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Doctoral Thesis

Selected Essays in Stock Market Liquidity. Innovative XLM Measure at the Frankfurt Stock Exchange: Cloudy Skies, Time of the Day and the Role of Designated Sponsors for Stock Market Liquidity.

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Selected Essays in Stock Market Liquidity.

Innovative XLM Measure at the Frankfurt Stock Exchange: Cloudy Skies, Time of the Day and the Role of Designated Sponsors for Stock Market Liquidity

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Preface

Writing a doctoral thesis is never easy or straightforward. I would not have been able to complete this work without the help of many people whom I would like to acknowledge here.

First of all, I would like to express my sincere gratitude to my doctoral supervisor Dirk Schiereck for his guidance and encouragement. I owe him much for the outstanding support and opportunities he made possible during my time as an external doctoral student at the European Business School (EBS).

Second, I would like to thank Andreas Hackethal for readily agreeing to provide the second opinion on my thesis and providing constructive feedback during my annual proposal defences.

Third, I am thankful to Christiane Goodfellow for her help and contribution to the essays and the publication of several research papers. I am also very grateful to Deutsche Börse AG for providing the dataset for all of my essays.

Last, but definitely not least, I would like to thank my family and especially my husband David. He has always encouraged me and provided with enormous support during all four years. He not only provided me with the emotional support, but also was a sounding board for research ideas and a lot of valuable academic advice as well as help and correction of my English language mistakes. His support and love gave me the necessary strength and motivation to finish this doctoral thesis. I dedicate this thesis to him and to our little son Daniel, who has joined us on this path just few months ago.

Brussels, 2010 Tatjana Verrier

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List of Abbreviations

AG	Aktiengesellschaft, joint stock company
AMP	Adverse Price Movement
Bp	Basis point
CCP	Central Counterparty Clearing
CRT	Cost of Round Trip
DAX	German equity index for 30 large-caps (blue chips)
DMM	Designated Market Makers
DS(s)	Designated Sponsors
EUR	Euro
LP	Liquidity premium
MDAX	German equity index for 50 mid-cap stocks
Mio	Million
NASDAQ	National Association of Security Dealers Automated Quotation System
NEMAX	German equity index, predecessor of TecDAX
Nr.	Number
NYSE	New York Stock Exchange
OLS	Ordinary least squares
SDAX	German equity index for 50 small-caps
SMAX	German equity index, predecessor of SDAX
TecDAX	German equity index for 30 largest technology stocks
US	United States of America
Xetra	Automated electronic trading system of Deutsche Boerse
XLM	Exchange Liquidity Measure

1 Introduction

1.1 Overview and General Research Objective

Liquidity is by far the most important decision-making criterion for investors (Schiereck (1995)) and is regarded as the central quality characteristic in securities markets. High liquidity means the ability to trade, buy and sell securities without impact and movement in the share price. At the macro-level, liquid capital markets are essential for the efficiency of capital allocation in modern economies and lead to low cost of capital for issuers. There is an economic welfare benefit from liquid markets because trading is the mechanism through which information is introduced into prices. More informative prices lead to more efficient allocation of capital across competing investments (Wurgler (2000)). At the micro-level, a liquid market enables access to a large number of trading interests and thus ensures that investors can carry out their transactions at any time.

For all of these reasons, there is considerable interest among investors, exchanges and regulators in understanding the determinants of secondary-market liquidity.

This doctoral thesis comprises three essays that address selected issues in stock market liquidity. All three essays conduct original empirical research using data from the German Xetra trading system and the set of stocks that belong to German TecDAX index (i.e. mid-cap stocks from technology, biotech and renewable energy sectors).

The first essay (Chapter 3) focuses on the weather effects on the stock market liquidity and tests for the potential influence of the cloudy weather on liquidity provided by market makers. The second essay (Chapter 4) focuses on the issue of market makers' effect on liquidity and investigates the role of designated sponsors in the Xetra electronic order book and their contribution to stock liquidity. Finally, the third essay (Chapter 5) investigates the intraday effect on liquidity.

Most of the liquidity studies relied on measuring liquidity using only the best bid and ask prices. For example, Chordia, Roll and Subrahmanyam (2000), Hasbrouck and Seppi (2001), Halka and Huberman (2001) and Brockman and Chung (2002) all measure liquidity by looking at quotes and quantities at best prices. However, if investors want to trade large positions, their orders will walk up the order book and therefore they will not only care about liquidity at best prices, but also about liquidity beyond best prices. The liquidity at the best limit prices represents only a fraction of the orders in the limit order book. Moreover, best limit prices are very heavily exposed to idiosyncratic shocks and attract a lot of noise.

Other studies of liquidity looked at the situation in the whole order book by reconstructing it. However, reconstructing the order book with data that is available to researchers often yields results that are less than perfectly accurate and might not capture the dynamic price formation aspect of the real life order book.

This doctoral thesis aims to add evidence to our understanding of the liquidity in stock markets by studying the whole order book in a dynamic setting based on the Exchange Liquidity Measure (XLM). The German Stock Exchange has been calculating XLM based on all information in the order book, i.e. including the hidden part of iceberg orders, for all stocks traded continuously in Xetra since July 2002. XLM therefore provides a more comprehensive analysis of liquidity costs than the bid-ask spread.

The concept of XLM was first developed and described by Gomber and Schweickert (2002). Later, Gomber, Schweickert and Theissen (2004) used XLM dataset for static and dynamic analysis of the liquidity in the German stock market, namely the impact of endogenous and exogenous events, intraday liquidity patterns and impact of Bloomberg news ticker on liquidity. Hachmeister (2006) also used XLM data studying the behaviour of informed traders as liquidity providers in Xetra order book. Hachmeister and Schiereck (2010) used XLM data to study the impact of the introduction of pre-trade anonymity. Apart from these studies, we failed to identify any other academic research based on XLM. Therefore, it can be concluded that the XLM data and methodology is still to be classified as innovative in the academic research inspite of its clear advantages.

XLM rates the liquidity of the traded instruments on the basis of a uniform methodology and provides investors and researchers with a tool for the objective assessment of the trading costs. On this basis, the liquidity of individual securities as well as whole marketplaces can be analyzed in a comparable and transparent manner.

Overall, the research objective of this doctoral thesis is to improve our understanding of the liquidity in stock markets by using XLM data and providing new evidence on the effects of weather, market makers and the time of the day on liquidity. The research results will be useful for practitioners and researchers in this field. For example, the operators of stock exchanges will be interested in these results as a way to continue improving their respective market models to achieve greater liquidity for the stocks listed and traded on their platforms. This provides competitive advantage for stock exchanges. The results will also be useful for investors, asset managers and trading community from the perspective of designing new trading strategies that are profitable net of transaction costs. Moreover, the issuers can use these research results to guide their decision on the choice of the listing place and the corresponding market model in order to achieve best liquidity for their stocks, thus lowering their cost of capital.

1.2 Essay 1: Research Question and Main Findings

The first essay entitled *"Xetra Weather the Weather: The Effects of Cloudy Skies and Stock Market Liquidity"* investigates the weather effects on stock market liquidity. While this phenomenon was first documented for stock returns, more recent studies find weather to influence liquidity in stock trading, potentially through moods and sentiments of market makers.

In essence, there is an ongoing debate about the existence of a weather effect, and about the direction of the established correlation between cloudy skies and liquidity.

We contribute to this by testing for a potential influence of the weather in Frankfurt (Main) on liquidity provided by market makers in the electronic trading system Xetra at the Frankfurt stock exchange. Rather than using the bid-ask spread as a proxy for liquidity, we apply the exchange liquidity measure (XLM) introduced by Gomber et al. (2002). The construction of this variable enables us to distinguish between the weather effect on liquidity provided by the market maker (Designated Sponsor), and its influence on the level of liquidity present in the market without the market maker's activities, i.e. natural liquidity.

We examine this question using a sample of daily trading data for a selection of 18 stocks that belong to TecDAX index between 1 January 2004 and 31 December 2005 based on the Exchange Liquidity Measure (XLM).

We find that the more clouds in the sky, the lower are the execution costs, and the higher the overall liquidity on Xetra. Remarkably, in such weather, market makers inject less liquidity than in sunshine. This could be due to market makers being more risk averse on overcast days.

Alternatively, it can be argued that overall liquidity is higher on cloudy days than in sunshine, thus market makers add less value in an already rather liquid market. This finding complements the results presented in Flemisch et al. (2009) in that it addresses directly the weather effect on Designated Sponsors. The finding that cloudy skies correspond with overall high liquidity in Xetra is inconsistent with the results presented by Goetzmann and Zhu (2005) for the New York Stock Exchange and thus it may be the avenue for further research.

1.3 Essay 2: Research Question and Main Findings

The second essay entitled "*Designated Sponsors on Xetra – Is One Designated Sponsor Enough?*" investigates the role of Designated Sponsors in Xetra electronic order book and their contribution to stocks' liquidity.

While the contribution of market makers to liquidity was first documented for dealer (quote-driven) markets (Ho and Stoll (1983), Grossmann and Miller (1988) and Leach and Madhavan (1993)), more recent studies find market makers to influence the liquidity in the order-driven markets as well.

This essay contributes to the ongoing debate about the relation between market makers and liquidity by testing the liquidity provided by market makers in the electronic trading system Xetra at the Frankfurt stock exchange. Rather than using bid-ask spread as a proxy for liquidity, we apply the exchange liquidity measure (XLM) introduced by Gomber et al. (2002). The construction of this variable enables us to distinguish between the effect on liquidity provided by the market maker, and the level of liquidity present in the market without the market maker's activities, i.e. natural liquidity. We directly test for an effect on liquidity induced by market makers.

The Chapter 4 examines this question using a sample of daily trading data for a selection of 16 stocks that belong to TecDAX index between 1 January 2004 and 31 December 2005. Based on the Exchange Liquidity Measure (XLM), we are able to separate the effects of market makers on liquidity and the natural liquidity (i.e. unsupported by market makers) in the electronic order book Xetra at the Frankfurt Stock Exchange. We find that the presence of Designated Sponsors in the order book improves liquidity and decreases total XLM. The tests show that the increase from one to more Designated Sponsors in a stock brings further benefits to liquidity. Especially large improvement is achieved in the move to three Designated Sponsors. Consistent with expectations, Designated Sponsors contribute more to the liquidity in the larger order sizes (i.e. volume classes).

The study did not confirm that Designated Sponsors are attracted to more liquid stocks, at least in our sample of TecDAX. Nevertheless, we believe that such a result is consistent with the Designated Sponsor model run on Xetra. It is because Designated Sponsors enter a stock for the variety of other reasons than just liquidity.

1.4 Essay 3: Research Question and Main Findings

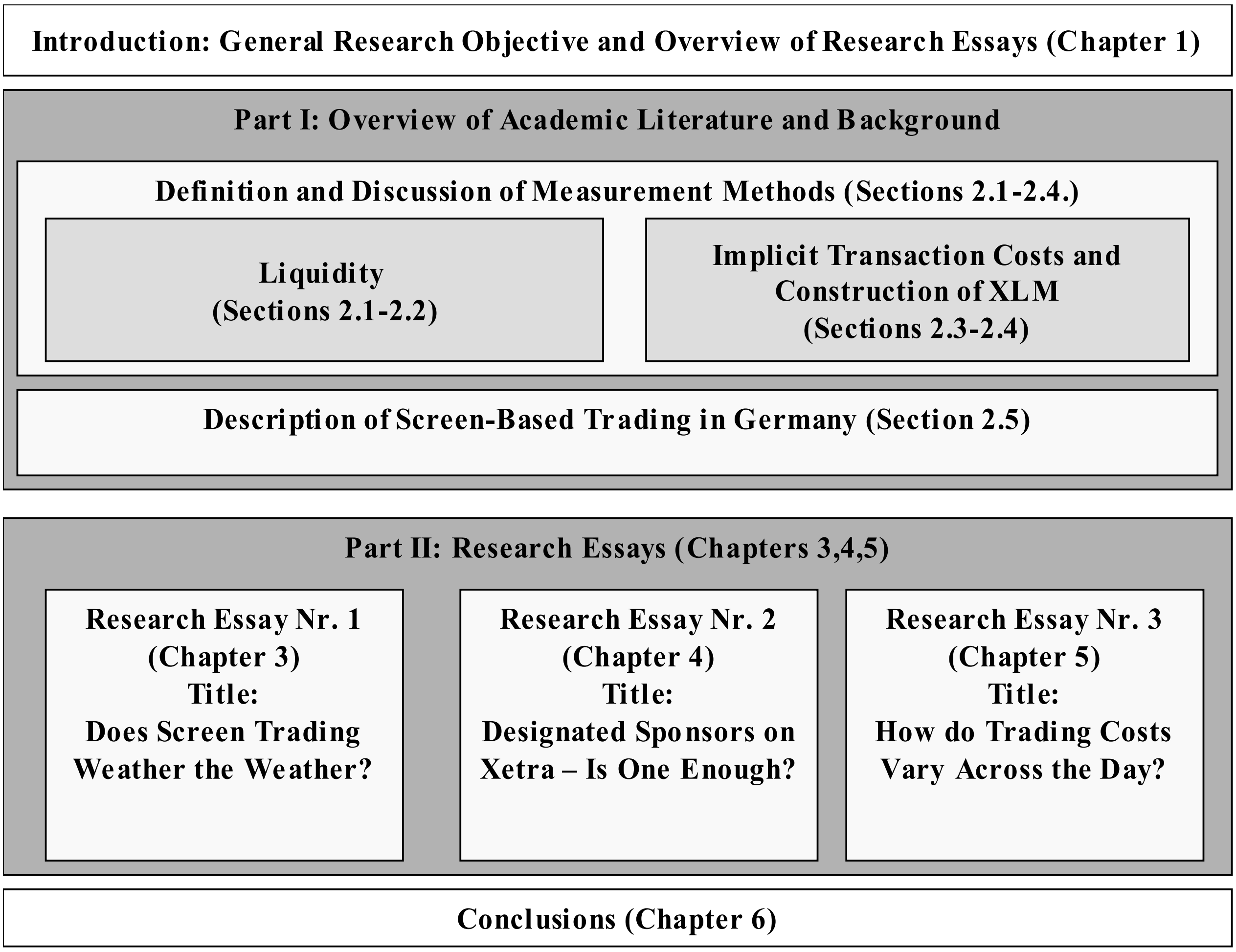
The aim of the third essay *"How Do Trading Costs Vary Across the Day? A note on the innovative XLM measure for Small Caps at the Frankfurt Stock Exchange"* is to investigate the intraday pattern of trading costs for small cap stocks in the electronic trading system Xetra at the Frankfurt Stock Exchange.

We analyse the XLM variable, which is a more comprehensive liquidity measure than the bid-ask spread or trading volume. Unlike previous studies, we focus on 28 less liquid technology stocks in the TecDAX index during the current Xetra opening hours. We use a sample of minute-based trading data for selection of stocks between 25 May 2006 and 23 June 2006.

We find a reverse J-shaped intraday profile of XLM, implying that liquidity is lowest immediately after the start of trading and highest in the early afternoon. This time of lowest execution costs and thus highest trading quality coincides with the opening of the NYSE. Order book imbalances, and thus execution possibilities, confirm this pattern. Imbalances are highest early in the morning, rendering execution possibilities worst compared to the remainder of the trading day. Order book imbalances are lowest at U.S. pre-opening, and execution possibilities in Xetra are best once the NYSE has started trading.

Based on these empirical results, it is most advantageous for liquidity traders to place their orders in the early afternoon, while trading in the first half hour of opening is not recommended. Similarly, trading should not be left until the last half opening hour of Xetra. For informed trades, however, higher trading costs in the early morning could be offset by the profits from superior information. This might be an avenue for further research.

Figure 1.1: Layout of Thesis



2 Overview of Academic Literature on Liquidity

2.1 The Importance of Liquidity

One of the most important criteria for the evaluation of capital markets and market places for securities' trading is liquidity. High liquidity means the ability to trade, buy and sell securities without impact and movement in the share price. It is important to understand secondary-market liquidity because of the various roles it plays in the capital markets. Liquidity encourages trading by reducing transaction costs. A market participant's ability to capture potential gains of trade depends directly on liquidity levels. For investors, in order to maximize the net return on an investment in securities, it is important to be able to execute their buy and sell transactions at the lowest possible transaction costs. The anticipated transaction costs should be included as a decision-making criterion when deciding on a specific investment, i.e. stock picking, so that securities can be compared and/or benchmarked in terms of the anticipated net return.

In the framework of portfolio restructuring, liquidity is by far the most important decision-making criterion for investors (Schiereck (1995)) and is regarded as the central quality characteristic in securities markets. At the macro-level, liquid capital markets are essential for the efficiency of capital allocation in modern economies and lead to low cost of capital for issuers. There is an economic welfare benefit from liquid markets because trading is the mechanism through which information is introduced into prices. More informative prices lead to more efficient allocation of capital across competing investments (Wurgler (2000)). At the micro-level, a liquid market enables access to a large number of trading interests and thus ensures that investors can carry out their transactions at any time.

Liquidity also plays a significant role in determining the firm's cost of capital. The more liquid the firm's stock is, the lower the illiquidity premium in expected stock returns will be and this will lead to a lower costs of capital for the firm and eventually a higher market capitalisation. (Amihud and Mendelson (1986) and Easley, Hvidkjaer and O'Hara (2002)).

For all of these reasons, there is considerable interest among managers, investors, exchange members, exchanges and regulators in understanding the determinants of secondary-market liquidity. Stock exchanges are especially interested in the nature of liquidity and focus on the choice and optimisation of market models and market segments to try to improve the liquidity.

However, there is neither a uniform agreement of the term liquidity, nor a common operational model for the analysis of liquidity and transaction costs neither in the practical world, nor in the academic literature (Oesterhelweg and Schiereck (1993)). The lack of unified criteria and approach is further complicated by the fact that the nature and patterns of liquidity are strongly influenced and often shaped by a variety of factors like market structure, trading rules, continuous trading versus firm quotes, the level and efficiency of market supervision, insider trading, order sizes and many more. These factors affect trading patterns of market participants, thus affecting the liquidity (Stoll (1992), Grossman and Miller (1988)).

In traditional specialist markets, traders typically only saw the buy and sell prices that market maker quotes for a stock. Larger trades often involved a different trading mechanism so-called "upstairs market". In these dealer markets, the spread might be an adequate description of a stock liquidity.

In modern automated auction markets, the liquidity supply solely depends on the state of the electronic order book, which consists of previously entered, non-executed buy and sell limit-orders. This set of standing orders determines the price-volume relationship that a trader who requires immediacy of execution is facing. If few limit buy or sell orders are present in the system or if many orders are present but for small trade sizes only, liquidity is low and marketable limit order trades may incur considerable price impacts. If an order is very large, it hits unexecuted limit orders, which have different price limits. The larger the order, the more price limits will be hit and the further a market order walks up the limit order book. Evidently, the spread and depth at best prices alone are not sufficient to characterize the liquidity of a limit order book market.

