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## Competition among electronic markets and market quality

**Peter Gomber, Markus Gsell and Marco Lutat**  
E-Finance Lab

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## DISCUSSION PAPERS

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**Chair of Business Administration,  
especially e-Finance  
Prof. Dr. Peter Gomber**

Campus Westend • RuW P.O. Box 69 • D-60629 Frankfurt am Main

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# Competition among electronic markets and market quality

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## *Abstract*

*With the Markets in Financial Instruments Directive (MiFID) in effect, new electronic markets emerged in European equities trading. We address the impact of market fragmentation on stock liquidity by examining samples of stocks before and after the introduction of MiFID. Panel regressions indicate a contrary development of liquidity for stocks with high competition among trading venues and stocks with a low level of competition. For the former, we find a significant positive liquidity effect between observation periods in the home market and a virtual order book consolidating multiple markets, while this could not be observed for stocks with low competition.*

# 1 Introduction

The rules set out by the *Market in Financial Instruments Directive* (MiFID) [1] and its implementing measures [2] [3] have harmonized regulation of financial markets on a European level and try to create new competition and a level playing field among different types of electronic financial markets (called trading venues in MiFID terminology). This new regulatory set-up has increased competition and within a short timeframe, incumbent exchanges like Deutsche Börse AG's Xetra trading system, Euronext Paris or the London Stock Exchange (LSE), have lost significant market share to new competitors, so-called *Multilateral Trading Facilities* (MTF). These new competitors, e.g. Turquoise, Chi-X or BATS Europe entered the market with a pan-European scope concerning tradable securities, offering similar market models and functionalities as the incumbent exchanges but at lower explicit trading costs. The capabilities of their trading systems accompanied by their attractive fee structures enable them to attract liquidity and trading activity onto their platforms. Thereby, the fragmentation of the European securities trading landscape is steadily increasing since early 2008.

The effects of fragmented trading are ambiguous. Investors and issuers articulate concerns whether fragmentation might reduce market quality. Some market participants try to overcome fragmentation by applying trading software tools like smart order routing engines (SOR) or liquidity aggregation mechanisms. In particular, new technologies like e.g. SOR enable investors to efficiently make use of liquidity available in more than one market. SOR access multiple liquidity pools, i.e. exchanges or alternative trading systems, to identify the best destination and apply proprietary algorithms to optimize order execution [4]. They continuously gather real-time data from the respective venues concerning their order book situations, i.e. current quoted volumes and prices. Based on this information, the routing engine slices investors' orders and decides where to route individual suborders in respect of the best prices available in that logical second.

Against this background, the goal of this paper is to investigate the impact of the fragmentation of European electronic financial markets on market quality. The quality of a securities market may be measured by the *liquidity* it offers, i.e. the trading interest

it attracts. A high degree of market liquidity will lower (implicit) transaction costs and therefore improve efficiency [5]. Hence, an empirical analysis will be conducted regarding variations in market liquidity due to the new competition among electronic markets introduced by MiFID. The analyses will have two dimensions: one is the time dimension (pre-MiFID, i.e. the period before competition and fragmentation started, vs. post-MiFID i.e. the period with competition and fragmentation in place), the other is the extent of fragmentation. The analysis regarding the extent of fragmentation is enabled by the fact, that there is one country within the European Economic Area that up to now is not facing relevant fragmentation in the trading of its securities: Spain. This allows investigating market characteristics for comparable securities allocated to one group of securities that are highly fragmented (e.g stocks traded on Xetra, Euronext Paris or the LSE) and another group of securities where the home market (here: Spain) still is the only relevant trading venue.

The following section will outline the status quo of liquidity fragmentation in European securities trading and summarize how MiFID has changed competition among electronic markets. Afterwards, section 3 will elaborate on academic research related to our work. The next section will address the impact of fragmentation on market quality measured in terms of liquidity. Section 5 will report on our findings while the last section provides conclusions and limitations of our study. The results are able to provide important input to investors, issuers and regulators concerning the effect of the introduction of the new competition on market quality.

## **2 Fragmentation of liquidity**

Before the applicability of MiFID, in some member states of the European Economic Area so-called *concentration* or *default rules* were in force, which eliminated or at least hindered the possibility to trade away from Regulated Markets (exchanges). Furthermore, different national regulations prevented market operators from offering pan-European market venues. Therefore, European securities trading was – on a per security basis – typically concentrated on a single market; the *home market* of the respective security. Since November 2007, with the harmonized regulation set out by MiFID, Regulated Markets and MTFs are set on a level playing field. This attracted

numerous new entrants to the market for markets<sup>1</sup> and led to the fragmentation of trading among the home market and MTFs. Some of the MTFs address a special niche<sup>2</sup> or region<sup>3</sup>; others actually have a pan-European scope.

The MTFs entered the market with significantly lower explicit cost schemes, which forced the Regulated Markets to adapt their fees schedules as well. However, explicit costs are not the only determinant for transaction costs in securities trading. An even more relevant share of cost is also determined by so-called implicit trading costs, which are driven by a market's liquidity<sup>4</sup>. As liquidity is subject to strong positive network externalities, market venues are eager to attract as much trading interest to their platforms as possible. Of the numerous MTFs, three excelled in attracting trading activity to their electronic platforms: Chi-X, BATS Europe and Turquoise. These three are currently among the top ten European equity market trading venues in terms of traded value.

The fragmented landscape in European securities trading increases the competitive pressure on all venues. Along with the increasing fragmentation of trading comes an increasing fragmentation of market data, as each venue has its own order book and its own trade reports. The clear picture of trading interest in a security that was given when trading was concentrated on one market is nowadays distorted. Therefore, it became more difficult to assess whether market quality in terms of liquidity has improved or worsened with market fragmentation. We address this issue with the empirical analysis presented in section 4.

### 3 Related literature

Our work as outlined in the introductory section addresses and contributes to the academic literature on the impact of market fragmentation and competition between electronic markets on quoting behavior in dealer markets as well as on overall liquidity

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<sup>1</sup> [6] provides a complete list of all Regulated Markets, MTFs and Systematic Internalisers.

<sup>2</sup> E.g. the MTFs Liquidnet Europe, Pipeline and POSIT offer special market models for the trading of large quantities (block trading).

<sup>3</sup> For bond trading there are numerous MTFs with a national scope, e.g. MTS France SAS or MTS Deutschland AG. Furthermore, some Regulated Market operate parts of their business as an MTF. E.g. Borsa Italiana's AIM Italia is registered as an MTF.

<sup>4</sup> See [7], who conclude that both implicit and explicit costs are important, but different markets show variations in the composition of costs.

in order driven markets. This section will outline some of the studies relevant to our research purpose and their findings.

