorter periods of analysis.

2.5.2 Implicit Costs

Implicit costs are normally understood to be all the costs that are not explicitly included in the final price paid by the investor. These costs depend on the price of the trade received by the investor relative to market conditions and are not insignificant. A study of 42 countries between 1996 and 1998 found that implicit costs represented roughly one-third of the total costs of trading (Domowitz et al, 2001). The most important implicit cost is normally identified as the bid/ask spread (Pollin & Heintz, 2011). The academic literature often breaks down the bid/ask spread into three separate components, namely: order processing costs; inventory management, and asymmetric information (de Jong et al, 1995). Order processing costs relate to the costs borne by the liquidity provider of simply being present in the market and handling the transaction. These can include costs of maintaining systems for trading, exchange fees and settlement charges. Inventory management costs and asymmetric information costs are derived from theoretical models of price formation. These relate to the need to compensate the market maker (or other liquidity provider) for the risk of holding less than optimal levels of inventory, and for the risk that they may be trading with someone who possesses better information. Various studies have been conducted on the size and nature of these three components of the bid-ask spread. For example, Glosten and Harris (1988) are not able to reject a hypothesis of a positive adverse-selection component in trade data. Stoll (1989) finds that adverse information accounts for ~43% of the quoted spread on the NASDAQ/NMS stocks and order processing costs account for a further ~47%. Inventory holding costs were found to account for just ~10%. Foster and Viswanathan (1993) found that the order processing costs showed little variation both intra- and inter-day. But that asymmetric information costs varied through the day and tended to increase in periods of high trading volumes. In a review of the literature on the topic, Biais et al (2005) found that transaction costs can cause both a temporary and a permanent impact on prices. The temporary impact arises from the cost components of order processing and inventory management, while permanent changes are linked to asymmetric information.

A possible objection to the use of bid/ask spreads is that the earlier theoretical models often assume the existence of a formal market-maker. But the models can be easily extended to order-driven markets if we allow for brokers to take on the role of informal market makers, or to view the compensation for immediacy as also relating to potential opportunity costs incurred by more patient investors. Colliard and Foucault (2012) investigate this potential model of order-driven markets using the concept of maker (liquidity providers) and takers in limit order markets. They note that a maker obtains a better execution price but faces a non-execution risk. Further, the trading venue can set different maker and taker fees to optimize revenue and trading. Madhavan (1992) modeled both a quote-driven and an order-driven market and found that the continuous trading periods were equivalent, as long as there was free entry into market-making. Finally, the move to electronic trading platforms (which are often order-driven) has also seen the rise of a new type of market maker, called an electronic market maker (EMMs) by Raman, Robe and Yadav (2012). These EMM's are typically traders operating in a proprietary fashion and seeking to profit from bid-ask spreads by providing liquidity. Given all the above, it seems reasonable to assume that the core idea underlying the use of bid/ask spreads is reasonable in both quote-driven and order-driven markets.

There are some further issues to using a simple bid-ask spread as a complete measure of implicit costs. As noted by Grossman and Miller (1988), the bid-ask spread is not a precise measure of the cost of trading immediately, especially when an order is large. In the case of large (typically institutional) orders, the volume of shares that a liquidity provider is willing to buy/sell may well be less than the volume that the investor wishes to transact. Hence, a large seller is more likely to be concerned with how the bid will change over time than the current bid/ask spread. Further, large trade sizes are often observed to be done at prices that are worse than smaller trades (Easley & O'Hara, 1987). This implies that the real transaction costs faced by differing types of investors will not be the same as that implied by the bid-ask spread, and may vary with the size of the order.

The point that costs may vary with trade size is especially important in the face of increased activity from institutional investors. The size of institutional investor trades can be very large relative to market volumes. For example, Chan and Lakonishok (1995) found that more than half the value of institutional trades in the sample they studied took four or more days for execution. This sample was based on data collected by SEI Corporation and covered the transactions of 37 large investment managers between the years 1986 to 1988. An analysis of the stocks in the Nasdaq 100 over a 10 month period from May 2000 found that approximately 86% of all trades over 10,000 shares originated from institutional investors (Griffin, Harris & Topaloglu, 2003). Keim and Madhavan (1995) reference the large growth and magnitude of institutional trading. More recently, Chordia et al (2010) found that institutional trading has played a principal role in the recent volume increases in the US market.

The focus on institutional investors has led to some recommendations that implicit trading costs could be better measured using alternative methods. While general consensus may be hard to find, an 'implementation shortfall' measure is suggested by both Bessembinder (2003) and Anand et al (2012). This method evaluates the average price received for an order against a reference price at the time of the trading decision. The idea behind such a method is to try isolate and capture the overall market impact of the order. Supporting the case for measuring costs in this fashion is the evidence that most institutional orders are normally filled. Intuitively, this means that the market impact costs of trading should be significantly higher than any opportunity costs of not trading (Keim & Madhavan, 1995; Chan & Lakonishok, 1995). Other options include benchmarking costs against the volume-weighted average price

(VWAP) or considering the mean of the open/high/low/close prices (Domowitz el al, 2001). The principal problem with these approaches is that the private order flow data required for measurement is often unavailable for institutions, and impossible to access for retail investors. Irrespective, the presence and size of institutional investors and their orders in the market highlights the need to consider more than just the bid/ask spread when evaluating implicit costs.

One other matter that should be considered is the stability of the bid-ask spread. While a detailed study of Ericsson on the Stockholm Stock Exchange for 59 trading days found that bid-ask spreads are remarkably stable (Hollifield, Miller & Sandas, 2004), there are a number of exogenous factors that can affect the size of the spread over time. For example, as previously mentioned, a reduction in minimum tick size is likely to reduce the spread (Chordia at al, 2008). Further, the growing number of trading venues and resulting fragmentation of liquidity has also been found to reduce effective spreads (O'Hara & Ye, 2011).

2.6 Algorithmic Trading

The proliferation of computers and connected networks has been a transformative force in financial markets and has led to the growth of algorithmic trading and its offshoot called high-frequency trading (HFT). Adding further impetuous to this movement has been both the growing complexity of the financial system; and the numerous advances made in the quantitative modelling of these markets (Kirilenko & Lo, 2013). Highlighting just how rapid this growth has been, algorithmic trading was thought to be responsible for as much as 73% of trading volumes in the US in 2009 – from a base of almost zero in the mid-1990s (Hendershott et al, 2011). HFT on its own is now estimated to be anywhere from 40% to 85% of daily volume in the US equity markets (Huh, 2014).

At its simplest, algorithmic trading is the use of mathematical models, computers and connected networks to automate the process of buying and selling shares (Kirilenko & Lo, 2013). The use of such systems allows for increased efficiency, meaning a smaller number of individuals can manage a much larger volume of orders. This is often achieved through the use of 'parent' and 'child' orders. The parent order is the actual order received from the client, and will normally be many magnitudes of size too large to allow for immediate execution. The trader will select an overall strategy for execution, based on client requirements and other factors. Once this strategy is selected, the whole or part of the parent order is entered into an algorithmic trading system, with various parameters selected based on the chosen execution strategy. This computer system then automatically submits 'child' orders to the exchange over time, based on a programmed logic designed to achieve a specific aim (for example; to be 20% of overall volume that trades, or to spread the trades evenly throughout a trading day).

High-frequency trading takes the logic of algorithmic systems one step further. HFT systems are specialised algorithmic systems programmed to automatically seek out profitable trading opportunities. Their recent growth has been driven by the increased market fragmentation found in markets like the US and Europe. In some ways, they can be viewed as simply closing arbitrage gaps in the market, although other strategies are employed. What makes them unique is that these profit opportunities may only exist for the tiniest fraction of a second, and it requires extremely high-speed systems to be able to identify and then exploit these opportunities (hence the term 'high-frequency'). As HFT systems are completely computer based, they are not limited to human perceptions of markets. This gives them a potential advantage over human traders as they can think in terms of cycles of the market (often related to volume of trading) rather than in terms of time. The benefit in such an approach is that these cycles have a return distribution that is far more normal in shape than the traditional leptokurtic shape of financial data series (O'Hara, 2014; Brooks, 2008).

Algorithmic trading and HFT are certainly not without their detractors. Fingers have been pointed at both as the reason behind events such as the 'Flash Crash' in 2010. This was when US markets experienced extraordinary volatility and spikes in trading volumes, as broad stock indices like the S&P500 initially collapsed before rebounding with astonishing speed. An empirical analysis of that period suggests that HFT did not initiate the crash, but contributed to the scale of events by demanding execution ahead of other market participants (Kirilenko, Kyle, Samadi & Tuzun, 2014). Another event that garnered significant attention was when the US stock market was thrown into turmoil one morning in August 2012 after Knight Capital failed to test its algorithmic systems adequately. Knight's systems bombarded US exchanges with incorrect orders that ultimately cost the firm ~$460 million in trading losses. Adding to the firms woes, it was later fined $12 million by securities regulators for the incident (Mamudi, 2013). What has made HFT such a specifically controversial topic is the contention that some stock exchanges have provided HFT players with an unfair advantage through better access to their systems and unique order types. Michael Lewis's (2014) recent book centered around this idea that HFT firms get preferential treatment from certain stock exchanges relative to normal traders, and it led to an uproar in the US market after its publication (Sukumar, 2014).

Irrespective of the public view, there is little doubt that these algorithmic systems have become an integral part of a modern equity market. As a consequence; many of the limit and market orders that are entered and trade on a stock market are generated from decisions made by computers, rather than from human traders. This 'rise of the machines' and its associated controversies has not escaped the academic community, and studies into the effects of algorithmic trading and HFT have proliferated in recent years. Hendershott and Moulton (2011) looked at the introduction of the NYSE hybrid market in 2006, which allowed for a large increase in the speed and automation of trade. The change was found to raise effective bid-ask spreads by ~10% as a consequence of higher risks of asymmetric information. The increase in adverse selection did have the positive impact of increasing the efficiency with which prices incorporate new information. In a study of NYSE stocks from 2001 to 2005, algorithmic trading was found to improve liquidity for stocks with a high market capitalization, although no such significant effects could be identified for small-cap stocks. In contrast with the previous study, higher levels of algorithmic trading was found to actually lower adverse selection (Hendershott et al, 2011). A study of the Paris exchange and LSE found that average trade size, trade value and bid-ask spreads all fell by a significant amount after a six-fold increase in algorithmic trading. Importantly, the same study found that algorithmic trading made the market more informationally efficient by reducing the incidence of both closing price manipulation and the leaking of private information (Aitken et al, 2014).

A number of recent studies have focused specifically on HFT. HFT firms employ various strategies in order to generate revenue. These strategies are normally jealously protected, as shown by events in 2009 when Goldman Sachs charged a former employee with theft after he allegedly took HFT code to a new employer (Glovin, Harper & Kisham, 2009). Despite the veil of secrecy that surrounds many of these firms, attempts have been made to characterize and document their behavior. One such approach is to divide them into those that use liquidity taking (aggressive) strategies and those that employ liquidity providing (passive) strategies (Baron et al, 2014; Huh, 2014).

Liquidity taking strategies revolve around speed, using aggressive order types to trade in an instant before others in reaction to some potentially profitable event. By contrast, liquidity-provision strategies are developed around passive market-making activities, which seek to identify informed trading activities. They then use speed to cancel and modify their orders in an effort to capture some of the economic profits away from the trader with asymmetric information. In general, models built around the actions of aggressive HFT strategies tend to find that they increase the adverse selection and trading costs of others. In contrast, theories that model passive strategies find that they actually increase the efficiency of prices and result in tighter bid-ask spreads (Baron et al, 2014). An analysis of public data on the NASDAQ during both a normal period, as well as a period of falling prices and heightened uncertainty, found that HFT enhanced market quality in both periods. This was measured through lower bid/ask spreads, greater depth of the order book and lower short-term price volatility. However, the possibility that HFT can increase the risk of a market failure during periods of severe market dislocation could not be discounted (Hasbrouck & Saar, 2013). Huh (2014) empirically studies the actions of liquidity-providing and liquidity-taking strategies separately and then looks at their joint impact. She finds that aggressive HFTs can effectively act in the role of informed traders through access to hard information. Hard information is machine readable data that is relevant for prices, but generally considered public. However, in the short period in which HFTs can react to this hard information before others, it takes on the role of private information. This creates a scenario where aggressive HFT operate in the role of informed traders while passive HFTs represent market-makers, bringing the issue of asymmetric information back into the academic spotlight – albeit at a much faster pace. A final observation from Huh (2014) is that liquidity-providing HFT typically provide less market making activities when markets are volatile, as the asymmetric information risks from aggressive HFTs increases. This would imply that in times of crisis, when liquidity is needed the most, the passive HFTs will withdraw from the market and potentially amplify the volatility. In investigating the success of aggressive against passive HFT strategies, Baron et al (2014) find that the HFT industry is a 'winner-takes-all' industry that is largely dominated by a small number of firms that typically follow a liquidity-taking approach and continue to seek improvements in speed in order to maintain their competitive edge.