2.2 Liquidity Definitions and Dimensions

In the literature, the notion of liquidity is generally conceived as the ability to trade quickly a large volume with minimal price impact or low transaction costs. This definition can be found in Harris (1990), Bernstein (1987) and Schwartz (1988). This definition includes three elements: volume, price continuity and time. These definition elements can be operationalised through liquidity dimensions as discussed in Oesterhelweg and Schiereck (1993). Although the term liquidity is common in the research and practice, there is still no agreement on its measurement.

Going back to earlier works on liquidity, Kyle (1985) identified three dimensions of liquidity:

- Tightness or width (reflected in the bid-ask spread): The possibility to buy and sell the same instrument at almost the same price.
- Market depth (reflects in volume): Ability to trade a large amount without influencing the price (takes into account only the volumes at the best bid and ask prices).
- Market resiliency or elasticity: the speed of liquidity return to equilibrium or “normal levels” after an adverse liquidity shock (defined in Foucault, Kadan and Kandel (2005)). Alternatively, a market is said to be resilient when prices quickly return to “normal” after a shock (Black (1971), Harris (1990)).

Tightness addresses the question of transaction costs and is hence closely related to the bid/ask spread. Market depth and resiliency on the other hand attempt to identify the size that is tradable with no or only a minimal influence on the quoted price.

Also in Bernstein (1987) and Garbade (1982), only the three above-mentioned dimensions of liquidity are considered. However, all these definitions of liquidity automatically assume that immediacy is not a dimension as such.

Later, Harris (1990) adds the forth dimension of liquidity being immediacy. He mentioned: width (equivalent to tightness in other definitions), depth, resilience and immediacy. The term liquidity is also described in four dimensions: market breadth, market depth, immediacy in execution and the market resiliency by Hasbrouck and Schwartz (1988) or Roll (1984).

All these liquidity measures are interdependent. Width and depth are interlinked. Width (defined through bid-ask spread) is an increasing function of order size (Lee, Mucklow and Ready (1993)). Both these dimensions depend on immediacy since it is possible to realize a different price for a given volume later. Immediacy is also only given if the market is resilient.

We can classify different liquidity measures available in the literature by a) calculation based on order book data or transaction data, referring to ex-ante or ex-post measures and b) the number of liquidity dimensions they cover. For a comparative analysis of various liquidity measures, see Brunner (1996).

When assessing liquidity, approximation factors or so-called liquidity indicators or ratios oriented towards transaction data are used. Ratios such as transaction volume (defined as value of a transaction) or a unit volume (defined as number of instrument units) or a transaction frequency (defined as a number of transactions executed within a certain time) and the relative transaction volume (defined as a ratio of transaction volume to free float of the respective security) are applied (Chordia, Roll and Subrahmanyam (2000), Hasbrouck and Saar (2002)). Another ex-post measurement (developed by Cooper, Groth and Avera (1985)) is “Amivest Liquidity ratio” which calculates the average trading volume needed to produce a 1% price change. It is defined by the ratio of average traded volume and average relative price change in the given time interval.

All these ratios are oriented to the past and they reflect the recent activity, but not necessarily the present liquidity in a given instrument. These transaction oriented figures risk being significantly distorted by a small number of very large or very small transactions. Gomber, Schweickert and Theissen (2004) provided evidence of a discretionary trading in Xetra. The study found that the large orders are timed and take place when liquidity is highest. The evidence of strategic order placement in the Swedish futures market was also reported (Coppejans, Domowitz and Madhavan (2004)). Therefore, transaction based measures ignore the fact that trades might only take place because of the provided level of ex-ante liquidity, thus possibly overestimating liquidity in the instrument.

Marsh and Rock (1996), Oesterhelweg and Schiereck (1993) and others consider that the liquidity ratios do not directly operationalize any liquidity dimension. Thus, we believe that ex-ante measures of liquidity based on order book data should be preferred to the ex-post measures based on transactions data.

The most widespread measure for the price is the quoted spread (corresponding to width) and for the quantity - the depth of the best bid and the best ask quote. Although the spread measures only one dimension of liquidity, it has been widely used as a way to measure and compare liquidity. For example, Demsetz (1968), Brockman and Chung (1998), Chordia, Rol and Subrahmanyam (2000) all measure liquidity by looking at quotes and quantities at best prices. This can be partially explained by the fact that the data on spreads and best bid and best ask prices is widely available but the data on the full order book or a data beyond best bid and ask was difficult to obtain in the past.

Of course, when looking at more general measures of liquidity, the analysis cannot be limited to the best bid/ask prices and quantities; rather it must extend to the whole order book. Due to the strong interactions of different dimensions of liquidity, all dimensions should be measured jointly to provide the full picture of liquidity.

A common measure in the computation of order book liquidity is the quote slope, defined as the bid and ask spread divided by the (logarithm) of the product of the respective quantities: Here, P_{ask} (P_{bid}) is the ask (bid) price and q_{ask} and q_{bid} are the corresponding quantities. The quote slope is therefore a measure of liquidity that combines both price and quantity information and relies on Hasbrouck and Seppi (2001). The lower is the quote slope; the more liquid is the market. This can be either due to a decrease in the difference between the bid price and the ask price or due to the fact that a larger quantity has appeared in the market. Numerically this can be formulated as follows:

$$100 \text{ x } \frac{Pask\text{-}Pbid}{log\ (q_{ask} \text{ x } q_{bid})}$$

In the case of a market model based on the limit order book, the limit orders in the order book can be used to calculate the weighted average price for each executable size. The computation is done for simultaneous buy and sell orders of the same size at the same time, thus computing liquidity from the point of view of a market order trader. The result of such measure is called Cost Of Round Trip, CRT (D), where D indicates the order size. It was developed by Irvine, Benson and Kandel (2000). Similar measure was constructed by Barclay et al. (1999) for Nasdaq dealer market. Other researchers implemented similar measures (Coppejans, Domowitz and Madhavan (2004); Domowitz and Wang (2002)).

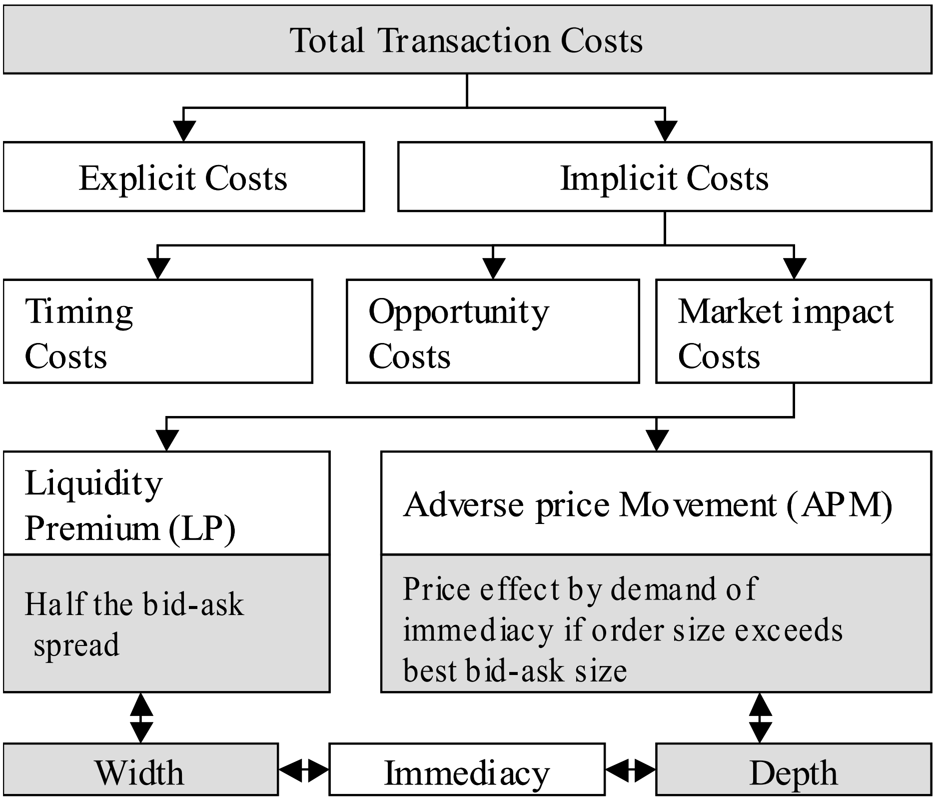
The Cost of Round Trip model for measuring the liquidity is starting to look at the costs of opening and closing the positions. It leads in our view to the more objective figure for the measurement of liquidity, which should be derived from its direct benefit for the market participants. The direct benefit of liquid markets for the investor derives from the minimization of performance loss resulting from opening and closing a position (round trip). The lower these costs are, the higher the liquidity of the respective security or of a market as such.

2.3 Implicit Transaction Costs and Market Impact

Gomber and Schweickert (2002) have adapted Irvine, Benson and Kandel (2000) formula of CRT and proposed Exchange Liquidity Measure (XLM). In July 2002 Deutsche Börse AG implemented the XLM measure in Xetra. XLM calculates the cost of liquidity based on the market impact concept. XLM represents an integrative view on liquidity as liquidity is measured through width, depth and immediacy and implicit transaction costs are measured as market impact.

There is a vast literature on trading costs and their determinants; see for example Keim and Madhavan (1998). Usually, the literature distinguishes explicit and implicit trading costs. The explicit part consists of fixed costs, such as commissions, taxes, and fees and incurred with the order processing and settlement by brokers, banks and exchanges. Implicit costs are built up of market impact costs (price impact), bid-ask spread, delay or timing costs (the costs of adverse price movements that may occur when trading is postponed), and opportunity costs (the costs of not trading or the lost profit due to the fact that the order in its full or its parts is not filled), see Figure 2.1 (adopted from Gomber and Schweickert).

Figure 2.1: Concept of Transaction Costs



Market impact costs are generally found to be the most important component of trading costs and occur when price effects cause execution prices to be less favourable than benchmark prices.

Keim and Madhavan (1997) investigate the total execution costs (defined as the sum of commission and market impact costs) of institutional trades in relation to investment styles, using data on the equity transactions of 21 institutions during the 1991−1993 period. The authors find that the magnitude of the average total execution costs varies between 49 basis points[1] (bp) and 123 bp for buys and between 55 bp and 143 bp for sells. Out of this commissions, on average, contribute about 40% to total execution costs, the rest being attributed to the implicit transaction costs.

The Market Impact measures the costs of the immediate demand for liquidity. The Market Impact as a liquidity measure methodologically covers three of the four liquidity dimensions. The fourth dimension, time, is assessed through the change in measurement results over the course of time.

2.4 Components of Transaction Costs and Construction of XLM

As can be seen in the Figure 2.1, width as a first of the dimensions of liquidity is described through Liquidity Premium (LP) and it equals half bid-ask spread. The depth, as a second dimension of liquidity is described here thought the calculation of adverse price movement (APM). APM is defined as a price effect by the demand of immediacy if order size is bigger than the best bid-ask size. The third dimension of liquidity – immediacy – is covered by the methodology of market impact costs though the assumption that it calculates the immediate demand for liquidity at certain time.

Figure 2.2 explains the calculation of XLM. The explanation of XLM is adopted from Gomber and Schweickert (2002). Market impact consists of the sum of the liquidity premium (LP) and the adverse price movement (APM).

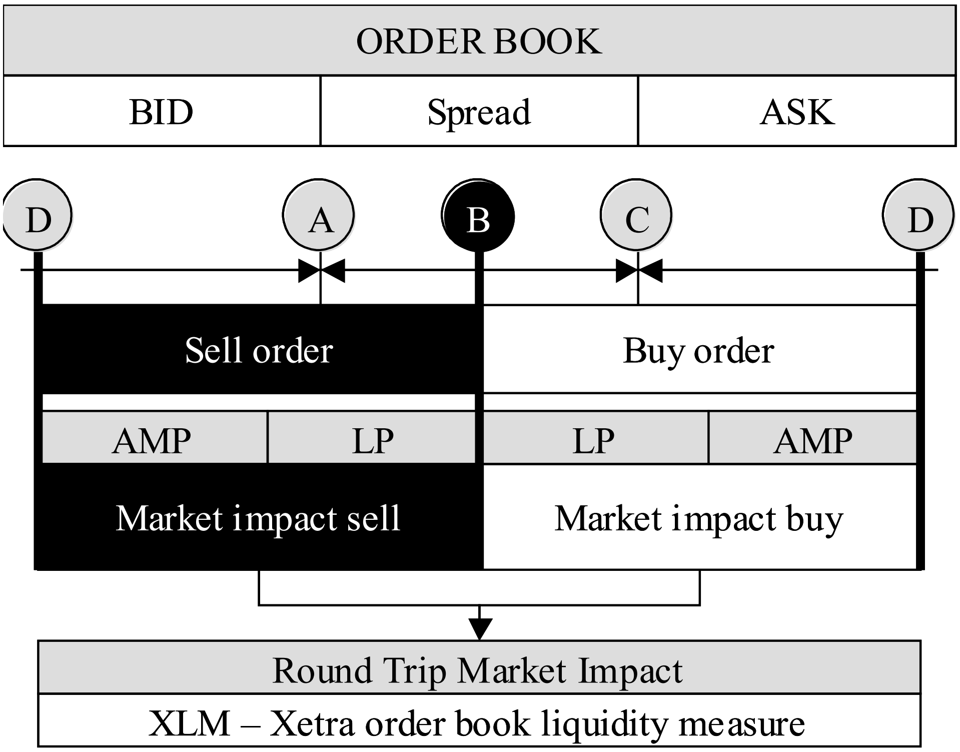
Liquidity premium (LP) is calculated as a half of the bid-ask spread and it is measured from the difference between the middle of the bid-ask spread (midpoint B) and the current best ask limit (point C) for a buy order (B-to-C) or the current best bid limit (point A) for a sell order (A-to-B). The midpoint of the spread serves as a proxy and the reference for the theoretical market value of the instrument.

The liquidity premium, however, does not measure the price effect if the order size is larger than the best bid-ask price. It represents the market width but not the depth. Larger orders in the limit order book are usually executed against several limits, and with every additional execution, the average

[1] 100 basis points equal 1%.

execution price for the order deteriorates. The market depth is then measured through adverse price movement (APM). The trading costs for the investor then increase additionally by the difference between the respective best bid or ask quote and the resulting average execution price (C-to-D for a buy order and/or A-to-D for a sell order). Both liquidity premium (LP) and adverse price movement (APM) are calculated for each side of the order book. The sum of the market impact on both sides of the order book represents the costs of round trip for a certain size.

Figure 2.2: Exchange Liquidity Measure Concept



Constructing XLM starts with the weighted average price *P* at which an order of a given size *V* can be settled immediately, separately for buys *(B)* and sells *(S)*. The execution cost, denoted in basis points is then

$$XLM_{B,t}(V) = 10{,}000\frac{P_{B,t}(V) - M_t}{P_{B,t}(V)} \quad \text{and} \quad XLM_{S,t}(V) = 10{,}000\frac{M_t - P_{S,t}(V)}{P_{S,t}(V)}$$

for buys and sells, respectively, with M_t being the quote midpoint at time *t.* Adding these up yields the cost of the roundtrip transaction.

$$XLM_t(V) = XLM_{B,t}(V) + XLM_{S,t}(V)$$

The higher are the transaction costs, the higher is XLM, and the lower is the liquidity.

In practice, in order to capture market impact costs in the Xetra order book, a hypothetical unlimited buy-and-sell order is entered into the order book. The result, the average execution price, is compared to the theoretical market value (average between best-buy and best-sell limit): smaller difference leads to lower XLM (i.e. the cost for the investor). Lower XLM indicates higher liquidity of a security.

The XLM is stated in basis points (100 basis points = 1 percent). It corresponds to the relative market impact costs for the so-called round trip (simultaneous buying and selling of a position) for a given order size. An XLM of ten basis points and an order volume of 25,000 EUR means, for instance, that the market impact costs for buying and selling this share have amounted to 25 EUR.

XLM is measured every minute during the trading day for hypothetical execution possibilities of different pre-defined order sizes of 10,000 EUR, 25,000 EUR, etc. Often, the order book situation is such that the execution of full hypothetical order is not possible. Partial execution possibilities are not taken into consideration. In such case, the measurement is simply ignored and left blank. However, the statistics are available on the percent-basis of minutes per trading day at which the measurement was possible - and at which not possible. For example, 80% would mean that only on 80% of trading minutes the hypothetical execution was available for measurement. On the remaining 20% - volume in the order book was not sufficient for the execution.

There are two types of XLM that are measured by Deutsche Börse – natural and total liquidity. This concept comes from the existence of Designated Sponsors (market makers) in Xetra order book. Natural liquidity measures the XLM for order book activity without Designated Sponsor quotes or trades. Total liquidity combines natural liquidity with the liquidity injected by Designated Sponsors.

2.5 Screen-based Stock Trading in Germany via Xetra

The German stock market when measured by its liquidity ranks comparatively well against other European or international markets. For example, Jain (2003) showed that Germany's transaction costs are lower than in the UK. Domowitz, Glen and Madhavan (2001) compared implicit transaction costs of 42 exchanges worldwide in the period 1996-1998 and found that European exchanges reveal a stronger decrease in transaction costs than the US exchanges and attributed it to the faster adoption of technology. In contrast, a study by Pagano and Padilla (2005) revealed that implicit transaction costs in Germany are on the higher end compared to other major European exchanges.

The German stock market is fragmented between seven German stock exchanges[2]. Frankfurt Stock Exchange FSE, which is operated by Deutsche Börse AG, operates both the electronic trading platform Xetra and the floor-based trading. This work is based on Xetra, the most liquid market for German stocks[3]. Xetra is an anonymous electronic limit order book.

In equities trading, Xetra plays a dominant role with a market share of 90.1%[4]. It is especially high in the stocks belonging to the German blue chip index DAX30, in which it is reaching 97.4%. In December 2007, the share of DAX trading accounted to 82% of the total order book turnover in equities across all German exchanges. For trading on Xetra, DAX equities represented 83%. TecDAX equities represented 3% of the total equities order book turnover on Xetra.

The index[5] family of Deutsche Börse AG consists of DAX, the German blue chip index of 30 most liquid and most traded companies listed on the FSE, the

[2] Alphabetically – Berlin-Bremen, Dusseldorf, Frankfurt, Hamburg, Hannover, Munich, Stuttgart

[3] Besides Xetra, in Germany there are the Frankfurt Stock Exchange (organized in a way similar to the NYSE) and several regional exchanges.