Academic literature on electronic markets and market microstructure has been examining the relationship between competition and market fragmentation for long. In one of the first papers on the effects of market fragmentation, [8] analyses the off-board trading of NYSE-listed stocks on regional exchanges and in the third market, the over-the-counter (OTC) trading of listed securities among institutional investors and broker/dealers for their own accounts. When studying the NYSE specialist bid-ask spreads (the prices of marketability) and the daily returns variance, Hamilton finds the competitive effect of several markets to reduce both the NYSE specialist spreads and the daily stock variances by more than the fragmentation effect tends to increase them, although this net effect is not seen to be large.

[9] study the competition between Nasdaq market makers and electronic communication networks (ECNs) in US equities. Their results show that informed trades more likely occurred in an ECN and that the lower bound for permanent price effects was 50 percent higher for ECNs than for Nasdaq market makers. Their conclusions suggest the majority of aggregated price discovery to occur in ECNs.

The quotation behavior of dealers at the Nasdaq market is also focused by [10]. His hypothesis of competitive quotes helping increase a dealer's market share on Nasdaq is analyzed after the introduction of new trading platforms such as SuperSOES and SuperMontage. As a result, SuperSOES is shown to increase the size elasticity, and SuperMontage to increase even both the size and price elasticity of dealer market share. A positive effect from the market participants' perspective represents the fact that market centers tend to provide greater price improvements and faster executions when they post competitive quotes.

The competitive impact of ECNs on the Nasdaq as studied in [11] has a positive effect on market liquidity as the development of these alternative trading platforms is associated with tighter quoted, effective, and relative bid-ask spreads, greater quotation depths and less concentrated markets. On the other hand the increase in ECN trading may have caused some traditional market makers (wholesalers and national retail

dealers) to exit the market for market making as their profits tend to decrease with lowered bid-ask spreads.

[12] examine a sample of actively traded, multiply listed US equity options against the background of growing competition for order flow in actively traded options during August 1999, followed by the introduction of payment for order flow thereafter and the launch of the International Securities Exchange in May 2000. They document substantial reductions in quoted and effective spreads between June 2000 and January 2002 due to competition.

[13] studies the effects of competition and market structure on the bid-ask spreads for stock options traded on the Chicago Board Options Exchange (CBOE) between 1986 and 1997. In this context options listed on multiple exchanges are found to have narrower spreads than those listed on a single exchange, but the difference is smaller for effective spreads than quoted spreads, and the effect diminishes as option volume increases. A competing exchange delisting a respective option leads to wider spreads in that option.

In their study, [14] examine the change in liquidity for 30 AMEX-listed exchange-traded funds (ETFs) upon being traded under unlisted trading privileges on the NYSE. The evidence presented indicates a substantial increase in liquidity following the NYSE entry.

The bid-ask spreads and volumes in options markets during the competition for listings in 1999 between the CBOE, the American Stock Exchange (AMEX) and the Pacific Exchange (PCX) are examined in [15]. Their findings indicate that effective and quoted bid-ask spreads decrease significantly after multiple listing, and that spreads generally maintain their initial lower levels one year later. Consequently, they reject that economies of scale in market making cause the decrease in spreads and support the view that inter-exchange competition reduces implicit transaction costs.

[16] investigate the competition in the Dutch stock market between Euronext and EuroSETS, which is operated by the London Stock Exchange (LSE). They compute the consolidated limit order book to be deeper and the Euronext depth to be larger after the entry of EuroSETS. They trace back the increased Euronext depth to the fact that



Euronext responded to the EuroSETS entry with a fee reduction on limit order submission.

The case of the ECN Island reducing its market transparency in September 2002 is addressed in [17]. Before this event, the trading of ETFs in the US was concentrated on Island. With a higher degree of market fragmentation after this event, Island's effective and realized spreads increased, while effective and realized spreads fell in other markets. The net effect is determined a substantial increase in overall effective and realized spreads and therefore a worsening in overall ETF market quality.

Against the background of MiFID [18] argues that more competition improves market liquidity and will result in innovations in the incumbent markets which are confronted by competitive market operators.

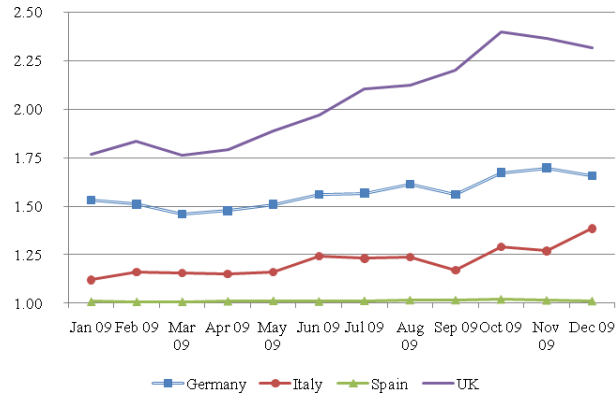
In September 2008, European MTF Chi-X made French blue-chip stocks available for trading. Chlistalla and Lutat [19] analyze the emergence of a new trading venue for French stocks and find the new competition to induce a positive effect in the incumbent market Euronext Paris. Therefore they conclude that the overall liquidity which is available to investors has improved following the Chi-X market entry.

As one can see from the outline above, the majority of studies support the hypothesis that the potential negative impact of market fragmentation on liquidity and overall market quality is overcompensated by the increase of liquidity resulting from a more competitive landscape. Embracing this hypothesis leads us to the following research question: Does the appearance of new competitive markets, mainly European MTFs, have a significant impact on the liquidity of incumbent exchanges?

## **4 Impact of competition on market quality – empirical analysis**

In order to assess the impact of fragmentation on market quality in electronic financial markets, we conduct an empirical analysis that investigates the evolution of liquidity from the non-fragmented pre-MiFID world into nowadays fragmented European post-MiFID trading landscape.

Thereby, we make use of one specific exception to the fragmented European securities trading landscape: Spain. While in most European countries trading significantly fragmented with the applicability of MiFID, Spanish securities are still strongly concentrated on their home market (see Figure 1).



**Figure 1: Fragmentation index for transparent markets (inverse HHI)<sup>5</sup>, based on data provided by [20]**

This is to some extent due to the fact that prior to MiFID there was a concentration rule in Spain. However, the main reason for the ongoing concentration of trading in Spanish equities on the Spanish exchange is grounded in post-trading procedures. Only recently the Spanish exchange announced to change a trade registration process “over the course of 2011 and 2012” that up to now effectively keeps competition out of the clearing business [21].

## 4.1 Methodology

### 4.1.1 Data aggregation

The fragmentation of trading also causes fragmentation of market data. Therefore, it is hard to assess the impact of market fragmentation on the overall liquidity. In order to address this issue, we reconstructed a virtual pan-European consolidated order book for selected stocks and evaluated several liquidity measures.

