Fourteen at One Blow:
The Market Entry of Turquoise

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September 21, 2009

This is a preliminary draft

Abstract

This paper analyzes the market entry of Turquoise in September 2008. Turquoise started trading stocks from 14 European countries at (almost) the same time. We find that Turquoise gained higher market shares in larger and less volatile stocks, and in stocks that had excessively high pre-entry spreads. The entry of Turquoise led to a decrease in spreads but not to an increase in trading volume. Turquoise does not generally offer lower execution costs than the primary market. Taken together our results are consistent with the view that the new entrant serves as a disciplinary device that reduces rents earned by the suppliers of liquidity in the primary market.

JEL Classification: G10, G12, G15.

Keywords: Competition for order flow, trading volume, liquidity.

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1 Introduction

Situations in which several trading venues compete for order flow in the same instruments are by now the rule rather than the exception. In the US alternative trading systems (ATS) exist since more than a decade and have gained significant market share in NYSE- and NASDAQ-listed stocks. Recent regulatory changes, in particular the Markets in Financial Instruments Directive (MiFID) of the European Union, have spurred competition in Europe.[1] The inception of new pan-European trading platforms like Chi-X and Turquoise puts established exchanges under pressure. Although some alternative trading systems entered the market successfully, others failed. A case in point is NASDAQ Europe which was unable to attract sufficient order flow. Consequently, the platform was closed in 2003, only about a year after the launch of SuperMontage Europe.

Competition for order flow raises several interesting and important questions. What determines the success of a new entrant? Does a new entrant attract volume only at the expense of incumbent trading venues or does the total trading volume increase? Does the increased level of competition increase market quality? From a theoretical point of view the answers to these questions are not straightforward because of the existence of network externalities. These externalities create barriers to entry. Consequently, a market entry may fail even though the entrant has superior technology. Because fragmentation of the order flow may be detrimental to liquidity, increased competition for order flow does not necessarily increase liquidity.

In the present paper we analyze the market entry of Turquoise in the summer of 2008. The entry of Turquoise is a particularly interesting event for at least two reasons. First, Turquoise was founded by nine large investment banks. These banks, through their own trading activity and their brokerage business, can direct significant order flow to the new trading venue. This arguably increases the odds for a successful entry. Second, Turquoise started trading stocks from 14 different European markets at the same time. In this respect the entry of Turquoise is close to a natural experiment and allows us to analyze the extent to which the success of Turquoise depends on characteristics of the home market.

We collected intradaily data for Turquoise and the home markets from Bloomberg. Our sample comprises 266 stocks from 14 different markets and covers three months prior to the entry of Turquoise and three months post-entry. We use this data to answer the three questions

[1] Descriptions of the regulatory environment in Europe and in the US can be found in Petrella (2009).

raised above. We analyze cross-sectional determinants of the Turquoise market share, considering both firm-specific and market-specific variables and use a panel approach to investigate whether changes in market design by primary exchanges had an impact on market shares. We further test whether the entry of Turquoise has led to an increase in total trading volumes and/or liquidity in the home market, and we analyze the determinants of changes in transaction volumes and liquidity using a panel approach. Obviously, when analyzing changes in volume and liquidity, we need to control for any other factors that may have contributed to changes in these variables. We achieve this by measuring both volume and liquidity relative to matched control samples of Spanish and Italian stocks. Spanish stocks were not traded on Turquoise during our sample period (trading started in February 2009) whereas trading of Italian stocks started on October 13 and 20, about six to seven weeks later than trading of stocks from the other 13 countries.

Our main results are that both stock and market characteristics are determinants of Turquoise market shares, the most important variables being measures of liquidity, volatility, firm size and market capitalization of the primary markets. A panel analysis provides some evidence that spreads decreased upon the entry of Turquoise. Trading volume, on the other hand, did not increase. Our data furthermore suggests that average best bid-ask spreads on Turquoise exceeded those on the primary markets in the period between November 2008 and January 2009.

Our paper is closely related to other papers analyzing competition for order flow. Hendershott and Mendelson (2000), Parlour and Seppi (2003) and Degryse, van Achter, and Wuyts (2009) have developed theoretical models of competition for order flow. Despite the different modeling approaches these papers agree in the conclusion that the introduction of an additional market has an ambiguous effect on overall welfare.

A famous episode that has spurred a host of empirical research is the "battle of the Bund". The London International Financial Futures Exchange (LIFFE) started trading in futures contracts on German government bonds in 1988. About two years later, the Deutsche Terminboerse (DTB), an electronic derivatives exchange founded in January 1990, launched an almost identical contract. The two markets co-existed for about eight years. The LIFFE had the larger market share until 1997. After that date, trading volume on the LIFFE deteriorated and it abandoned the Bund contract soon thereafter. For a detailed account of this episode see Cantillon and Yin (2008).

Lee (1993) analyzes trading of New York Stock Exchange (NYSE)-listed securities at different trading venues and finds that execution costs differ significantly across venues. Conrad, Johnson, and Wahal (2003) demonstrate that execution costs are lower for trades executed in ATS than for trades executed via traditional brokers. Boehmer, Jennings, and Wei (2007) show that differences in execution costs indeed affect investors' future order routing decisions. Batallio (1997) compares execution costs before and after Madoff Investment Securities started to selectively purchase order flow. He finds that spreads decreased upon the entry of Madoff. Boehmer and Boehmer (2003) analyze the entry of the NYSE in the market for exchange traded funds (ETFs). The NYSE started trading of some ETFs which were listed on the American Stock Exchange in 2002. Upon entry of the NYSE spreads decreased significantly. Foucault and Menkveld (2008) analyze the rivalry between Euronext and the London Stock Exchange (LSE) in the Dutch equity market. They conclude that the consolidated limit order book after the entry of the LSE is deeper than the Euronext order book prior to the entry. Mayhew (2002) confirms the result that competition decreases execution costs. He finds that options which are listed on multiple exchanges have narrower spreads than those listed on only one exchange.

Taken together, the extant empirical literature yields the conclusion that competition is "good". Our own results are somewhat ambiguous but point in the same direction. Pairwise comparison of matched samples (Turquoise stocks versus Spanish and Italian stocks) do not reveal a significant decrease of the bid-ask spreads after the introduction of Turquoise. The comparison with the Italian stocks indicates that volume may have increased after the introduction of Turquoise. When we use a weekly panel instead we find evidence that spreads have declined and volume has increased after the introduction of Turquoise. These results are consistent with a positive impact on market quality of competition between trading venues.

From a methodological point of view our paper is also related to previous papers analyzing the impact of changes in market structure on market quality (e.g. Boehmer, Saar, and Yu (2005) who analyze a change in transparency on the NYSE and Foucault, Moinas, and Theissen (2007) who analyse a change in anonymity on Euronext). A common problem in this type of analysis is that the structural change affects all sample stocks at the same time. It is thus necessary to control for other factors that may have affected market quality around the event day. Boehmer, Saar, and Yu (2005) and Foucault, Moinas, and Theissen (2007) achieve this by including control variables in their analysis. We also included appropriate control variable. In addition, we implemented the control sample approach described above.

The remainder of the paper is organized as follows. Section 2 introduces the reader to the institutional details. Section 3 provides a description of the data set and descriptive statistics. In section 4 we analyze the determinants of the Turquoise market share. Section 5 investigates changes in liquidity and trading volumes after the entry of Turquoise, while section 6 compares measures of market quality for Turquoise to those for the primary exchanges. Section 7 concludes.

2 The Launch of Turquoise

In November 2006, seven of the largest European investment banks in Europe announced their plans to found a new pan-European equity trading platform. The stated objective of the member banks Citigroup, Credit Suisse, Deutsche Bank, Goldman Sachs, Merrill Lynch, Morgan Stanley and UBS was to be able to execute orders for their clients at markedly lower costs compared to those paid to existing exchanges.[2] The new platform was intended to compete with existing markets and attract liquidity from them. The creation of the venture became possible because of changes in European regulation, specifically the European Union's Markets in Financial Instruments Directive (MiFID) which came into force in November 2007. A stated objective of MiFID was to promote competition in equity trading in Europe, e.g. by allowing the creation of new trading platforms (*Multilateral Trading Facilities*, MTFs) to challenge incumbent equity markets.