[4] See Deutsche Börse AG cash market statistics available online under www.deutsche-boerse.com in the section Info-centre/Statistics/Cash market/ Monthly Statistics Cash market, December 2007

[5] For more details on indexes and their compositions, see Deutsche Borse AG "Guide to Equity indices" available online

TecDAX[6] that tracks 30 largest and most liquid companies from various technology related sectors, the MDAX with other 50 midcap stocks and SDAX that combines the next 50 liquid stocks.

Xetra divides stock trading into different trading models depending on the liquidity of an instrument. Instruments are either traded in:

a) auction-only, implying very low liquidity, or
b) in the continuous trading with auctions and liquidity providers called Designated Sponsors or
c) continuously without any support of liquidity providers.

Two criteria are used to define the trading model for the security:

i) average liquidity, measured by XLM with the reference order size of 25,000 EUR and
ii) order book turnover of the security (as average daily trading volume).

Based on these two criteria, Deutsche Börse will separate all stocks continuously traded on Xetra into two liquidity categories, A and B, see Figure 2.3. Securities in liquidity category A will not require a Designated Sponsor for continuous trading as they are deemed to have sufficient liquidity. Category A includes all equities with XLM measure being 100 basis points or less (1 basis point = 0.01 percent) and an average daily order book turnover of at least 2.5 million EUR.

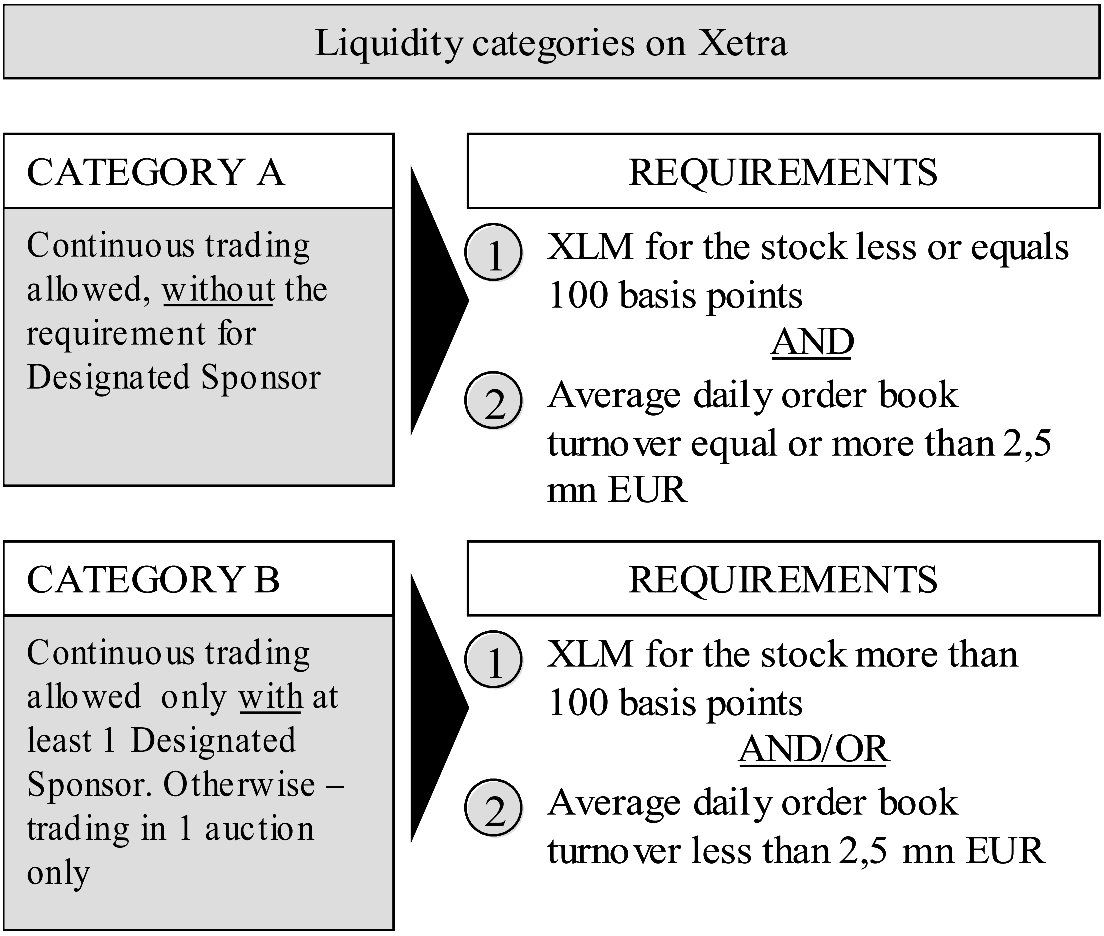
Securities with an XLM of more than 100 basis points and/or an average daily order book turnover of less than EUR 2.5 million belong to liquidity category B. Here, at least one Designated Sponsor is needed for continuous trading in Xetra. The Figure below is adopted from Deutsche Börse AG publication “Stock&Standarts”, No 2/2002.

The market model for stock trading on Xetra can be described as order-driven. The liquidity is provided by limit orders and by Designated Sponsor quotes. Besides normal limit orders, market participants may submit market orders and hidden orders ("iceberg orders"). These orders have a visible part,

[6] TecDAX was introduced in March 2003 as a successor to the ill-fated index NEMAX50

which is displayed on the trading screens and an invisible part. When the visible part is executed, it is replaced by a portion of the hidden part that is equal in size to the original visible part. This procedure is repeated until the hidden part is exhausted.

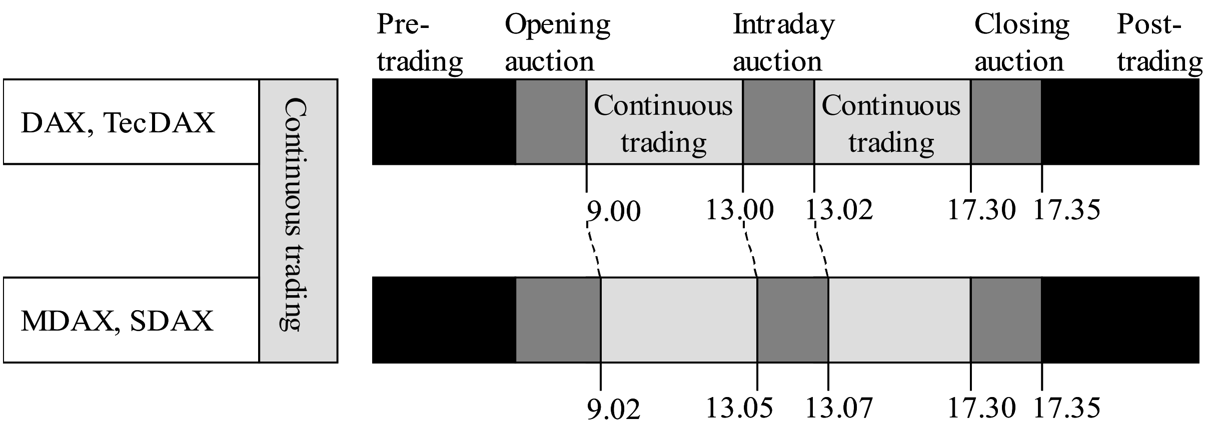
Figure 2.3: Liquidity Categories on Xetra



The general task of Designated Sponsors is to offer binding prices for bid- and ask side (quotes) for the appointed shares in continuous trading and auctions. In principle, several Designated Sponsors can support one stock, and equally a stock can have several Designated Sponsors acting in it. As a benefit for Designated Sponsor, Deutsche Börse waves the fees for trades on Designated Sponsor account. Designated Sponsors offer listed companies additional services like research reports, preparation of analyst presentations or active distribution of shares. Such services are possibly pay-for services by the issuers but the exchange does not regulate or intervene in this part of the relationship between Designated Sponsor (DS) and the issuer. Designated Sponsors' quoting must satisfy certain quality criteria (minimum requirements) stipulated by Deutsche Börse AG with respect to the trading characteristics of the respective share and include for example minimum quote size, maximum spread, response time and participation time.

Trading on Xetra starts at 9 am with an opening call auction and (during our sample period) ends at 17.30 pm with a closing auction. There is one intraday call auctions at 1 pm. Figure 2.4 is adopted from the website of Deutsche Börse AG[7].

Figure 2.4: Trading Time and Phases on Xetra



The instrument tick size, the minimum increment by which prices can move, representing the smallest variation of price setting for limit orders, is defined at Euro 0.01.

Xetra offers extensive pre- and post-trade transparency for all prices and orders in the order book (pre-trade) and all transactions with volume and price (post-trade) are immediately distributed to the members. Nevertheless, Xetra is an anonymous order book and identities of traders for both orders and trades are not shown. It is interesting to note that as Hachmeister and Schiereck (2010) showed the implementation of post-trade transparency rules on Xetra in 2003 led to significant increase in liquidity. Pre-trade transparency was available before that.

[7] http://deutsche-boerse.com/dbag/dispatch/en/kir/gdb_navigation/trading/10_trading_platforms/200_xetra/300_auction_plan

Xetra market model contains additional safeguards in auctions and in continuous trading to improve price continuity and increase execution probability of market orders as follows: a) volatility interruptions that are triggered if the potential execution price lies outside a defined static or dynamic price corridor around reference price which is the last traded price and b) market order interruptions which are not frequent and implemented for auctions.

In the next Chapters we will present the three essays that address selected issues in the stock market liquidity. All three essays conduct original empirical research using data from the German Xetra trading system and the set of stocks that belong to German TecDAX index.

The first essay (Chapter 3) focuses on the weather effects on the stock market liquidity. The second essay (Chapter 4) focuses on the issue of market makers' effect on liquidity and investigates the role of Designated Sponsors in the Xetra electronic order book and. Finally, the third essay (Chapter 5) investigates the intraday effect on liquidity.

3 Does Screen Trading Weather the Weather? A Note on Cloudy Skies, Liquidity and Computerized Stock Markets[8]

Abstract

This paper tests for the presence of a weather effect on liquidity in a screen-based electronic stock market. The use of the Exchange Liquidity Measure XLM enables us to separate the effect of cloudy skies on liquidity provided by market makers from this effect on liquidity naturally in the market.

The empirical evidence suggests that cloudy skies correspond with high natural liquidity levels and low liquidity injected by market makers. This result is consistent with findings for floor-based stock trading and with the hypothesis that market makers add less value in markets with high natural liquidity.

[8] The earlier version of this paper is accepted for publication in the Journal of Trading, co-authored by Christiane Goodfellow and Dirk Schiereck.

3.1 Introduction

The weather effect refers to the positive correlation between sunshine and stock returns. This phenomenon was first documented by Saunders (1993), followed by mixed empirical evidence on its presence. More recently, the literature has been focusing on different groups of market participants driving the weather effect. Both Goetzmann and Zhu (2005) and Flemisch et al. (2009) attribute the weather effect to market maker actions. This paper contributes to this ongoing debate by investigating the effect of the weather conditions in Frankfurt, Germany, on stock market liquidity in the electronic trading system Xetra at the Frankfurt stock exchange (FSE). The choice of a particular liquidity variable, which only this market provides officially, enables us to explicitly test for weather effects on the liquidity provided by market makers.

Research in psychology shows that sunlight influences people's moods, sentiments, and judgements. Specifically, lack of sunlight is associated with depression (Eagles (1994)). Likewise, sunshine induces optimism, which results in market participants incorrectly attributing their upbeat mood to a positive economic outlook rather than to the weather. Furthermore, individuals in a positive mood are less likely to engage in critical analyses of economic factors than people in a depressed state of mind. The combination of a favorable perception of the economic outlook and a lack of doubts on this leads to less risk-averse market participants than on overcast days.

The empirical evidence on the presence of a weather effect is mixed.[9] Both Saunders (1993) and Hirshleifer and Shumway (2003) report evidence in favor of a weather effect. Specifically, Saunders (1993) finds New York City sunshine to statistically significantly raise daily stock market returns from 1927 to 1989. Hirshleifer and Shumway (2003) provide international evidence from 1982 to 1997 and confirm, overall, a statistically significant negative relation between cloud cover and stock return. For New York City, for example, Hirshleifer and Shumway (2003) report an annualized nominal return of 9%

[9] A related strand of literature investigates seasonal stock market anomalies (e.g. Kamstra et al. (2003)). This is not discussed further as this paper focuses on daily weather effects on liquidity.

per year for cloudy days while the respective return for sunny days amounts to 25%. The weather effect is, therefore, economically significant. For data availability reasons, the German stock market is excluded from Shumway's (2003) dataset.

By contrast, Trombley (1997) and Loughran and Schultz (2004) present evidence against the weather effect. Trombley (1997) examines the 1927 to 1992 period in New York City and finds that the choice of days for which to compare returns determines the statistical significance of the results in Saunders (1993), who compares average returns on completely cloudy days with average returns on 0% to 20% cloudy days. When Trombley (1997) contrasts returns on 0% cloudy days with returns on 100% cloudy days, the weather effect disappears, although intuitively it should be strongest in this setting.

Moreover, investors whose orders drive asset prices submit these orders from all over the world and are hence unlikely to be affected by the local weather at the stock exchange. Loughran and Schultz (2004) therefore test for the influence of the local weather at the firms' headquarters on the return of their stocks which are traded at the Nasdaq system in New York City from 1988 to 1997. Remarkably, local weather appears to have no effect on stock returns, even though trading volume is predominantly originated by local investors (Coval and Moskowitz (1999), Grinblatt and Keloharju (2001)).

Against the background of this debate on the existence and origin of the weather effect, Goetzmann and Zhu (2005) investigate the influence of weather on individual investors' trading activities at five major U.S. stock exchanges from 1991 to 1996. They find evidence in favor of a weather effect, but this cannot be attributed to individual investors' trading activities. Assuming that institutional investors are less sentiment-driven and mood-dependent in their trading strategies than individuals (Barber and Odean (2009), Cohen et al. (2002)), there is only one group of market participants left that could be causing the weather effect: market makers. This is plausible as market makers are physically at the exchange and are hence more subject to local weather than investors who could be elsewhere.

In order to test for weather effects on market makers' behaviour, Goetzmann and Zhu (2005) examine the bid-ask spread. In fact, cloud cover and bid-ask spreads are found to be positively correlated, which is explained by more risk-averse market makers in cloudy weather than in sunshine (Gehrig and Jackson (1998)). More importantly, the weather effect on stock returns is much reduced when the weather impact on spreads is controlled for, and the weather effect on stock returns appears to be partially driven by weather-induced changes in liquidity.

For the German electronic trading system Xetra, however, Flemisch et al. (2009) report narrower spreads in cloudy weather than with sunshine. They argue that leisure activities are less attractive to market makers in cloudy weather than with clear skies. As a result, market makers work harder by providing additional liquidity when the alternative, i.e. leisure, is valued less highly.

In essence, there is an ongoing debate about the existence of a weather effect on stock returns, and about the direction of the established correlation between cloudy skies and liquidity. We contribute to this by testing for a potential influence of the weather in Frankfurt (Main) on liquidity provided by market makers in the electronic trading system Xetra at the Frankfurt stock exchange. Rather than using the bid-ask spread as a proxy for liquidity, we apply the exchange liquidity measure (XLM) introduced by Gomber et al. (2005). The construction of this variable enables us to distinguish between the weather effect on liquidity provided by the market maker, and its influence on the level of liquidity present in the market without the market maker's activities, i.e. natural liquidity.

Specifically, we raise four research questions. First, we analyze the relation between weather and natural liquidity. In light of Flemisch et al. (2009), we hypothesize that transaction costs are lower on overcast days than on clear days. Second, we examine the effect of weather on liquidity injected by market makers. We expect that market makers' contribution to liquidity is higher on overcast days than in sunshine. Third, we investigate the influence on liquidity of multiple market makers acting in one stock. In light of Bosch (2001), who reports a significantly positive correlation between the liquidity in a stock and the number of market makers acting in it, we assume that injected liquidity rises with the number of market makers. Finally, we study the relation between trading volume in a particular stock and injected liquidity. If trading volume and injected liquidity are negatively correlated, market makers add less value in liquid stocks.

In order to investigate a potential Frankfurt German stock exchange, section 3.2 provides some institutional details of this trading platform, before section 3.3 introduces the methodology and our dataset. Section 3.4 presents the empirical results, and section 3.5 concludes.

3.2 Screen-based Stock Trading in Germany via Xetra

Xetra is the fully electronic screen-based trading platform run by the German Stock Exchange, Deutsche Boerse AG, and organized as an anonymous open limit order book.[10] It started to operate in November 1997 and is currently open daily from 9.00am to 5.30pm. Continuous trading is interrupted by an opening, an intraday and one closing auction, which concentrate liquidity. Financial institutions, securities trading houses and brokers can participate in Xetra trading independently of their location. Trading in Xetra is anonymous, with a central counterparty (CCP) clearing the offsetting orders.[11] On busy days, more than 2 million trades per day are executed in Xetra.

Tradable instruments are primarily equities, certificates, warrants, exchange-traded funds, and subscription rights. Equities can be traded in all order sizes in Xetra, and orders are executed according to price-time priority. The German stock exchange groups many of these together in indices. The most prominent equity index is the German blue-chip index DAX, comprising the 30 stocks with the largest market capitalization.

This study focuses on TecDAX stocks, the 30 largest technology stocks that are not included in the DAX. In our sample period, 3% of total equities turnover was originated by TecDAX equities. The limited liquidity levels and

[10] The information in this section is based on Deutsche Boerse's website, http://deutsche-boerse.com, unless stated otherwise.
[11] See Grammig et al. (2001) and Hachmeister and Schiereck (2010) for effects of anonymity

significant market making activities in these stocks provide an ideal testing ground for our research questions.

Market Maker activities are provided by so-called ‘Designated Sponsors’ who offer additional liquidity and transaction opportunities, especially in less liquid stocks, by offering binding quotes for both buys and sells. These quotes are required to have a certain maximum bid-ask spread and a certain minimum quote size. Banks and securities firms act as Designated Sponsors. In principle, several Designated Sponsors can support one stock, and equally a stock can have several Designated Sponsors acting in it. Less liquid stocks can only be traded continuously if they have been adopted by at least one Designated Sponsor.

Transaction fees are only charged for executed orders. These fees amount to 0.48 basis points, a minimum of 0.60 Euros and a maximum of 18.00 Euros per order. Discounts are available for computer-generated orders, i.e. algorithmic trading. Xetra’s function XetraBest ensures full and immediate execution for private investors’ orders at a price that is automatically better than the order book, and fixed clearing fees are waived.