<sup>5</sup> The inverse HHI is calculated as follows:

$$\text{Inverse HHI} = \frac{1}{\sum_{i=0}^N s_i^2}, \text{ where } s_i \text{ denotes market share of market } i.$$

For a sample of European stocks (see section 4.3), intraday market depth tick data has been retrieved from Thomson Reuters Tick History for the securities' home markets as well as for the three main MTFs Chi-X, BATS Europe and Turquoise [22]. Based on the data's time-stamp precision of one millisecond, order books have been aggregated across the different venues to construct a European consolidated order book. For all securities in the sample, the combined market share for the home market and the three main MTFs has been above 97% during the observation period<sup>6</sup>.

To ensure data validity, stale data has not been regarded in the consolidation process, i.e. if a venue's last reported order book snapshot is older than five minutes it is not integrated in the consolidated order book anymore<sup>7</sup>. Another issue is the consistency of the data. In few cases, the Thomson Reuters Tick History reports crossed order books for a market venue, i.e. the best bid is higher than or equal to the best ask. Such obviously erroneous order book snapshots have been ignored in consolidating the order book snapshots from the different venues.

#### *4.1.2 Regression model*

For the analysis, on each trading day during the observation periods several order book characteristics have been calculated in one minute intervals between 09:05:00 and 17:25:00. By choosing these times, the opening and closing call auctions are excluded and the analysis focuses on the market phase of continuous trading.

In order to measure liquidity, for both the consolidated order book as well as the order book of the securities home market the following dependent variables in our regression model have been calculated from the order book snapshots:

- Relative quoted spread
- eXchange Liquidity Measure (XLM) for values of 50,000 € and 100,000 €
- Quoted value at best bid and quoted value at best ask

We use the second measure to capture order book depth, i.e. the order book liquidity beyond the best bid and ask [23]. The XLM is an inverse measure of liquidity as it

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<sup>6</sup> For one stock in the sample, Nokia, Xetra has been added as well as it had a market share of 3.2% in the observation period.

<sup>7</sup> A five minute old order book snapshot may still be correct, if actually no order book activity occurred in the mean time. But it is most likely that either data is missing in the Thomson Reuters Tick History or that the venue had technical problems.

captures the execution costs of a round-trip transaction and uses the information about all the visible orders in an order book to calculate the weighted average price at which an order of given size could be executed immediately at time  $t$ . A similar measure has been suggested in [24], as they considered spreads not to be sufficient measures for market liquidity.

In our setup we estimate the means of these measures for both observation periods (pre- and post-MiFID; see section 4.2), changes in these means, and test for the statistical significance of these changes applying panel data techniques. For testing the significance of changes in the means we assume that a liquidity measure  $y_{i,t}$  (i.e. the relative quoted spread, XLM and quoted value) for stock  $i$  and day  $t$  can be expressed by adding up a stock-specific mean  $\mu_i$ , an event effect  $\delta_i$ , potential control variables  $X_{i,t}$  and an error term  $\varepsilon_{i,t}$ :

$$y_{i,t} = \mu_i + \delta_i I_{[t \text{ in post-MiFID period}]} + \beta' X_{i,t} + \varepsilon_{i,t} \quad (1)$$

$$\varepsilon_{i,t} = \xi_t + \eta_{i,t} \quad (2)$$

where  $I_{[t \text{ in post-MiFID period}]}$  is an indicator variable which equals 1 if  $t$  lies within the post-MiFID period and 0 otherwise. We will compute the changes within the quartiles for both events as

$$\mu_p = \frac{1}{N_p} \sum_{j \in J_p} \mu_j \quad (3)$$

$$\delta_p = \frac{1}{N_p} \sum_{j \in J_p} \delta_j \quad (4)$$

where  $p$  is the quartile index,  $N_p$  is the number of stocks in the respective quartile and  $J_p$  contains the indices of the stocks in quartile  $p$ .  $\delta_p$  will indicate the impact of the event on a liquidity measure. Following [25], [26] and [27], we apply Rogers standard errors for testing of significances of liquidity changes in the means of pre- and post-MiFID period. These standard errors control for commonalities across stocks, heteroscedasticity, and non-zero stock-specific autocorrelation.

[7] argue, an exogenous increase in volatility affects liquidity through its direct effect on transaction costs and [28] finds trading activity, price level and volatility to be related to liquidity. We retrieve the sample stocks' daily traded volumes from the

Thomson Reuters Tick History and calculate the stock specific daily means of a stock's midpoint, i.e. the mid between the best bid and the best ask limit in an order book) and the midpoint's standard deviation and take these as measures for price level and volatility. [29], [30] and [31] find significant co-movement in liquidity across various stocks and so the error term in equation (1) consists of a factor common to all stocks and a stock-specific term as presented in equation (2).

Eventually, in our regression model we account for changes in a stock's traded volume, price level, volatility and minimum tick size by including them as control variables in the regression term  $X_{i,t}$  in equation (1).

## 4.2 Observation periods

To conduct the analysis, two distinct observation periods have been chosen, each with a length of 60 trading days. The first observation period focuses on trading before the competition in and fragmentation of European securities trading started, as it refers to the 60 trading days prior to the applicability of MiFID on November 01, 2007. This observation period is referred to as *pre-MiFID* in the following<sup>8</sup>. In this observation period we only refer to the home market, as fragmentation was not present yet.

For the choice of the second observation period a number of constraints had to be met. Most important, fragmentation shall have fully unfolded its effect. Therefore, periods directly after the applicability of MiFID are inappropriate, as fragmentation steadily increased: On the one hand, the new competitors gradually expanded the set of securities traded on their systems and on the other hand, some new competitors started their operations several months after the applicability of MiFID. E.g. Turquoise did not start before September 2008. Further, the economic and financial crisis, which had its outburst with the breakdown of Lehman Brothers in September 2008 and thereafter, had significant effects on securities trading. To lessen the impact of this market turmoil on the results of our analysis, we decided to use a very recent observation period which is obviously not close to our pre-MiFID observation period<sup>9</sup>. Thereby, the market values in terms of index levels are also as close as possible to the values of the first observation

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<sup>8</sup> As August 15, 2007 was a holiday in Italy and no trading was conducted at Borsa Italiana, this day is not evaluated in this analysis for any security. Instead, an additional trading day has been added upfront. Therefore, the pre-MiFID observation period ranges from August 8 to October 31, 2007.

<sup>9</sup> A similar setup regarding the observation periods can be found e.g. in [32].

period. To avoid impact of the recent Greece crisis in May 2010, we chose the 60 trading days prior to May 1, 2010 as our *post-MiFID* observation period<sup>10</sup>.

### 4.3 Sample

The sample for our analysis is made up by two distinct groups of equities, which we analyze in the two distinct observation periods as outlined above. The first group of stocks is made up of the constituents of the Spanish IBEX 35 blue-chip index, the second group of constituents of the EURO STOXX index<sup>11,12</sup>. Both samples have been restricted by only considering those securities that were a constituent of the respective index during our first observation period as well as during the second observation period<sup>13</sup>. The group of Spanish stocks was further restricted to those securities that were also present in the EURO STOXX<sup>14</sup>. This procedure left 24 Spanish stocks in our control group of securities where no relevant competition/fragmentation can be observed up to now.