The nine founding members (the seven investment banks listed above and BNP Paribas and Société Générale Corporate & Investment Banking who joined the consortium in 2007) are the owners of Turquoise Services Limited, a regulated entity authorised to operate a Multilateral Trading Facility by the Financial Services Authority. Turquoise is independently managed. The Swedish firm Cinnober provided the platform technology. The European Central Counterparty Ltd (EuroCCP), a subsidiary of the Depositary Trust & Clearing Corporation (DTCC) serves as the central counterparty for all trades and provides clearing and settlement services.

While the launch of Turquoise's trading platform was originally scheduled for the end of 2007, the system finally started to operate with 5 sample firms per exchange (so-called soft launch) between August 15 and August 22, 2008. In September 2008, trading was extended to about 1270 firms from 13 European stock exchanges.[3] Italian firms started trading in October 2008, Spanish

[2] All information on Turquoise is obtained from the official website www.tradeturquoise.com.

[3] The exchanges are London Stock Exchange (United Kingdom), Deutsche Börse (Germany), NYSE Euronext Paris (France), NYSE Euronext Amsterdam (Netherlands), NYSE Euronext Brussels (Belgium), NYSE Euronext Lisbon (Portugal), OMX Copenhagen (Denmark), OMX Stockholm (Sweden), OMX Helsinki (Finland), Oslo Bors (Norway), Wiener Börse (Austria), Swiss Exchange (Switzerland) and Irish Stock Exchange (Ireland).

stocks were added on February 16, 2009, after the end of our sample period. On November 1, 2008 (the beginning of our post-entry period) 311 stocks from 14 countries were traded in the integrated order book described in more detail below. The remaining stocks were only traded in the dark pool.

Turquoise initially offered two different trading systems, an integrated order book and a dark pool. In March 2009 (after the end of our sample period) stocks traded in the dark pool thus far were migrated to the integrated order book. Our empirical analysis only considers stocks traded in the integrated order book.

The integrated order book is a hybrid trading facility that combines a transparent open limit order book with a hidden order book (dark pool) within the same matching engine and order book. It is designed to "increase execution and price improvement for small orders, whilst minimizing information leakage and market impact for larger, institutional-size orders."[4] Orders in the open book enjoy time priority over hidden volume. A feature that distinguishes Turquoise's dark pool from traditional hidden orders is the fact that orders submitted to the dark pool do not have a visible part.[5] Therefore, there may be hidden liquidity inside the visible spread. Consequently, the quoted spread visible on the trading screens may overstate the actual cost of executing an order. Another distinguishing feature of the trading system is the possibility to submit limit orders with a price limit that is pegged to the best bid or ask quote. To provide an example, a trader can submit a buy order such that the price limit is always one tick below the best bid. When the best bid changes the price limit will be automatically adjusted. Obviously, the order in the example will only execute when a large market sell order that walks up the book is submitted.

Trading in Turquoise starts with a pre-opening phase from 08:40:00 CET to 08:59:30, followed by an opening call auction which takes place between 08:59:30 and 09:00:00. The exact time of the matching is determined randomly. The continuous trading session begins at 09:00:00 and extends until 17:30:00. There is no closing call auction.

According to the Turquoise rule book the minimum tick size is the same as in the home market unless the Turquoise management specifies a different tick size. For most of our sample stocks (217 out of 260) the minimum tick sizes in Turquoise and the home market were equal.

[4] See http://www.tradeturquoise.com/tq_about.shtml.

[5] Several markets, e.g. Xetra and NYSE allow the submission of hidden orders (iceberg orders). These orders must, however, have a visible part. Therefore, there can be no hidden liquidity inside the quoted spread. NYSE Euronext has recently launched Smart Pool, a dark pool for block trades. It is not part of the main order book but is rather operated and regulated as an independent MTF.

Nine stocks (all from Germany) have a lower tick size in Turquoise. 34 stocks (from Sweden and Switzerland) have (at least in parts of the sample period) a larger tick size in Turquoise.

During our sample period five potentially important changes in market structure occurred.[6] On November 24, 2008, Deutsche Börse introduced Xetra MidPoint, a dark pool integrated into the Xetra order book.[7] Also in November 2008 Italian stocks migrated to the LSE TradElect platform. On January 14, 2009, Euronext introduced the single order book for the Amsterdam, Brussels and Paris market. Prior to that date some stocks were traded in more than one of Euronext's markets. The resulting fragmentation may have adversely affected liquidity. OMX introduced a new real time data feed in January 2009. Also in January 2009 the LSE introduced Member Authorised Connection, a facility which provides faster access to trading for members' customers via direct connection to the electronic trading system TradElect. In our empirical analysis we controlled for the effect on market shares of these events.

3 Data Set and Descriptive Statistics

Our initial data set consists of all 311 firms from 14 European countries that started trading in Turquoise's integrated order book between August 15, 2008 and October 20, 2008. We obtained intradaily data from Bloomberg. The data covers both the home markets and Turquoise and consists of one-minute snapshots. Variables include the aggregated trading volume and the number of trades over the previous minute, the last bid, ask and transaction price of the one-minute interval, depth at the ask and at the bid, and the number of quote updates within the minute. The trading volume and the number of transactions in Turquoise includes transactions involving hidden orders. The best bid and ask quotes, on the other hand, are based on visible orders only.

We had to discard 41 firms from the initial data set because of missing or incomplete Bloomberg data. Four firms were listed on two incumbent markets but we only include them once in our sample.[8] This reduces the sample to 266 firms. In our regression analyses we include

[6] Besides these changes in market structure, there were several fee reductions. Fees on Euronext, the LSE, Oslo Bors and Xetra were reduced on September 1, 2008; in Switzerland on October 1, 2008, and Clearstream reduced its fees on November 1, 2008. All these reductions were already in place at the beginning of our post-entry period. Therefore we cannot assess the extent to which they may have affected the success of Turquoise. Turquoise itself reduced its fees after trading volume fell markedly in March 2009 (after the end of our sample period) when a market making agreement between Turquoise and the founding members expired.

[7] Xetra MidPoint matches orders at the quote midpoint of the Xetra order book. MidPoint orders are completely hidden, and they are only matched with other MidPoint orders.

[8] Consider Royal Dutch Shell as an example. The stock is listed on the London Stock Exchange and on Euronext

additional control variables (e.g. market capitalization and free float). For six firms this data was unavailable. Therefore, we include 260 firms in our baseline regressions.

As noted in the previous section, trading in Turquoise started with a "soft launch" in August 2008. During the soft-launch period, only a small number of stocks were traded in Turquoise. The market share of Turquoise was below 1%. It stayed at that level through September 2008. Market shares increased markedly in October. The Italian stocks included in our sample started trading in Turquoise only in October 2008. The intradaily data for Turquoise available from Bloomberg includes information on best bid and ask quotes only from November 2008 onwards. We therefore consider the three-month period from May to July 2008 as our pre-Turquoise benchmark period and the three-months period from November 2008 to January 2009 as our post-entry period. Summary statistics for the sample stocks, sorted by the country of the primary listing, are depicted in Table 1.

[Insert Table 1 about here]

The United Kingdom accounts for the largest share of our sample firms, followed by France, Italy, Sweden and Germany. The Turquoise market share (defined as trading volume in Turquoise divided by the sum of trading volume in Turquoise and the home market) spans a wide range. It is highest for the Netherlands (7.1%) and lowest for Ireland (0.15%).

The changes in market capitalization, trading volume, quoted spreads and depth between the pre-Turquoise and the post-entry period reflect the deteriorating market environment in the fall of 2008. The average market capitalization (measured in Euro) fell significantly, in some countries to less than half its initial level. Trading volume also fell, albeit to a much lesser extent. The increased spreads and the decreased depth indicate that liquidity deteriorated. Obviously, thus, the impact of the introduction of Turquoise on market quality can not be assessed by simply comparing measures of market quality for the pre- and the post-entry period. Rather, we will include appropriate control variables in our analysis and, in addition, use a control sample.