3.3 Methodology and Data

An examination of the weather effect on liquidity requires two variables, one measuring liquidity and one capturing sunshine. As the former, we focus on the Exchange Liquidity Measure XLM (Gomber et al. (2005)), which measures the cost of a roundtrip trade dependently on order size. The German Stock Exchange has been calculating XLM based on all information in the order book, i.e. including the hidden part of iceberg orders, for all stocks traded continuously in Xetra since July 2002. XLM therefore provides a more comprehensive analysis of liquidity costs than the bid-ask spread.

Constructing XLM starts with the weighted average price P at which an order of a given size V can be settled immediately, separately for buys (B) and sells (S). The execution cost, denoted in basis points[12], is then

[12] 100 basis points equal 1%.

$$XLM_{B,t}(V) = 10{,}000\frac{P_{B,t}(V) - M_t}{P_{B,t}(V)} \text{ and } XLM_{S,t}(V) = 10{,}000\frac{M_t - P_{S,t}(V)}{P_{S,t}(V)}$$

for buys and sells, respectively, with M_t being the quote midpoint at time *t*. Adding these up yields the cost of the roundtrip transaction $XLM_t(V) = XLM_{B,t}(V) + XLM_{S,t}(V)$. The higher are the transaction costs, the higher is XLM, and the lower is the liquidity.

This liquidity variable XLM comes in two flavours. Natural XLM measures the liquidity in the market without that provided by market makers. Total XLM, by contrast, includes that part of liquidity that is injected into the order book by market makers. Thus, this choice of liquidity variable enables us to test directly for the effect of weather on liquidity injected by market makers. Because XLM captures transaction costs and these are inversely related to liquidity, total XLM is smaller than natural XLM. In other words, the presence of market makers reduces execution costs. The XLM data are based on hypothetical order sizes of 10,000 EUR, 25,000 EUR, and 50,000 EUR, which are included in our regression analyses as volume classes.

Trading volume is the average daily traded volume per stock in millions of Euros. As for the weather variable, we follow Saunders (1993), Hirshleifer and Shumway (2003), and Flemisch et al. (2009) and use sky coverage at the headquarters of the German stock exchange in Frankfurt. In order to quantify the weather effect on liquidity, we follow Flemisch et al. (2009) and estimate a fixed effects panel regression model with the basic specification

$$XLM_{i,t} = \alpha + \beta_1 VolumeClass_i + \beta_2 SkyCover_t + \beta_3 TradgVolume_{i,t} + \varepsilon_{i,t}$$

With this panel approach, we analyze the observations on individual stocks *i* over time *t*, and the statistical inference hinges on these individual stocks. For the first research question, we use natural liquidity as the dependent variable. By contrast, in order to address the second question, total liquidity is used, which includes that injected by Designated Sponsors. Turning to the third research question, the number of Designated Sponsors is introduced as an additional independent variable.

Deutsche Boerse AG provided daily XLM and trading volume data for all TecDAX stocks for the two-year period from 1 January 2004 to 31 December 2005. We include in our sample 16 stocks that belonged to TecDAX for at least two consecutive months in our sample period and for which at least one Designated Sponsor was acting. These stocks are all domestic, including QIAGEN NV that was established in Germany but included in the TecDAX and listed on Xetra under a Dutch ISIN. This selection results in a dataset with 24,666 observations for each of the parameters of trading volume, natural and total liquidity. Each Designated Sponsor is located in Frankfurt.

Sky coverage data are available from the German Weather Service (Deutscher Wetterdienst) online (www.dwd.de). These data measure the daily mean sky coverage, calculated across the hours of the day. This average is presented in 9 classes, with zero referring to cloudless skies and 8 meaning fully overcast. Dickey-Fuller and Philips-Perron tests suggest that this weather variable is stationary.

Table 3.1 presents summary statistics on our dataset.

Table 3.1: Summary Statistics On Cloudy Sky and Liquidity

Instrument	XLM natural in basis points		XLM total in basis points		Avg. daily volume	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
AIXTRON.	99.68	39.17	95.24	35.54	1.28	1.55
DRAEGERWERK	72.98	37.67	62.10	22.35	1.38	1.53
ELMOS SEMICOND.	129.83	95.05	81.01	28.21	.65	.84
EVOTEC	205.62	120.03	185.4	91.88	.39	.45
FREENET.DE	44.84	15.65	44.04	14.59	4.97	4.42
GPC BIOTECH	94.34	46.50	81.80	30.43	1.57	2.70
IDS SCHEER	97.31	50.67	86.28	33.79	.70	.62
JENOPTIK	83.88	41.67	73.71	31.52	1.18	1.00
KONTRON	84.83	44.92	76.72	31.76	.99	.97
MOBILCOM	37.36	13.06	37.34	13.02	7.03	5.52
PFEIFFER VAC.	113.46	82.86	89.12	44.52	.54	.51
QIAGEN	40.51	15.48	40.10	14.64	4.31	3.36
SINGULUS TECH.	54.45	22.08	50.38	17.51	2.23	2.24
SOFTWARE	55.98	38.48	48.62	20.50	2.89	2.66
T-ONLINE INT.	27.14	11.11	26.76	10.70	13.70	27.60
UTD.INTERNET	52.88	27.16	50.04	21.63	2.87	2.55

Daily trading volume is denominated in millions of Euros. The mean XLM is calculated for all three volume classes of 10,000 EUR, 25,000 EUR, and 50,000 EUR.

3.4 Empirical Results

The primary goal of this paper is to determine weather effects on liquidity in the electronic trading system Xetra. The choice of the XLM measure for liquidity enables us to test directly for the influence of sky coverage on liquidity injected by market makers. From this, we can draw conclusions regarding the extent to which moods and sentiments drive liquidity in Xetra. Table 3.1 presents the empirical results.

First, we test for the weather effect on natural liquidity. This is the level of liquidity in the market without any contribution by market makers. The estimated coefficient on sky coverage is highly significant and negative and robust towards the inclusion of trading volume as a control variable. Thus, the cloudier the sky over Frankfurt is, the lower the XLM measure will be. This means lower transaction costs and higher natural liquidity. This finding refers to overall liquidity in the market and therefore does not permit any conclusions specifically about market makers. This empirical result is at odds with the findings of Goetzmann and Zhu (2005) for the U.S. but consistent with Flemisch at al. (2009) for the German market, whose sample period overlaps with ours.

Second, we analyze the relation between sky coverage and liquidity injected by market makers. Again, this relation is statistically significant and negative implying that the more overcast the sky, the lower the liquidity contribution by market makers. Controlling for trading volume does not change this finding, which can be viewed as evidence supporting Goetzmann and Zhu (2005). Cloudier weather renders market makers more risk averse, thus providing less liquidity than on sunny days. Alternatively, it can be argued that overall liquidity is higher on cloudy days than in sunshine, thus market makers add less value in an already rather liquid market. This finding complements the results presented in Flemisch et al. (2009) in that it addresses directly the weather effect on Designated Sponsors.

Third, we investigate if more Designated Sponsors providing transaction services for a particular stock reduce execution costs more strongly than fewer Designated Sponsors would. The estimated coefficient on the number of Designated Sponsors is statistically significant and positive. Hence, the larger the number of Designated Sponsors, the larger is the injected XLM. This result is in line with our hypothesis that market makers have a favorable effect on liquidity.

Fourth, we examine the relation between trading volume and injected liquidity. This relation is statistically significant and negative, suggesting that the more liquid a stock, the less value Designated Sponsors add in providing liquidity.

Table 3.2: Weather Effect on Liquidity in Xetra: Fixed Effects Panel Regression

Daily trading volume is denominated in millions of Euros. Standard errors are given in brackets. Columns (1) and (2) address the weather effect on natural liquidity, with column (2) including trading volume as a control variable. Columns (3) and (4) analyze the weather effect on the total liquidity on the market (i.e. including the contribution of Designated Sponsors (DS)), with column (4) including trading volume as a control variable. Furthermore, column (5) presents the relationship between the number of Designated Sponsors and injected liquidity. ***, **, * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)
	XLM natural	XLM natural	XLM total	XLM total	XLM injected
(Constant)	3.456**	4.804***	13.995***	15.065***	-25.470***
	(1.525)	(1.532)	(.961)	(.965)	(1.355)
Vol class/1000	1.456***	1.456***	1.033***	1.033***	.422***
	(.018)	(.018)	(.012)	(.012)	(.010)
Sky cover	-.794***	-.776***	-.596***	-.581***	-.215***
	(.146)	(.146)	(.092)	(.092)	(.079)
Nr. of DSs					5.529***
					(.389)
Trading volume Mio. EUR		-.335***		-.266***	-.105***
		(.041)		(.026)	(.022)
Adj.R^2	0.520	0.522	0.640	0.641	.232
F-statistics	1573.748	1493.912	2576.932	2449.862	393.311

In essence, we test for the presence of a weather effect on liquidity in the electronic trading system Xetra at the Frankfurt stock exchange. Weather lends itself for an examination of patterns in liquidity since it is an economically exogenous variable not subject to data snooping (Roll (1992)), i.e. the hypotheses were not chosen to explain an established pattern in liquidity.

The empirical evidence suggests that sky coverage has a statistically significant influence on liquidity. Specifically, the cloudier the sky, the lower the transaction costs. On overcast days, market makers provide less liquidity than in sunshine. Overall, the more liquid a stock, the less value Designated Sponsors add in injecting liquidity.

3.5 Summary and Conclusions

This paper investigates the weather effect on liquidity in the electronic trading system Xetra at the Frankfurt stock exchange. While this phenomenon was first documented for stock returns, more recent studies find weather to influence liquidity in stock trading, potentially through moods and sentiments of market makers. The choice of the exchange liquidity measure XLM enables us to directly test for a weather effect on liquidity induced by market makers.

In fact, the empirical evidence suggests a significant weather effect on liquidity in Xetra. The more clouds in the sky, the lower are the execution costs, and the higher the liquidity. Interestingly, in such weather, market makers inject less liquidity than in sunshine. This could be due to market makers being more risk averse on overcast days, or it could result from high natural liquidity in the market so that market makers add less value. Analogously, the more liquid a stock, the less additional benefit the market maker provides.

The finding that cloudy skies correspond with high liquidity in Xetra is inconsistent with the results presented by Goetzmann and Zhu (2005) for the New York Stock Exchange. We suggest that future research further analyzes the weather effect on liquidity by extending the sample period and by providing international evidence. Furthermore, it should be tested whether trading strategies can be derived from these findings that are profitable net of transaction costs. In light of our results, investors should primarily trade in Xetra on overcast days.

4 Designated Sponsors on Xetra – Is One Designated Sponsor Enough?

Abstract

This paper tests for the impact of Designated Sponsors on liquidity in the electronic trading system Xetra at the Frankfurt stock exchange. By applying the Exchange Liquidity Measure XLM, we separate the natural liquidity in the order book from the liquidity provided by market makers.

The empirical results suggest that Designated Sponsors improve liquidity and that the increase in a number of Designated Sponsors improves liquidity further.

4.1 Introduction

Demsetz (1968) identifies the lack of “predictable immediacy of exchange in financial markets” as a fundamental trading problem that occurs because buyers and sellers arrival is not synchronized. As a result, there might be no counterparty at a time when liquidity is demanded. It is especially true for less liquid firms. Such trading uncertainty can be mitigated by the regular presence of a market maker. Garbade and Silber (1979) and Grossman and Miller (1998) look at the role of a market maker and demonstrate that market makers, through maintaining market presence, reduce temporary imbalances in order flow and lower investors’ price risks of delayed trade.

The role of market makers and their impact on market quality has received considerable attention in the area of financial market design. Other studies include Madhavan and Smidt (1993), Madhavan and Sofianos (1998), Madhavan and Panchapagesan (2000). It was demonstrated that when the limit orders are added to the market model as a competition to the market makers, the bid-ask spread is being reduced significantly; see Barclays,Christie,Harris,Kandel and Schulz (1999) who studied the introduction of limit orders to NASDAQ in 1997.

Electronic market structure does not eliminate the market making function, although it possibly modifies it. Few automated continuous markets function without some form of market making activity. Studies by Seppi (1997), Viswanathan and Wang (2002) and Parlour and Seppi (2003) demonstrated that designated dealers could increase the supply of liquidity offered by the public limit orders. Depending on the extend of the immediacy demands, often market making is encouraged by the exchanges, through agreements that impose obligations of posting two-sided quotes in return for some other benefits. In other cases, market-making activity arises endogenously and for-profit as a result of the demand for immediacy.

Market makers contribute to liquidity by enabling executions of orders that otherwise would have remained unexecuted. The empirical evidence on the correlation between participation rate of market makers and trading volume is mixed. Gerke and Bosch (1999) studied the role of Designated Sponsors on Xetra in the segment of Neuer Markt for small stocks. They found that the participation rate of Designated Sponsors in the trading volume is around 8.9% in 1998. They also found a negative correlation between the participation rate and volume. Madhavan and Sofianos (1998) analysed the specialist market on the NYSE and also found a negative correlation between trading volume and the rate of participation of the specialists in trading. On the contrary, Freihuber, Kehr, Krahnen and Theissen (1998) showed positive correlation between participation rate of the specialists on the floor-based trading platform of Frankfurt Exchange and the trading volume. This is explained by the competition of floor-based trading with trading in Xetra order book in the same stocks.

Taking into consideration that Designated Sponsors have some price setting latitude, their activities have potential impact on price volatility. It was shown that for the specialist-based model, specialist might increase volatility (Stoll and Whaley (1990)) or to reduce volatility (Madhavan and Panchapagesan (2000)) who based their analyses on NYSE. Freihuber, Krahnen and Theissen (2001) showed that a Makler on the Frankfurt Stock Exchange (FSE) Floor also decreases the price volatility. Venkataraman and Waisburd (2007) in the study of the Euronext order book showed that designated dealers contribute to the lower variability in returns and trading volume.

Microstructure theory suggests two arguments in favour of multiple market makers: a) competition argument (Glosten (1989), Bernhardt and Hughson (1997), Biais, Martimort and Rochet (2000), Biais, Glosten and Spatt (2005)) and b) “classic” inventory-sharing, (Stoll (1978); Ho and Stoll (1981, 1983)).

In quote-driven markets, the increase in number of market makers in the dealer market increases liquidity due to the introduced competition. Ho and Stoll (1983), Grossmann and Miller (1988) and Leach and Madhavan (1993) show the negative correlation between the number of market makers and spread. This is consistent with the competitive model of dealer pricing. The same results demonstrated Gerke and Bosch (1999) in the study of Neuer Markt stocks on the Xetra trading platform, the largest effect being seen in the increase of market makers from one to two and smaller effects with more than two market makers. They also showed that the spread to the large extent is explained by the market capitalisation. Bosch (2001) also reports a significantly positive correlation between the liquidity in a stock in Xetra and the number of market makers acting in it.

Menkveld (2007) on Euronext showed that the quoted spread decreased in relation to the number of designated market makers (DMM) with diminishing marginal effect (2% for one DMM to 1% for eight DMMs). This is consistent with the theory of competition among DMMs and the theory of risk sharing. The study of Bongard and Klar (2006) of Designated Sponsors on Xetra (stocks selections from MDAX, SMAX and NEMAX indices) while using spread data finds that trading with more than one Designated Sponsor reduces the order processing and inventory cost component of the spread. However, only having more than three Designated Sponsors significantly reduced the spread estimate at a level of 7%.

In order to examine how market makers contribute to the liquidity, we first present our hypotheses in section 4.2, before section 4.3 introduces some institutional details about the electronic trading platform Xetra. Section 4.4 explains the methodology and describes the dataset. The empirical results are presented and discussed in section 4.5, with section 4.6 concluding.

4.2 Testable Hypothesis

This paper tests for market maker contribution to liquidity on the German electronic trading platform Xetra at the Frankfurt Stock Exchange. Specifically, we raise four research questions.

First, we analyse the relation between natural liquidity and the stock specific variables like market capitalisation, trading volume, volatility and price. In light of Gerke and Bosch (1999), we hypothesise that natural liquidity is higher in the stocks with higher market capitalisations.

Second, we examine the effect of the presence of Designated Sponsors and total liquidity. We expect that market makers' contribution to liquidity is significant and it is more pronounced in the stocks with lower natural liquidity.

Third, we investigate the influence on liquidity of multiple market makers acting in one stock. In light of Bosch (2001) and Bongard and Klar (2006), who report a significantly positive correlation between the liquidity in a stock in Xetra and the number of market makers acting in it, we assume that injected liquidity rises with the number of market makers.

Finally, we study if market markers are particularly attracted to enter stocks with higher natural liquidity. This hypothesis aims to test whether Designated Sponsors have a preference to act as liquidity providers in more liquid stocks.

We contribute to the ongoing debate about the relation between market makers and liquidity by testing the liquidity provided by maker makers in the electronic trading system Xetra at the Frankfurt stock exchange. Rather than using bid-ask spread as a proxy for liquidity, we apply the exchange liquidity measure (XLM) introduced by Gomber et al. (2002). The construction of this variable enables us to distinguish between the effect on liquidity provided by the market maker, and the level of liquidity present in the market without the market maker's activities, i.e. natural liquidity.

4.3 Screen-based Stock Trading in Germany via Xetra

Xetra is a fully electronic open limit order book run by the German Stock Exchange, Deutsche Börse AG, in Frankfurt (Main)[13]. It started to operate in November 1997 and is currently open daily from 9.00am to 5.30pm. Continuous trading is interrupted by an opening, an intraday and one closing auction, which concentrate liquidity. Financial institutions, securities trading houses and brokers can participate in Xetra trading independently of their location. Trading in Xetra is anonymous, with a central counterparty (CCP) clearing the offsetting orders. On busy days, more than 2 million trades per day are executed in Xetra.

Tradable instruments are equities, certificates, warrants, exchange-traded funds, and subscription rights. Deutsche Börse groups many of these together in indices. The most prominent equity index is the German blue-chip index

[13] The information in this section is based on Deutsche Börse's website, http://deutsche-boerse.com, unless stated otherwise

DAX, comprising the 30 stocks with the largest market capitalisation. TecDAX consists of the 30 largest technology stocks that are not included in the DAX. In our sample period, 3% of total equities turnover was originated by TecDAX equities. Equities can be traded in all order sizes in Xetra, and orders are executed according to price-time priority.

Transaction fees are only charged for executed orders. These fees amount to 0.48 basis points, a minimum of 0.60 Euros and a maximum of 18.00 Euros per order. For example, an executed order of 1 million Euros costs 48.00 Euros in fees. Discounts are available for computer-generated orders, i.e. algorithmic trading. Xetra's function XetraBest ensures full and immediate execution at a price that is automatically better than the order book, and fixed clearing fees are waived.