The sample of fragmented securities was constructed with the goal to identify stocks that are comparable to those in the sample of Spanish stocks. Therefore, we restricted the EURO STOXX constituents to stocks from those countries that are nowadays among the top-fragmented according to the Fidessa Fragmentation Index (FFI) [34]<sup>15</sup>. Based on the ten most-fragmented markets according to the FFI (Table 1) this leads to the Euro-denominated markets Netherlands, France, Germany, Finland, Belgium and

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<sup>10</sup> The post-MiFID observation period ranges from February 4 to April 30, 2010.

<sup>11</sup> The EURO STOXX index is a subset of the STOXX Europe 600 index, which focuses on securities denominated in Euro from 12 Eurozone countries: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain. The other Eurozone countries Malta, Slovakia, Slovenia and Cyprus are represented in neither of the two indices. Due to its subset feature the number of EURO STOXX constituents is not fixed.

<sup>12</sup> The two indices have shown a similar performance in recent years. In relation to the index value on August 01, 2007, IBEX 35 has dropped to 71.9% on April 30, 2010. EURO STOXX has dropped to 65.6% in the same period of time.

<sup>13</sup> One Spanish stock, Endessa SA, had to be excluded as it was temporarily excluded from the IBEX 35 due to a takeover bid. See e.g. [33].

<sup>14</sup> Two IBEX 35 stocks had to be excluded, as they were not part of the EURO STOXX due to their low free float market capitalization.

<sup>15</sup> The FFI gives a measure for the fragmentation of actual trading in a stock or index and its calculation corresponds to the inverse Herfindahl-Hirschmann index (inverse HHI). The more concentrated trading is on one venue, the closer the index value is to 1.0. The more fragmented trading is, the higher is the index value.

Italy (UK and Swiss stocks do not belong to the EURO STOXX index as they are traded in different currencies than the Euro).

Country	Index	FFI
UK	FTSE 100	2.51
UK	FTSE 250	2.24
Netherlands	AEX	1.95
France	CAC 40	1.85
Germany	DAX	1.82
Switzerland	SMI	1.81
Finland	OMX H25	1.8
Sweden	OMX S30	1.78
Belgium	BEL 20	1.74
Italy	FTSE MIB	1.54

**Table 1: Ten most- fragmented markets according to the FFI for the first week of trading in May 2010 [35].**

Within the remaining set of EURO STOXX constituents we identified stocks comparable to the securities in our Spanish sample by selecting those 24 stocks with the closest free float market capitalization<sup>16</sup> before our first observation period<sup>17</sup>. The sample of fragmented stocks consists of nine French, eight German, three Finnish, three Dutch and one Italian stock. For both groups of securities, i.e. the group of fragmented EURO STOXX constituents and the group of Spanish securities) a classification based on their market capitalization into quartiles has been conducted. An overview of the selected stocks and the classification into the quartiles is given by Table 2.

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<sup>16</sup> Free float market capitalization as of August 01, 2007. The respective data has been provided by Stoxx free of charge. Any commercial use of the data presented in this paper requires a previous written agreement with Stoxx.

<sup>17</sup> One stock, Christian Dior S.A., had to be excluded as it is not tradable on BATS and Chi-X. It was replaced by the stock with the next closest free float market capitalization.

	IBEX 35 Sample	EURO STOXX Sample
Q1	Banco Santander	Nokia
	Telefonica	BNP Paribas
	BBVA	ING Groep
	Iberdrola	Deutsche Telekom AG
	Repsol YPF	L'Oreal
	Inditex	Banco Popolare
Q2	Banco Popular Espanol	Peugeot
	ACS	UPM Kymmene
	Banco Sabadell	Koninklijke DSM
	Abertis Infraestructuras	CGG Veritas
	Grupo Acciona	Sodexo Alliance
	Gas Natural	Lufthansa AG
Q3	Gamesa	Deutsche Postbank
	Sacyr-Vallehermoso	Beiersdorf
	Grupo Ferrocil	CNP Assurances
	Red Electrica de Espana	Hochtief
	Bankinter	Wacker Chemie
	Enagas	Elisa Corporation
Q4	Fomento de Construcy Contra	Stada Arzneimittel
	Bolsas y Mercadores Espanoles	Valeo
	Acerinox	Klepierre
	Mapfre SA	Bam Groep
	Indra Sistemas	Wincor Nixdorf
	Iberia	Bourbon

**Table 2: Selected stocks and classification into quartiles**

For each sample there was one stock which had a stock split during the first observation period and one stock which had a stock split between the two observation periods. As the market depth data retrieved from Thomson Reuters Tick History is not adjusted for these splits, we adjusted the data for these stocks before processing, i.e. the order book limits and their according volumes were adjusted according to the split ratio.

## 5 Results

In the following, the results from the regression model as described in subsection 4.1.2 will be presented in order to assess the effect of liquidity fragmentation on market quality. Detailed descriptive statistics for the liquidity variables applied in the analysis can be found in the appendix<sup>18</sup> of this paper. For the EURO STOXX instruments, table

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<sup>18</sup> There, Table 5 provides the descriptive statistics for the EURO STOXX home market sample, Table 6 provides the descriptive statistics for the EURO STOXX consolidated books, while Table 7 and 8 provide the descriptive statistics for the IBEX 35 home market sample and the consolidated books for IBEX 35 respectively.



3 reports our findings for the liquidity measures relative spread, XLM with associated values of 50,000 and 100,000 Euros<sup>19</sup> and the quoted value at the top of the bid and the ask side of the order book. The upper part of the table presents results for quartiles Q1 to Q4 in the consolidated order book while the lower part presents results for the same quartiles in the home market only. Results over all quartiles,  $R^2$  and the number of observations<sup>20</sup> are also reported. Here, *Change Qj* ( $\delta_j$ ) denotes the regression coefficient of the indicator variable for quartile  $j$  and thus indicates the impact of the liquidity fragmentation induced by MiFID on the respective liquidity measure. *Rel. Change Qj* reports a liquidity measure's change relative to its pre-MiFID level in quartile  $j$ . Analogically, table 4 presents our findings from the regression model for the Spanish IBEX 35 instruments.

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<sup>19</sup> It should be noted here that relative spread and XLM are inverse liquidity measures and thus an increase in those measures translates into a decline in liquidity.

<sup>20</sup> The number of observations is based on a total of 120 trading days, i.e. 60 trading days in the pre-MiFID and 60 trading days in the post-MiFID period for 24 stocks in each sample.