Chapter Summary

Market microstructure is concerned with matters like the design, structure and rules of the financial markets and how they can affect price formation. Market microstructure is important as it plays a role in determining asset price returns and can provide guidance in the optimal design and regulation of financial markets. The study of market microstructure covers a wide range of topics including: market structure; price discovery and formation; price transparency, and linkages to other areas of finance.

Market structure considers the design and rules of an exchange. A key distinction is drawn between quote-driven and order-driven markets. Order-driven markets do not have formal market makers and can make use of call auction or continuous auction markets. Equity exchanges are typically structured as continuous auction markets, but often complement this with call auction sessions at specific points in the day.

Crossing networks are also important trading venues, and can provide institutional investors with an anonymous way to try locate counterparties to trade large blocks.

Price formation and price discovery has been an active field for research. Earlier models of price formation focused more on the impact of inventory levels on prices, with later models increasingly incorporating the concept of asymmetric information. The analysis of transaction costs focuses on the costs paid by the investor in turning latent demand or supply into a transaction. It considers both explicit and implicit costs. Explicit costs are easily understood and are directly measurable, assuming the data is available. Implicit costs are all the other costs that are not directly included in the final price paid by the investor. Harking back to the pioneering work of Demetsz (1968), bid/ask spreads are normally used in the measurement of implicit costs. However, this measure may not fully capture the implicit costs faced by institutional investors as their orders can be too big to allow for immediate execution.

Algorithmic trading and HFT has been described as a paradigm shift for financial markets and consequently become a key talking point amongst both market professionals and the academic community. Studies of algorithmic trading have found slightly conflicting results about it effects on asymmetric information, but that it does generally improve price efficiency. HFT firms can be usefully divided into those that follow liquidity-taking strategies and those that pursue liquidity-providing strategies. Studies of liquidity-taking strategies generally find that they tend to increase the trading costs of others, while liquidity-providing strategies can reduce trading costs. In times of severe market dislocation, it cannot be discounted that HFT firms will remove liquidity from the market at the moment when it is needed the most. The next chapter will provide more details on the data used in the study and the specific methodology that will be followed in obtaining results.

CHAPTER 3 DATA AND METHODOLGY

3.1 Introduction

The purpose of this chapter is to provide an overview of the data and the methodology used in this study. Section 3.2 begins the discussion by providing details around the underlying data. Section 3.3 presents the research design. A chapter summary concludes the chapter.

3.2 Data and Data Sources

The daily and intra-day data used in this research covers all the stocks listed on both the Main board and the Alt-X board of the Johannesburg Stock Exchange on the 30th of September 2013. Warrants and investment products on the ZA04 segment of the JSE were not included for two reasons. Firstly, instruments in this segment trade very sporadically, and it is not unusual for there to be no trades for days or weeks at a time. Secondly, the investment characteristics and structure of these instruments can vary widely, making it impossible to draw any reasonable comparisons between different instruments. Daily and intraday data is obtained from *Bloomberg Professional* service. Daily data obtained includes the closing price, VWAP, high and low prices for the day as well as volumes and the number of trades concluded on each day. Intraday data includes the bid and ask prices in one minute increments for the week preceding the change, along with the same data over several subsequent one week periods. In total, intraday data over the full 24 hours from the 23rd of September 2013 to the 31st of January 2014 is available, providing over 186,000 bid/ask observations per stock. This data has been cleaned to cover only the trading period running from 09:01 to 16:49 each day. The start and end times for each day were selected to remove call auction periods from the data. This is done as the bid/ask spread inverts during these periods due to the manner in which the JSE reports data during call auction phases. One complication for comparability between small-cap stocks and the rest of the market is the presence of a midday call auction. Stocks designated as segment ZA03[1] by the JSE, which represents stocks with a small

[1] The JSE classifies each instrument listed on the exchange into specific segments. The segment in which a stock or other product is assigned is important in that the JSE trading rules primarily vary only by segment. The major segments in the equity market are ZA01 (which is made up of all the members of the Top40 index and typically represents the largest stocks by market capitalization on the exchange). The next segment is ZA02, which consists of all the members of the All-Share index that are not in the Top40 index. The All-Share index represents the top 164 stocks on the JSE. Finally, the ZA03 segment represents all the stocks that do not fall within the All-Share index, including members of the Alt-X board, and are the smallest stocks on the exchange by market capitalization.

market capitalisation, have an additional call auction phase between 12:00 to 12:15 daily. The values of the bid/ask spreads for ZA03 stocks during this midday auction period is also removed from the data.

In total, the sample consists of 404 companies listed on the JSE with daily data captured for the period running from the 1st of April 2013 to the 31st of March 2014. Out of this total number of stocks, 69 companies were excluded from the analysis for various reasons including not having any pricing or trade information or price and trade information that is very sporadic (the stock may only trade a few times in each month). Companies were also taken out of the analysis if there was a corporate action that resulted in no data being available after any point in the date range. In the case where corporate actions could affect the comparability of historical prices over the analysed period (such as stock splits), the historical data was backwardly adjusted using the appropriate adjustment factor from the *Bloomberg Professional* service to ensure data consistency.

To help capture if there are potentially different changes in market quality and transaction costs amongst different classes of companies, the stocks are segmented in two separate ways. The first is on the basis of closing price as of the date of the official change in exchange fees. Prices are used because, intuitively, a R4.00 minimum charge per transaction is a greater friction to trade in a low-priced stock than in a high-priced stock. A separate classification is also done by market capitalisation, based on the same date as the closing price segmentation. In each case, the stocks are subdivided into equally sized quintiles. This provides a greater level of granularity in market capitalisation groups than the ZA01, ZA02 and ZA03 classification used by the JSE. The data used to subdivide the sample is also obtained from the *Bloomberg Professional* service.

3.3 Research design

The aim of this research is to establish the impact of the change in the JSE billing system that was implemented from the 30th of September 2013 on overall market quality. This is evaluated within the framework suggest by Harris and DiMarco (2012), which considers how market design affects both market efficiency and market integrity. The student t-test is used to measure for any changes in market efficiency and integrity before and after the change in the billing system.

Additional tests are performed to compare any potential identified changes in the JSE to another market with similar return and structural characteristics. The intention is to provide a control market to help isolate if any potential changes arose from the amendment in exchange fees, or if they may have resulted from other exogenous factors. To determine the most appropriate market for comparison, weekly price returns of the JSE All-Share index are correlated against a range of indices from both developed and developing markets globally. The market with the highest correlation co-efficient is used for comparison. A limitation of the comparisons is that only end-of-day data is available for other markets, so intraday bid/ask spreads cannot be compared.

3.3.1 Measuring Market Efficiency

Market efficiency relates to the topics of transaction costs and price efficiency and represents the more traditional measures of market quality. Transaction costs are evaluated using bid/ask spreads as in Harris & DiMarco (2012). Bid/ask spreads (BID_ASK) are measured using realised spreads rather than effective spreads. This is because the interval data used makes it impossible to accurately ascertain the ruling bid/ask prices at the exact time of a transaction. This is not expected to create a problem as realised spreads and effective spreads are highly correlated (Hasbrouck, 2005). Lower realised bid/ask spreads imply that investors pay less for immediacy at any given point in time and would indicate both lower implicit transaction costs as well as a higher level of market efficiency.

BID_ASK values for each one minute increment in the trading day are initially calculated for the weekly period just prior to the change in exchange fees, which covers the dates from the 23rd to the 27th of September (Monday through to Friday). These values are then compared to the week running from the 30th of September to the 4th of October. Further, other selected weekly periods were also examined in subsequent months, in an attempt to capture any potential delayed changes in BID_ASK arising from traders being slow to update the parameters of their algorithmic systems. The first full weeks in November and December are used, as they represent the weeks that are effectively one month and two months after the change in exchange fees. Finally, the week running from the 20th to the 24th of January is also examined. The first weeks in January are not used, as South Africa has a number of public holidays from late December to the start of January. For this reason, trading in the early parts of January tends to be slow and not representative of normal activity levels (average daily value traded on the JSE over 2013 was approx. R15.8bln but only averaged R10bln in the first full week of January 2014, according to *Bloomberg* data). In each period, t-tests are conducted on the overall average BID_ASK, as well as on each individual stock BID_ASK, with a null hypothesis (H_o) of no change in BID_ASK between periods. In the individual cases where the null is rejected, it is also determined if the BID_ASK value showed a reduction or increase in transaction costs faced by investors.

Liquidity measures the sensitivity of asset returns to order flow (Chan, Hong & Subrahmanyam, 2006). An improved level of liquidity makes it easier for investors to implement their transactions quickly with lower market impact. As access to order flow data is often restricted, measures of liquidity look at both bid/ask spreads and traded volumes. Spreads have already been discussed above. Liquidity measures using volume data face several issues. One issue specifically relating to the JSE data is the requirement for local investors to put all trades through the exchange, even when they are just moving an existing investment from one internal account to another internal account. These 'booking' trades are normally done after the close using the Late Trade rule. This rule allows the institutional investor to put through an unchallenged trade at either the close or the VWAP price on the day. These trades can be large enough at times to skew the final volume figures reported by the JSE, especially in small-cap stocks. To ensure that the measures of liquidity are not adversely skewed by these trades, we use a volume figure that excludes trades that are reported to the exchange after the market close. An equivalent measure of volume is also used for the market selected for comparison purposes. A more general issue with simple volume data is that it may see swings due to numerous external events such as earnings announcement, new information entering the public domain (both on a stock and market level) and global portfolio flows. To help correct for these events, two specific measures of liquidity are considered.

The first is the Amihud (2002) measure of liquidity (ILLIQUID), which divides the absolute percentage return over a period by the volume (or value) over the same period. This is actually a measure of illiquidity, and has been found to have the best correlation amongst several other daily measures to dynamic higher-frequency measures of liquidity (Hasbrouck, 2005). The calculation behind ILLIQUID does not readily lend itself to aggregation of individual data. As a consequence, overall measures of ILLIQUID for each market are determined using the return and value traded numbers from the respective benchmark indices. Individual stock level data is examined by conducting t-tests at the 5% level of significance, with a H_o of no change in ILLIQUID pre- and post the change in billing methodology. If H_o is rejected, the direction of the change is identified to determine if it shows an improvement in liquidity post the change.

The second measure of liquidity is the average daily trade size (TRADE_VALUE). It has been negatively linked to daily volumes (Barclay et all, 1998) and has the benefit of not being influenced by the changes in general market activity that arise naturally from global events. It is also especially interesting to this study as the removal of a minimum exchange fee per trade should improve the economic efficiency of trading in smaller increments. TRADE_VALUE is calculated by taking the total volume on the day and dividing it by the total number of trades.

In order to allow for the comparison and aggregation of TRADE_VALUE, the resulting average volume for each stock is multiplied by its average VWAP over the measured period to convert it into a value figure. The average VWAP over the full period is used instead of the ruling VWAP on each day to avoid the results being affected by any potential large changes in the stock price over time. These values are determined both for each individual stock, as well as aggregated by segments and across the whole market. This aggregation effectively gives a higher weighting to the bigger stocks, as these larger stocks typically trade in bigger increments per trade. T-Tests are conducted on both the individual stocks and also on the aggregated numbers with the null hypothesis (H_o) of no change in TRADE_VALUE. Further, for the individual stocks that do show a statistically significant change, the proportion that show an improvement (decrease) in TRADE_VALUE is also calculated. For ease of reading the values, TRADE_VALUE for the JSE stocks is converted into South African Rands by multiplying by 100 (as the exchange prices are denominated in cents).