Market Makers are called 'Designated Sponsors' and provide additional liquidity, especially in less liquid stocks, by offering binding quotes for both buys and sells. These quotes are required to have a certain maximum bid-ask spread and a certain minimum quote size. Banks and securities firms act as Designated Sponsors. During volatility interruptions, Designated Sponsors still enter quotes for their stocks. In principle, a Designated Sponsors can support more than one stock, and equally a stock can have several Designated Sponsors acting in it. Less liquid stocks can only be traded continuously if they have been adopted by at least one Designated Sponsor.

In addition to the function of providing liquidity, Designated Sponsors may offer listed companies additional services such as research reports, preparation of analyst presentations or active distribution of shares. Such services may be either paid for or free, but the Exchange does not regulate or intervene in this part of the relationship between Designated Sponsors and the issuers. As a benefit for Designated Sponsors, Deutsche Börse waves transaction fees (trading and clearing fees), subject to full compliance with the performance requirements.

Designated Sponsors' quoting must satisfy certain performance requirements stipulated by Deutsche Börse AG with respect to the trading characteristics of the respective security (e.g. its Exchange Liquidity Measure). These criteria include: minimum quote size (smallest, permissible number of stocks on buy and sell side); maximum bid/ask spread of the quotes (largest permissible spread between bid- and ask limit); reaction time parameters (i.e. in answering a quote request); participation rules (i.e. percent of the time to be present in the order book). For example, TecDAX stocks require minimum quote size at 20,000EUR, and the maximum spread is no more than 0.10EUR if the stock price is below 1 EUR; for the price from 1 EUR to 2 EUR it is 10% and from the price of 2 EUR to 5.60 EUR it is maximum 0.20 EUR. Above 5.60EUR the spread is set not more than 2,5%.

Designated Sponsors may resign as a whole or with respect to specified securities by submitting a written notice. Five exchange days after the receipt of such notice, the Designated Sponsor shall no longer be authorized or obliged to supply quotes for the securities concerned.

4.4 Methodology and Data

An examination of the market maker effect on liquidity requires defining a variable that captures liquidity. We use the Exchange Liquidity Measure XLM (Gomber et al. (2005)), which measures the cost of a roundtrip trade dependently on order size. The German Stock Exchange has been calculating XLM based on all information in the order book, i.e. including the hidden part of iceberg orders, for all stocks traded continuously in Xetra since July 2002. XLM therefore provides a more comprehensive analysis of transaction costs than the bid-ask spread.

Constructing XLM starts with the weighted average price P at which an order of a given size V can be settled immediately, separately for buys (B) and sells (S). The execution cost, denoted in basis points[14], is then

$$XLM_{B,t}(V) = 10{,}000\frac{P_{B,t}(V) - M_t}{P_{B,t}(V)} \quad \text{and} \quad XLM_{S,t}(V) = 10{,}000\frac{M_t - P_{S,t}(V)}{P_{S,t}(V)}$$

[14] 100 basis points equal 1 percent.

for buys and sells, respectively, with M_t being the quote midpoint at time *t*. Adding these up yields the cost of the roundtrip transaction,

$XLM_t(V) = XLM_{B,t}(V) + XLM_{S,t}(V)$ .The higher are the transaction costs, the higher is XLM, and the lower is the liquidity.

This liquidity variable XLM comes in two flavours. Natural XLM measures the liquidity in the market without that provided by market makers. Total XLM, by contrast, includes that part of liquidity that is injected into the order book by market makers. Thus, this choice of liquidity variable enables us to test directly for the effect of market makers on liquidity. Because XLM captures transaction costs and these are inversely related to liquidity, total XLM is smaller than natural XLM. In other words, the presence of market makers reduces execution costs. The XLM data are based on hypothetical order sizes of 10,000 EUR, 25,000 EUR, and 50,000 EUR, which are included in the regression as volume classes.

Deutsche Börse AG provided daily XLM, trading volume data, open, high, low and close stock price for all TecDAX stocks for the two-year period from 1 January 2004 to 31 December 2005. This dataset includes natural and total liquidity, so that the liquidity injected by market makers can be derived. We include in our sample 16 stocks that belonged to TecDAX for at least two consecutive months in our sample period and for which at least one Designated Sponsor was acting.

We eliminated the stocks with the significant non-stationary mean or stocks with visible shocks or discontinuity. We believe this coincide with the entry or exit from TecDAX or other company specific behaviour. This results in a dataset with 24,666 observations for all parameters. We also received the information on the changes in the Designated Sponsors over 2004-2005 periods, including a date of change. Overall, we have at different times 8 stocks with 1 DS, 10 stocks with 2 Designated Sponsors, 6 stocks with 3 Designated Sponsors, 3 stocks with 4 Designated Sponsors and 1 stock with 5 Designated Sponsors. Over time of the study, several stocks started with a larger number of Designated Sponsors but the number decreased over time.

Table 4.1 presents summary statistics on our dataset.

Table 4.1: Summary Statistics
This Table reports for the cross section of instruments of the TecDAX means and standard deviations for the average daily volume in million EUR, for the XLM natural and XLM total in basis points. XLM mean is calculated for all three-volume classes of 10,000 EUR, 25,000 EUR, and 50,000 EUR.

	XLM natural in basis points		**XLM total in basis points**		**Avg. daily volume in Mio. EUR**	
Instrument	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
AIXTRON	99.68	39.17	95.24	35.54	1.28	1.55
DRAEGERWERK	72.98	37.67	62.10	22.35	1.38	1.53
ELMOS SEMICON.	129.83	95.05	81.01	28.21	.65	.84
EVOTEC	205.62	120.03	185.4	91.88	.39	.45
FREENET.DE	44.84	15.65	44.04	14.59	4.97	4.42
GPC BIOTECH	94.34	46.50	81.80	30.43	1.57	2.70
IDS SCHEER	97.31	50.67	86.28	33.79	.70	.62
JENOPTIK	83.88	41.67	73.71	31.52	1.18	1.00
KONTRON	84.83	44.92	76.72	31.76	.99	.97
MOBILCOM	37.36	13.06	37.34	13.02	7.03	5.52
PFEIFFER	113.46	82.86	89.12	44.52	.54	.51
QIAGEN	40.51	15.48	40.10	14.64	4.31	3.36
SINGULUS TECH.	54.45	22.08	50.38	17.51	2.23	2.24
SOFTWARE	55.98	38.48	48.62	20.50	2.89	2.66
T-ONLINE INT.	27.14	11.11	26.76	10.70	13.70	27.60
UTD.INTERNET	52.88	27.16	50.04	21.63	2.87	2.55

Previous research shows that the liquidity is a function of price, volume and volatility, see for example Stoll (2000). It was shown in Benston and Hagerman (1974) and, most recently, by Theissen (1998) for study of Neuer Markt stocks that the bid-ask spreads are strongly influenced by trading volume and market capitalisation. A similar relationship is expected for XLM as well. Therefore, we gather data on free float, number of shares issued and the resulting market capitalisation.

Using the approach developed in Theissen (1998) for the definition of determinants of bid-ask spread, in the regression analysis of liquidity we use the variables of the **logarithmic market capitalisation**, number of DSs and trading volume. In order to avoid risks of **multicollinearity**, in the regression we will use the trading volume as a **Turnover-Ratio defined as the ratio of trading volume and market capitalisation**. There is no significant correlation between market capitalisation and turnover-ratio. We calculate **Volatility** as difference between daily highest price minus lowest price divided by close price and we take a logarithm of this. **Volume Class** represents the size of the hypothetical order that is sent to the order book in order to measure XLM. To see the results more clearly, we divide Volume Class by 1000.

Model (1)

$$XLMnatural_i = \alpha + \beta_1 Turnover\ Ratio_i + \beta_2\ Log\ Volatility_i + \beta_3\ Log\ Markcap_i + \beta_4 Volume\ Class_i + \beta_5 Price_i$$

Further, we study empirically whether the presence of Designated Sponsors and the quantity of Designated Sponsors that a firm hires matters for liquidity supply. To study the total liquidity or the XLM value that is calculated taking into consideration the presence of Designated Sponsors in the order book, we use the same variables as above but add the number of Designated Sponsors as an explanatory variable.

Model (2)

$$XLMtotal_i = \alpha + \beta_1 Turnover\ Ratio_i + \beta_2\ log\ Volatility_i + \beta_3\ log\ Markcap_i + \beta_4\ Volume\ Class_i + \beta_5 Price_I + \beta_6\ NumberDSs_I$$

Natural XLM de facto stands for the case of trading with no Designated Sponsors contributing to liquidity. This would mean that the total XLM could be also explained by using natural XLM as an explanatory variable. The new model (3) looks as follows:

Model (3)

$XLMtotal_i = \alpha + \beta_1\ Volume\ Class_i + \beta_2\ NumberDSs_I + \beta_3\ mean\ XLM\ natural_i$

The natural XLM dataset could have several problems related to autocorrelation within 1 stock and different stock-specific development. The first model shows significant heteroskedacity in the residuals. To overcome this problem, we calculated XLM mean as a mean of all daily XLMs for a specific stock over the 2 years time period. The new model shows significantly improved histogram. The introduction of XLM mean also reduces the impact of any stock specific development.

Model (4) modifies the model (3) in such that it tests for the change in total XLM due to the increase in the number of Designated Sponsors. We use the dummy variables 2DSs, 3DSs and 4DSs.

Model (5) studies the question if designated Sponsors are particularly attracted to enter the stocks with higher natural liquidity. To study this, we construct a model in which the variable Nr of DSs becomes a dependant variable:

Model (5)

$NumberDSs_I = \alpha + \beta_1 Turnover\ Ratio_i + \beta_2\ log\ Volatility_i + \beta_3\ log\ Markcap_i + \beta_4\ Price_i + \beta_5\ mean\ XLM\ natural_i$

4.5 Empirical Results

The primary goal of this paper is to determine market maker effects on liquidity in the electronic trading system Xetra at the Frankfurt stock exchange. The choice of the XLM measure for liquidity enables us to test directly for the influence of market makers and multiple market makers on injected liquidity. Table 4.2 presents the empirical results.

First, we test the link between natural liquidity and stock-specific factors like market capitalisation, trading volume, price and volatility. Natural liquidity is the level of liquidity in the market without any contribution by market makers. In Model (1) we see that the share price has very small explanatory power. The market capitalization has highest explanatory value and is inversely related with cost of liquidity. Turnover ratio is also inversely related to XLM. Volatility also has significant explanatory power. The remaining part of natural XLM should be explained by other stock-specific factors as well as general market conditions. This empirical result is consistent with the findings of Gerke and Bosch (1999) that showed that liquidity is higher in the stocks with higher market capitalisations.

Second, we examine the effect of the presence of Designated Sponsors and total liquidity. We expect that market makers' contribution to liquidity is significant. In the Model (2) in Table 4.2, we see that his relation is statistically significant and negative, implying that the higher is total liquidity, the lower the liquidity contribution by market makers. This result is confirmed in the Model (3) that tests for the relation between total XLM and natural XLM in combination with the number of Designated Sponsors as explanatory variables. This result is in line with our hypothesis that market makers have a favourable effect on liquidity.

Moreover, we investigate if more Designated Sponsors acting for a particular stock reduce execution costs more strongly than fewer Designated Sponsors would. The estimated coefficient on the number of Designated Sponsors is statistically significant and negative. Hence, the larger the number of Designated Sponsors acting for one particular stock, the lower the total XLM. This result is in line with our hypothesis that more market makers have a favourable effect on liquidity. In Model (4) we see that especially the increase to three Designated Sponsors significantly increases the liquidity. The result is consistent with Bosch (2001) and Bongard and Klar (2006), who report a significantly positive correlation between the liquidity in a stock in Xetra and the number of market makers acting in it. Our results also confirm Bongard and Klar (2006) findings that having three Designated Sponsors significantly increase liquidity. In Appendix 4.1 we provide an alternative model for testing the impact of multiple Designated Sponsors. This model also confirms the most significant increase in liquidity with three Designated Sponsors.

Finally, we examine the relation between the number of Designated Sponsors and the natural liquidity of a stock. We assumed that Designated Sponsors might be attracted more to act in stocks with higher natural liquidity.

Table 4.2: Regression Results

Std. errors in brackets; *** denotes statistical significance at 1% level

	(1)	(2)	(3)	(4)	(5)
	XLM natural	XLM total	XLM total	XLM total	Nr of DSs
(Constant)	251.112*** (3.381)	204.186*** (2.511)	20.351*** (.367)	19.200*** (.252)	3.605*** (.058)
log Turnover ratio	-77.332*** (.732)	-59.001*** (.526)			.582*** (.013)
log Volatility	91.456*** (1.240)	76.142*** (.859)			-.395*** (.021)
log Markcap	-97.290*** (1.016)	-66.932*** (.701)			-.180*** (.018)
Volume Class/1000	1.521*** (.018)	1.071*** (.013)	.062*** (.008)		
Price (close)	-.288*** (.022)	-.464*** (.016)			-.018*** (.000)
Number DSs		-3.000*** (.261)	-2.749*** (.133)		
XLM natural mean			.667*** (.002)	.672*** (.002)	-.001*** (.001)
2 DSs				-2.694*** (.279)	
3 DSs				-8.680*** (.320)	
4 DSs				-.708 (.545)	
Adj. R^2	0.565	0.610	.861	.862	0.167
F-statistics	6004	6029	50920	38468	1162

However, it is possible that here the problem or endogeneity or two-way causality may exist between dependent (number of Designated Sponsors) and independent (XLM natural) variables. This implies that the regression coefficient in OLS regression is biased and it is better to use instrumental variable regression instead of OLS The endogeneity problem is particularly relevant in the context of time series analysis of causal processes. It is common for some factors within a causal system to be dependent for their value in period N on the values of other factors in the causal system in period N-1. An OLS regression was performed to examine the explanatory power of natural XLM and the number of Designated Sponsors and the residuals were stored. The Pearson correlation of the error term with natural XLM and number of Designated Sponsors was calculated and no significant correlation was found. The explanatory variable is not correlated with the error term. It means that we can use OLS regression.

In Model (5) we see that adj. R^2 is only 16.7%. The largest explanatory effect lies with turnover ratio and it is positively correlated to the number of Designated Sponsors. Interestingly, market capitalisation is negatively correlated with the number of Designated Sponsors. Thus, we conclude that there is no evidence that Designated Sponsors are particularly attracted to select stocks with high market capitalisation or high natural liquidity. There are clearly a lot of other factors that should explain the decision of Designated Sponsors to enter an instrument, being for example a private compensation by the issuer, other strategic reasons of gaining issuer corporate banking business, etc.

This is consistent with the Designated Sponsor model run at the Deutsche Boerse AG (see Appendix 4.2 for details). Most Designated Sponsors enter a stock because of other reasons. For example, Makler at Frankfurt Stock Exchange Floor becomes a Designated Sponsor on Xetra usually in the same stocks in which he is a monopolistic specialist in order to have more cost effective off-setting of his positions. Thus, he is not guided by the desire to be in more liquid stocks. Another category of Designated Sponsors enter the stock as a package offered to issuers, which includes IPO services, corporate banking and so on. In the times of a significant number of IPOs, many banks decide to become Designated Sponsors in order to demonstrate their ability and use it as an argument to win new coming issuers that plan an IPO. So, this type of Designated Sponsor also does not enter a stock for liquidity reasons. Only a third category of Xetra members become Designated Sponsors for the reasons of cost benefits of this function for their trading strategies. These members usually run proprietary trading across several exchanges and, depending on their strategies, most likely will be interested in a relatively liquid stock.

4.6 Summary and Conclusions

This paper investigates the market marker effect on liquidity in the electronic trading system Xetra at the Frankfurt stock exchange. While the contribution of market makers to liquidity was first documented for dealer (quote-driven) markets, more recent studies find market makers to influence the liquidity in the order-driven markets as well. The choice of liquidity measure enables us to directly test for an effect on liquidity induced by market makers.

In fact, the empirical evidence suggests a significant market maker effect on liquidity in Xetra. The more Designated Sponsors in a stock, the lower the execution costs, and the higher the liquidity.

In line with other studies we see that the presence of Designated Sponsors in the order book improves liquidity and decreases total XLM. We also see that the increase from one to more Designated Sponsors in a stock brings further benefits to liquidity. Especially large improvement is achieved in the move to three Designated Sponsors. Consistent with expectations, Designated Sponsors contribute more to the liquidity in the larger order sizes (i.e. volume classes).

The study did not confirm that Designated Sponsors are attracted to more liquid stocks, at least in our sample of TecDAX. Nevertheless, we believe that such result is consistent with the Designated Sponsor model run on Xetra. It is because Designated Sponsors enter a stock for the variety of other reasons than just liquidity. Also, Deutsche Boerse AG separates very liquid stocks into a separate category for which the presence of Designated Sponsors is not required in order to be included in the continuous trading on Xetra. It is based on the experience that liquidity providers do not improve liquidity in very liquid stocks.

We suggest that future research further analyses the multiple market maker effect on liquidity by extending the sample of stocks to small-caps (SDAX, etc) or extending the sample period. Furthermore, it should be tested whether trading strategies can be derived from these findings that are profitable net of transaction costs. In light of our results, lower transactions costs could be observed in stocks with multiple market makers.

Appendix 4.1: Alternative Model for Testing the Impact of Multiple Designated Sponsors

Table A4.1: Alternative Model for Impact of Multiple DSs

Std. errors in brackets; *** denotes statistical significance at the 1% level

	(1)	(2)
	XLM Total/ 1,2 or 4 DSs	XLM Total/ 1,3 or 4 DSs
(Constant)	10.400*** (.278)	16.377*** (.235)
XLM natural mean	.672*** (.002)	.672*** (.002)
1 DS	9.000*** (.319)	3.023*** (.280)
2 DSs	6.125*** (.309)	
3 DSs		-5.849*** (.310)
4 DSs	8.107*** (.506)	2.121*** (.539)
Adj. R^2	.862	.862
F-statistics	38578	38511

In Model (1) we see that:

- total XLM with one DS is equal 20.072 bp
- total XLM with two DSs is already lower at 17.197 bp.

Similarly, in Model (2) we see that:

- total XLM with one DS is equal 20.072 bp
- total XLM with 3 DSs is lower at 11.2 bp.

We see that the largest gains for liquidity are achieved with three Designated Sponsors. Having four Designated Sponsors does not improve situation further.