	<b>Consolidated</b>				
	Relative Spread	XLM 50K	XLM 100K	Quoted Value BB	Quoted Value BA
Change Q1 ( $\delta 1$ )	-0.60 **	-1.64 **	-2.37 **	-1121.69 **	-1060.11 **
Rel. Change Q1	-12.05%	-12.74%	-11.31%	-89.94%	-89.37%
Change Q2 ( $\delta 2$ )	-2.99 **	-4.70 **	-7.38 **	-351.51 **	-342.34 **
Rel. Change Q2	-18.70%	-24.59%	-35.23%	-81.97%	-81.36%
Change Q3 ( $\delta 3$ )	-2.54 **	-4.36 **	-12.76 **	-11.79 **	-15.49 **
Rel. Change Q3	-24.67%	-14.86%	-28.06%	-27.89%	-33.42%
Change Q4 ( $\delta 4$ )	-3.97 **	-14.95 **	-38.11 **	-71.56	-11.76 **
Rel. Change Q4	-32.75%	-46.80%	-58.69%	-59.97%	-40.62%
Change All Quartiles	-2.10 **	-5.13 **	-12.65 **	-301.73 **	-282.13 **
Rel. Change All Quartiles	-24.66%	-30.70%	-43.12%	-85.73%	-84.83%
R2	0.30	0.25	0.21	0.12	0.13
No. of Observations	2880	2880	2880	2880	2880

	<b>Home Market</b>				
	Relative Spread	XLM 50K	XLM 100K	Quoted Value BB	Quoted Value BA
Change Q1 ( $\delta 1$ )	0.64 **	0.83 **	0.38	-1009.37 **	-939.12 **
Rel. Change Q1	6.76%	22.97%	26.60%	-91.53%	-90.86%
Change Q2 ( $\delta 2$ )	-1.65 **	-2.12 **	-4.43 **	-345.10 **	-334.90 **
Rel. Change Q2	-1.70%	-2.56%	-16.50%	-84.18%	-83.40%
Change Q3 ( $\delta 3$ )	-1.28 **	-1.02	-7.14 **	-13.52 **	-17.33 **
Rel. Change Q3	-12.64%	4.36%	-6.73%	-33.51%	-38.81%
Change Q4 ( $\delta 4$ )	-2.67 **	-10.96 **	-31.26 **	-71.69	-16.05 **
Rel. Change Q4	-22.67%	-33.46%	-47.32%	-64.21%	-46.08%
Change All Quartiles	-0.91 **	-2.17 **	-8.13 **	-286.82 **	-266.46 **
Rel. Change All Quartiles	-11.39%	-12.00%	-25.97%	-87.64%	-86.64%
R2	0.26	0.19	0.17	0.14	0.14
No. of Observations	2880	2880	2880	2880	2880

\* / \*\* significant at 95 / 99 percent level

**Table 3: Liquidity change with controls for trade volume, price level, volatility and tick size for EURO STOXX instruments**

For the EURO STOXX instruments, an increase in liquidity, measured in terms of relative spreads and XLM, can be observed for the consolidated order book across all quartiles. For instance, for the total sample spreads narrow by 24.66 % and the XLM for a roundtrip of 50,000 Euros and 100,000 Euros reduces by 30.70 % and 43.12 % respectively. Nevertheless, the value quoted at the top of the order book reduces by 85.73 % and 84.83 % for the bid and the ask side respectively, which represents a decrease in the thickness of the order book's top. This finding is primarily driven by a strong reduction of tick sizes which most markets experienced between the pre-MiFID and post-MiFID observation period based on a European harmonization of tick sizes [36]. Therefore, limit orders can be quoted with a higher granularity resulting in a more even distribution of orders across different limits in the book. As the coefficients of the

indicator variable in our regressions are throughout negative, statistical inference suggests a highly significant positive impact of the MiFID induced competition between markets and the consequent fragmentation on overall liquidity for the total sample and the investigated quartiles.

When considering a stock's home market solely, the increase in liquidity is pronounced less intensively, but still present. For instance, while for the consolidated order book relative spreads for the entire sample reduce by 24.66 %, for the home market a decrease of merely 11.39 % is observable. Those findings stress the contribution to overall liquidity of the new competitors, i.e. coming from markets other than a stock's respective home market. In our regression model for most quartiles and the entire sample, a statistically significant positive impact of market fragmentation on a stock's home market liquidity can be derived with one exception found in Q1.

	Consolidated				
	Relative Spread	XLM 50K	XLM 100K	Quoted Value BB	Quoted Value BA
Change Q1 ( $\delta 1$ )	-0.29	-0.69	-1.04	-178.57 **	-186.53 **
Rel. Change Q1	-4.61%	-0.15%	3.21%	-78.74%	-78.85%
Change Q2 ( $\delta 2$ )	2.16 **	1.54 **	0.42	-25.34 **	-21.84 **
Rel. Change Q2	10.12%	8.92%	7.74%	-55.67%	-52.34%
Change Q3 ( $\delta 3$ )	3.09 **	4.25 **	5.36 **	-9.93 **	-6.16 **
Rel. Change Q3	26.26%	33.05%	34.53%	-46.27%	-40.93%
Change Q4 ( $\delta 4$ )	-2.14 **	1.84 **	6.90 **	-152.08 **	-143.78 **
Rel. Change Q4	-10.28%	10.58%	24.97%	-83.94%	-82.08%
Change All Quartiles	0.85 *	2.44 **	4.24 **	-143.42 **	-141.66 **
Rel. Change All Quartiles	4.96%	15.68%	21.75%	-75.01%	-73.98%
R2	0.20	0.28	0.30	0.47	0.47
No. of Observations	2880	2880	2880	2880	2880

	Home Market				
	Relative Spread	XLM 50K	XLM 100K	Quoted Value BB	Quoted Value BA
Change Q1 ( $\delta 1$ )	0.02	-0.35	-0.55	-173.53 **	-178.81 **
Rel. Change Q1	-0.09%	3.80%	8.20%	-78.21%	-77.98%
Change Q2 ( $\delta 2$ )	2.45 **	2.10 **	1.24	-25.74 **	-22.52 **
Rel. Change Q2	12.46%	11.94%	11.16%	-56.21%	-53.12%
Change Q3 ( $\delta 3$ )	3.25 **	5.24 **	6.29 **	-11.10 **	-8.08 **
Rel. Change Q3	27.55%	38.11%	37.73%	-48.44%	-44.43%
Change Q4 ( $\delta 4$ )	-1.92 **	2.76 **	8.16 **	-152.61 **	-145.21 **
Rel. Change Q4	-9.22%	14.06%	28.70%	-84.51%	-83.18%
Change All Quartiles	1.09 **	3.12 **	5.09 **	-142.30 **	-140.39 **
Rel. Change All Quartiles	6.87%	19.58%	25.37%	-75.03%	-74.01%
R2	0.20	0.28	0.30	0.48	0.47
No. of Observations	2880	2880	2880	2880	2880

\* / \*\* significant at 95 / 99 percent level

**Table 4: Liquidity change with controls for trade volume, price level, volatility and tick size for Spanish IBEX 35 instruments**

For the Spanish IBEX 35 instruments results as given in table 4 are contrary to those for the EURO STOXX. In the consolidated order book, the liquidity measures relative spread and XLMs increase for the entire sample by 4.96 %, 15.68 % and 21.75 % respectively which translates into a decline in overall liquidity available to investors in Spanish blue chips. Again, quoted values at the top of the order book experience a strong decrease which can mainly be attributed to tick size reductions. Most regression coefficients for the indicator variable are measured to be different from zero at a significant level, but contrary to our EURO STOXX findings coefficients are regularly estimated to be positive. In the regressions for relative spread and XLM, those positive coefficients indicate a negative impact on liquidity in the comparison of the pre-MiFID and the post-MiFID period.