Amsterdam. We kept the data from Euronext Amsterdam because trading volume in this market was higher in the pre-Turquoise period. The other three stocks with double listings are Nokia (data from Finland retained, data from Sweden discarded), ABB (Switzerland retained, Sweden discarded) and AstraZeneca (UK retained, Sweden discarded).

4 Cross-Sectional Determinants of Market Shares

In this section we analyze the determinants of the Turquoise market shares. We start with a cross-sectional analysis and then turn to a panel approach. The variable of interest, $Market\ Share\ TQ$, is defined as the number of shares traded on Turquoise between November 2008 and January 2009 divided by the number of shares traded on Turquoise and the home market in the same period. We regress $Market\ Share\ TQ$ on a number of stock and market characteristics. $LnMcap$ denotes the natural logarithm of market capitalization measured in Euro[9] as of July 31, 2008. $FreeFloat^{Pre}$ denotes the average free float of a share in the period from May to July 2008, expressed as a fraction of the total number of shares outstanding. $Volume^{Pre}$, $Spread\ in\ \%^{Pre}$ and $Depth^{Pre}$ denote the average daily trading volume in shares, the average percentage quoted spread and the average quoted depth in the pre-Turquoise period. $Std.Dev.Return^{Pre}$ is the standard deviation of daily returns in the same period. The indicators $\mathbf{1}_{NYSE}$ and $\mathbf{1}_{DJ\ STOXX50}$ are set to 1 if a stock is cross-listed on the NYSE or is included in the Dow Jones Stoxx 50 index and is set to 0 otherwise.[10] Market-related variables include $TickSize^{Pre}$,[11] the average absolute tick size of a stock in the period between May and July 2008 as well as $LnMcapExchange^{Pre}$, the overall market capitalization on the respective exchange as of July 2008 in Euro.

Results are presented in Table 2. Model (1) is a baseline specification that includes main stock and market characteristics. Model (2) adds four dummy variables $\mathbf{1}_{EURONEXT}$, $\mathbf{1}_{OMX}$, $\mathbf{1}_{LSE}$ and $\mathbf{1}_{XETRA}$. They identify stocks listed in markets belonging to the institutional groups NYSE Euronext, OMX, London Stock Exchange and Xetra.[12] Model (3) is analogous to specification (1) but additionally includes indicator variables for the national stock markets (coefficient estimates are not reported in the table). As documented in Table 1, UK stocks are by far the largest group in our sample. To make sure that our results are not driven by the UK stocks, we repeated the analysis after exclusion of the UK stocks. We obtain similar results (not shown but available upon request). All t-statistics are based on robust Huber/White standard errors.

[9]Exchange rates used for conversion were obtained from the website of the European Central Bank.

[10]Note that including an indicator variable for the Dow Jones Euro Stoxx 50 index instead of the Dow Jones Stoxx 50 index does not change results.

[11]Note that using relative tick size, defined as average tick size over average midpoint in the pre-entry period, yields qualitatively similar results. Since the correlation between relative tick size and some country indicator variables as well as the predicted spread component as described below exceeds 60%, we use the absolute tick size in our estimations.

[12]NYSE Euronext comprises the primary markets of France, the Netherlands, Belgium and Portugal. OMX covers the Danish, Swedish and Finnish markets. Borsa Italiana is a member of the London Stock Exchange group and migrated equity trading to the LSE TradElect platform in November 2008. Xetra is not an institutional group but a trading platform. It is used in Germany, Ireland and Austria.

[Insert Table 2 about here]

Turning to results we find that, although significance levels and magnitude of the estimated coefficients vary, the results are qualitatively similar across specifications. The market share of Turquoise tends to be larger for firms with higher market capitalization and firms with higher free float. The respective coefficients are positive and significant in all cases. The sign of the indicator variable standing for index membership in the Dow Jones Stoxx 50, however, is negative in all specifications, partly reducing size effects since index membership is largely a function of market capitalization.[13] A cross-listing on the NYSE does not affect the Turquoise market share.

Firms with high execution costs in the pre-entry period (as measured by the quoted bid-ask spread) have a higher market share on Turquoise. Similarly, Turquoise market shares tend to be higher for firms with lower quoted depth and lower trading volume in their home markets. These results are consistent with the notion that liquidity in the home market determines the attractiveness of an alternative trading venue.

The relation between volatility (measured in the pre-entry period) and the Turquoise market share is negative. This indicates that the alternative trading venue may be relatively more attractive for less volatile stocks. Firms with lower absolute tick size in the pre-Turquoise period tend to have higher market shares on Turquoise. This is a somewhat surprising result because the tick sizes in Turquoise and in the home market are in most cases the same.

Stocks from countries with a higher aggregate market capitalization tend to be traded more actively on Turquoise. This is consistent with the descriptive statistics presented in the previous section. A possible explanation is that the portfolios and trading activities of the nine investment banks that founded Turquoise (among them four US-based institutions) are tilted towards larger markets.

When we add dummy variables for the institutional groups (model (2)) we find that the market share of firms with a primary listing on Euronext or LSE is higher as compared to firms listed on an OMX member exchange, using the Xetra market model or listed on one of the

[13]It might be the case that the relation between Turquoise market share and size is nonlinear and that the DJ Stoxx 50 dummy picks up this nonlinearity. To test whether this is the case, we included the square of the size variable as an additional regressor and found corresponding evidence in the data: While the square of the size variable was negative and significant in all estimations, the DJ Stoxx 50 dummy lost its significance in all estimations and in some cases changed its sign. Note that multicollinearity is not an issue here; the pairwise correlations between the independent variables do not exceed 40%.

other exchanges. Using country dummies instead of the institutional group dummies (model (3)) increases the explanatory power of the model significantly (the adjusted R^2 increases from 0.38 to 0.49,[14]) but yields otherwise similar results. Only the tick size variable loses its significance.

Turquoise was designed to cater to the needs of institutional investors. We therefore expect its market share to be higher for firms with larger institutional shareholdings. Unfortunately, we did not have access to accurate ownership data at the firm level. However, Thompson Reuters Datastream provides some ownership information as of May 2008. With respect to institutional ownership data, it features information on shareholdings of investment companies with a strategic focus, shareholdings by foreign institutional investors and by pension funds. While the latter group is non-zero in only 6 out of 260 observations, there is more variation in the other two sub-groups. We hence use the variables $InvestmentHoldings$ and $ForeignHoldings$ ((items NOSHIC and NOSHFR) which indicate the percentage of shares in issue held by investment companies or, respectively, foreign institutions. However, both categories together only account for about 12.3% of shareholdings, which appears to be very low. Further, for more than one third of the sample firms both values are zero. We thus doubt that these variables provide an accurate estimate of institutional shareholdings. We nevertheless repeated estimations of models (1) to (3) including these variables, expecting a positive sign for both coefficients. Estimation results from models (4) to (6) show that as expected, $InvestmentHoldings$ is significantly positive in all cases. Contrary to expectations, $ForeignHoldings$, which may include holdings by foreign investment banks, is significantly negative. Without having detailed access to ownership data, we can only speculate about the reasons for this finding which may relate to the origin of the foreign institution or to its strategic interest in the company. Using ownership data on a country level as a robustness check, results are somewhat ambiguous. They indicate a positive impact of institutional ownership on Turquoise market shares and no impact of private ownership.[15]

Our results suggest that firms with high spreads tend to have higher Turquoise market shares. Spreads can be large for two reasons. First, the characteristics of the firm (e.g. its size, the volatility of its returns) may be such that the equilibrium spread is large. Second, the spread may be high because suppliers of liquidity earn rents or because structural features of the stock market lead to operational inefficiencies. In the second case the spread is above its equilibrium

[14]The country dummies alone explain 18.7% of the cross-sectional variation of the market shares.