The speed and path by which prices adjust to reflect new information is an important determinant of the overall level of market quality. However, measuring this process can be difficult as the timing of when private information moves into the public domain is often uncertain. Further, we may not have any matched pairs over an event date that will allow us to draw any inferences. One method that is used to proxy the efficiency with which prices reflect new information is to look at the dispersion of individual daily stock returns (DISPERSE) against the index before and after the event (Amihud et al, 1997). This is calculated by working out the difference between the actual returns and estimated returns for each stock before and after the event. Estimated returns are based on the standard market model. A Relative Return Dispersion index level for each day can then be computed by summing the squares of the individual stock excess returns on each day. DISPERSE index values for each market overall are calculated. Additionally, separate index levels are determined for each market capitalisation and stock price segment. A 10 day moving average of each index is then derived to provide a clearer picture of the trend. An overall average value for DISPERSE is calculated for each market and segment using the 120 days before and the 120 days after the change in exchange fees. To determine if there is any overall change in DISPERSE, the difference in the average values between the two markets pre- and post the change is evaluated using the student t-test with a null hypothesis of no change.

Finally, high to low ranges are often used in studies to provide a sense of volatility (Bennet & Wei, 2006). The study considers high-low ranges relative to the overall day's VWAP (HI_LOW). This provides an additional metric to analyse the implicit transaction costs faced by institutional investors and is similar in calculation to the effective bid/ask spread. The rationale of this measure is that it covers a longer period than a simple bid/ask spread, and hence is more closely aligned to the large order sizes of institutional investors. Using VWAP provides the average transaction price that an investor could have expected to receive on the day, irrespective of whether they were buying or selling. In this manner, it is similar to the transaction price in an effective spread, while the high and low can be thought of as being analogous to the quoted bid and ask prices. Alternatively, the high and low can be viewed as the highest price that a buyer would have paid and the lowest price a seller would have received respectively.

3.3.2 Measuring Market Integrity

The level of market integrity is an important element of overall market quality and focuses on the level of market manipulation, insider trading and potential broker-agent conflicts. The scope of this study will limit itself to market manipulation. This is partly because the change of exchange fees is unlikely to have any significant impact on the incidence or profitability of insider trading. And it is also partly as identifying incidents of insider trading is complex and fraught with difficulties as the individuals and firms involved in such practices are unsurprisingly secretive about their activities. Broker-agent conflicts cannot be measured as there is no access to private order flow to enable any reasonable evaluation of this potential issue.

Market manipulation (MARKET_MANIP) involves deliberate action to move the price of a financial instrument away from its true level in order to make profit. It is often done on the closing price as this is an important level for many market participants. For example, the value of funds and derivative contracts are normally marked to market at closing prices. The general approach used in Aitken et al (2014) is followed as far as possible in seeking incidences of market manipulation. This approach is based on the experience of the surveillance industry which monitors for such events closely. Potential incidents of manipulation occur when the price return just before and in the closing auction deviates significantly from its average return and then mean reverts at least halfway in the early part of the next trading day. However, given limitations of the available intraday data on the JSE over the period, VWAP prices need to be substituted into the calculations as the exact prices just prior to the closing auction and just after the following day's opening auction are not available. On this basis, market manipulation is suspected if both of the following conditions hold. Firstly, the closing price change against the days VWAP is more than 3 standard deviations away from the average over the previous 30 days. The second condition is that the following days VWAP shows at least a 75% reversion back from the closing level. Where an incidence of market manipulation is suspected, news stories over the period are screened to determine if there was potential information that could reasonably account for the move. Any incidents which may be explained by the release of price sensitive news (either released on the day in question or after market had closed on the prior day) are then subsequently excluded. In total, 100 days before and 100 days after the event where examined for each stock in each market investigated

Chapter Summary

This chapter discussed the data and methodology used in the study. The data covers 404 stocks listed on the JSE, with 69 stocks excluded for various data reasons. Stocks are segmented by both closing price and market capitalisation. The data is sourced from the *Bloomberg Professional* service and covers both intraday and daily public information.

The general methodology employed is one of a trend analysis around the JSE billing model change on the 30th of September 2013. Market quality is evaluated according to a framework which considers measures of market efficiency and measures of market integrity. Wherever possible, the results for the JSE will be compared to those of another exchange to provide a control variable. A limitation of this comparison is that only end-of-day data is available for comparison purposes. Market efficiency is evaluated using realised bid/ask spreads, the Amihud illiquidity ratio, average daily trade value, the dispersion of stock returns to market returns and a high-low to VWAP measure to capture daily 'effective spreads'. Market integrity uses measures developed by market surveillance units to identify possible incidents of market manipulation. The next chapter presents the results of the statistical analysis using the methodology outlined in this chapter.

CHAPTER 4 RESULTS

4.1 Introduction

This chapter presents the results of the statistical analysis undertaken on various metrics of overall market quality. The chapter starts with a discussion in section 4.2 on the choice of market that is selected for the purposes of comparison to the JSE data. Section 4.3 provides summary and descriptive data from the two markets on which the analysis is conducted. This is followed by the analysis of various metrics of market efficiency in section 4.4. Section 4.5 looks at the aspect of market integrity, presenting results relating to incidents of potential manipulation of closing prices. The chapter summary concludes the chapter.

4.2 Selection of Market for Comparison

To ensure that any measured changes in the metrics considered reflect the impact of the change in exchange fees, and not an event exogenous to this study, the results of the JSE are compared with another market. A total of 21 developed and emerging-market indices are considered, with the goal of identifying the most appropriate market to use to compare to the JSE. These indices are selected on the basis that they are broadly representative of overall market returns in their respective individual countries. The underlying countries in the analysis cover all major time-zone regions, and include South Africa's major peers and trading partners.

Following the selection of the indices, the local currency price returns of each index are correlated against the weekly local currency price returns of the FTSE/JSE All-Share index. The correlation co-efficient is determined using the weekly data for the two-year period prior to the change in the JSE exchange fees. The All-Share index is selected for South Africa as it represents all ZA01[2] and ZA02 stocks, and is the broadest stock-exchange index on the JSE. The results of this analysis is shown in Table 4.1. The five indices with the highest level of correlation to the All-Share index come almost exclusively from the same time-zone region as South Africa; namely EMEA (Europe, Middle East and Africa). On the basis of the analysis, the German stock exchange is selected as it has the highest correlation and t-test.

[2] See footnote 1 in Chapter 3 for more details on the ZA segmentation used by the JSE.

Table 4.1: Correlation with FTSE/JSE ALSI Weekly Returns				
Index	**Country**	**Region**	**Correlation**	**T-statistic**
DAX	Germany	EMEA	0.76	11.759
FTSE-100	UK	EMEA	0.744	11.195
OMX-30	Sweden	EMEA	0.724	10.545
CAC	France	EMEA	0.7	9.892
AEX	Netherlands	EMEA	0.69	9.574
Hang-Seng	Hong-Kong	Asia-Pac	0.68	9.397
SMI	Switzerland	EMEA	0.659	8.798
Bovespa	Brazil	Americas	0.655	8.465
Nasdaq	USA	Americas	0.65	8.632
BEL-20	Belgium	EMEA	0.65	8.698
ASX-200	Australia	Asia-Pac	0.648	8.54
S&P500	USA	Americas	0.64	8.361
KOSPI	South Korea	Asia-Pac	0.62	7.86
FTSE-MIB	Italy	EMEA	0.606	7.65
MICEX	Russia	EMEA	0.596	7.416
Merval	Argentina	Americas	0.557	6.745
Bolsa IPC	Mexico	Americas	0.538	6.406
IBEX-35	Spain	EMEA	0.525	6.193
ISE-100	Turkey	EMEA	0.491	5.667
Nikkei-225	Japan	Asia-Pac	0.375	4.071
Shanghai	China	Asia-Pac	0.325	3.382
Data used sourced from the *Bloomberg Professional* service				

4.3 Descriptive statistics

This section provides separate summary statistics for both the JSE and German Xetra exchanges. Similarities and differences between each market are highlighted in the final part of this section.

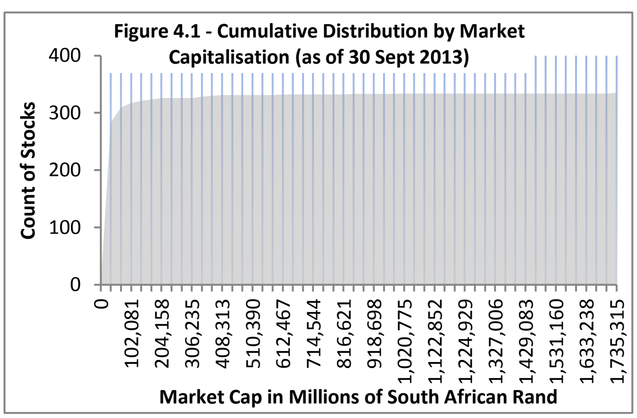
4.3.1 Descriptive Analysis of JSE Stocks

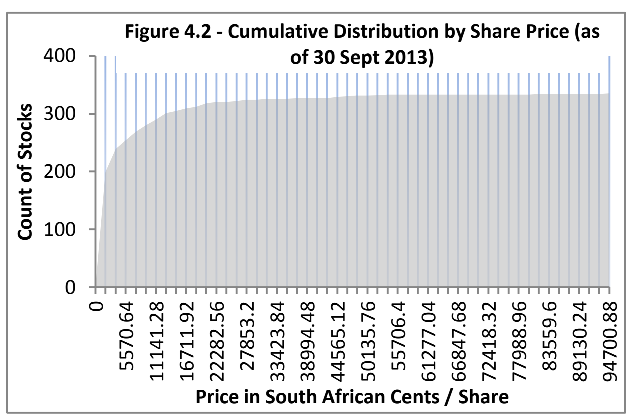
Details of the structure and trading rules of the Johannesburg Stock Exchange were discussed in chapter one, and a discussion of the key features of the data is provided in chapter three. Summary statistics of the data is shown in Table 4.2 below. The daily volume and daily value traded figures are determined by averaging the values for each trading day from the 30th of June 2013 to the 30th of September 2013 (a three month average).

Table 4.2: Summary Statistics for included JSE-listed stocks (as of 30th September 2013)				
	Market Capitalisation (in Millions of Rand)	**Closing Price** (in SA cents)	**3 Month Daily Volume** (in shares)	**3 Month Daily Average Value Traded** (in Rand)
Mean	31,001.86	5,027.79	472,609.48	27,978,417.90
Median	2,378.21	941.00	111,923.45	448,195.30
Std Deviation	129,101.04	10,485.04	1,006,476.85	106,631,451.38
Minimum	4.23	2.00	72.81	4.31
Maximum	1,701,288.97	92,844.00	7,752,657.75	960,997,455.16
Data used sourced from the *Bloomberg Professional* service				

Table 4.2 shows that there is a wide spread between the lowest and highest values in each case. Further, the median value is well below the mean value for both market capitalisation and closing price. This suggests a long tail of stocks with low prices and also a long tail of stocks with a low market capitalisation. The same trend is also evident in the volume data, suggesting that the data set includes a large number of low price/ low market cap stocks with low levels of trade.

Figure 4.1 and 4.2 presents the cumulative total number of stocks against market capitalisation and share price respectively. Figure 4.1 shows that the vast majority of stocks included in the study have a low relative market cap compared to the largest stocks covered. Out of the 335 stocks included, 283 stocks have a market cap of less that R35 billion and 317 have a market cap below R103 billion. The largest company, BHP Billiton, had a market capitalisation of approximately R1,701 billion on the date in question. The distribution of prices shown in figure 4.2 is slightly wider than that displayed by market capitalisation. However, nearly 60% of the stocks (199 of 335) have a price under R18.55 and nearly 90% (301 of 335) have a price under R130 / share.