Appendix 4.2: Types of Designated Sponsors and their Motivation

Stock Exchanges often offer trading incentives to market makers in the order book. We believe that these incentives often serve as one of the reasons for market makers to take a stock. We can identify several types of motivation of trading firms to become Designated Sponsors on Xetra:

a) Proprietary traders: proprietary trading firms that execute their trading strategies in certain instruments or indices could benefit by acting as Designated Sponsor in related stocks by reducing transaction fees

b) Makler offsetting positions: the Maklers on the Frankfurt Stock Exchange Floor trading act as monopolistic specialists in the same stocks that are traded on Xetra, an electronic order book. Maklers usually service small orders, which often represent retail trading. To minimize their inventory risks, Maklers prefer to offset their positions by parallel trading on Xetra. To do so, a Makler might want to benefit from reduced transaction costs on Xetra acting as Designated Sponsors.

c) Corporate banking: many banks try to win corporate banking deals from listed firms by offering them full service packages including liquidity provision, analyst coverage, etc. This might be done for a defined fee or free-of-charge and subject to other business delivered to the bank. Such firms act as Designated Sponsors not to complement their trading strategies but simply to provide promised services. It is possible that such firms take especially “reserved” or low risk liquidity provision strategy by which they fulfil all Designated Sponsors obligations set by the Exchange but aim to avoid being executed. Such behaviour can be a large contributor to the overall very low Designated Sponsors execution ratio (Gerke and Bosch (1999)) showed that in Neuer Markt stocks in 1998 Designated Sponsors execution ratio was 8.9%. TecDAX is a later index that was created on the basis of Neuer Markt).

5 How Do Trading Costs Vary Across the Day?

A note on the innovative XLM measure for Small Caps at the Frankfurt Stock Exchange[15]

Abstract

This paper provides empirical evidence on the intraday pattern of trading costs for German small cap stocks in the electronic trading system Xetra at the Frankfurt Stock Exchange. Theoretical papers draw ambiguous conclusions as to whether trading costs should increase or decrease with concentrated liquidity, and there is only very limited empirical evidence on intraday execution costs for stock trading in Germany. We investigate the XLM variable, which is a more comprehensive measure of trading costs than conventional indicators such as the bid-ask spread or trading volume. The empirical evidence for the TecDAX stocks under investigation suggests a reverse-J shaped intraday profile for execution costs. Thus, trading is most expensive in the first 30 minutes after Xetra opens, and it is cheapest at the time when the NYSE starts trading. We conclude that cross-border integration of stock exchanges fosters market quality.

[15] The earlier version of this paper is under submission to International Review of Financial Analysis co-authored by Christiane Goodfellow and Dirk Schiereck.

5.1 Introduction

Market microstructure theory predicts the presence of intraday patterns in the bid-ask spread, trading volume, and stock return volatility (Admati and Pfleiderer (1988), Brock and Kleidon (1992), Madhavan et al. (1997)). In fact, numerous studies provide empirical evidence of different intraday seasonalities on different trading platforms (e.g. Abhyankar et al. (1997) for the London Stock Exchange, Foster and Viswanathan (1990) for the New York Stock Exchange, Chan et al. (1995) for Nasdaq stocks, or Hamao and Hasbrouck (1995) for the Tokyo Stock Exchange). This finding has two implications. First, trading costs vary across the day, which is directly relevant to investors. Second, it confirms that the institutional design of a trading platform affects trading quality and is therefore of interest to exchanges that are, in principle, competing for trading volume.

We test for the presence of intraday regularities of liquidity for small cap stocks in the electronic trading system Xetra at the Frankfurt Stock Exchange. Unlike most previous studies investigating trading volume or the spread as proxies for liquidity, we examine liquidity directly by studying the exchange liquidity measure (XLM) introduced by Gomber et al. (2005). This variable captures real-time order book execution situations by sending hypothetical orders to the order book at every minute of trading. In contrast to previous studies, we focus on TecDAX stocks, the 30 largest technology stocks that are not included in the DAX, and we investigate the intraday patterns for the current opening hours of Xetra.

Admati and Pfleiderer (1988) develop a model with uninformed liquidity traders and informed traders who act based on private information. While liquidity traders have to trade a certain amount for their liquidity or portfolio balancing needs, they have some discretion over when exactly to place their orders. It is most advantageous for them to trade at times of heavy trading activity, when their orders do not influence the price and can be settled immediately and cheaply. As a result, liquidity trading is concentrated at certain times of the day. These are also preferred trading times for informed traders. If they share the same private information, competition among these informed traders is beneficial for liquidity traders, leading to further concentration of liquidity. If informed traders with diverse private information enter the market, prices become more informative, from which also liquidity traders benefit. Even then is it advantageous for liquidity traders to concentrate their activities. Admati and Pfleiderer (1988) further show that these periods of concentrated trading have higher stock return volatilities than times with lower trading volume. Heavy trading at the open and close of a stock exchange could be initiated by nondiscretionary liquidity traders, as they cannot trade either beforehand or afterwards. This trading behaviour of uninformed and informed traders results in observed intraday patterns.

In summary, Admati and Pfleiderer (1988) find high-volume periods to be caused by comparatively low transaction costs. In this model, transaction costs only arise as liquidity traders pay the profits of informed traders. Subrahmanyam (1991) extends the Admati and Pfleiderer (1988) model by introducing risk-averse informed traders. As these enter the market, liquidity reduces, with trading costs rising. Discretionary liquidity traders will be dropping out of the market to avoid the increased trading costs, leaving the market to nondiscretionary traders and informed traders. For both these types of market participants, the motives for trade lie outside of the model. Madhavan (1992) adds that the number and size of trades also affect the spread, rather than just trading volume. For a given volume, a stock with a few large trades has a wider spread than a security with many small trades.

Brock and Kleidon (1992) extend the Merton (1971) model by allowing stock trading to periodically stop (at the close of the exchange) and resume (at the open of the exchange), and they apply their theoretical findings to the New York Stock Exchange (NYSE). In this model, trading volume increases at the open and close, and prices become less elastic. At the open, investors rebalance their portfolios taking into account information that only became available over night, when trading was impossible. Similarly, before trading stops for the night, portfolio compositions will be different compared to earlier in the day when trading remains possible. For example, in order to limit overnight exposure, traders tend to close out positions before the exchange shuts for the day. The intuition for less elastic prices is that the monopolist specialist at the NYSE will widen the spread in times of higher trading demand. Grossman and Miller (1988) argue that spreads are larger during high-volume periods even if there is competition among the market makers. This conclusion is at odds with Admati and Pfleiderer (1988).

Madhavan et al. (1997) derive a structural model that explains intraday variations in price volatility and spreads. Information flow and trading frictions are found to be the key contributors to intraday patterns. Information asymmetry decreases during the day as market makers learn from the order flow (Madhavan (1992)) and as overnight information is incorporated in security prices. By contrast, inventory costs increase during the day as dealers face costs from holding inventory over night. Order processing costs are independent of the time of day. The regularities in these three spread components explain that spreads are highest in the morning, decrease during the day and increase again slightly at the end of the trading day.

Empirical studies for the NYSE find reverse J-shaped patterns (e.g. McInish and Wood (1992), Foster and Viswanathan (1993), Lee et al. (1993)) in the bid-ask spread, which is a proxy for the implicit transaction costs. This result does not necessarily apply to the electronic trading platform Xetra at the Frankfurt Stock Exchange, since the latter is an anonymous open limit order book, while the NYSE has a specialist.

In fact, the empirical evidence for electronic trading at the Frankfurt Stock Exchange suggests a U-shaped intraday pattern for roundtrip transaction costs for DAX and non-DAX stocks (Gomber et al. (2005), Wuensche et al. (2007))[16]. On 3 November 2003, the Frankfurt Stock Exchange brought forward its closing time from 8.00 pm to 5.30 pm. The sample period in Gomber et al. (2005) is August 2002 and thus before the Frankfurt Stock Exchange brought forward its closing time. At that time, transaction costs only started rising after 5.30pm. Gomber et al. (2005) argue that institutional investors closed their positions just before the exchange shut for the night, thereby raising transaction costs between 5.30 pm and 8.00 pm. Wuensche et

[16] Kopp et al. (2008) also investigate intraday data from Xetra. However, their study focuses on factors determining liquidity rather than an intraday pattern of execution costs.

al. (2007), by contrast, examine January to March 2004, when Xetra closed at 5.30 pm. They attribute the U-shape in the spread for the 30 DAX stocks to higher adverse selection and order processing costs in the morning and to higher order processing costs shortly before 5.30 pm.

In essence, there are contradicting theories regarding the intraday pattern of trading costs. Empirical evidence for the German electronic trading platform Xetra is limited. While Wuensche et al. (2007) examine intraday regularities of the bid-ask spread of the 30 most liquid Xetra stocks, we focus on the more comprehensive liquidity measure XLM and study 30 less liquid, more volatile stocks constituting the TecDAX index. The empirical results of Gomber et al. (2005) regarding the intraday pattern of execution costs are somewhat out of date as the Frankfurt Stock Exchange has since changed its opening hours. We overcome these shortcomings and contribute empirical evidence on four testable hypotheses.

In order to examine how trading costs vary across the day, we first present our hypotheses in section 5.2, before section 5.3 introduces some institutional details about the electronic trading platform Xetra. Section 5.4 explains the methodology and describes the dataset. The empirical results are presented and discussed in section 5.5, with section 5.6 concluding.

5.2 Testable Hypothesis

This paper tests for intraday patterns of execution costs on the German electronic trading platform Xetra at the Frankfurt Stock Exchange. Specifically, we raise four research questions.

First, we test whether transaction costs in Xetra follow a reverse J-shape, as found for the NYSE (McInish and Wood (1992), Foster and Viswanathan (1993), Lee et al. (1993)), or a U-shape, as discovered for Xetra (Wuensche et al. (2007), Gomber et al. (2005)), or neither.

Second, we examine the impact of the opening of US trading on Xetra transaction costs. Gomber et al. (2005) find the start of futures trading in Chicago and the opening of the NYSE to drop liquidity in Xetra. Similarly, Giot et al. (2002) show that the spread in Xetra increases just before trading starts in the US[17].

Third, we investigate intraday patterns of order book imbalances in Xetra. Ranaldo (2004) finds order book imbalances at the Swiss Exchange in Zürich to vary across the trading day. In particular, soon after the opening, a large number of buy orders is submitted, while sellers appear to lag behind by about an hour but subsequently provide a more stable level of liquidity during the day.

Fourth, we study execution possibilities across the day by counting the number of minutes when full order execution was possible. This is closely related to the third hypothesis as large order book imbalances imply limited execution possibilities.

We contribute new empirical evidence in several ways. First, the liquidity variable XLM is a more comprehensive measure of implicit transaction costs than trading volume or the bid-ask spread. Second, our sample period runs from 25 May 2006 to 23 June 2006 and thus falls into the shorter Xetra opening hours. Finally, we examine the 30 stocks constituting the TecDAX index, a mid-cap index of companies in technology sectors, rather than the most liquid 30 DAX stocks.

5.3 Screen-based Stock Trading in Germany via Xetra

Xetra is the fully electronic screen-based trading platform run by the German Stock Exchange, Deutsche Boerse AG[18]. It is organised as an anonymous open limit order book and started to operate in November 1997. It is currently open daily from 9.00 am, i.e. after the opening auction, to 5.30 pm, followed by the closing auction. Continuous trading is interrupted by an intraday auction (1.00 pm to 1.01 pm). Financial institutions, securities trading houses and brokers can participate in Xetra trading independently of their location. Trading in Xetra is anonymous, with a central counterparty (CCP) clearing the

[17] We could further test for the effect of the lunch break on liquidity. The intuition behind this is that when traders are at lunch, they will inject less liquidity into the market than when they are at their desks. However, it is impossible to determine when exactly traders go to lunch. Moreover, the order book is balanced at the midday auction at 1.00 pm.

[18] This section is based on Deutsche Börse's website, http://deutsche-boerse.com, and on Goodfellow et al. (2010). A few passages have been taken from that paper.

offsetting orders[19]. On busy days, more than 2 million trades are executed in Xetra per day.

Tradable instruments are primarily equities, certificates, warrants, exchange-traded funds, and subscription rights. Equities can be traded in all order sizes in Xetra, and orders are executed according to price-time priority. The German stock exchange groups many of these together in indices. The most prominent equity index is the German blue-chip index DAX, comprising the 30 stocks with the largest market capitalization.

This study focuses on TecDAX stocks, the 30 largest technology stocks that are not included in the DAX. In our sample period, 3% of total equities order book turnover was originated by TecDAX equities (Deutsche Börse (2006)). The limited liquidity levels in these stocks enable us to report empirical evidence beyond previous studies.

Market Maker activities are provided by so-called 'Designated Sponsors' who offer additional liquidity and transaction opportunities, especially in less liquid stocks, by offering binding quotes for both buys and sells. These quotes are required to have a certain maximum bid-ask spread and a certain minimum quote size. Banks and securities firms act as Designated Sponsors. In principle, one Designated Sponsors can support several stocks, and equally a stock can have several Designated Sponsors acting in it. Less liquid stocks can only be traded continuously if they have been adopted by at least one Designated Sponsor.

Transaction fees are only charged for executed orders. These fees amount to 0.48 basis points, a minimum of 0.60 Euros and a maximum of 18.00 Euros per order. Discounts are available for computer-generated orders, i.e. algorithmic trading. Xetra's function XetraBest ensures full and immediate execution for private investors' orders at a price that is automatically better than the order book, and fixed clearing fees are waived.

For stocks to be allowed to trade continuously, they have to be liquid according to two criteria. First, the average liquidity is measured with XLM, based on a 25,000-Euro order size, and has to be 100 basis points or less.

[19] See Grammig et al. (2001) and Hachmeister and Schiereck (2010) for effects of anonymity on market liquidity in the German stock market.

Second, the average daily trading volume has to be at least 2.5 million Euros. Stocks that satisfy these two criteria are automatically admitted into continuous trading. Stocks that fail either criterion require at least one Designated Sponsor in order to be allowed to participate in continuous trading. Otherwise, the stock can trade in auctions only.

5.4 Methodology and Data

In order to capture liquidity, we focus on the Exchange Liquidity Measure XLM (Gomber et al. (2005)), which measures the cost of a roundtrip trade dependently on order size. The German Stock Exchange has been calculating XLM based on all information in the order book, i.e. including the hidden part of iceberg orders, for all stocks traded continuously in Xetra since July 2002. XLM therefore provides a more comprehensive analysis of liquidity costs than the bid-ask spread.

Constructing XLM starts with the weighted average price P at which an order of a given size V can be settled immediately, separately for buys (B) and sells (S). The execution cost, denoted in basis points, with 100 basis points = 1%, is then

$$XLM_{B,t}(V) = 10{,}000\frac{P_{B,t}(V) - M_t}{P_{B,t}(V)} \quad \text{and} \quad XLM_{S,t}(V) = 10{,}000\frac{M_t - P_{S,t}(V)}{P_{S,t}(V)}$$

for buys and sells, respectively, with M_t being the quote midpoint at time t. Adding these up yields the cost of the roundtrip transaction. The higher are the transaction costs, the higher is XLM, and the lower is the liquidity.

$$XLM_t(V) = XLM_{B,t}(V) + XLM_{S,t}(V)$$

This liquidity variable XLM comes in two flavours. Natural XLM measures the liquidity in the market without that provided by market makers. Our study is based on this variable. Total XLM, by contrast, includes that part of liquidity that is injected into the order book by Designated Sponsors. Because XLM captures transaction costs and these are inversely related to liquidity, total XLM is smaller than natural XLM. In other words, the presence of market makers reduces execution costs. The XLM data are based on hypothetical order sizes of 10,000 EUR and 25,000 EUR and are calculated every minute during the trading day.

Unlike previous studies that focus on the most liquid stocks, we examine liquidity for TecDAX stocks across 22 trading days from 25 May 2006 to 23 June 2006. These data were obtained from Deutsche Börse AG. The TecDAX index consists of 30 mid-cap stocks. During the sample period, one stock was replaced in the index. In order for the sample to be consistent across the period under investigation, we omit these two stocks from the analysis (i.e. the stock that left the index and the stock that replaced it), resulting in a dataset with 28 stocks continuously in the TecDAX.

The dataset contains the following information for hypothetical order sizes of 10,000 EUR and 25,000 EUR in each minute: measures of full execution possibilities (partial execution possibilities are ignored), XLM for natural liquidity (i.e. without the contribution by Designated Sponsors), and a buy or sell indicator. Each trading day consists of 8.5 trading hours, thus 510 minutes, less two minutes of intraday auction. The maximum number of data entries per day is therefore 5102=508 for the sell and equally 508 for the buy side, totalling 1,016 entries.

The first research question revolves around intraday regularities of execution costs in Xetra. In order to investigate these, we analyse the natural XLM measure. This variable captures trading costs without the liquidity contribution by Designated Sponsors and is denominated in basis points. A reverse J-shape pattern in execution costs is therefore equivalent to low liquidity at the beginning of the trading day, continuous increasing liquidity during the day, and liquidity remaining stable towards the end of trading. A reverse J-shape pattern further implies no particular effect of closing on liquidity. In other words, liquidity is higher in the afternoon than in the morning, with no spike at the end of the trading day similar to that immediately after the opening. We further test whether different volume classes of XLM follow the same reverse J-shape intraday pattern.

Based on the natural XLM data in the dataset, we calculate the variable MeanXLM as the average XLM for each stock in either volume class on both sides of the order book across the entire sample period. Further, we calculate the variable DiffXLM, which is the difference between the XLM data point in the original dataset and the MeanXLM for the same stock, order size and side of the order book. DiffXLM thus measures the variation of natural XLM relative to its average across the 22 trading days under investigation. A negative DiffXLM means that natural XLM was below its average for a particular minute and stock. We use DiffXLM per minute as the dependent variable in the regression analysis to test for intraday patterns in liquidity. We further construct three dummy variables to capture the trading time: D_{open} = 1 for all trades from 9.00 am to 9.29 am and zero otherwise. Similarly, D_{NYSE} = 1 for all trades from 3.30 pm to 3.59 pm and zero otherwise. Finally, D_{close} = 1 for all trades from 5.00 pm to 5.29 pm and zero otherwise.

In order to test for the presence of intraday regularities in execution costs in Xetra, we estimate the regression model (1):

$$DiffXLM_t = \alpha + \beta_1 D_{open,t} + \beta_2 D_{NYSE,t} + \beta_3 D_{close,t} + \varepsilon_t \quad (1)$$

with t denoting trading time in minutes. This analysis is thus carried out for each of the 28 stocks in the sample, for each order size (10,000 EUR and 25,000 EUR), and for both the ask and bid sides of the Xetra order book. Because DiffXLM is the difference between the individual XLM observations and their mean MeanXLM, DiffXLM is zero on average. We therefore also estimate regression (2) without the intercept α, resulting in the model specification:

$$DiffXLM_t = \beta_1 D_{open,t} + \beta_2 D_{NYSE,t} + \beta_3 D_{close,t} + \varepsilon_t \quad (2)$$

The coefficient β_1 captures the effect of the opening of Xetra at 9.00 am on the XLM liquidity measure, while the coefficient β3 indicates the impact of the closing time of Xetra at 5.30 pm on liquidity. D_{NYSE} is included to test for an effect of the opening of the NYSE on Xetra liquidity, which is our second research question. If β_2 is statistically significantly negative (positive), this would imply the U.S. opening to have a reducing (increasing) effect on execution costs in Xetra.