[15]Information at the country level is obtained from the publication *Share Ownership Structure in Europe*, Final Version, December 2008, available on the homepage of the Federation of European Securities Exchanges FESE. The information relates to the year 2007. Results are available upon request.

level. We expect that high equilibrium spreads do not result in a higher Turquoise market share whereas above-equilibrium spreads do. To test this conjecture we decompose the pre-Turquoise average spreads into two components. To this end we first regress average quoted spreads from the pre-Turquoise period on the natural logarithm of market capitalization in Euro as of July 31, 2008, the average free float in percentage of shares outstanding, the average daily trading volume in shares, the standard deviation of returns and average relative tick size in the pre-Turquoise period. Coefficient estimates of this regression (not shown) are in line with expectations,[16] the adjusted R^2 amounts to 18.04%.

[Insert Table 3 about here]

We use the predicted values from this regression, *Pred. Spread in* $\%^{Pre}$, as an estimate of the equilibrium spread and the residual, *Spread Residual*, as an estimate of the deviation from the equilibrium spread. We then use these two variables as regressors in the market share regression. We estimate the same six specifications as above. The results are shown in Table 3. The coefficient on the spread residual is always positive and significant, as expected. The coefficient on the predicted values is positive but is only significant in the two models that include country dummies. Thus, the results of our cross-sectional market share regressions confirm the intuition that the new entrant, Turquoise, gains market share particularly in those cases where pre-Turquoise spread levels were excessively high.

4.1 Panel Analysis of Market Share Determinants

The analysis so far considered the average Turquoise market share in the post-entry period. This approach is well suited to uncover the cross-sectional determinants of the Turquoise market shares, but it does not exploit the time-series variation in the market share data. In order to include the time-series dimension we construct a daily panel data set. The sample period is the post-entry period from November 2008 to January 2009. The panel includes the explanatory variables introduced in the previous section as well as further variables that incorporate information about changes in the market model that occurred during the sample period. The model we estimate has the following form:

[16] Spreads are negatively related to the free float, firm size and trading volume. They are positively related to return volatility, relative tick size and depth.

$$y_{it} = x'_{it}\alpha + w'_{it}\beta + v_i + u_{it}, \quad i = 1, ..., N; \quad t = 1, ..., T. \tag{1}$$

x_{it} is a vector of strictly exogenous covariates, possibly including time constants. w_{it} is a vector of potentially endogenous covariates, all of which might be correlated with v_i, the unobserved individual heterogeneity. w_{it} might include lagged values of the dependent variable y_{it}. u_{it} is the i.i.d. error term. The list of explanatory variables includes the logarithm of the market capitalization in Euro at the end of the previous day, $LnMcap_{t-1}$, the logarithm of the trading volume on the previous day, $LnVolume_{t-1}$, the average quoted depth and the average percentage quoted spread on the previous day, $Depth_{t-1}$ and $Spread\ in\ \%_{t-1}$, respectively, the intraday midpoint volatility on day $t-1$, $Std.Dev.Return_{t-1}$, the average absolute tick size $TickSize_{t-1}$ on the previous day, and time fixed effects. We use first lags in order to avoid endogeneity problems.

When estimating model (4), we have to account for unobserved firm heterogeneity v_i and potential endogeneity of the regressors in w_{it}. We remove heterogeneity by first differencing and obtain the following model:

$$\Delta y_{it} = \Delta x'_{it}\alpha + \Delta w'_{it}\beta + \Delta u_{it}, \quad i = 1, ..., N; \quad t = 1, ..., T, \tag{2}$$

where $\Delta a_{it} = (a_{it} - a_{it-1})$. Note that first-differencing eliminates explanatory variables without time-series variation (e.g. the institutional group dummies) from the model. If a variable is endogenous (i.e., depends on y_{it}) lagged first differences of that variable are not strictly exogenous. Therefore we use second and further lags as instruments in order to obtain consistent estimators. We estimate the model by GMM.

As noted in section 2, five potentially important changes in the trading protocols of Euronext, LSE, OMX and Xetra occurred during our sample period. We include indicator variables in order to capture any impact these changes may have had on market shares. The indicator variable is set to one for stocks affected by the change from the day of the change onwards, and is set to zero otherwise.

[Insert Table 4 about here]

Results from a static specification (P1) and a dynamic specification (P2) which includes the lagged Turquoise market share as an additional regressor are presented in Table 4. In model (P1) the Turquoise market share is positively related to the lagged spread in the home market. Thus, when execution costs in the home market increase, traders switch to Turquoise. The relation between Turquoise market share and lagged volume in the home market is negative.[17] This is surprising at first sight but may be explained by serially correlated trading activity in the home market. If the order flow of retail investors (who typically do not have access to Turquoise) is serially correlated then low trading activity in the home market on day $t-1$ predicts low activity on day t which, in turn, results in a higher Turquoise market share on day t. The coefficients on the change-in-market-structure dummies indicate that the introduction of Xetra MidPoint lowered the market share of Turquoise. This trading platform was explicitly targeted at investors making use of non-displayed liquidity (as e.g. the dark pool on Turquoise) for large trading volumes and our results indicate that it was successful in attracting liquidity.

In contrast, the introduction of the single order book in Euronext led to a higher Turquoise market share. This is a surprising result because one would expect that the consolidation of the order flow improves market quality. We do not have a good explanation for this result. The other changes in market structure (i.e., the introduction of LSE Member Authorized Connection, the introduction of the OMX real time data feed, and the migration of Italian stocks to the LSE TradElect platform) did not significantly affect Turquoise market shares.

In model (P2) the coefficient on the lagged Turquoise market share is positive and significant, implying that market shares are persistent even after controlling for the other explanatory variables. The other results are similar, except that the lagged spread in the home market, although retaining its sign, loses significance.

5 Spread and Volume Changes after the Entry of Turquoise

As can be seen from Table 1 the post-entry period has been characterized by an uncertain market environment and a significant decrease in liquidity due to the world-wide financial crisis. In assessing the question of whether measures of market quality such as the bid-ask spreads or trading volume have improved due to the market entry of Turquoise, it is therefore important to control for the general changes in market quality. We accomplish this by including appropriate control variables and by using two control samples of stocks that are not traded in Turquoise.

[17] Note that this is not a spurious relation because the Turquoise market share is measured on day t and the volume in the home market on day $t-1$.

The first control sample consists of Spanish stocks which were not traded on Turquoise during our entire sample period. The second control sample consists of Italian stocks which could not be traded on Turquoise prior to mid-October 2008.

5.1 The First Control Group

As noted above, Spanish stocks started trading on Turquoise in February 2009, after the end of our sample period. Therefore, we can benchmark changes in market quality that those stocks experienced, which were traded on Turquoise, against the change in market quality of Spanish stocks between the pre- and the post-entry period. In doing so we have to control for the characteristics of the stocks. To this end we use a matched-sample approach. Our sample of Spanish stocks consists of the component stocks of the IBEX 35 index as of July 2008. These are the most liquid Spanish stocks. We match each IBEX 35 stock with a stock of our Turquoise sample based on average market capitalization in Euro in the pre-Turquoise period and average price in Euro in the pre-Turquoise period (for guidance on how to use matched samples see Davies and Kim (2009)).[18] Unfortunately we do not have intradaily data for the Spanish stocks. Rather, we obtained daily data on trading volume, closing prices, and closing bid-ask spreads. For consistency we use the same data for the Turquoise sample. We lose one observation because of lacking data. We are thus left with 34 pairs.

The results are depicted in Tables 5 and 6. We first note that the two groups of stocks are similar with respect to market capitalization. The matched Turquoise stocks have a median pre-Turquoise market capitalization (price level) of 7.1 billion Euro (16.96 Euro), as compared to a median of 7.2 billion Euro (18.06 Euro) for the Spanish stocks.

[Insert Tables 5 and 6 about here]

The figures shown in Tables 5 indicate that median quoted spreads of the Turquoise stocks and the Spanish stocks are very similar in the pre-Turquoise period. We define the relative spread increase as $Spread\ Increase = 1 - (Spread\ in\ \%^{Post}/Spread\ in\ \%^{Pre})$. The relative increase is larger for the Turquoise stocks than for the Spanish stocks when we consider the mean and larger for the Spanish stocks when we consider the median. However, a Wilcoxon signed rank test as

[18] We match stocks without replacement and choose the match as to minimize the sum of relative squared deviations over the whole sample.

suggested by Davies and Kim (2009) does not reject the null hypothesis of equality of the median between the groups. Similarly, a t-test does not reject the null hypothesis of equality of the mean between the groups.