4.3.2 Descriptive Analysis of the German Xetra market

Following the selection of the German market for comparison purposes, the study obtained data on the stocks listed on the Xetra trading system. The limitation of only taking data from the Xetra market was deliberate. While the German financial landscape consists of a number of different exchanges, the majority of these are regional in nature and/or are simply alternative trading venues. Further, the selection of Germany was based on the high correlation of the FTSE/JSE All-Share with the DAX index. And the DAX index considers only prices and stocks from the electronic Xetra market. A useful feature of the Xetra market is the existence of the regulated market and the open market (also called the regulated unofficial market). The difference between the two relates to the entry standards for listing, with the stocks in the regulated market needing to meet a higher standard. In this way, it is analogous to the JSE's structure of a Main board and the Alt-X board. In total, data on 611 stocks from the Xetra exchange was originally downloaded. However, as with the JSE data, this number was reduced by excluding any stocks with insufficient pricing data. This resulted in a final sample of 490 stocks being analysed.

Table 4.3 provides the summary statistics of the included German Xetra stocks. This table is retained in the original currency denomination of Euros. Again, there is a wide spread between the minimum and maximum values in each case. Further, for each metric, the median value is once again much lower than the average - again implying a long tail of illiquid, smaller-cap stocks in the sample.

Table 4.3: Summary Statistics for included German Xetra-listed stocks (as of 30th September 2013)

	Market Capitalisation (in Millions of Euro)	**Closing Price** (in Euro)	**3 Month Daily Volume** (in shares)	**3 Month Daily Average Value Traded** (in Euro)
Mean	2,657.65	23.85	272,087.89	6,835,896.16
Median	97.39	9.00	10,732.73	67,533.44
Std Deviation	9,636.14	46.79	1,182,911.34	26,275,383.50
Minimum	1.07	0.01	78.41	436.24
Maximum	79,169.95	606.35	13,968,072.64	196,083,587.27

Data used sourced from the *Bloomberg Professional* service

Figure 4.3 and figure 4.4 provide the same cumulative plot of the number of stocks against market capitalisation and closing price that was shown for the JSE stocks. While the distributions look generally similar, it is worth noting that the market capitalisation picture does show evidence of a slightly more even distribution than the JSE.

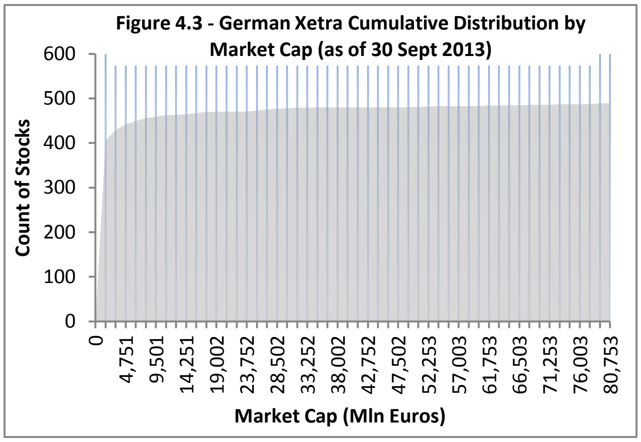


Figure 4.3 - German Xetra Cumulative Distribution by Market Cap (as of 30 Sept 2013)

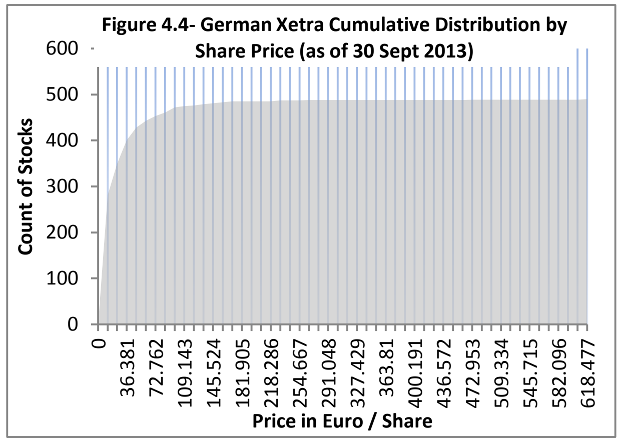


Figure 4.4- German Xetra Cumulative Distribution by Share Price (as of 30 Sept 2013)

4.3.3 Comparison of JSE and Xetra Summary Statistics

The data for the German Xetra stocks was converted into South African terms by using the prevailing EUR-ZAR exchange rate as of the 30th September 2013. The statistical measures of the two exchanges were then compared to each other and the results are shown in Table 4.4. Any value above 1 in Table 4.4 indicates that the Xetra value is greater than the JSE value for that measure.

Table 4.4 shows that the average market capitalisation of JSE stocks is smaller than Xetra. However, the median and maximum values are much larger for the JSE. The maximum value is driven by the extremely high market capitalisation of BHP Billiton, the world's biggest miner, on the JSE. On a price level, the Xetra stocks carry much higher prices than the JSE across the board – and the knock-on effect of this is seen in the volume data with median and average volumes proving much lower on the Xetra. This can be expected, given the higher prices. More interestingly, the value traded statistics show greater levels of trade on the Xetra. Overall, the picture emerges that the Xetra has a slightly more even distribution of stocks by market capitalisation. These stocks are typically much higher priced, and while they do subsequently trade in correspondingly smaller volumes, the overall value traded is still far greater on the Xetra than on the JSE.

Table 4.4: Comparison of JSE and Xetra stocks included in the study				
	Market Capitalisation (German Xetra in ZAR / JSE)	**Closing Price** (German Xetra in ZAR / JSE)	**3 Month Daily Volume** (German Xetra / JSE)	**3 Month Daily Average Value Traded** (German Xetra in ZAR / JSE)
Mean	1.17	6.45	0.58	3.32
Median	0.56	13.00	0.10	2.05
Std Deviation	1.01	6.07	1.18	3.35
Minimum	3.44	9.52	1.08	1376.48
Maximum	0.63	8.88	1.80	2.77

Data used sourced from the *Bloomberg Professional* service

4.4 Results of Market Efficiency Measures

This section evaluates a number of measures of market efficiency to capture any changes in the overall level of market efficiency on the JSE post the change in the exchange fees billing model. The discussion begins by examining realised spreads (BID_ASK), before turning to Amihud's Measure of Liquidity (ILLIQUID). Results for the average value of each trade (TRADE_VALUE) are then presented in their own sub-section. The Relative Return Dispersion (DISPERSE) index is considered next, before the section concludes by looking at the daily high-low range (HI_LO)

4.4.1 Realised Spreads (BID_ASK)

Realised spreads were measured using the closing values for the bid and ask in one minute increments for each stock in the study from the JSE, over the weekly periods outlined in chapter 3. As intraday data for the dates in question was not available for the Xetra market, only the JSE stocks were investigated for changes in BID_ASK.

Table 4.5 shows the results of the analysis across the total market, considering all 335 stocks before looking separately at the 303 included stocks on the main board and the 32 included stocks listed on the Alt-X board.

Table 4.5: BID_ASK for JSE stocks – Summary							
Period	**Mean**	**Median**	**Std Deviation**	**T-statistic**	**P-Value**	**% Individual Reject Ho**	**% Individual Lower**
Panel 1: All Stocks on the JSE BID_ASK							
23rd - 27th Sept	777.19	774.00	12.43				
30th Sept - 4th Oct	839.45	852.85	13.87	Yes**	0.00000	88.36%	53.72%
4th Nov - 8th Nov	731.97	754.55	11.59	Yes**	0.00000	91.64%	53.75%
2nd Dec - 6th Dec	704.01	732.61	12.02	Yes**	0.00000	92.24%	45.31%
20th Jan - 24th Jan	769.31	793.87	13.22	Yes*	0.04657	94.03%	49.21%
Panel 2: Main Board of the JSE BID_ASK							
23rd - 27th Sept	644.76	622.19	10.90				
30th Sept - 4th Oct	691.44	704.12	11.34	Yes**	0.00000	87.79%	54.14%
4th Nov - 8th Nov	594.38	617.62	9.49	Yes**	0.00000	90.76%	53.82%
2nd Dec - 6th Dec	612.86	635.92	10.33	Yes**	0.00000	91.75%	42.81%
20th Jan - 24th Jan	639.96	659.63	10.63	No	0.15044	93.73%	48.24%
Panel 3: Alt-X Board of the JSE BID_ASK							
23rd - 27th Sept	2109.43	2140.14	14.37				
30th Sept - 4th Oct	2303.70	2291.37	19.63	Yes**	0.00000	93.75%	50.00%
4th Nov - 8th Nov	2090.16	2091.61	12.06	Yes**	0.00001	100.00%	53.13%
2nd Dec - 6th Dec	1642.13	1625.50	9.61	Yes**	0.00000	96.88%	67.74%
20th Jan - 24th Jan	2049.47	2052.79	18.96	Yes**	0.00000	96.88%	58.06%
Data used sourced from the *Bloomberg Professional* service. Yes* indicates significance at the 5% level and Yes** indicates significance at the 1% or better level.							

Table 4.5 above shows that there is strong statistical significance of change in spreads between most periods (at the 1% level or better). However, the overall direction of the change is inconsistent, with average spreads across the full market increasing between the week before (23rd to 27th Sept) and the week directly after (30th Sept to 4th Oct) the change in exchange billing. Spreads are then typically lower in the following two subsequent week-long periods before returning back towards levels seen in the period prior to the change in fees. On an individual stock level, a large portion of stocks showed significantly different BID_ASK levels across each week. However, the direction of the change was generally mixed.

The overall picture drawn is one of unstable BID_ASK values over the measured periods, implying that realised spreads are being driven by multiple factors beyond exchange fees. The value in incorporating additional periods is shown, as simply comparing the pre- and post-change weeks could have led to the simple inference that spreads increased and market efficiency worsened. One other feature of the data is that simple average spreads on the JSE are very high, typically over 600bp on the main board.

Table 4.6 shows the analysis in market cap quintiles with an equal number of stocks per band (67). The bands are sorted from largest market-capitalisation on the top to smallest on the bottom.

Table 4.6: BID_ASK for JSE stocks – By Market Cap

Period	Mean	Median	Std Deviation	T-statistic	P-Value	% Individual Reject Ho	% Individual Lower
Panel 1: Stocks with Market Capitalisations from 20,052 mln to 1,707,220 mln							
23rd - 27th Sept	92.81	73.25	4.77				
30th Sept - 4th Oct	72.75	61.41	3.26	Yes**	0.00000	80.60%	57.41%
4th Nov - 8th Nov	52.87	51.49	1.26	Yes**	0.00000	86.57%	48.28%
2nd Dec - 6th Dec	87.96	92.56	2.42	Yes**	0.00006	83.58%	28.57%
20th Jan - 24th Jan	61.57	58.78	1.46	Yes**	0.00000	88.06%	32.20%
Panel 2: Stocks with Market Capitalisations from 4,304 mln to 20,051 mln							
23rd - 27th Sept	108.25	110.61	2.05				
30th Sept - 4th Oct	117.84	115.99	2.53	Yes**	0.00000	83.58%	48.21%
4th Nov - 8th Nov	94.12	92.31	2.79	Yes**	0.00000	86.57%	36.21%
2nd Dec - 6th Dec	105.97	101.40	2.37	Yes**	0.00083	88.06%	23.73%
20th Jan - 24th Jan	128.10	119.68	3.91	Yes**	0.00000	91.04%	29.51%
Panel 3: Stocks with Market Capitalisations from 1,162 mln to 4,303 mln							
23rd - 27th Sept	462.22	475.40	7.89				
30th Sept - 4th Oct	594.74	611.24	16.71	Yes**	0.00000	92.54%	59.68%
4th Nov - 8th Nov	544.75	530.21	9.46	Yes**	0.00000	92.54%	59.68%
2nd Dec - 6th Dec	454.70	467.84	9.75	Yes**	0.00556	94.03%	52.38%
20th Jan - 24th Jan	526.19	474.06	14.58	Yes**	0.00000	97.01%	64.62%
Panel 4: Stocks with Market Capitalisations from 197 mln to 1,161 mln							
23rd - 27th Sept	1224.58	1161.02	28.98				
30th Sept - 4th Oct	1335.89	1325.86	25.81	Yes**	0.00000	91.04%	49.18%
4th Nov - 8th Nov	1323.42	1334.37	24.85	Yes**	0.00000	95.52%	56.25%
2nd Dec - 6th Dec	1041.23	1019.89	8.10	Yes**	0.00000	98.51%	53.03%
20th Jan - 24th Jan	1245.66	1212.82	27.32	Yes*	0.01595	95.52%	51.56%
Panel 5: Stocks with Market Capitalisations from 5 mln to 196 mln							
23rd - 27th Sept	2072.92	2071.87	38.64				
30th Sept - 4th Oct	2145.62	2189.93	41.46	Yes**	0.00000	94.03%	53.97%
4th Nov - 8th Nov	1704.89	1741.99	30.66	Yes**	0.00000	97.01%	66.15%
2nd Dec - 6th Dec	1876.05	1933.27	31.53	Yes**	0.00000	97.01%	64.62%
20th Jan - 24th Jan	1937.90	1955.66	35.03	Yes**	0.00000	98.51%	65.15%

Data sourced from the *Bloomberg Professional* service. Yes* indicates significance at the 5% level and Yes** indicates significance at the 1% or better level.