Similar observations can be made when considering the Spanish home market solely. Since fragmentation in IBEX 35 stocks was shown to be less intense than for EURO STOXX instruments, differences in the results for the consolidated order book and the home market are less pronounced here. Between our observation periods liquidity in terms of relative spreads and the 50,000 Euro and 100,000 Euro XLM deteriorates by 6.87 %, 19.58 % and 25.37 % respectively for the entire sample. Quoted value declines by 75.03 % on the bid side and 74.01 % on the ask side of the order book. Statistical significance of the indicator variables' coefficient can be verified in most cases except for the regressions on relative spread and XLMs in Q1 and the regression on XLM 100K in Q2. As in the consolidated order book, signs on the coefficients are ambiguous across quartiles but are reported positive for the entire sample. This indicates a negative impact on market liquidity in Spanish blue chip stocks when comparing the pre-MiFID to the post-MiFID observation period.

In summary, while for EURO STOXX instruments a significant positive liquidity effect can be observed between both sample periods, results for the less fragmented Spanish equity market indicate a significant decline in liquidity. A significant decrease in quoted value at the top of the book has been reported for both instances which can be attributed to tick size reductions, i.e. a change in market parameters.

## **6 Conclusions**

The Competition and fragmentation in European electronic financial markets triggered by the introduction of MiFID has significantly changed the way equities are traded in the European landscape. While before MiFID, trading activity in Europe was highly concentrated on a stock's home market, competition between markets has been promoted since the directive has to be applied at the end of 2007. Mostly MTFs have lured order flow in European blue chip stocks from the incumbent electronic exchanges which until then faced few or no competitors at all.

The new competition was indeed appreciated by many in the equity market, but at the same time concerns over liquidity fragmentation and lowered market quality arose among investors. As liquidity and the cost of capital are negatively correlated those

concerns must not be limited to investors, but also issuers need to be aware of potential effects resulting from a fragmented European trading landscape.

This paper addresses the impact that competition and market fragmentation in electronic financial markets has on a stock's liquidity and thereby on cost of capital. For this purpose two distinct samples of stocks have been examined before and after the introduction of the new competition triggered by MiFID. The main difference in the characteristics of those samples is the degree of fragmentation: The first sample consists exclusively of non-Spanish EURO STOXX instruments which in the post-MiFID era are traded actively in multiple markets, the home market and several MTFs, and thus exhibit a relatively high degree of market fragmentation. The other sample features stocks from the Spanish blue chip index IBEX 35. Mainly due to infrastructural issues, trading is still highly concentrated on the home market in the post-MiFID era for those Spanish stocks and therefore this sample exhibits a low degree of fragmentation.

Order book snapshots for the sample stocks have been considered to estimate the means of various liquidity variables in an observation period before and after the introduction of competition triggered by MiFID. Results from panel regression models indicate a contrary development of liquidity in EURO STOXX and Spanish IBEX 35 stocks. For the former, a significant positive liquidity effect in the home market and a virtual order book consolidating multiple markets can be found between the observation periods. In our model, those changes can be attributed to the positive effect of competition. This positive impact competition and the resulting fragmentation has on liquidity can be split up into two parts. A direct effect arises from the mere existence of new electronic trading venues in which liquidity is collected. In our sample those new trading venues contribute to the liquidity improvements in the consolidated order book. The other part can be referred to as an indirect home market effect. As pointed out in some former academic work on fragmentation in the US, the competition for order flow between traders in different markets is one potential explanation for our findings in the home market. In order to attract order flow in form of marketable orders to their market and thus increase the probability of execution, traders are tempted to post more aggressive quotes in a competitive environment. Those results are encouraged by the fact, that for the Spanish stocks in our sample, a significant negative liquidity effect is observable.

During the same period those stocks experienced little competition between markets resulting in a low degree of fragmentation.

Certain limitations arise from the study setup and factors that the authors cannot have an influence on. Most MTFs did not launch their trading services from day one of the post-MiFID era, but delayed their start to a later point in time and thus fragmentation increased steadily over time. In order to capture a high degree of fragmentation we considered a very recent post-MiFID observation period away from the actual introduction. Given the long period between pre-MiFID and post-MiFID observations other incidents may have affected the markets under investigation, e.g. the Lehman Brothers' bankruptcy and the financial crisis thereafter. Moreover, most markets have experienced a deliberate reduction of tick sizes which affects quoted volumes at the best bid and offer in a stock's order book. Nevertheless, this effect of new market design parameters had no negative influence on the total available liquidity.

Concluding, the study at hand presented empirical evidence that competition and market fragmentation among electronic financial markets in Europe has lead to higher market quality in terms of liquidity.

The results provide relevant input for market participants in Europe and the European Commission as the Commission is currently in the process of an intensive MiFID Review where a new draft of a Directive is expected in early 2011.