Figures on daily trading volume (measured in million Euro) are shown in Table 6. In the pre-Turquoise period the mean trading volume is higher for the Spanish stocks whereas the median is larger for the Turquoise stocks. For both groups trading volume is markedly lower in the post-entry period. The decline is slightly more pronounced for the Spanish sample but neither a Wilcoxon test nor a t-test rejects the null hypothesis of equality between the groups.

To summarize, when we compare bid-ask spreads and trading volume before and after the introduction of Turquoise and use Spanish stocks as a control sample we do not find a positive effect of increased competition on market quality.

5.2 The Second Control Group

In order to check whether the results are sensitive to the choice of the control group we chose a second control group, consisting of highly liquid Italian stocks. These stocks could not be traded on Turquoise prior to October 20, 2008.[19] We therefore redefine the post-entry period. It now extends from September 1 to October 17. Even though all stocks we use in our analysis could be traded on Turquoise on September 1, the official Turquoise market opening only occurred on September 22. Therefore, we use a second post-entry period extending from September 22 to October 17 as a robustness check. We again use a matched-sample approach. Each of the 25 Italian stocks in the sample is matched with a Turquoise stock using the matching procedures described in the previous section.[20] The selected groups are larger in terms of market capitalization and price. The Turquoise stocks have a median pre-Turquoise market capitalization (price) of 9.2 billion Euro (9.07 Euro), as compared to a median of 8.3 billion Euro for the Italian stocks (6.51 Euro).

[Insert Tables 7 and 8 about here]

[19] Note that two Italian firms were traded from October 13, 2008 onwards. For these firms and their matches we compute data based on a post-entry period lasting until October 10, 2008. Results remain unchanged when we exclude these two firms from the analysis.

[20] The Italian stocks we consider here are those in our Turquoise sample which we also use in our cross-sectional estimations. See Table 1 for details. Note that Table 1 includes three Italian stocks for which Bloomberg firm data was incomplete and which hence not were included in the estimations.

Results on percentage quoted spreads are depicted in Tables 7. We find that the median percentage bid-ask spreads are similar whereas the mean percentage spread is markedly higher for the Turquoise stocks. In the post-entry period percentage quoted spreads are higher for both Italian and Turquoise stocks, irrespective of which post-entry period is considered. The increase is less pronounced for the Turquoise stocks. However, the difference is (based on a Wilcoxon signed rank test and on a t-test) not significant.

Table 8 shows the results on trading volume. The Italian stocks are more actively traded than the Turquoise stocks if mean trading volumes are regarded. Trading activity in terms of median trading volume is similar for Italian and Turquoise stocks. Average trading volumes for the Turquoise stocks increased between the pre-entry and the post-entry period. The average trading volume of the Italian stocks, on the other hand, decreased. For the first (second) post-entry sample period, the null hypothesis of no difference in differences is rejected by a Wilcoxon signed rank test at a level of 1% (1%) and by a two-sided t-test at a level of 2% (1%).

To summarize, when we consider changes in liquidity benchmarked against a control sample of Italian stocks we find that the introduction of Turquoise did not materially affect quoted bid-ask spreads but did result in an increase in trading volume.

5.3 Panel Estimations

In this section we use an alternative procedure to measure the impact the introduction of Turquoise had on bid-ask spreads and trading volumes. We construct a weekly panel data set that spans the period from May 1, 2008 to January 31, 2009. The panel thus includes both the pre- and the post-entry period. In the cross-sectional dimension we include all Turquoise stocks analyzed previously (including the Italian stocks) as well as the Spanish stocks which were not traded on Turquoise during the entire sample period. The dependent variables are two measures of liquidity, the quoted bid-ask spread and the trading volume. We include explanatory variables that are known to be related to liquidity. Specifically, we include lagged values of the log of market capitalization in Euro, trading volume (only in the spread regression), the bid-ask spread (in the volume regression), volatility, and the relative tick size. Lags are used in order to avoid endogeneity problems.

As noted previously we do not have access to intradaily data for the Spanish stocks. Therefore, the analysis is based on daily data obtained from Bloomberg. The quoted spread is measured by the percentage closing spread. Market capitalization and relative tick size are calculated based on closing prices. The daily values for all variables are then averaged over the days of the week. We obtain an estimate of daily volatility from the daily high, low, opening and closing price as proposed by Garman and Klass (1980).[21] In order to capture the impact of Turquoise on the spread we include the variable $Market\ Share\ TQ_{it}$ as a regressor. This variable is zero whenever a stock i is not traded on Turquoise in week t and is set to the Turquoise market share in week t otherwise. If increased competition leads to reduced spreads we should expect a negative coefficient. In order to allow for a non-linear effect of the Turquoise market share on spreads we also include the square of $Market\ Share\ TQ_{it}$.

We further allow for time fixed effects and include two stock-specific indicator variables. $\mathbf{1}_{SoftLaunch}$ is equal to one for stocks that were listed on Turquoise during the soft launch test period when only a limited number of stocks was tradable on Turquoise. For all countries except for Italy, the soft launch took place on differing dates between August 15 and 31, 2008. For Italian stocks the soft launch consisted of the trading week from October 13 to 17, 2008. Spanish stocks were not traded on Turquoise during the sample period. Therefore, the soft launch indicator is always zero for Spanish stocks. The second indicator variable $\mathbf{1}_{Post^{TQ}}$ is set to one for all stocks except the Italian and Spanish ones from September 22, 2008 (the official launch date) onwards. For Italian stocks it is set to one from October 20, 2008 onwards, for Spanish stocks it is always zero. These indicator variables are used to investigate whether the mere existence of an alternative trading venue has an impact on spreads. They thus complement the variable $Market\ Share\ TQ_{it}$ which measures the impact that actual trading activity in the new trading platform has on spreads.

[Insert Table 9 about here]

The results from GMM estimation are reported in Table 9. We consider the results for the spread first. We estimated two models. Model (P3) is the baseline specification, model (P4) is a dynamic specification where the lagged spread is added as a regressor. In both specifications we find that the coefficient of $Market\ Share\ TQ$ is significantly negative while the coefficient of $Market\ Share\ TQ^2$ is significantly positive. Hence, using standard control variables, we find

[21] $Volatility^{OHLC} := \sqrt{1/n[(log(H_t/L_t))^2 - (2log(2)-1)(log(C_t/O_t))^2]}$, where n is the number of observations, H_t is the daily high, L_t is the daily low, O_t is the daily opening and C_t is the daily closing price.

that spreads decrease (in a non-linear way) when the Turquoise market share increases. Thus, competition appears to increase liquidity as measured by the spread. Note that while the sign of the soft launch and post Turquoise indicator variables is negative as expected, only one out of four coefficients is significantly different from zero. The negative sign and significance of market capitalization and trading volume are in line with expectations.

In models (P5) and (P6) the trading volume is the dependent variable. Here, the Turquoise market share is only significant at the 10% level in specification (P5). Both the soft launch and the post-Turquoise indicators are insignificant. These results provide, at best, weak evidence that the introduction of Turquoise has led to an increase in trading volume.

6 Turquoise versus Primary Markets

In the last step of our analysis, we compare measures of market quality in Turquoise to those for the home markets. The measures we consider are the bid-ask spread, the quoted depth, and average trade size. All measures are averaged over the three-months post-entry period. Tables 10 and 11 show the results separately for each home market.

[Insert Tables 10 and 11 about here]

The results shown in the upper panel of Table 10 indicate that the average quoted spread is larger in Turquoise than in the home market for all countries except Austria and Ireland. The differences are significant in most cases. The last two columns show the smallest and the largest value for the stocks in the respective country. For 8 out of 14 countries the minimum is negative, implying that in these countries there are stocks for which the average spread in Turquoise is smaller than the average spread in the home market. However, the total number of firms to which this applies is only 24 (out of 260).