Table 4.6 shows that spreads increase as we go from the stocks with the largest market capitalisation through to the smallest stocks. Further, the results for the 1st quintile in panel 1 are very interesting. While this is numerically only 67 out of 335 stocks, it represents ~99% of total combined market capitalisation on the JSE and ~91% of total average value traded. Thus, this quintile represents the largest and most liquid portion of the JSE. And in this case, the mean BID_ASK is lower in all cases when compared with the pre-change week, and the difference is statistically significant in all periods. Further, the standard deviation of BID_ASK is also lower, potentially indicating that BID_ASK is more stable. This implies that transaction costs faced by investors in this critical segment of the JSE were lower following the change in exchange fees.

It can be seen that the increases in overall average spreads shown in Table 4.5 are in fact driven mainly by the stocks with a market cap under R4.3Bln (the third to fifth quintiles). Intuitively, the difference in results found between the first and subsequent quintiles could arise as the stocks in the first quintile are the most actively traded by a long margin. As such, use of algorithmic trading systems is likely to be much more evident in these stocks, and improvements in market efficiency may well be driven by adaptations in the logic of such systems.

Finally, Table 4.7 shows the bid-ask spread broken down into stock price quintiles, again with 67 stocks in each segment.

Table 4.7: BID_ASK for JSE stocks – By Stock Price

Period	Mean	Median	Std Deviation	T-statistic	P-Value	% Individual Reject Ho	% Individual Lower
Panel 1: Stocks with Prices from 7151c to 93625c							
23rd - 27th Sept	32.06	34.54	0.91				
30th Sept - 4th Oct	34.68	35.78	0.90	Yes**	0.00000	76.12%	58.82%
4th Nov - 8th Nov	34.13	32.01	1.24	Yes**	0.00000	85.07%	42.11%
2nd Dec - 6th Dec	42.63	44.29	1.58	Yes**	0.00000	83.58%	17.86%
20th Jan - 24th Jan	31.02	27.69	1.23	Yes**	0.00171	88.06%	23.73%
Panel 2: Stocks with Prices from 1921c to 7150c							
23rd - 27th Sept	106.18	84.79	5.04				
30th Sept - 4th Oct	103.17	92.62	3.78	Yes*	0.03122	83.58%	51.79%
4th Nov - 8th Nov	73.28	67.97	2.10	Yes**	0.00000	88.06%	42.37%
2nd Dec - 6th Dec	106.78	105.00	3.36	No	0.65981	89.55%	30.00%
20th Jan - 24th Jan	148.66	88.52	10.79	Yes**	0.00000	91.04%	42.62%
Panel 3: Stocks with Prices from 573c to 1920c							

23rd - 27th Sept	350.66	295.10	11.29				
30th Sept - 4th Oct	266.21	263.35	4.33	Yes**	0.00000	91.04%	54.10%
4th Nov - 8th Nov	301.83	280.40	7.41	Yes**	0.00000	92.54%	64.52%
2nd Dec - 6th Dec	305.31	307.21	5.20	Yes**	0.00000	89.55%	48.33%
20th Jan - 24th Jan	278.75	263.95	7.00	Yes**	0.00000	94.03%	57.14%
Panel 4: Stocks with Prices from 124c to 572c							
23rd - 27th Sept	850.90	816.15	19.76				
30th Sept - 4th Oct	895.24	935.80	18.94	Yes**	0.00000	98.51%	59.09%
4th Nov - 8th Nov	792.59	796.34	13.79	Yes**	0.00000	95.52%	64.06%
2nd Dec - 6th Dec	583.78	584.77	10.89	Yes**	0.00000	100.00%	61.19%
20th Jan - 24th Jan	701.82	700.20	12.31	Yes**	0.00000	100.00%	58.21%
Panel 5: Stocks with Prices from 1c to 123c							
23rd - 27th Sept	2894.01	2635.32	137.07				
30th Sept - 4th Oct	3246.04	2990.98	131.51	Yes**	0.00000	92.54%	45.16%
4th Nov - 8th Nov	2713.25	2576.92	98.85	Yes**	0.00000	97.01%	53.85%
2nd Dec - 6th Dec	2608.50	2585.45	12.12	Yes**	0.00000	98.51%	63.64%
20th Jan - 24th Jan	2899.57	2672.01	101.92	No	0.88366	97.01%	61.54%
Data sourced from the *Bloomberg Professional* service. Yes* indicates significance at the 5% level and Yes** indicates significance at the 1% or better level.							

Table 4.7 again draws a picture of generally unstable BID_ASK values, which makes deriving any specific inferences around the effect of the change in exchange fees difficult to tease out. An interesting feature of the data is that BID_ASK values in the 2nd and 3rd price quintile actually fell overall between the pre- and post-change weeks. This is against the overall increase in spreads seen in table 4.5. Further, it is interesting to note how spreads clearly increase as price falls, echoing the trend seen in the market capitalisation quintiles. The average BID_ASK in the top quintile is between 30-40bp, while spreads in the bottom quintile vary between 2600bp to 3250bp. To a certain extent, some of these higher bp spreads are a mathematical effect as the lowest price increment on the JSE is 1c[3]. Yet the trend of higher spreads in lower-priced stocks is still clear across the quintiles.

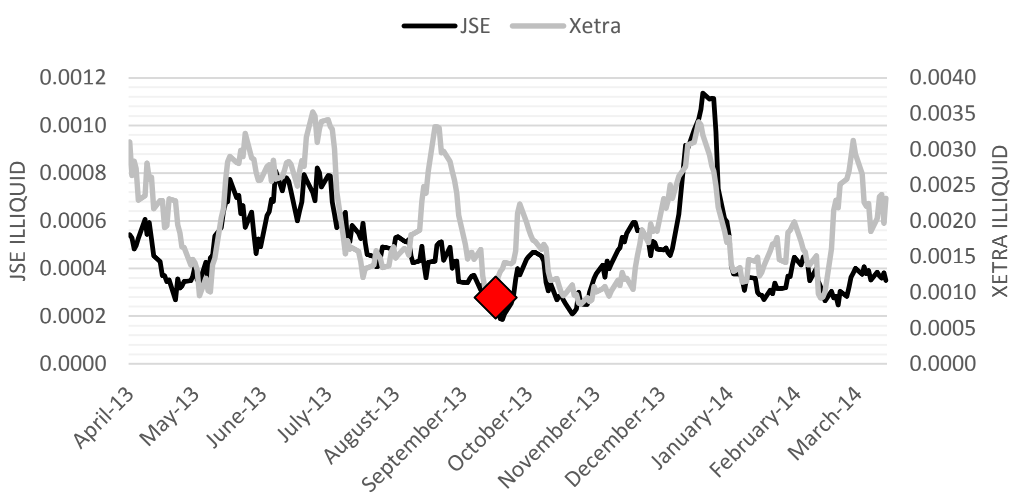
4.4.2 Amihud Measure of Liquidity (ILLIQUID)

The results for ILLIQUID are evaluated in this section, beginning with an examination of the overall market in each country. The results derived using the data from the FTSE-JSE All-Share and Xetra DAX Indices are

[3] If a stock has a bid price of 10c and a ask price of 11c, then the spread is as low as possible given the minimum tick size, yet it is still 10% or 1000bp. By contrast, a 1c spread on a share with a bid / ask price of 10000 to 10001 is only 1bp.

shown in Figure 4.5. The key date when the change in billing methodology became effective is shown by the diamond shape on the graph. Both series show a similar overall trend, and what is immediately noticeable for both markets is the large spikes experienced over the end of 2013. This is typically a period of low volumes in both markets. In South Africa, both the 24th and the 31st of December are only half-days (with the market hours running from 9:00 – 12:00, rather than the normal 9:00 – 17:00). In Germany, there were five non-trading days during the period from the 24th of December to the 1st of January (excluding any weekends). To reduce the impact of this on our analysis, these outlier points are removed from the individual stock measures of ILLIQUID. Comparing the two markets, there seems to be little evidence from the chart that the change in billing methodology had any real significant change on ILLIQUID across the overall market, beyond changes which may be the result of other external events.

Figure 4.5: ILLIQUID; Overall



The summary results of ILLIQUID on each individual stock are shown in Table 4.8. The table shows the percentage of stocks in each category in which the null hypothesis that ILLIQUID was unchanged was rejected at the 5% level of significance. The percentage of stocks that showed an improvement in ILLIQUID in the cases where the null is rejected is also shown.

The results from the JSE show no significant evidence that the change in exchange billing had any strong impact on ILLIQUID. A relatively small percentage of stocks showed a statistically significant change in the metric, and there was no specific trend in the direction of the change. If anything, there does appear to be slightly more evidence of a change in the metric within the large market capitalisation and higher priced stocks. But the direction of the change remains ambivalent.

Table 4.8: Individual ILLIQUID for JSE and Xetra Stocks					
Panel 1: JSE					
	Total	**Main Board**	**Alt-X**		
Individual Reject H_0 (% of total)	11.94%	12.54%	6.25%		
Of which Improvement	57.50%	57.89%	50.00%		
Market Cap (mln ZAR):	**1 707 220-20 052**	**20 051-4 304**	**4 303-1 162**	**1 161-197**	**196-5**
Individual Reject H_0 (% of total)	28.36%	14.93%	11.94%	2.99%	1.49%
Of which Improvement	68.42%	50.00%	37.50%	100.00%	0.00%
Stock Price (ZAR cents):	**93 625-7 151**	**7 150-1 921**	**1 920-573**	**572-124**	**123-1**
Individual Reject H_0 (% of total)	22.39%	20.90%	7.46%	4.48%	4.48%
Of which Improvement	40.00%	71.43%	60.00%	66.67%	66.67%
Panel 2: Xetra					
	Total	**Regulated**	**Open**		
Reject H_0 as Percent	24.49%	28.15%	12.82%		
Improvement as Percent	91.67%	90.48%	100%		
Market Cap (mln EUR):	**1103600-18001**	**18000-2521**	**2520-797**	**796-284**	**283-10**
Individual Reject H_0 (% of total)	29.59%	42.86%	17.35%	17.35%	15.31%
Of which Improvement	79.31%	95.24%	94.12%	100.00%	93.33%
Stock Price (EUR):	**606.35-33.01**	**33.00-14.26**	**14.25-5.09**	**5.08-2.176**	**2.175-0.01**
Individual Reject H_0 (% of total)	25.51%	29.59%	23.47%	23.47%	20.41%
Of which Improvement	92.00%	86.21%	86.96%	100.00%	95.00%

Data sourced from the *Bloomberg Professional* service.