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## Appendix

		pre-MiFID				post-MiFID			
		mean	SD	min	max	mean	SD	min	max
Q1	Relative Spread	5.95	1.87	2.66	13.09	6.36	3.12	2.46	14.25
	XLM 50K	7.24	2.59	3.38	17.34	8.91	4.89	3.23	21.37
	XLM 100K	8.67	3.63	4.21	21.62	10.98	6.12	4.02	27.40
	Quoted Value BB	1,080,647.00	1,143,282.00	37,864.95	7,304,534.00	91,499.20	94,743.01	23,956.60	506,935.80
	Quoted Value BA	1,028,352.00	1,119,209.00	39,817.58	6,984,099.00	94,042.55	97,374.31	22,387.57	530,866.50
	Volume (shares in mn)	14.90	16.50	0.74	149.00	13.40	14.30	0.49	174.00
Q2	Relative Spread	9.16	2.52	4.64	20.54	9.00	3.03	3.23	22.73
	XLM 50K	14.14	5.18	6.18	34.75	13.78	5.22	5.96	32.13
	XLM 100K	21.52	11.33	8.21	65.84	17.97	6.45	8.46	38.49
	Quoted Value BB	230,205.40	414,718.80	14,550.94	3,718,967.00	36,428.96	16,680.50	15,764.90	110,994.40
	Quoted Value BA	230,355.60	329,899.60	20,606.46	2,361,173.00	38,245.34	17,428.72	14,813.87	96,655.69
	Volume (shares in mn)	2.32	2.04	0.20	14.50	2.32	1.90	0.21	17.20
Q3	Relative Spread	13.03	4.08	4.29	30.23	11.38	3.44	5.20	22.83
	XLM 50K	20.64	6.49	8.34	43.78	21.55	11.64	7.08	74.26
	XLM 100K	33.68	16.52	11.65	114.45	31.41	21.21	8.71	131.20
	Quoted Value BB	41,368.08	27,093.36	14,722.97	294,717.90	27,506.81	10,806.78	8,608.87	85,362.94
	Quoted Value BA	45,773.82	56,420.00	11,868.94	952,088.70	28,008.09	13,065.02	7,676.01	147,339.00
	Volume (shares in mn)	0.65	0.58	0.08	4.03	0.44	0.33	0.04	3.01
Q4	Relative Spread	16.01	4.66	6.76	37.67	12.38	2.74	5.89	22.66
	XLM 50K	33.75	11.28	13.25	84.11	22.46	6.80	11.54	47.94
	XLM 100K	61.21	27.81	19.40	230.95	32.24	10.65	17.35	75.49
	Quoted Value BB	50,116.10	262,878.20	8,452.73	4,928,217.00	17,937.28	5,413.46	6,386.73	61,929.81
	Quoted Value BA	34,414.70	34,061.83	8,764.46	427,861.30	18,556.14	5,266.27	6,059.69	51,282.13
	Volume (shares in mn)	0.50	0.33	0.06	2.68	0.69	0.85	0.06	6.95
All Quartiles	Relative Spread	11.04	5.15	2.66	37.67	9.78	3.87	2.46	22.83
	XLM 50K	18.95	12.09	3.38	84.11	16.67	9.46	3.23	74.26
	XLM 100K	31.27	25.95	4.21	230.95	23.15	15.55	4.02	131.20
	Quoted Value BB	350,584.30	754,914.50	8,452.73	7,304,534.00	43,343.06	56,227.88	6,386.73	506,935.80
	Quoted Value BA	334,723.90	712,234.50	8,764.46	6,984,099.00	44,713.03	57,887.80	6,059.69	530,866.50
	Volume (shares in mn)	4.60	10.20	0.06	149.00	4.22	9.02	0.04	174.00

**Table 5: Descriptive statistics for the EURO STOXX home market sample**

		pre-MiFID				post-MiFID			
		mean	SD	min	max	mean	SD	min	max
Q1	Relative Spread	5.95	1.87	2.66	13.09	5.24	2.90	2.05	13.10
	XLM 50K	7.24	2.59	3.38	17.34	6.32	3.91	2.63	17.41
	XLM 100K	8.67	3.63	4.21	21.62	7.69	4.85	3.14	20.89
	Quoted Value BB	1,080,647.00	1,143,282.00	37,864.95	7,304,534.00	108,718.40	114,096.90	21,623.98	681,508.50
	Quoted Value BA	1,028,352.00	1,119,209.00	39,817.58	6,984,099.00	109,268.50	108,130.70	23,401.19	562,026.70
	Volume (shares in mn)	14.90	16.50	0.74	149.00	18.50	20.20	0.75	249.00
Q2	Relative Spread	9.16	2.52	4.64	20.54	7.44	2.92	2.81	40.72
	XLM 50K	14.14	5.18	6.18	34.75	10.67	3.79	4.45	32.09
	XLM 100K	21.52	11.33	8.21	65.84	13.94	5.45	5.75	49.25
	Quoted Value BB	230,205.40	414,718.80	14,550.94	3,718,967.00	41,499.01	22,243.39	10,761.59	127,401.40
	Quoted Value BA	230,355.60	329,899.60	20,606.46	2,361,173.00	42,948.56	22,224.66	12,004.17	115,851.30
	Volume (shares in mn)	2.32	2.04	0.20	14.50	3.08	2.45	0.28	23.60
Q3	Relative Spread	13.03	4.08	4.29	30.23	9.81	2.97	4.26	21.00
	XLM 50K	20.64	6.49	8.34	43.78	17.58	9.37	5.87	62.88
	XLM 100K	33.68	16.52	11.65	114.45	24.23	14.06	7.32	83.61
	Quoted Value BB	41,368.08	27,093.36	14,722.97	294,717.90	29,830.26	12,066.43	8,007.01	85,182.13
	Quoted Value BA	45,773.82	56,420.00	11,868.94	952,088.70	30,478.28	14,885.12	9,647.11	148,185.00
	Volume (shares in mn)	0.65	0.58	0.08	4.03	0.56	0.41	0.04	3.62
Q4	Relative Spread	16.01	4.66	6.76	37.67	10.76	2.42	5.79	19.18
	XLM 50K	33.75	11.28	13.25	84.11	17.96	4.88	9.31	36.89
	XLM 100K	61.21	27.81	19.40	230.95	25.29	8.50	12.19	55.42
	Quoted Value BB	50,116.10	262,878.20	8,452.73	4,928,217.00	20,062.52	8,455.20	6,455.17	90,120.88
	Quoted Value BA	34,414.70	34,061.83	8,764.46	427,861.30	20,434.94	7,725.66	4,876.02	59,100.65
	Volume (shares in mn)	0.50	0.33	0.06	2.68	0.86	1.02	0.08	7.79
All Quartiles	Relative Spread	11.04	5.15	2.66	37.67	8.31	3.54	2.05	40.72
	XLM 50K	18.95	12.09	3.38	84.11	13.13	7.69	2.63	62.88
	XLM 100K	31.27	25.95	4.21	230.95	17.79	11.59	3.14	83.61
	Quoted Value BB	350,584.30	754,914.50	8,452.73	7,304,534.00	50,027.54	68,058.57	6,455.17	681,508.50
	Quoted Value BA	334,723.90	712,234.50	8,764.46	6,984,099.00	50,782.56	65,688.69	4,876.02	562,026.70
	Volume (shares in mn)	4.60	10.20	0.06	149.00	5.74	12.60	0.04	249.00