The lower panel of Table 10 shows results on average trade size. The average trade size on Turquoise is smaller than the average trade size in the home market. The difference is significant for 10 countries. Consistent with the results on average trade size, Table 11 shows that the quoted depth at the bid and at the ask is markedly lower in Turquoise as compared to the home market. The difference is significant for the majority of countries. It should be noted, though, that the quoted depth does not include hidden volume. Thus, to the extent that hidden volume is relatively more important in Turquoise than it is in the home market, the results may be biased to the disadvantage of Turquoise.

6.1 Effective Spreads

As noted previously, there may be hidden liquidity *inside* the best quotes in Turquoise. Consequently, the quoted spread in Turquoise may overstate the true execution cost. One way to correct for this potential bias is to consider effective spreads instead of quoted spreads. Given the one-minute snapshot data we use we cannot apply the standard effective spread estimator. We therefore proceeded as follows. We relate the last transaction price of each one-minute interval to the last midquote of the interval. The absolute value of the difference is our estimate of the effective half-spread ($S^{'effective'} = 2|P_t - M_t|$). As a robustness check we also match transaction prices with the midquote at the end of the previous interval.

The results shown in Table 12 demonstrate that effective spreads are lower than quoted spreads in most markets. This may be surprising at first sight because in an electronic open limit order book transactions can only occur at the quoted prices and, consequently, the effective spread is equal to the quoted spread at the time when the transaction occurs. However, transactions tend to occur when the quoted spread is small. Therefore, the average effective spread is likely to be lower than the quoted spread even in markets without price improvement.

If price improvements due to hidden liquidity inside the best quotes were very frequent in Turquoise we should expect the differences between quoted and effective spreads to be larger in Turquoise than in the home market. This is not generally the case, however. When we consider mean [median] values, the differences are larger for Turquoise in 5 [9] out of 14 countries.

[Insert Tables 12 and 13 about here]

Given that quoted spreads are wider in Turquoise and that the difference between quoted and effective spreads is not generally more pronounced in Turquoise, we do not expect effective spreads in Turquoise to be lower than those in the home market. This is borne out by the results shown in Table 13. Effective spreads are larger in Turquoise, no matter whether we consider the mean or the median, absolute or percentage spreads, and no matter whether we match the last transaction price of a one-minute interval to the midquote effective at the end of the same or the previous interval (the latter results are not depicted).

Our results in this section yield the conclusion that Turquoise does not appear to be more liquid than the home market. Quoted and effective spreads are higher, average trade size is smaller, and the depth at the best quotes is lower.

7 Conclusion

This study analyzes the market entry of the pan-European MTF Turquoise in August 2008. The fact that Turquoise covered shares of 14 European countries by November 2008 enables us to investigate its launch in a setup which is close to a natural experiment.

We first examine the market share of Turquoise and its determinants. Results from cross-sectional regressions indicate that market shares of Turquoise are particularly high for large stocks with a high relative free float and a low level of volatility, hence for stocks that pose a relatively low risk for market makers. Furthermore, the market share is c.p. high for firms with higher levels of illiquidity as measured by the bid-ask spread and depth at the best quotes before the entry of Turquoise. Decomposing bid-ask spreads into a predicted component (the predicted value from a regression of the spread on a set of explanatory variables, performed for the pre-Turquoise period) and an unpredicted component (the residual from that regression), it turns out that market shares are particularly high for firms the spreads of which are "too high" relative to the set of explanatory variables used. Regarding market characteristics, firms from a market with a larger overall market capitalization tend to have relatively higher market shares, as do firms from markets in which the share of investment bank ownership is relatively high or the share of ownership by foreign institutions is relatively low. Finally, the market share of firms with a low tick size is higher. Results of a panel analysis of daily changes in market shares provide additional evidence that high spreads in the home market lead to higher Turquoise market share. They also show that organizational changes by some primary exchanges had an impact on Turquoise market shares while others had not.

We further analyze whether market quality improved after the entry of the new trading venue. We consider the bid-ask spread and trading volume as measures of liquidity. To control for changes in the market environment (in particular the crisis which culminated in the month of the official launch of Turquoise) we use control variables and control samples. The results are somewhat ambiguous. Pairwise comparison of matched samples (Turquoise stocks versus Spanish and Italian stocks) do not reveal a significant decrease of the bid-ask spreads after the introduction of Turquoise. The comparison with the Italian stocks indicate that volume may have increased after the introduction of Turquoise. When we use a weekly panel instead we find evidence that spreads have declined after the introduction of Turquoise. These results are consistent with a positive impact on market quality of competition between trading venues.

Finally, we compared measures of market quality for Turquoise and the primary markets. It turned out that quoted and effective spreads are higher on Turquoise, average trade size is smaller, and the depth at the best quotes is lower.

Our results draw a differentiated picture of competition between exchanges. Turquoise was able to attract order flow without generally offering higher liquidity than the primary market. At the same time, Turquoise gained higher market shares in stocks for which spreads in the home market are "too" high relative to fundamentals. Higher Turquoise market shares, in turn, lead to lower spreads and thus to an improvement of market quality. All in all, our results are consistent with the new entrant serving as a disciplinary device which reduces rents earned by the suppliers of liquidity in the primary market. Whether the post-entry revenue to the suppliers of liquidity and the operators of the trading systems are sufficient is a question we are unable to answer. The fact that trading volume did not generally increase upon the entry of the new competitor is, however, an indication that the overall revenue has decreased.

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Tables

Table 1: Summary Statistics

Country	TQ Share Obs.	in %	MarketCap *Pre*	*Post*	Trading Volume *Pre*	*Post*	Spread in % *Pre*	*Post*	Depth *Pre*	*Post*
UK	90	6.10	18,565	12,185	12,535,564	10,912,011	0.035	0.188	30,353	25,631
Germany	24	4.94	26,811	18,792	4,534,131	4,844,253	0.067	0.151	4,829	9,947
France	36	6.03	28,227	21,039	4,152,496	3,923,820	0.078	0.134	13,226	6,379
Netherlands	16	7.10	16,268	10,685	5,958,844	5,594,090	0.088	0.154	17,559	8,087
Belgium	4	1.53	15,249	7,033	2,266,022	1,267,681	0.116	0.232	7,692	3,897
Portugal	4	0.53	9,978	6,390	8,260,206	5,011,553	0.177	0.175	150,078	24,487
Denmark	3	0.33	20,636	10,180	1,214,290	1,457,027	0.192	0.343	11,241	9,900
Sweden	25	4.13	9,791	5,847	6,389,600	5,610,756	0.299	0.375	108,838	55,578
Finland	4	1.48	25,845	16,246	8,749,001	8,439,632	0.128	0.175	27,214	25,045
Norway	5	0.42	26,066	11,997	6,419,895	7,264,741	0.153	0.213	28,428	18,840
Ireland	4	0.15	8,068	3,275	3,906,911	5,615,480	0.362	1.335	6,444	15,824
Switzerland	19	3.33	29,854	24,789	4,802,008	4,028,953	0.115	0.204	17,171	15,755
Austria	4	5.93	12,263	4,683	1,156,439	1,026,820	0.110	0.271	3,039	3,331
Italy	28	3.30	17,171	11,014	25,505,150	17,765,724	0.121	0.165	13,251	35,604

The table presents summary statistics aggregated on a country-wide level. Unless otherwise stated, *Pre* indicates the average of the respective variable over the period May to July 2008 and *Post* indicates the average from November 2008 to January 2009. MarketCap denotes market capitalization in million Euro. Trading volume depicts average daily trading volume in shares. Spread depicts the quoted bid-ask spread in percentage terms. Depth stands for the sum of average bid and ask volume available at best quotes. TQ share denotes the share of trading volume transacted on Turquoise relative to the volume transacted on Turquoise and the incumbent exchange. Obs. stands for the number of observations.