The data for the German market corroborates the view that the change in JSE exchange fees did not impact the ILLIQUID ratio. The numbers show that a higher portion of individual stocks on the Xetra actually experienced a statistically significant change in ILLIQUID over the same period. Further, the direction of the change in these cases shows a clear bias towards improvements in liquidity. Overall, on the basis of ILLIQUID, there is little reason to believe that the JSE saw any improvement in individual stock liquidity as a consequence of the change in exchange fees.

4.4.3 Average value of individual trades (TRADE_VALUE)

The removal of the floor in exchange fees should reduce the economic cost associated with trading in smaller increments. TRADE_VALUE measures if there has been any reduction in the average value of each individual trade done on the exchange subsequent to the change in exchange fees. The results for the JSE are shown first in Table 4.9, with the results from the Xetra exchange in Table 4.10.

The results for TRADE_VALUE on the JSE in Table 4.9 appear consistent with the results for ILLIQUID. Overall, there is no statistically significant change in aggregate values. On an individual level, there appears to be a greater level of deviation in TRADE_VALUE amongst larger stock in terms of both stock price and market capitalisation. Yet the direction of the change does not show any specific trend.

Table 4.9: TRADE_VALUE for JSE Stocks					
Overall	**Total**	**Main Board**	**Alt-X**		
Mean (Pre / Post)	53,536.19 / 51,787.86	56,319.73 / 54,821.77	15,180.14 / 13,067.70		
Std Dev (Pre / Post)	10293.67 / 13252.89	10753.15 / 14390.06	23650.2 / 20369.66		
T-statistic (Reject Ho)	No	No	No		
Individual Reject Ho (% of total)	24.18%	25.08%	15.63%		
Of which Improvement	55.56%	52.63%	100.00%		
Market Cap (Mln ZAR)	**1707220-20052**	**20051-4304**	**4303-1162**	**1161-197**	**196-5**
Mean (Pre / Post)	78,650.24 / 79,119.24	56,705.83 / 54,801.64	58,105.94 / 53,047.99	37,158.57 / 37,067.96	13,041.43 / 13,534.64
Std Dev (Pre / Post)	9,537.16 / 15,016.86	12,012.87 / 18,358.66	29,380.68 / 43,924.57	36,203.79 / 30,947.32	10,119.80 / 12,945.30
T-statistic (Reject Ho)	No	No	No	No	No
Individual Reject Ho (% of total)	40%	37%	18%	10%	15%
Of which Improvement	56%	56%	50%	57%	60%
Stock Price (ZA Cents)	**93625-7151**	**7150-1921**	**1920-573**	**572-124**	**123-1**
Mean (Pre / Post)	86,015.74 / 83,006.04	56,262.07 / 55,143.43	59,177.25 / 56,127.92	34,376.92 / 36,724.00	13,950.61 / 13,065.88
Std Dev (Pre / Post)	14,021.33 / 15,980.11	13,228.67 / 19,797.80	38,657.14 / 34,505.26	17,766.12 / 45,789.31	7,101.01 / 6,559.98
T-statistic (Reject Ho)	No	No	No	No	No
Individual Reject Ho (% of total)	43%	31%	13%	15%	18%
Of which Improvement	45%	57%	67%	80%	50%
Data sourced from the *Bloomberg Professional* service. Yes* indicates significance at the 5% level and Yes** indicates significance at the 1% or better level.					

Moving to the values for the Xetra exchange shown in Table 4.10. The actual values for TRADE_VALUE for the Xetra are smaller than the JSE in numerical terms but are typically between 1 to 2 times the sizes for the JSE if we adjust for the differences in exchange rate (results not shown). Looking at the results of the aggregated t-tests show a distinct contrast to the JSE, with H_o rejected in a number of cases. Both the total data and the data from the regulated board show a statistically significant decline in TRADE_VALUE. The breakdown of the results by stock price may give us further clues as to what is driving these changes. All price segments, with the exception the highest priced stocks, show a statistically significant change on the aggregated level. However, there is no definitive directional pattern across the various price buckets. Further, the individual stock results highlight that the direction of any change in TRADE_VALUE is not clear.

The data seems to point to a non-statistically significant change in the highest priced stocks resulting in the finding of an overall reduction in TRADE_VALUE. Yet the statistically significant changes in the lower priced segments do not point to any specific, systemic reduction in TRADE_VALUE. In total, the results for the JSE and Xetra on TRADE_VALUE do not appear to support the idea of any change in liquidity arising from the change in exchange fees.

Table 4.10: TRADE_VALUE for Xetra Stocks					
Overall	**Total**	**Regulated**	**Open**		
Mean (Pre / Post)	5,639.55 / 5,461.97	6,505.09 / 6,301.27	2,652.78 / 2,608.81		
Std Dev (Pre / Post)	458.84 / 552.74	591.17 / 706.31	248.27 / 248.07		
T-statistic (Reject Ho)	Yes*	Yes*	No		
Individual Reject Ho (% of total)	45.10%	49.06%	32.48%		
Of which Improvement	47.06%	50.27%	31.58%		
Market Cap (mln EUR)	**1103600-18001**	**18000-2521**	**2520-797**	**796-284**	**283-10**
Mean (Pre / Post)	12,050.28 / 11,682.07	5,872.19 / 5,154.80	4,643.98/ 4,657.84	2,937.98 / 2,865.90	2,026.07 / 2,354.37
Std Dev (Pre / Post)	1,203.83 / 1,539.50	736.93 / 591.39	1,456.83 / 1,637.83	377.39 / 380.83	744.53 / 887.50
T-statistic (Reject Ho)	No	Yes**	No	No	Yes**
Individual Reject Ho (% of total)	61%	60%	44%	26%	35%
Of which Improvement	58%	54%	42%	40%	26%
Stock Price (EUR)	**606.35-33.01**	**33.00-14.26**	**14.25-5.09**	**5.08-2.176**	**2.175-0.01**
Mean (Pre / Post)	12,270.42 / 11,673.37	6,589.85 / 6,283.12	4,468.69 / 4,574.24	2,749.25 / 2,640.85	1,656.70 / 1,795.85
Std Dev (Pre / Post)	1,917.32 / 2,235.16	580.17 / 570.67	289.38 / 381.85	402.41 / 241.07	234.44 / 175.33
T-statistic (Reject Ho)	No	Yes**	Yes*	Yes*	Yes**
Individual Reject Ho (% of total)	51%	56%	44%	39%	36%
Of which Improvement	56%	56%	44%	42%	29%

Data sourced from the *Bloomberg Professional* service. Yes* indicates significance at the 5% level and Yes** indicates significance at the 1% or better level.

4.4.4 Relative Return Dispersion (DISPERSE)

The values for the Relative Return Dispersion indices for each market and segment are plotted and displayed in Appendix B. In each chart, all values for the JSE are shown on the left-axis, with the values for the Xetra shown on the right-axis. The overall average for the JSE for the pre- and post-period is shown as a dotted line on each chart.

While the overall DISPERSE average for all stocks on the JSE does not change dramatically, it does show a small reduction. By contrast, the overall average for the Xetra stocks actually increases (not shown on the charts). From the individual charts, it can be seen that the fall in average DISPERSE seems to be higher for the larger market capitalisation stocks on the JSE. The average DISPERSE for Xetra shows a slightly similar pattern (not shown on the charts), but the reduction in average DISPERSE is not as dramatic and also turns to an increase after the 1st and 2nd market cap segments. However, when testing more formally by conducting a t-test on the difference between the values for DISPERSE for the JSE and the Xetra over the two periods, the null hypothesis of no change cannot be rejected (with a p-value of the test of 0.40). Overall, while there is some surface evidence of a reduction in DISPERSE on the JSE that is not seen on Xetra following the change in exchange fees, it is not supported by statistical testing.

4.4.5 Daily High-Low Range (HI_LO)

Following an identical approach used in TRADE_VALUE, aggregate and individual t-tests were conducted on HI_LO values with a null hypothesis (H_o) of no change. The results are shown for the JSE and Xetra markets in Tables 4.11 and 4.12 respectively. As can be seen from the tables, the JSE shows some evidence of a reduction in HI_LO range for the important large capitalisation sector. However, this same improvement is also seen in Xetra stocks (which has the higher power of the test) and hence cannot be attributed solely to the change in JSE exchange fees. Overall, the results for HI_LO appear consistent with a view that the change in exchange fees did not directly impact on levels of market volatility. However, other variables may have caused a narrowing of the high-low range over the second-half of the period investigated.

Table 4.11: HI_LO for JSE Stocks

Overall	**Total**	**Main Board**	**Alt-X**		
Mean (Pre / Post)	3.20% / 3.22%	3.03% / 3.02%	5.56% / 5.83%		
Std Dev (Pre / Post)	0.426% / 0.385%	0.406% / 0.348%	2.558% / 2.546%		
T-statistic (Reject Ho)	No	No	Yes*		
Individual Reject Ho (% of total)	29.25%	29.37%	28.13%		
Of which Improvement	59.18%	61.80%	33.33%		
Market Cap (Mln ZAR)	**1707220-20052**	**20051-4304**	**4303-1162**	**1161-197**	**196-5**
Mean (Pre / Post)	2.70% / 2.53%	2.90% / 2.84%	2.89% / 2.84%	2.99% / 3.37%	5.60% / 5.65%
Std Dev (Pre / Post)	0.512% / 0.409%	0.484% / 0.414%	0.641% / 0.456%	0.588% / 0.653%	1.972% / 1.717%

T-statistic (Reject Ho)	Yes*	No	No	Yes**	No
Individual Reject Ho (% of total)	42%	36%	25%	27%	16%
Of which Improvement	86%	63%	41%	39%	45%
Stock Price (ZA Cents)	**93625-7151**	**7150-1921**	**1920-573**	**572-124**	**123-1**
Mean (Pre / Post)	2.50% / 2.37%	2.92% / 2.86%	2.57% / 2.46%	3.38% / 3.40%	5.31% / 5.68%
Std Dev (Pre / Post)	0.426% / 0.416%	0.459% / 0.421%	0.769% / 0.428%	0.752% / 0.695%	1.463% / 1.591%
T-statistic (Reject Ho)	Yes*	No	No	No	No
Individual Reject Ho (% of total)	45%	30%	21%	21%	30%
Of which Improvement	80%	65%	43%	57%	35%

Data sourced from the *Bloomberg Professional* service. Yes* indicates significance at the 5% level and Yes** indicates significance at the 1% or better level.

Table 4.12: HI_LO for Xetra Stocks

Overall	**Total**	**Regulated**	**Open**		
Mean (Pre / Post)	4.89% / 4.84%	4.41% / 4.41%	6.55% / 6.32%		
Std Dev (Pre / Post)	0.297% / 0.380%	0.291% / 0.636%	0.598% / 0.432%		
T-statistic (Reject Ho)	No	No	Yes**		
Individual Reject Ho (% of total)	43.88%	41.29%	52.14%		
Of which Improvement	65.12%	63.64%	68.85%		
Market Cap (Mln EUR)	**1103600-18001**	**18000-2521**	**2520-797**	**796-284**	**283-10**
Mean (Pre / Post)	2.54% / 2.33%	3.18% / 3.09%	4.71% / 4.72%	5.41% / 5.48%	9.24% / 9.13%
Std Dev (Pre / Post)	0.379% / 0.432%	0.342% / 0.426%	0.475% / 0.641%	0.458% / 0.617%	0.770% / 0.759%
T-statistic (Reject Ho)	Yes**	No	No	No	No
Individual Reject Ho (% of total)	35%	41%	48%	43%	53%
Of which Improvement	91%	63%	60%	57%	62%
Stock Price (EUR)	**606.35-33.01**	**33.00-14.26**	**14.25-5.09**	**5.08-2.176**	**2.175-0.01**
Mean (Pre / Post)	2.67% / 2.43%	3.25% / 3.14%	3.84% / 3.76%	5.31% / 5.41%	9.80% / 9.81%
Std Dev (Pre / Post)	0.381% / 0.371%	0.356% / 0.406%	0.391% / 0.392%	0.427% / 0.508%	0.797% / 1.005%
T-statistic (Reject Ho)	Yes**	Yes*	No	No	No
Individual Reject Ho (% of total)	41%	45%	37%	51%	46%
Of which Improvement	88%	59%	69%	50%	64%

Data sourced from the *Bloomberg Professional* service. Yes* indicates significance at the 5% level and Yes** indicates significance at the 1% or better level.