**Table 6: Descriptive statistics for the EURO STOXX sample's consolidated order books**

		pre-MiFID				post-MiFID			
		mean	SD	min	max	mean	SD	min	max
Q1	Relative Spread	7.43	2.08	4.60	17.89	7.42	2.66	3.42	19.11
	XLM 50K	8.93	3.29	4.82	24.43	9.26	3.31	3.78	22.59
	XLM 100K	10.45	4.97	4.97	33.44	11.30	4.22	4.10	26.98
	Quoted Value BB	493,441.50	487,623.90	33,873.71	3,389,709.00	107,538.00	56,436.24	25,545.37	291,693.80
	Quoted Value BA	503,658.10	524,248.00	28,173.52	3,570,852.00	110,898.50	59,550.09	33,565.10	344,707.20
	Volume (shares in mn)	29.30	24.40	0.74	160.00	25.30	23.10	0.70	189.00
Q2	Relative Spread	12.88	3.85	5.40	28.34	14.49	3.46	6.57	28.71
	XLM 50K	17.96	5.30	8.02	37.50	20.11	4.09	11.10	39.34
	XLM 100K	23.90	8.18	10.31	54.43	26.57	5.40	15.16	52.05
	Quoted Value BB	98,016.07	84,953.32	23,930.95	691,558.20	42,917.36	11,085.88	20,928.86	87,953.21
	Quoted Value BA	96,713.50	85,865.45	21,142.68	674,753.10	45,340.62	12,899.12	13,261.31	102,516.70
	Volume (shares in mn)	3.34	3.23	0.10	19.40	3.60	4.26	0.15	38.90
Q3	Relative Spread	13.91	4.12	6.25	34.04	17.74	5.75	7.97	45.95
	XLM 50K	22.74	8.08	8.92	56.62	31.41	14.23	10.76	83.80
	XLM 100K	32.90	13.32	12.42	84.54	45.32	21.28	14.76	134.12
	Quoted Value BB	55,281.33	27,457.97	17,284.50	173,006.30	28,504.98	13,372.21	7,282.02	88,234.50
	Quoted Value BA	54,093.92	25,161.21	12,944.84	162,826.20	30,059.04	12,482.39	8,406.76	75,968.38
	Volume (shares in mn)	1.55	1.11	0.23	8.11	2.12	1.86	0.24	16.20
Q4	Relative Spread	19.13	9.50	6.89	43.62	17.37	3.72	9.07	44.09
	XLM 50K	25.98	7.91	12.14	50.54	29.63	6.66	18.08	69.38
	XLM 100K	33.55	8.19	16.66	67.50	43.18	10.17	24.86	91.07
	Quoted Value BB	184,039.10	266,550.30	13,240.65	1,961,517.00	28,515.84	6,925.60	14,952.23	54,587.11
	Quoted Value BA	176,412.70	247,325.30	12,844.23	1,767,509.00	29,678.12	7,553.19	10,550.54	75,976.38
	Volume (shares in mn)	3.59	5.81	0.16	77.20	2.72	3.21	0.17	17.30
All Quartiles	Relative Spread	13.34	6.98	4.60	43.62	14.25	5.79	3.42	45.95
	XLM 50K	18.90	9.11	4.82	56.62	22.60	12.10	3.78	83.80
	XLM 100K	25.20	13.08	4.97	84.54	31.59	18.46	4.10	134.12
	Quoted Value BB	207,694.50	329,275.10	13,240.65	3,389,709.00	51,869.06	44,160.91	7,282.02	291,693.80
	Quoted Value BA	207,719.60	342,002.90	12,844.23	3,570,852.00	53,994.07	45,819.03	8,406.76	344,707.20
	Volume (shares in mn)	9.43	17.10	0.10	160.00	8.43	15.40	0.15	189.00

**Table 7: Descriptive statistics for the IBEX 35 home market sample**

		pre-MiFID				post-MiFID			
		mean	SD	min	max	mean	SD	min	max
Q1	Relative Spread	7.43	2.08	4.60	17.89	7.08	2.60	3.14	18.66
	XLM 50K	8.93	3.29	4.82	24.43	8.91	3.20	3.49	21.95
	XLM 100K	10.45	4.97	4.97	33.44	10.78	4.02	3.95	25.97
	Quoted Value BB	493,441.50	487,623.90	33,873.71	3,389,709.00	104,907.90	56,881.62	26,175.38	292,508.60
	Quoted Value BA	503,658.10	524,248.00	28,173.52	3,570,852.00	106,509.70	57,898.45	33,657.45	319,531.30
	Volume (shares in mn)	29.30	24.40	0.74	160.00	25.60	23.30	0.72	190.00
Q2	Relative Spread	12.88	3.85	5.40	28.34	14.19	3.40	6.54	28.28
	XLM 50K	17.96	5.30	8.02	37.50	19.56	3.92	11.00	38.30
	XLM 100K	23.90	8.18	10.31	54.43	25.75	5.12	15.04	50.97
	Quoted Value BB	98,016.07	84,953.32	23,930.95	691,558.20	43,454.14	11,278.44	21,235.47	91,503.79
	Quoted Value BA	96,713.50	85,865.45	21,142.68	674,753.10	46,091.97	13,677.35	13,882.74	115,759.40
	Volume (shares in mn)	3.34	3.23	0.10	19.40	3.64	4.29	0.15	39.00
Q3	Relative Spread	13.91	4.12	6.25	34.04	17.56	5.73	7.85	45.95
	XLM 50K	22.74	8.08	8.92	56.62	30.26	13.26	10.32	81.59
	XLM 100K	32.90	13.32	12.42	84.54	44.26	21.07	13.98	133.88
	Quoted Value BB	55,281.33	27,457.97	17,284.50	173,006.30	29,703.55	13,322.12	8,976.79	87,360.80
	Quoted Value BA	54,093.92	25,161.21	12,944.84	162,826.20	31,950.91	12,545.67	10,631.49	77,165.20
	Volume (shares in mn)	1.55	1.11	0.23	8.11	2.13	1.87	0.24	16.20
Q4	Relative Spread	19.13	9.50	6.89	43.62	17.16	3.66	9.05	43.97
	XLM 50K	25.98	7.91	12.14	50.54	28.73	6.44	17.54	67.57
	XLM 100K	33.55	8.19	16.66	67.50	41.93	9.95	24.59	88.69
	Quoted Value BB	184,039.10	266,550.30	13,240.65	1,961,517.00	29,562.81	7,063.38	16,637.39	55,194.61
	Quoted Value BA	176,412.70	247,325.30	12,844.23	1,767,509.00	31,610.75	7,987.48	10,557.09	77,966.55
	Volume (shares in mn)	3.59	5.81	0.16	77.20	2.75	3.25	0.17	17.50
All Quartiles	Relative Spread	13.34	6.98	4.60	43.62	14.00	5.81	3.14	45.95
	XLM 50K	18.90	9.11	4.82	56.62	21.87	11.55	3.49	81.59
	XLM 100K	25.20	13.08	4.97	84.54	30.68	18.14	3.95	133.88
	Quoted Value BB	207,694.50	329,275.10	13,240.65	3,389,709.00	51,907.11	43,180.16	8,976.79	292,508.60
	Quoted Value BA	207,719.60	342,002.90	12,844.23	3,570,852.00	54,040.83	43,481.43	10,557.09	319,531.30
	Volume (shares in mn)	9.43	17.10	0.10	160.00	8.53	15.50	0.15	190.00

**Table 8: Descriptive statistics for the IBEX 35 sample's consolidated order books**