Table 2: Cross Sectional Determinants of Turquoise Market Share

	Market Share TQ					
Specification	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)	OLS (6)
Variable	Coef. ($\|t-stat\|$)	Coef. ($\|t-stat\|$)	Coef. ($\|t-stat\|$)	Coef. ($\|t-stat\|$)	Coef. ($\|t-stat\|$)	Coef. ($\|t-stat\|$)
$LnMcap^{Pre}$	0.009**	0.011***	0.014***	0.010***	0.013***	0.016***
	(2.46)	(2.89)	(4.49)	(2.75)	(3.29)	(5.17)
$FreeFloat^{Pre}$	0.031***	0.044***	0.048***	0.023**	0.035***	0.038***
	(3.27)	(3.90)	(4.08)	(2.33)	(3.14)	(3.18)
$Volume^{Pre}$	-7e-11	-2e-10**	-1e-10*	-7e-11	-2e-10**	-2e-10*
	(0.81)	(2.01)	(1.71)	(0.82)	(2.14)	(1.82)
$Spread\ in\ \%^{Pre}$	17.635*	21.758**	26.352***	17.913*	22.405***	27.229***
	(1.83)	(2.44)	(4.14)	(1.87)	(2.58)	(4.59)
$Depth^{Pre}$	-6e-08*	-4e-08	-5e-08**	-5e-08*	-4e-08	-4e-08**
	(1.86)	(1.65)	(2.39)	(1.80)	(1.57)	(2.25)
$Std.Dev.Return^{Pre}$	-7e-04***	-3e-04**	2e-04*	-7e-04***	-3e-04*	2e-04
	(3.92)	(2.17)	(1.90)	(3.97)	(1.92)	(1.57)
$TickSize^{Pre}$	-4e-04***	-2e-04***	-7e-05	-4e-04***	-2e-04***	-1e-04*
	(3.86)	(3.25)	(1.26)	(4.02)	(3.41)	(1.74)
$LnMcapExchange^{Pre}$	0.024***	0.018***	0.042***	0.024***	0.018***	0.043***
	(3.95)	(3.93)	(7.04)	(3.94)	(3.84)	(7.55)
$InvestmentHoldings$				6e-04**	7e-04***	7e-04***
				(2.40)	(2.84)	(2.94)
$ForeignInstHoldings$				-4e-04**	-4e-04***	-5e-04***
				(2.16)	(2.58)	(2.61)
$\mathbf{1}_{NYSE}$	0.002	-0.002	-0.001	0.002	-0.002	-0.001
	(0.50)	(0.43)	(0.36)	(0.55)	(0.47)	(0.38)
$\mathbf{1}_{DJ\ STOXX50}$	-0.010*	-0.008	-0.013**	-0.010*	-0.008	-0.013**
	(1.95)	(1.50)	(2.46)	(1.86)	(1.43)	(2.46)
$\mathbf{1}_{EURONEXT}$		0.029***			0.028***	
		(5.64)			(5.53)	
$\mathbf{1}_{OMX}$		-0.006			-0.008	
		(0.77)			(0.93)	
$\mathbf{1}_{XETRA}$		0.014			0.014	
		(1.45)			(1.48)	
$\mathbf{1}_{LSE}$		0.030***			0.032***	
		(4.22)			(4.40)	
$Const.$	-0.725***	-0.628***	-1.312***	-0.735***	-0.630***	-1.333***
	(3.65)	(4.06)	(6.74)	(3.70)	(4.14)	(7.27)
$Country\ Dummies$	no	no	yes	no	no	yes
$Obs.$	260	260	260	260	260	260
R^2	0.34	0.41	0.54	0.36	0.44	0.56
Adj. ^{2}	0.31	0.38	0.49	0.33	0.40	0.52

Remark: ***, ** and * denote significance at the 1%, 5%, and 10% level, respectively. t-statistics are based on robust standard errors. Variable definitions are given in section 4.

Table 3: Determinants of Turquoise Market Share Using Predicted Spreads and Residuals

	Market Share TQ					
Specification	OLS (1a)	OLS (2a)	OLS (3a)	OLS (4a)	OLS (5a)	OLS (6a)
Variable	Coef. ($\lvert t-stat \rvert$)	Coef. ($\lvert t-stat \rvert$)	Coef. ($\lvert t-stat \rvert$)	Coef. ($\lvert t-stat \rvert$)	Coef. ($\lvert t-stat \rvert$)	Coef. ($\lvert t-stat \rvert$)
$LnMcap^{Pre}$	0.004	0.003	0.012***	0.005*	0.004	0.014***
	(1.33)	(0.72)	(3.81)	(1.76)	(1.20)	(4.41)
$FreeFloat^{Pre}$	0.023***	0.032***	0.044***	0.016*	0.024**	0.035***
	(2.70)	(3.42)	(3.71)	(1.75)	(2.51)	(2.87)
$Volume^{Pre}$	-1e-10	-3e-10***	-2e-10*	-1e-10	-3e-10***	-2e-10*
	(1.44)	(2.81)	(1.90)	(1.42)	(2.91)	(1.94)
Pred. Spread in $\%^{Pre}$	1.347	-5.779	20.837***	2.074	-5.520	23.183***
	(0.22)	(0.75)	(3.08)	(0.34)	(0.71)	(3.34)
Spread Residual	18.371**	24.465***	26.377***	18.595**	25.104***	27.246***
	(2.00)	(3.29)	(4.14)	(2.03)	(3.53)	(4.59)
$Depth^{Pre}$	-6e-08**	-4e-08	-5e-08**	-6e-08*	-4e-08	-4e-08**
	(1.98)	(1.62)	(2.38)	(1.92)	(1.54)	(2.24)
$Std.Dev.Return^{Pre}$	-3e-04***	5e-04*	3e-04**	-3e-04***	5e-04*	3e-04
	(2.60)	(1.74)	(2.12)	(2.61)	(1.87)	(1.63)
$TickSize^{Pre}$	-4e-04***	-2e-04***	-7e-05	-4e-04***	-2e-04***	-1e-04*
	(4.06)	(3.07)	(1.25)	(4.19)	(3.18)	(1.73)
$LnMcapExchange^{Pre}$	0.022***	0.014***	0.039***	0.022***	0.014***	0.040***
	(4.04)	(3.04)	(6.25)	(4.01)	(2.89)	(6.29)
$InvestmentHoldings$				6e-04**	7e-04***	7e-04***
				(2.46)	(3.15)	(2.93)
$ForeignInstHoldings$				-3e-04**	-4e-04**	-5e-04***
				(1.97)	(2.38)	(2.60)
$\mathbf{1}_{NYSE}$	0.003	-0.001	-0.002	0.003	-0.001	-0.002
	(0.76)	(0.30)	(0.43)	(0.80)	(0.35)	(0.43)
$\mathbf{1}_{DJ\ STOXX50}$	-0.011**	-0.009*	-0.013**	-0.011**	-0.009*	-0.013**
	(2.09)	(1.75)	(2.42)	(2.01)	(1.69)	(2.43)
$\mathbf{1}_{EURONEXT}$		0.030***			0.030***	
		(5.70)			(5.61)	
$\mathbf{1}_{OMX}$		-0.014			-0.015*	
		(1.52)			(1.68)	
$\mathbf{1}_{XETRA}$		0.022**			0.022**	
		(2.10)			(2.14)	
$\mathbf{1}_{LSE}$		0.035***			0.037***	
		(4.69)			(4.89)	
Const.	-0.609***	-0.398**	-1.184***	-0.621***	-0.396**	-1.239***
	(3.53)	(2.55)	(5.83)	(3.59)	(2.54)	(5.91)
Country Dummies	no	no	yes	no	no	yes
Obs.	260	260	260	260	260	260
R^2	0.36	0.45	0.54	0.37	0.48	0.57
Adj. ^{2}	0.33	0.42	0.49	0.34	0.44	0.52

Remark: ***, ** and * denote significance at the 1%, 5%, and 10% level, respectively. t-statistics are based on robust standard errors. Variable definitions are given in section 4.