4.5 Results for Market Integrity Measures (MARKET_MANIP)

The data for both the JSE and Xetra was scanned to identify any potential incidents of manipulation on daily closing prices. After removing incidents that may be explained by news stories, the final number of net incidents is shown in Table 4.13 for the JSE, and in Table 4.14 for the Xetra market. One important feature of the JSE data should be mentioned. There were a large number of identified incidents on both the 24th of December and the 31st of December in the South African market. These specific dates are the only two shortened (half) trading days on the annual JSE trading calendar. Volumes in both days are typically very poor. This can be seen in the overall value traded data for each day, with just over R2.2bln trading on the 24th of December 2013 and just over R3.1bln trading on the 31st of December 2013. This compares with an average figure for 2013 of approximately R15.8bln per day. The low levels of value traded would suggest that the strong clustering of MARKET_MANIP on these two days could have arisen from the very low level of trade activity, or equally, from an increased opportunity for manipulation. Irrespective, it seems reasonable to exclude these two specific days from the results as unique outliers, as there are no such equivalent extreme low-volume days in the pre-event period. By contrast, no such pattern exists for the Xetra market, which is closed on both the 24th and the 31st of December (equally, there was no other specific dates on the Xetra, like the 23rd of December, that showed any sign of clustering of incidents).

In total, there are an exactly equal number of net incidents on the JSE in the two time periods. However, when we exclude the two half-days in December, the picture is very different. What is also clear from the data is that the majority of the MARKET_MANIP incidents on the 24th and the 31st of December occurred within the smaller stocks on both a price and market capitalisation basis. Amongst the larger cap stocks, there is a clear reduction of MARKET_MANIP events in the post-period.

Table 4.13: MARKET_MANIP for JSE Stocks					
Overall	**Total**	**Main**	**Alt-X**		
Prior	61	60	1		
Post / Excl half days	61 / 36	55 /34	6 / 2		
Market Cap (Mln ZAR)	**1707220-20052**	**20051-4304**	**4303-1162**	**1161-197**	**196-5**
Prior	18	12	19	7	5
Post / Excl half days	6 / 6	16 / 14	15 / 7	17 / 6	7 / 3
Stock Price (ZA Cents)	**93625-7151**	**7150-1921**	**1920-573**	**572-124**	**123-1**
Prior	14	17	13	9	8
Post / Excl half days	10 / 9	14 / 12	16 / 7	10 / 5	11 / 3
Data sourced from the *Bloomberg Professional* service.					

The picture from the Xetra looks quite different from the JSE. There is actually an overall tick-up in the number of MARKET_MANIP events in the post-change period. Further, much of this increase came from the stocks with the highest prices and market capitalisation – in direct contrast to the experience on the JSE. Overall, this would seem to support a view that the change in exchange billing may have reduced levels of market manipulation on the exchange.

Table 4.14: MARKET_MANIP for Xetra Stocks					
Overall	**Total**	**Reg.**	**Open**		
Prior	69	45	24		
Post	75	56	19		
Market Cap (Mln EUR)	**1103600-18001**	**18000-2521**	**2520-797**	**796-284**	**283-10**
Prior	4	17	13	19	16
Post	13	21	13	14	14
Stock Price (EUR)	**606.35-33.01**	**33.00-14.26**	**14.25-5.09**	**5.08-2.176**	**2.175-0.01**
Prior	8	16	14	19	12
Post	18	9	16	18	14
Data sourced from the *Bloomberg Professional* service.					

Chapter Summary

This chapter presented the results of the statistical analysis conducted to examine metrics of market quality on the JSE following the change in exchange fee billing methodology. The German Xetra market was selected for comparison purposes as the DAX index had the highest correlation of weekly local currency price returns with the South African All-Share index. Each market was characterised by a long-tail of fairly low priced, small cap stocks with low levels of trading activity.

Investigation into metrics of market efficiency found little clear evidence of any overall improvement. Realised spreads showed significant instability across periods, making any clear inferences difficult. However, there did seem to be some evidence of a reduction of transaction costs amongst the largest stocks by market capitalisation. Amihud's Measure of Liquidity suggested little change in liquidity, and there is no statistical support for any change in the speed in which prices reflect new information. There was little evidence of any change in the average value of each trade or the daily high-low range. Market integrity did seem to be improved by reducing the number of potential incidents of market manipulation, after removing the results from the 24th and 31st of December. The following chapter provides the conclusions of the study.

5 DISCUSSION AND CONCLUSION

5.1 Introduction

This chapter presents a discussion of the findings and draws out the conclusions of the study. It begins in 5.2 with a discussion of the findings in relation to the existing literature. This is followed by section 5.3 which provides the conclusion and possible directions for future research.

5.2 Discussion

This study investigated how a change in the fees charged by the JSE onto members to trade stocks affected various metrics of market quality. This topic falls within the broader subject of market microstructure, which considers how frictions in trading can affect both the costs and behaviour of investors. More specifically, using the framework suggest by Madhavan (2000), it primarily relates to the issues of market structure and design, along with the issues of price discovery and price formation. While the subject of exchange fees does not appear to have attracted previous studies (to the authors best knowledge), work in related areas has shown that changes in market design can affect overall market efficiency and integrity. The final results of this work does seem to provide partial corroboration with previous studies such as Chordia et al (2008) in finding some identifiable changes in a limited subset of metrics of market quality as a consequence of the change. A feature of this study is that stocks with large market capitalisations exhibit more signs of potential improvement in market quality than was evident in small cap stocks.

One aspect in which this study does differ with other empirical studies is in the area of transaction costs. When immediate transaction costs are measured by BID_ASK, the overall pattern of spreads is too volatile over the several weekly periods measured to be useful in drawing any overall conclusions about the influence of exchange fees. This looks to be the result of other exogenous factors driving South African bid-ask spreads. This differs from the experience of Hollifield et al (2004) who found stable bid-ask spreads over similar short-term horizons on the Stockholm Stock Exchange. It also contrasts with Chordia et al (2008) who found that a change in another element of market design (tick size) resulted in lower bid/ask spreads. The use of HI_LO to capture any possible changes in longer-term implicit transaction costs presents a different dilemma, with no notable changes being identified. However, it is worth noting that the measurement of transaction costs in other studies is often done using effective or realised spreads, and so represents a very different frequency of data.

It is also worth highlighting the difference in the results of this study to those of Duong & Kalev (2014). The stability of the liquidity metrics that use volume data (ILLIQUID and TRADE_VALUE) are the exact opposite findings to the afore-mentioned study. However, the Duong & Kalev study analyses a very different event (change from an attributed to an anonymous market) and uses a different metric (slope of the order book).

Algorithmic trading and HFT are topics that are presently getting a lot of attention from both market participants and academic scholars. This study has not directly investigated this area. However, the segmentation by market capitalisation does provide some interesting read-through. Stocks with a higher market capitalisation typically evidence higher levels of trade and are more suited to these types of automated electronic trading systems. The evidence across the metrics of market efficiency suggests higher levels of liquidity and tighter spreads amongst higher market capitalisation stocks following the change in exchange fees. Following from the results of Hendershott et al (2011), this may imply an increase in the volume of general algorithmic trading post the change in exchange fees. It could also suggest an increased presence of liquidity-providing HFT strategies after the change.

5.3 Conclusion

Overall, the findings point to an improvement in market integrity by reducing the incidents of market manipulation. There is also some evidence that realised bid/ask spreads narrowed for the larger and most liquid stocks, implying lower implicit transaction costs.

In answer to the specific research questions posed in chapter one, the following findings are relevant. The change in the JSE billing model appears to have reduced implicit transaction costs for immediacy in the largest and most actively traded pool of stocks on the JSE. However, there is no evidence of any reduction in transaction costs for other stocks. Further, the instability of bid/ask spreads over different weekly periods implies that investors constantly face significant uncertainty around the immediate cost of execution. For institutional investors, transaction costs for larger sized orders that cannot be executed quickly appears unchanged when measured by the daily high-low range. With regards to the level of market liquidity, the hypothesis that liquidity was unchanged before and after the change in exchange fee billing cannot be rejected. There is also no statistical support to suggest that market prices more quickly reflect market information after the change. Finally, market integrity does appear to have improved post the change with a significant reduction in incidents of market manipulation observed (after excluding shortened, highly illiquid trading days). This reduction occurred against a backdrop of an increase in events in the comparable Xetra market over the same period.

Several potential areas for further research have been identified. The instability of the realised bid/ask spreads over the weekly time frames implies investors face uncertainty over the level of implicit transaction costs at any given point in time. Deeper analysis on what drives these changes in spread and possible ways that market design can improve stability could lead to enhanced market quality by reducing this uncertainty. The strong clustering feature of incidents of market manipulation over the two half-trading days on the JSE also seems deserving of greater attention. Identification of what underlies this anomaly, and if it appears consistently over a number of years, could provide new evidence of a type of seasonality in trading activity. Finally, while the volume of trade done by algorithmic and HFT systems was not investigated in this study, it may prove fruitful to determine if there was any change in the overall incidence of such activity pre- and post the change that can explain the stronger improvements in market quality identified amongst larger market-capitalisation stocks.

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APPENDIX A: JSE Market Notice

Market Notice

Number: 136
Date 01 July 2013
JSE Equity Market Transaction Billing Model Methodology Change Notice

As members are aware, the JSE embarked on an extensive consultative process to review the Equity Market Trading Fee Billing Model, which concluded during June 2013 where the JSE finally proposed a 0.0053% value based charge with a maximum fee per transaction leg of R350.

The above parameters were based on certain assumptions the JSE made with regards to a potential reduction in OP and OD reported transactions. The feedback from members during June 2013 resulted in slightly revised assumptions for OP and OD reported transaction reductions.

Taking all of the above into account, the JSE has decided that as from 30 September 2013, the existing hybrid billing model will be replaced with a value based billing model with no minimum charge and a maximum charge (excluding VAT) as follows:

	Charge	Ceiling
Equities (including all boards and products)	0.0053%	R 300

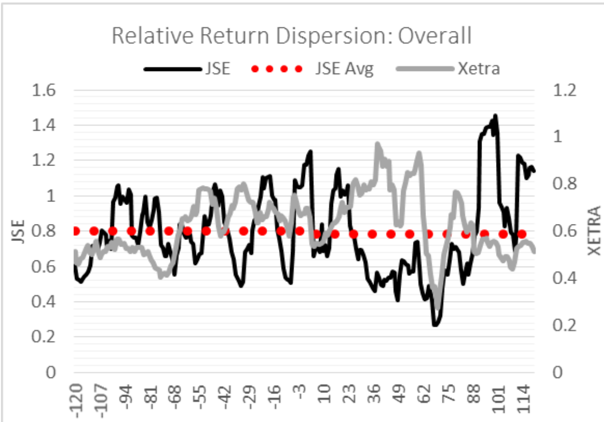
This notice should also be regarded as formal notice in terms of clause 4.7 of the JSE Limited Services Agreement of the change in the equity market transaction billing model which will come into effect on 30 September 2013. It should be noted that this notice is not applicable to the Namibia Stock Exchange and its members.

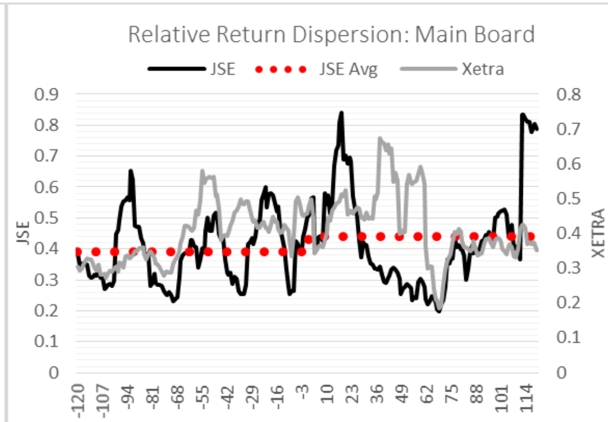
The JSE will be hosting a communication session on Thursday 4 July 2013 where feedback from the June 2013 market consultation will be provided.