Turning to the third research question, we study order book imbalances across the trading day by comparing hypothetical buy orders sent to the ask-side of the order book with hypothetical sell orders sent to the bid-side of the order book for each stock. Specifically, we contrast MeanXLM on the ask side with MeanXLM on the bid side. The t-test indicates whether the difference between both order book sides is statistically significant.

The fourth research question focuses on execution possibilities. When full hypothetical order sizes cannot be executed, the XLM observation is ignored, as partial execution possibilities are not taken into account. XLM data per trading day give the fraction of trading minutes when full execution was possible. For example, an 80% XLM measure implies that in 80% of the time, full execution was possible, while in the remaining 20% of the time, the volume in the order book was insufficient. Based on the execution possibilities, we count the number of XLM data points per day and thus have the percentage of trading minutes when full execution was possible.

As in McInish and Wood (1992), McInish et al. (2002) and Lee et al. (1993), we split the trading time into 30-minute intervals, and within each interval the average number of minutes with full execution is calculated per share per day. This method preserves the characteristics of each stock in each interval and follows Abhyankar et al. (1997). The interval with the 2-minute intraday auction consists of only 28 minutes.

5.5 Empirical Results

5.5.1 Intraday Pattern of Execution Costs

We first turn to the investigation of intraday patterns in liquidity. Figure 5.1 presents the intraday profile of the DiffXLM variable for both volume classes and for both order book sides. This variable captures execution costs and is therefore inversely related to liquidity. Indeed, the execution costs follow a reverse J-shape. This implies that liquidity in the afternoon is higher than in the morning. As DiffXLM decreases in the first half of the day, liquidity is building up and thus trading costs are going down.

Figure 5.1: DiffXLM Across the Trading Day

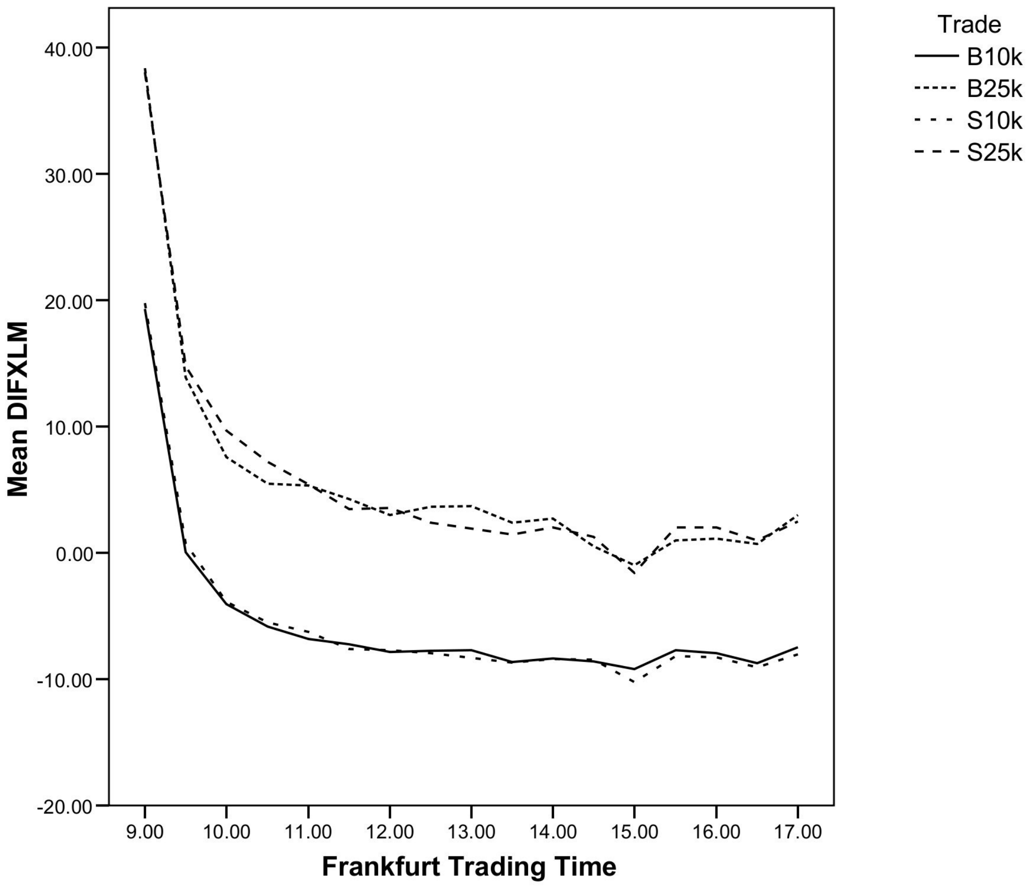


Table 5.1 presents the regression results for two models, one with an intercept, and one forcing the intercept to be zero. At the opening of Xetra, the dependent variable DiffXLM is statistically significantly higher by 20.27 basis points than the average for the trading day. This result is confirmed by the second model. The statistical significance of the closing of Xetra differs between the two models. In the first specification, the closing hour has no significant impact on DiffXLM. However, in the second model, the execution costs in the last hour of trading in Xetra are 2.52 basis points lower than the DiffXLM average across the day. This is driven by the early morning hours when XLM is highest.

Table 5.1: Intraday Patterns in Xetra Execution Costs

DiffXLM captures the execution costs and is calculated as the difference between the natural XLM data point in the original dataset and the average XLM for the same stock, order size and side of the order book. The three dummy variables represent the Xetra opening (D_{open}), the NYSE opening (D_{NYSE}), and the Xetra closing (D_{close}). ** denotes statistical significance at the 1% level.

	Model specification (1)		Model specification (2)	
	Point estimate	t-statistic	Point estimate	t-statistic
α	-2.175	-8.626**		
β_1	20.268	29.681**	18.094	27.964**
β_2	-3.331	-3.603**	-5.506	-6.017**
β_3	-0.369	-0.397	-2.518	-2.751**
Adj.R^2	0.329		0.303	
F-Statistic	466.167		275.258	

These empirical results are broadly consistent with Gomber et al. (2005) and Wuensche et al. (2007) who report a U-shaped intraday pattern for execution costs. During the period under investigation in Gomber et al. (2005), trading in Xetra only closed at 8.00 pm. The intraday pattern for this long trading day is similar to the pattern for the shorter day studied in this paper. Interestingly, execution costs appear to rise towards the end of the trading day, whenever that happens to be. This is plausible as inventory costs go up towards the closing of the exchange, regardless of whether that is at 5.30 pm or at 8.00 pm. However, this rise in execution costs at the end of the trading day is weaker in our sample than in Gomber et al. (2005) or in Wuensche et al. (2007).

5.5.2 Impact of the NYSE Opening on Xetra Trading Costs

We now study the effect of the opening of the U.S. stock exchange on liquidity in Xetra. The NYSE opens at 9.30 am Eastern Time, which corresponds to 3.30 pm Frankfurt Time during our sample period. Table 5.2 presents the empirical results for the variable D_{NYSE}. In both models, the U.S. opening has a statistically significant negative impact on DiffXLM in Xetra. When the NYSE opens, liquidity in Xetra goes up, thereby lowering execution costs, compared to the average across the day. Overall, the U.S. opening improves trading quality in Xetra.

This finding is at odds with Gomber et al. (2005) and Giot et al. (2002). Both studies report increased transaction costs in Xetra around the start of trading at the NYSE. However, the sample periods may account for some of the differences in empirical results, since Giot et al. (2002) examine August to October 1999, Gomber et al. (2005) analyse August 2002, while we study May and June 2006. Technical innovations have entered financial markets since the 1990s, potentially resulting in markets becoming more integrated across borders.

5.5.3 Intraday Patterns in Order Book Imbalances

In order to examine order book imbalances, we compare MeanXLM for the ask side with MeanXLM for the bid side of the Xetra order book. Table 5.2 summarises the empirical results.

There are order book imbalances throughout the trading day, and it appears that the buy side is more liquid regardless of time of the day. In other words, trading costs on the ask side are lower than on the bid side across the day.

The order book imbalance is largest within the first hour of Xetra opening, and the imbalances at Xetra closing time are low compared to the earlier trading times for either order size. For both order sizes, the order book imbalance is lowest between 3.00 pm and 3.30 pm, which coincides with the pre-opening at the NYSE. Overall, the imbalance in the afternoon hours is less pronounced than in the morning hours.

Table 5.2: Order Book Imbalances in Xetra across the Trading Day
Order book imbalances are measured by comparing MeanXLM for the ask side with MeanXLM for the bid side of the Xetra order book. ** and * denote statistical significance at the 1% and 10% levels, respectively. All figures are in basis points.

	Order size 10,000 eur				**Order size 25,000 eur**			
Time	Buy Mean XLM	Sell Mean XLM	Sell minus Buy	t-test	Buy Mean XLM	Sell Mean XLM	Sell minus Buy	t-test
09.00-9.29	53.23	54.59	1.35	-1.47*	72.29	72.84	0.55	-.23
09.30-09.59	33.96	35.54	1.57	-2.57**	47.81	49.56	1.75	-1.25*
10.00-10.29	29.84	30.93	1.08	-2.10*	41.51	44.49	2.98	-2.18*
10.30-10.59	28.08	29.27	1.19	-2.56**	39.41	41.99	2.58	-1.69*
11.00-11.29	27.11	28.54	1.42	-2.69**	39.25	40.21	0.96	-.84
11.30-11.59	26.69	27.17	0.48	-.89	38.21	38.28	0.07	-.06
12.00-12.29	26.08	27.09	1.00	-1.79*	36.91	38.37	1.45	-1.36*
12.30-12.59	26.16	26.85	0.68	-1.71*	37.59	37.17	-0.42	.43*
13.02–13.29	26.23	26.47	0.24	-.66	37.61	36.72	-0.90	.80
13.30-13.59	25.31	26.13	0.82	-1.37*	36.32	36.28	-0.03	.028
14.00-14.29	25.55	26.39	0.83	-2.12*	36.63	36.84	0.21	-.25
14.30-14.59	25.32	26.34	1.02	-1.79*	34.47	36.09	1.62	-2.00*
15.00-15.29	24.73	24.57	-0.16	.33	32.98	33.22	0.25	-.25*
US pre-opening								
15.30-15.59	26.23	26.62	0.39	-.81	34.92	36.80	1.89	-1.85*
16.00-16.29	26.01	26.55	0.53	-1.34*	35.04	36.80	1.77	-2.10*
16.30-16.59	25.17	25.74	0.56	-1.77*	34.62	35.78	1.16	-1.56*
17.00-17.29	26.47	26.76	0.28	-.75	36.95	37.28	0.32	-.34

Ranaldo (2004) reports that the Swiss Exchange is least imbalanced following the U.S. opening in the sample period March and April 1997. However, prior to that, the order imbalances at the Swiss Exchange tip over. Early in the morning and around lunch time, the buy side is more liquid, while the sell side provides larger trading volume in the remaining trading hours. By contrast, in Xetra, the buy side remains more liquid throughout the day. Ranaldo (2004) argues that the buy side is more liquid during bull market phases, and that buy orders are more likely information-motivated than sell orders. Sell orders, by contrast, primarily provide liquidity. Thus, overall market performance and the institutional composition of traders in our sample period may influence the empirical results.

5.5.4 Execution Possibilities across the Trading Day

In order to examine the execution possibilities across the trading day, we report the number of minutes with full execution relative to the 30 minutes in each 30-minute interval. This results in the percentages presented in Table 5.3. The larger the percentage, the more often full order execution was possible across all stocks in the sample. Figure 5.2 shows the results detailed in Table 5.3. The intraday profile of execution possibilities mirrors the intraday pattern of transaction costs depicted in Figure 5.1.

Figure 5.2: Execution Possibilities Across the Trading Day

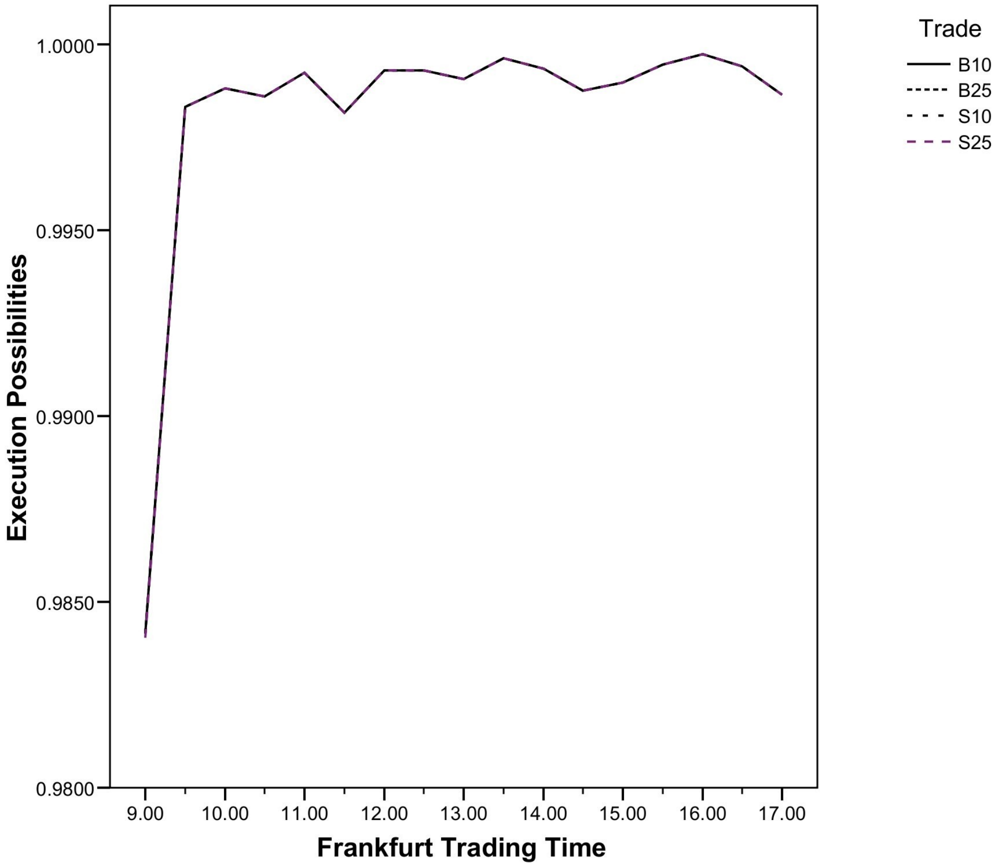


Table 5.3: Execution Possibilities in Xetra across the Trading Day
Reported is the number of minutes with full execution possibility relative to the 30 minutes in each 30-minute interval. The larger the percentage, the more often full order execution was possible across all 28 stocks in the sample. These results are equal for both volume classes (10,000 EUR and 25,000 EUR) and both order book sides (buy and sell).

Time	Execution possibilities, in percent
09.00-9.29 Opening	98.41
09.30-09.59	99.83
10.00-10.29	99.88
10.30-10.59	99.86
11.00-11.29	99.92
11.30-11.59	99.82
12.00-12.29	99.93
12.30-12.59	99.93
13.02–13.29 post auction	99.91
13.30-13.59	99.96
14.00-14.29	99.94
14.30-14.59	99.88
15.00-15.29 US pre-opening	99.90
15.30-15.59 US opening	99.95
16.00-16.29	99.97
16.30-16.59	99.94
17.00-17.29 closing	99.86

Not surprisingly, the results are very similar to those shown in Table 5.2. Large order book imbalances imply that hypothetical orders cannot be (fully) executed. Thus, the intraday patterns discovered for order book imbalances also manifest themselves in the execution possibilities across the day. Execution possibilities are most limited immediately after Xetra opens. The midday auction appears to have only a slight effect, while the NYSE opening seems to increase the execution possibilities and thus improve trading quality in Xetra. In the last half hour of trading in Xetra, it appears that traders have already closed out their positions for the day, and thus liquidity reduces just before closing.

Comparatively limited execution possibilities immediately after the open are consistent with the estimation results of the regression analyses and also in line with the evidence presented in Gomber et al. (2005) and Wuensche et al. (2007).

5.6 Summary and Conclusions

The aim of this paper is to investigate the intraday pattern of trading costs for small cap stocks in the electronic trading system Xetra at the Frankfurt Stock Exchange. We analyse the XLM variable, which is a more comprehensive liquidity measure than the bid-ask spread or trading volume. Unlike previous studies, we focus on 28 less liquid technology stocks in the TecDAX index during the current Xetra opening hours.

We find a reverse J-shaped intraday profile of XLM, implying that liquidity is lowest immediately after the start of trading and highest in the early afternoon. This time of lowest execution costs and thus highest trading quality coincides with the opening of the NYSE. Order book imbalances, and thus execution possibilities, confirm this pattern. Imbalances are highest early in the morning, rendering execution possibilities worst compared to the remainder of the trading day. Order book imbalances are lowest at U.S. pre-opening, and execution possibilities in Xetra are best once the NYSE has started trading.

Based on these empirical results, it is most advantageous for liquidity traders to place their orders in the early afternoon, while trading in the first half hour of opening is not recommended. Similarly, trading should not be left until the last half opening hour of Xetra. For informed trades, however, higher trading costs in the early morning could be offset by the profits from superior information. This might be an avenue for further research.

From the stock exchanges’ perspective, the technical integration with the spot market at the NYSE appears to increase liquidity. Further research could investigate the effect of the opening of futures trading in Chicago on Xetra. It can be conjectured that further integration will benefit trading quality and thus give the exchange an advantage in the competition for trading volume.

6 Overall Conclusions for Three Essays

Overall, this doctoral thesis follows the research objective to improve our understanding of the liquidity in stock markets by providing new evidence on the effects of various factors on liquidity by using XLM data.

To achieve this objective, this doctoral thesis comprises three essays that address selected issues in stock market liquidity. All three essays conduct original empirical research using German Xetra trading system data and the set of stocks that belong to German TecDAX index.

The choice of the liquidity measure (Exchange Liquidity Measure (XLM)) enables us to study the whole order book in a dynamic setting. The German Stock Exchange has been calculating XLM based on all information in the order book, i.e. including the hidden part of iceberg orders, for all stocks traded continuously in Xetra since July 2002. XLM therefore provides a more comprehensive analysis of liquidity costs than the bid-ask spread.