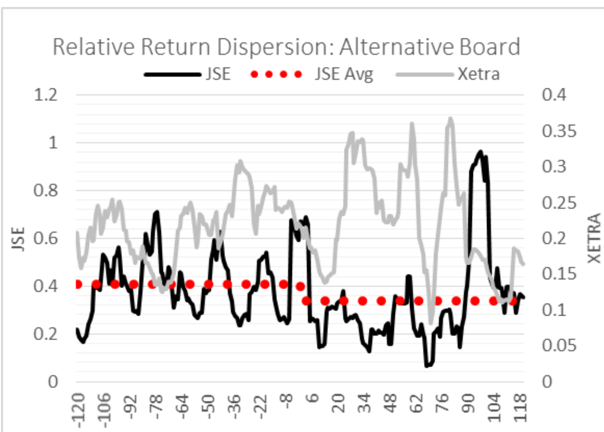
Should you require any additional information or clarification on the billing model please contact Suhagna Mansura on (011) 520 7738 or at SuhagnaM@jse.co.za or you are also welcome to contact me.

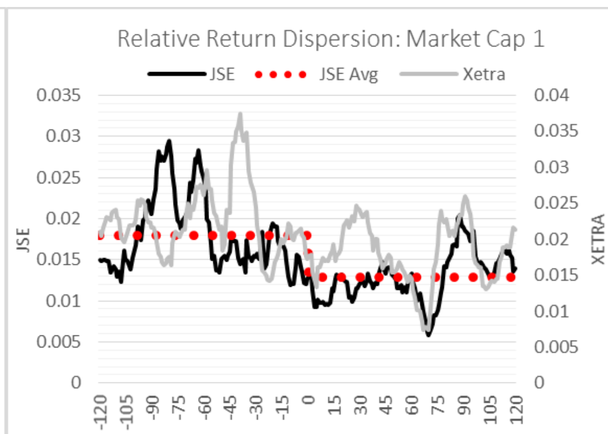
Leanne Parsons
Designation Director: Equity Market
Division Equity Market Division
Tel +27 11 520 7340
Fax +27 11 520 8340
E-mail address: leannep@jse.co.za

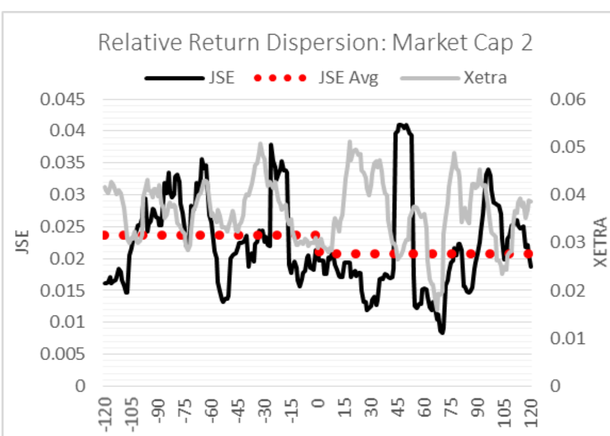
APPENDIX B: Relative Return Dispersion Charts (DISPERSE)

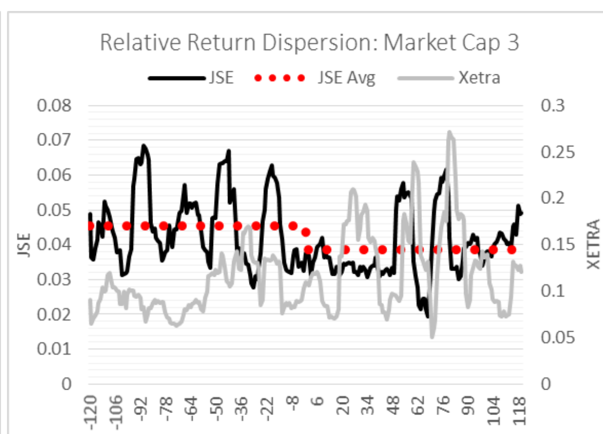


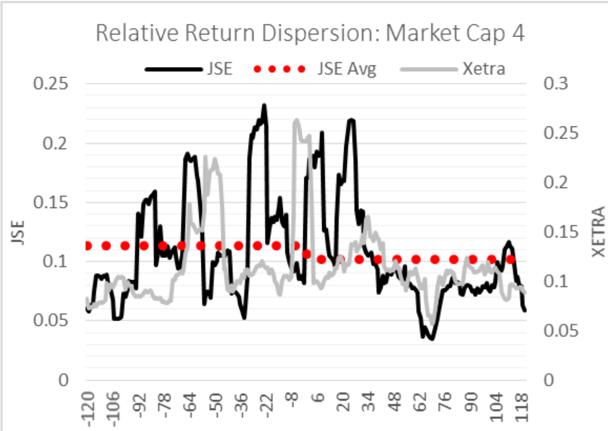


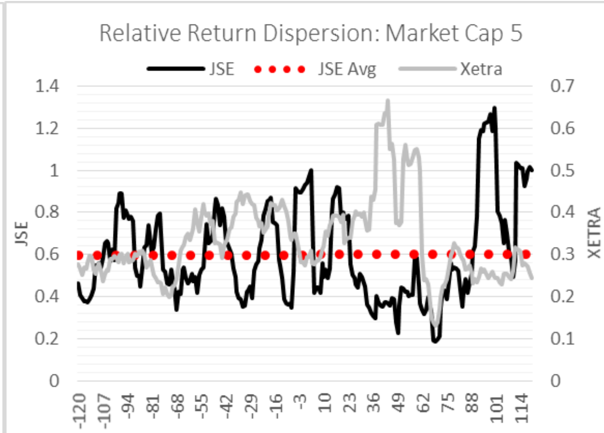


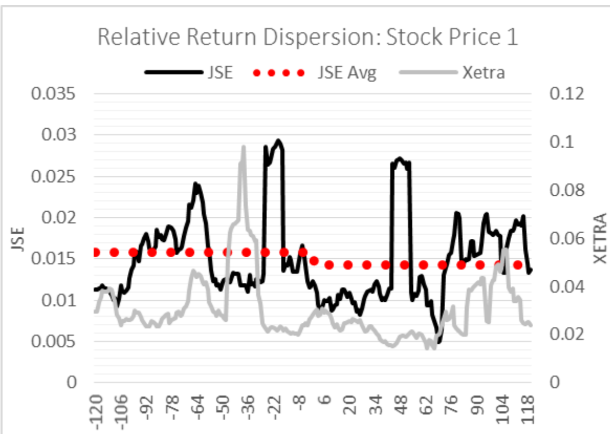


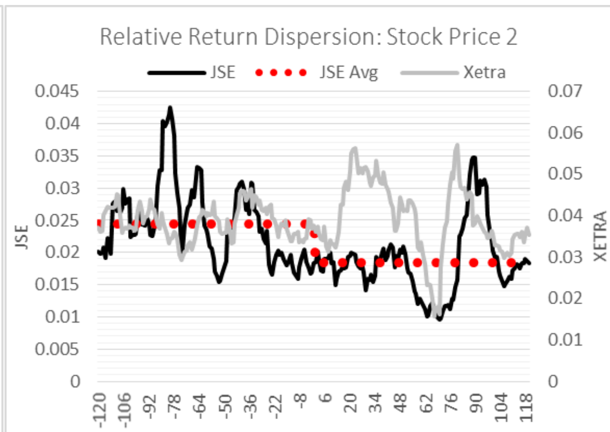


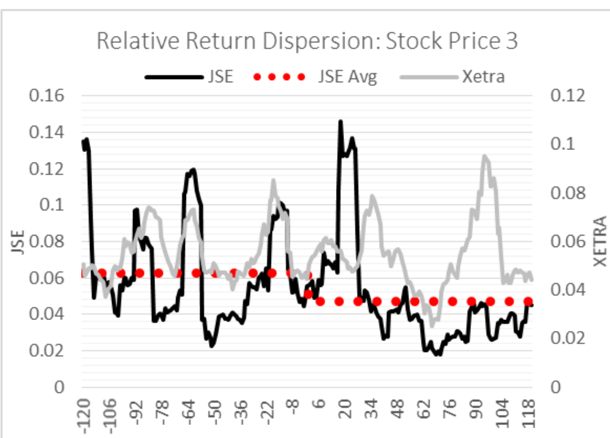


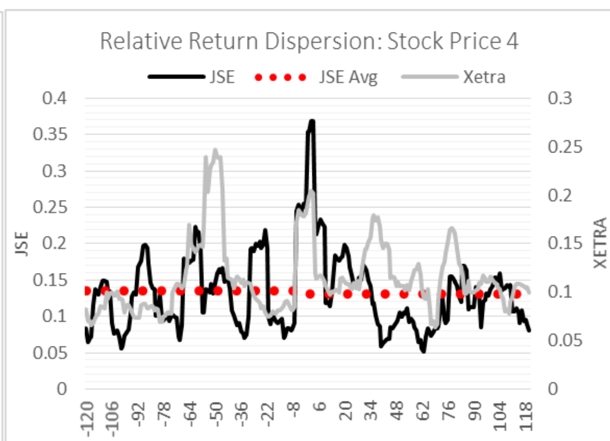

Relative Return Dispersion: Market Cap 4
JSE
JSE Avg
Xetra
JSE
XETRA
0.25
0.2
0.15
0.1
0.05
0
0.3
0.25
0.2
0.15
0.1
0.05
0
-120 -106 -92 -78 -64 -50 -36 -22 -8 6 20 34 48 62 76 90 104 118

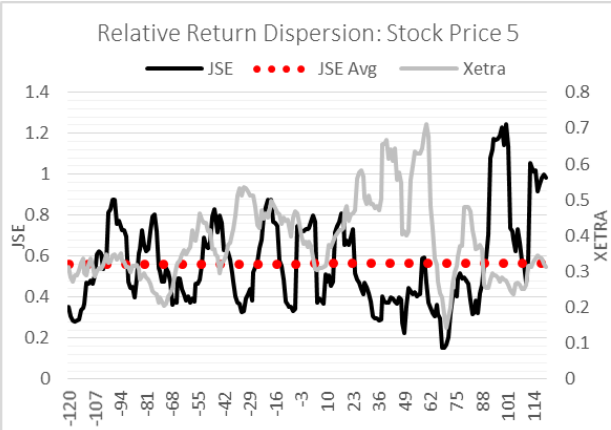

Relative Return Dispersion: Market Cap 5
JSE
JSE Avg
Xetra
JSE
XETRA
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-120 -107 -94 -81 -68 -55 -42 -29 -16 -3 10 23 36 49 62 75 88 101 114


Relative Return Dispersion: Stock Price 1
JSE
JSE Avg
Xetra
JSE
XETRA
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0.12
0.1
0.08
0.06
0.04
0.02
0
-120 -106 -92 -78 -64 -50 -36 -22 -8 6 20 34 48 62 76 90 104 118


Relative Return Dispersion: Stock Price 2
JSE
JSE Avg
Xetra
JSE
XETRA
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-120 -106 -92 -78 -64 -50 -36 -22 -8 6 20 34 48 62 76 90 104 118


Relative Return Dispersion: Stock Price 3
JSE
JSE Avg
Xetra
JSE
XETRA
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.12
0.1
0.08
0.06
0.04
0.02
0
-120 -106 -92 -78 -64 -50 -36 -22 -8 6 20 34 48 62 76 90 104 118


Relative Return Dispersion: Stock Price 4
JSE
JSE Avg
Xetra
JSE
XETRA
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.3
0.25
0.2
0.15
0.1
0.05
0
-120 -106 -92 -78 -64 -50 -36 -22 -8 6 20 34 48 62 76 90 104 118


Relative Return Dispersion: Stock Price 5
JSE
JSE Avg
Xetra
JSE
XETRA
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-120
-107
-94
-81
-68
-55
-42
-29
-16
-3
10
23
36
49
62
75
88
101
114