The first essay (Chapter 3) focuses on the weather effects on the stock market liquidity and tests for the potential influence of the cloudy weather on liquidity provided by market makers. The second essay (Chapter 4) investigates the role of designated sponsors in Xetra electronic order book and their contribution to stock liquidity. Finally, the third essay (Chapter 5) investigates the intraday effect on liquidity.

Although different in focus and approach, all three essays contribute to the main challenge of developing a better understanding of the factors that influence liquidity in the electronic order book.

In general, we find new evidence supporting the views of many researchers in capital markets that the liquidity in the electronic order book can be influenced by various factors. In three different essays we document the positive impact on liquidity of the mood affective factor like weather, of the increase of market makers per instrument and of the time of the day.

Our findings fit well into the results of recent research on the weather effects in capital markets (Goetzmann and Zhu (2005), Flemisch et al. (2009)) and on the contribution of multiple market makers (Bongard and Klar (2006); Menkveld (2007)) to liquidity.

Overall, this thesis yields new insights into the patterns of liquidity that can be useful for practitioners and researchers in this field. New questions that arise from the results should be addressed in the future research.

First of all, the exchanges can incorporate the results of my research in the design of market models. The impact on liquidity by the increased number of market makers in a stock is especially interesting in this respect and it provides guidance for the design of market models for less liquid instruments. From the stock exchanges' perspective, the technical integration with the spot market at the NYSE appears to increase liquidity. Thus, further research could investigate the effect of the opening of futures trading in Chicago on Xetra. Also the impact of opening of other markets (i.e. Asia) could be investigated. It can be conjectured that further integration will benefit trading quality and thus give the exchange an advantage in the competition for trading volume.

Secondly, the findings can be used in the design of trading strategies in the asset management and banks' stock trading areas. Based on these empirical results, it is most advantageous for liquidity traders to place their orders in the early afternoon, while trading in the first half hour of opening is not recommended. Similarly, trading should not be left until the last half opening hour of Xetra. For informed trades, however, higher trading costs in the early morning could be offset by the profits from superior information. This might be an avenue for further research. Furthermore, it should be tested whether trading strategies can be derived from these findings that are profitable net of transaction costs. In light of our results, lower transactions costs could be observed in stocks with multiple market makers as well as during trading in Xetra on overcast days.

For the further research, we suggest repeating these studies for another period and extending the sample of stocks to more illiquid instruments like SDAX. This could in particular be interesting to further analyse the impact of multiple market makers in less liquid stocks. Additionally, the analysis of high frequency data based on XLM for more liquid stocks (e.g. DAX) during the exogenous events could yield interesting results. Furthermore, the finding that cloudy skies correspond with high liquidity in Xetra is inconsistent with the results presented by Goetzmann and Zhu (2005) for the New York Stock Exchange. We suggest that future research further analyzes the weather effect on liquidity by extending the sample period and by providing international evidence.

Like most empirical research, it is important to consider any potential limitations of this study when interpreting the results. First of all, the nature and patterns of liquidity are strongly influenced by a variety of factors like market structure, trading rules, continuous trading versus firm quotes, the level and efficiency of market supervision, insider trading, order sizes and many more. These factors affect trading patterns of market participants, thus affecting the liquidity. One obvious constraint is that our results are representative for the Xetra market model. Even though the Xetra market model is generally quite representative of the other European market models, certain differences still exist, thus making the transferability of these results to other market and market models uncertain.

Secondly, it is important to recall that the sample of stocks used in these studies is limited to TecDAX stocks. This may make the results better, by concentrating on a group of stocks with broadly similar characteristics, but this may also limit the applicability of the results to other stocks.

Thirdly, the stocks that belong to the TecDAX index might be best classified as a medium-liquidity stocks, rather than pure less liquid stocks. Thus, the transferability of our findings on other more illiquid stocks could be constrained.

Finally, it is likely that more robust results could be obtained by extending the sample of stocks and possibly a time period. Moreover, the data series used are daily in nature (apart from the study of intraday when the data is minute-based), but a more accurate analysis can be done by using hourly or even minute-based data series.

7 References

Amihud, Y., Mendelson, H., (1986), Asset Pricing and Bid-Ask Spread, Journal of Financial Economics 17, 223-249.

Barber, Brad M., Terrance O., (2009), All that Glitters: The Effect of Attention and News on the Buying Behavior of Individual and Insititutional Investors, Review of Financial Studies, forthcoming.

Barclay, M. Christie, W., Harris, J., Kandel, E., Schultz P., (1999), Effects of Market Reform on the Trading Costs and Depths of Nasdaq Stocks, Journal of Finance 54, 1-34.

Barclay, M.J., Christie, W.G, Harris, J.H., Kandel, E., Schultz, P.H., (1999), The effects of market reform on the trading costs and depths of NASDAQ stocks, Journal of Finance 54, 1-34.

Bernhardt, D., Hughson, E., (1997), Splitting Orders, Review of Financial Studies 10/1, 69-101.

Bernstein, P.L., (1987), Liquidity, Stock Markets, and Market Maker, Financial Management 16 (2), 54-62.

Biais, B., Glosten, L., Spatt, C., (2005), Market Microstructure: A Survey of Microfoundations, Empirical Results and Policy Implications, Journal of Financial Markets 8, 217-264.

Biais, B., Martimort, D., Rochet, J., (2000), Competing Mechanisms in a Common Value Environment, Econometrica 68 (4), 799-837.

Black, F., (1971), Toward a Fully Automated Stock Exchange, Financial Analysts Journal 27, 28-44.

Bongard, I., Klar, J., (2006), Determinants of the Bid-Ask Spread and the Role of Designated Sponsor: Evidence from Xetra, University of Bonn, available at: www.lrz-muenchen.de/~u5001ah/webserver/webdata/paper/Klar.pdf

Bosch, R., (2001), Market-Maker als liquiditätsspendende Intermediäre in Börsenmärkten: das Betreuerkonzept der Deutschen Börse AG. Wiesbaden: Dt. Univ.-Verlag, 2001 (zugl. Diss. Univ. Nürnberg, Erlangen 2001).

Brockman, P., Chung, D., (2002), Commonality in Liquidity: Evidence from an Order-driven Market Structure, Journal of Financial Research 25, 521-539.

Brockman, P., Chung. D., (1998), Inter- and Intra-day Liquidity Patterns on the Stock Exchange of Hong Kong, Journal of International Financial Markets, Institutions and Money 8, 279-300.

Brunner, A., (1996), Messkonzepte zur Liquidität auf Wertpapiermärkten, Institut für Kapitalmarktforschung (eds): Beiträge zur Theorie der Finanzmärkte, Institut für Kapitalmarktforschung 13, Frankfurt/Main.

Chordia, T., R. Roll, Subrahmanyam, A., (2000), Commonality in Liquidity, Journal of Financial Economics 56, 3-28.

Cohen, Randolph B., Paul A. Gompers, Vuolteenaho, T., (2002), Who Underreacts to Cash-Flow News? Evidence from Trading between Individuals and Institutions, NBER Working Paper No. W8793, Available at SSRN: http://ssrn.com/abstract=300755

Cooper, S.K., Groth, J.C., Avera, W.E., (1985), Liquidity, Exchange Listing, and

Common Stock Performance, Journal of Economics and Business 38, 1457-1469.

Coppejans, M., Domowitz, I., Madhavan, A., (2001), Liquidity in an Automated Auction, Working Paper.

Coppejans, M., Domowitz, I., Madhavan, A., (2004), Resiliency in an automated auction, Working Paper, Duke University.

Coval, Joshua D., J. Moskowitz, T.J., (1999), Home Bias at Home: Local Equity Preference in Domestic Portfolios, Journal of Finance 54 (6), 2045-2073.

Demsetz, H., (1968), The Cost of Transacting. Quarterly Journal of Economics 82, 33-53.

Deutsche Borse AG, Designated Sponsor Guide Version 5.0 (2005)

Deutsche Börse AG publication "Stock&Standarts" 2/2002

Deutsche Borse AG, cash market statistics, available online under www.deutsche-boerse.com in the section Info-centre, Statistics, Cash market, monthly. On indexes and their compositions, see Deutsche Borse AG "Guide to Equity indices".

Domowitz, I., Glen, J., Madhavan, A., (2001), Liquidity, Volatility and Equity Trading Costs across Countries and Over Time, International Finance 4(2), 221-255.

Domowitz, I., Wang, X., (2002), Liquidity, Liquidity Commonality and its Impact on Portfolio Theory, Working Paper, available at: http://ssrn.com/abstract=294870.

Eagles, John M., (1994), The relationship between mood and daily hours of sunlight in rapid cycling bipolar illness, Biological Psychiatry 36, 422-424.

Easley, D., Hvidkjaer, S., O'Hara, M., (2002), Is Information Risk a Determinant of Asset Returns?, Journal of Finance 57, 2185-2221.

Flemisch, M., Hackethal, A., Schiereck, D., (2009), Market Maker unter Wolken – Wettereffekte am deutschen Aktienmarkt, Kredit und Kapital, forthcoming.

Foucault, T., O. Kadan, O., Kandel, E., (2005), Limit Order Book as a Market for Liquidity, Review Of Financial Studies 18, 1171-1217.

Freihube, T., Kehr, C.-H., Krahnen, J. P., (1999), Limitorderbuecher und der Liquiditatsbeitrag der Kursmakler, Working Paper, Universität Frankfurt a. M.

Freihube, T., Kehr, C.-H., Krahnen, J. P., Theissen, E., (1998), Was leisten Kursmakler? Eine empirische Untersuchung am Beispiel der Frankfurter Börse, Working Paper, Universität Frankfurt a. M.

Freihube, T., Krahnen, J. P., Theissen, E., (2001), Market Structure, Intermediation and Liquidity, available at:

www.ifk-cfs.de/papers/marketstructure_intermediation_liquidity.pdf

Garbade, K. D., (1982), Securities Markets, New York, McGraw-Hill.

Garbade, K., Silber, W., (1979), Structural Organization of Secondary Markets: Clearing frequency, Dealer Activity and Liquidity Risk, Journal of Finance 34, 577– 593.

Gehrig, T., Jackson, M., (1998), Bid-Ask Spreads with indirect Competition among Specialists, Journal of Financial Markets 1 (1), 89-119.

Gerke, W., Bosch, R., (1999), Die Betreuer am Neuen Markt- eine empirische Analyse, 1999/12, CFS working papers, available at:

www.ifk-cfs.de/content/veroeffentlichungen/data/19990112DieBet.htm

Glosten, L., (1989), Insider Trading, Liquidity and the Role of the Monopoly Specialist, Journal of Business 62, 211–235.

Glosten, L., (1994), Is the Electronic Open Limit Order Book Inevitable?, Journal of Finance 49, 1127-1161.

Goetzmann, William N., Zhu, N., (2005), Rain or Shine: Where is the Weather Effect?, European Financial Management 11 (5), 559-578.

Gomber, P., Schweickert, U., (2002), Der Market Impact: Liquiditätsmaß im elektronischen Wertpapierhandel, Die Bank 7, 485-489.

Gomber, P., Schweickert, U., (2002), The Market Impact - Liquidity Measure in Electronic Securities Trading, Working Paper.

Gomber, P., Schweickert, U.,Theissen, E., (2005), Zooming in on Liquidity, Working Paper, available at http://ssrn.com/abstract=559406.

Grammig, J., Schiereck, D., Theissen, E., (2001), Knowing Me, Knowing You: Trader Anonymity and Informed Trading in Parallel Markets, Journal of Financial Markets, 4, 385-412.

Grinblatt, M., Keloharju, M., (2001), How Distance, Language and Culture Influence Stockholdings and Trades, Journal of Finance 56 (3), 1053-1073.

Grossman S.J., Miller, M.H., (1988), Liquidity and Market Structure, Journal of Finance 43, 617-633.

Hachmeister, A., (2006), Informed Traders as Liquidity Providers: Evidence from German Equity Market, Dissertation.

Hachmeister, A., Schiereck, D., (2006), The Impact of Post-Trade Anonymity on Liquidity and Informed Trading: Evidence from the Introduction of the Xetra Central Counterparty (CCP), Working Paper, available at: www.campus-forfinance.com/fileadmin/content/cffrc/documents/2007/Liquidity_Hachmeister.pdf.

Hachmeister, A, Schiereck, D., (2010), Dancing in the Dark: Post-trade Anonymity, Liquidity, and Informed Trading, Review of Quantitative Finance and Accounting 27, forthcoming.

Harris, L., (1990), Liquidity, Trading Rules, and Electronic Trading Systems, NYU Salomon Center Monograph Series in Finance and Economics 1990-4.

Hasbrouck, J., Seppi, D.J., (2001), Common factors in prices, order flows, and liquidity, Journal of Financial Economics 59, 383-411.

Hasbrouck, J., Saar, G., (2002), Limit Orders and Volatility in a Hybrid Market: The Island ECN, Working Paper, New York University, available at: http://ssrn.com/abstract=310940

Hasbrouck, J., Schwartz, R.A., (1988), Liquidity and Execution Costs in Equity Markets, Journal of Portfolio Management 14, 10-16.

Hirshleifer, D. A., Shumway, T., (2003), Good Day Sunshine: Stock Returns and the Weather, Journal of Finance 58 (3), 1009-1032.

Ho, T. S., Stoll, H. R., (1983), The Dynamics of Dealer Markets under Competition, Journal of Finance 38, 1053-1074.

Huberman, G., Halka, D., (2001), Systematic Liquidity, Journal of Financial Research 24, 161-178.

Irvine, P., Benston, G., Kandel, E., (2000), Liquidity Beyond the Inside Spread: Measuring and Using Information in the Limit Order Book, Working Paper, Emory University and He-brew University, July, available at: http://ssrn.com/abstract=229959.

Kamstra, M. J., Kramer, L.A., Levi, M.D., (2003), Winter Blues: A SAD Stock Market Cycle, American Economic Review 93 (1), 324-343.

Keim, D., Madhavan, A., (1997), Transaction Costs and Investment Performance: An Inter-exchange Analysis of Institutional Equity Trades, Journal of Financial Economics 46, 265-292.

Keim, D., Madhavan, A., (1998), The Cost of Institutional Equity Trades., Financial Analysts Journal July/August 1998, 50-68.

Kyle, A., (1985), Continuous Auctions and Insider Trading, Econometrica 53, 1315-1335.

Leach, J.C., Madhavan, A., (1993), Price Experimentation and Security Market Structure, Review of Financial Studies 6, 375-404.

Lee, Ch., Mucklow, B., Ready, M., (1993): Spreads, Depths, and the Impact of Earnings Information: An Intraday Analysis. Review of Financial Studies 6, 345-374.

Loughran, T., Schultz, P., (2004), Weather, Stock Returns, and the Impact of Localized Trading Behavior, Journal of Financial and Quantitative Analysis 93 (2), 343-364.

Madhavan, A. N., Panchapagesan, V., (2000), Price Discovery in Auction Markets: A Look Inside the Black Box, Review of Financial Studies 13, 627-658.

Madhavan, A., Smidt, S., (1993), An Analysis of Changes in Specialist Quotes and Inventories, Journal of Finance 48, 595-1628.

Madhavan, A., Sofianos, G., (1998), An Empirical Analysis of NYSE Specialist Trading, Journal of Financial Economics 48, 189-210.

Marsh, T., Rock, K., (1986), Exchange Listing and Liquidity: A Comparison of the American Stock Exchange with the Nasdaq National Market System, American Stock Exchange Transactions Data Research Project, Report 2, New York.

Menkveld, A., (2007), Designated Market Makers for Small-Cap Stocks Is One Enough?, available at: www.amf-france.org/documents/general/7741_1.pdf

Oesterhelweg, O., Schiereck, D., (1993): Meßkonzepte für die Liquidität von Finanzmärkten, Die Bank 33, 390-397.

Pagano, M., Padilla, J., (2005), The Economics of Cash Trading: An Overview, A report for Euronext, LEGG.

Parlour, C., Seppi, D., (2003), Liquidity-based Competition for Order Flow, Review of Financial Studies 16, 301-343.

Pastor, L., Stambaugh, R., (2003), Liquidity Risk and Expected Stock Returns, Journal of Political Economy 111, 642-685.

Roll, R., (1984), A Simple Implicit Measure of the Bid/Ask Spread in an Efficient Market, Journal of Finance 39 (4), 1127-1139.

Roll, R., (1992), Weather, in Peter Newman, Murray Milgate, and John Eatwell, eds.: The New Palgrave Dictionary of Money and Finance, Macmillan Press, London.

Saunders, E.M., (1993), Stock prices and Wall Street Weather, American Economic Review 83 (5), 1337-1345.

Schiereck, D., (1995), Internationale Börsenplatzentscheidungen institutioneller Investoren, Gabler, Wiesbaden.

Schiereck, D., (1996), Börsenplatzetscheidungen institutioneller Investoren beim Handel deutscher Aktien, Zeitschrift für Betribswirtschaft 66, 1057-1079.

Schwartz, R., (1988), A Proposal to Stabilize Stock Prices, Journal of Portfolio Management 15, 4–11.

Seppi, D., (1997), Liquidity Provision with Limit Order and a Strategic Specialist, Review of Financial Studies 10, 103-150.

Stoll, H., (1978a), The Supply of Dealer Services in Securities Markets, Journal of Finance 33, 1133-1151.

Stoll, H., (1978b), The Pricing of Security Dealer Services: An Empirical Study of NASDAQ Stocks, Journal of Finance 33, 1153-1172.

Stoll, H., (1992), Principles of Trading Market Structure, Journal of Financial Services Research 6, 75-106.

Stoll, H., (2000), Friction, Journal of Finance 55, 1479-1514.

Stoll, H., Whaley, R., (1990), Stock Market Structure and Volatility, Review of Financial Studdies 3, 233–253.

Trombley, M.A., (1997), Stock prices and Wall Street Weather: Additional Evidence, Quarterly Journal of Business and Economics 36 (3), 11-21.

Venkataraman, K., Waisburd, A., (2007), The Value of Designated Market Maker, Working Papper, available at: http://kvenkataraman.cox.smu.edu/papers/VW.pdf

Viswanathan, S., Wang, J., (2002), Market Architecture: Limit-order Books Versus Dealership Markets, Journal of Financial Markets 5, 10-15.

Wurgler, J., (2000), Financial Markets and the Allocation of Capital, Journal of Financial Economics 58, 187–214.

HONOUR STATEMENT

I declare upon my word of honour that the dissertation submitted herewith is entirely my own research and that only the sources listed have been used. Two papers were submitted for publications in international journals with the co-authors listed. All references in any form have been clearly identified in the source of reference. I declare that this work was not submitted to any other university for any degree.

Tatjana Verrier

Brussels, August 2010