Table 4: Determinants of Turquoise Market Shares: Panel Estimations

	Market Share TQ	
Specification	GMM (P1)	GMM (P2)
Variable	Coef. ($\|z-stat\|$)	Coef. ($\|z-stat\|$)
$LnMcap_{t-1}$	-0.005	-0.011**
	(1.10)	(2.54)
$LnVolume_{t-1}$	-0.010***	-0.005***
	(6.15)	(4.59)
$Spread\ in\ \%_{t-1}$	0.619**	0.548
	(2.14)	(1.50)
$Depth_{t-1}$	-1e-09	-1e-09
	(0.23)	(0.25)
$Std.Dev.Return_{t-1}$	5e-07	5e-07
	(1.00)	(1.09)
$TickSize_{t-1}$	-0.009	-0.005
	(1.17)	(0.57)
$\mathbf{1}_{ChangeEuronext}$	0.015***	0.014***
	(3.51)	(3.10)
$\mathbf{1}_{ChangeXetra}$	-0.009**	-0.010**
	(2.20)	(2.08)
$\mathbf{1}_{ChangeLSE}$	-0.004	0.001
	(0.60)	(0.21)
$\mathbf{1}_{ChangeBorsaItaliana}$	-0.003	0.009
	(0.41)	(1.16)
$\mathbf{1}_{ChangeOMX}$	2e-04	-9e-04
	(0.05)	(0.16)
$Market\ Share\ TQ_{t-1}$		0.205***
		(4.47)
Obs.	14,886	14,874

Remark: ***, ** and * denote significance at the 1%, 5%, and 10% level, respectively. z-statistics are based on robust standard errors. Instruments for GMM specifications are lag $t-2$ to lag $t-5$ of averages of quoted depth, quoted bid-ask spreads and log daily trading volume in stocks on the primary exchange. $LnMcap_{t-1}$ stands for the logarithm of stock market capitalization in Euro at day $t-1$. $LnVolume_{t-1}$, $Spread\ in\ \%_{t-1}$ and $Depth_{t-1}$ stand for the average daily trading volume in logarithms, average percentage spread and average depth on trading day $t-1$. $Std.Dev.Return_{t-1}$ is the standard deviation of intraday returns on day $t-1$. $TickSize_{t-1}$ denotes the average tick size on the primary exchange on day $t-1$. $Market\ Share\ TQ_{t-1}$ is the relative market share of Turquoise in terms of trading volume on the prior trading day $t-1$. $\mathbf{1}_{ChangeXY}$ is an indicator variable equal to one if the primary exchange XY has introduced a change in the market model or technology in the estimation period from the day of change onwards and zero otherwise. Daily time indicator variables are not depicted.

Table 5: Changes in Percentage Quoted Spreads over Time - TQ Sample versus Spanish Stocks

		Quoted Spreads in %				Spread Increase		
		TQ Sample		Spain		TQ Sample	Spain	
	Obs.	*Pre*	*Post*	*Pre*	*Post*	(i)	(ii)	(i)-(ii)
Mean	34	0.29%	0.42%	0.16%	0.24%	61.23%	58.35%	2.88%
Median	34	0.17%	0.25%	0.14%	0.21%	38.41%	60.44%	-25.30%

Table 6: Changes in Turnover over Time - TQ Sample versus Spanish Stocks

		Turnover in Million Euro				
		TQ Sample		incl. TQ	Spain	
	Obs.	*Pre*	*Post*	*Post*	*Pre*	*Post*
Mean	34	100	53	55	135	90
Median	34	43	24	25	33	18
		Percentage Change				
		TQ Sample	incl. TQ	Spain		
	Obs.	(a)	(b)	(c)	(a)-(c)	(b)-(c)
Mean	34	-42.97%	-40.31%	-44.63%	1.66%	4.32%
Median	34	-48.44%	-44.61%	-47.24%	-1.12%	0.13%

Table 7: Changes in Percentage Quoted Spreads over Time - TQ Sample versus Italian Stocks

		Quoted Spreads in %				Spread Increase		
		TQ Sample		Italy		TQ Sample	Italy	
01.09.08-17.10.08	Obs.	*Pre*	*Post*	*Pre*	*Post*	(i)	(ii)	(i)-(ii)
Mean	25	0.25%	0.30%	0.13%	0.20%	40.07%	50.17%	-10.11%
Median	25	0.15%	0.24%	0.12%	0.20%	24.91%	46.68%	-20.84%
22.09.08-17.10.08	Obs.							
Mean	25	0.25%	0.36%	0.13%	0.24%	66.31%	75.35%	-9.04%
Median	25	0.15%	0.27%	0.12%	0.23%	45.86%	77.02%	-24.26%

Table 8: Changes in Turnover over Time - TQ Sample versus Italian Stocks

		Turnover in Million Euro				
		TQ Sample		incl. TQ	Italy	
01.09.08-17.10.08	Obs.	*Pre*	*Post*	*Post*	*Pre*	*Post*
Mean	25	65	71	73	130	121
Median	25	45	45	45	47	42
22.09.08-17.10.08						
Mean	25	65	68	71	130	113
Median	25	45	45	48	47	39

		Percentage Change				
		TQ Sample	incl. TQ	Italy		
01.09.08-17.10.08	Obs.	(a)	(b)	(c)	(a)-(c)	(b)-(c)
Mean	25	16.14%	20.90%	-6.38%	22.52%	27.28%
Median	25	16.15%	16.29%	-11.08%	26.42%	32.52%
22.09.08-17.10.08	Obs.					
Mean	25	7.49%	12.43%	-16.47%	23.96%	28.90%
Median	25	3.08%	11.05%	-18.46%	39.69%	41.45%

Table 9: Determinants of Bid-Ask Spreads and Turnovers: Weekly Panel Estimations

	Spread in %		*LnTurnover*	
Specification	GMM (P3)	GMM (P4)	GMM (P5)	GMM (P6)
Variable	Coef. ($\|z-stat\|$)	Coef. ($\|z-stat\|$)	Coef. ($\|z-stat\|$)	Coef. ($\|z-stat\|$)
$Market\ Share\ TQ_{t-1}$	-0.006**	-0.007**	1.011*	0.525
	(2.00)	(2.51)	(1.86)	(1.13)
$Market\ Share\ TQ^2_{t-1}$	0.018**	0.021***	-2.367	-1.590
	(2.38)	(3.37)	(1.24)	(0.96)
$LnMcap_{t-1}$	-0.001*	-0.001	0.301***	0.130
	(1.78)	(1.45)	(2.65)	(1.03)
$LnVolume_{t-1}$	-5e-04***	-6e-04***		
	(3.32)	(3.01)		
$Volatility^{OHLC}_{t-1}$	0.002	0.003	-1.314***	-2.409***
	(0.60)	(1.01)	(5.46)	(5.72)
$TickSize_{t-1}$	-6e-04	-7e-04	-0.015	0.012
	(0.73)	(0.81)	(0.14)	(0.08)
$\mathbf{1}_{SoftLaunch}$	-8e-05	-3e-04**	-0.018	-0.020
	(1.12)	(2.39)	(0.44)	(0.49)
$\mathbf{1}_{Post^{TQ}}$	-2e-04	-1e-04	-0.021	-0.019
	(0.96)	(0.69)	(0.48)	(0.63)
$Spread^{Last}\ in\ \%_{t-1}$		-0.047*	-7.791*	-6.139
		(1.81)	(1.66)	(1.51)
$LnTurnover_{t-1}$				0.267***
				(6.85)
Obs.	11,190	11,186	11,186	11,186

Remark: ***, ** and * denote significance at the 1%, 5%, and 10% level, respectively. z-statistics are based on robust standard errors. $Market\ Share\ TQ_{t-1}$ is the average relative market share of Turquoise in terms of trading volume in the prior trading week, $Market\ Share\ TQ^2_{t-1}$ is its square. $LnMcap_{t-1}$ stands for the average logarithm of stock market capitalization in week $t-1$ in Euro, $LnVolume_{t-1}$ denotes the logarithm of average daily trading volume in week $t-1$. $Volatility^{OHLC}_{t-1}$ is lagged weekly volatility, computed as described in section 5.3. $TickSize_{t-1}$ is the average daily absolute tick size in week $t-1$. $\mathbf{1}_{SoftLaunch}$ is equal to one if the stock is traded in the soft launch period and zero otherwise. $\mathbf{1}_{Post^{TQ}}$ is zero before and during the soft launch period and equal to one afterwards if the stock is traded on Turquoise. Weekly time dummies are not depicted. Instruments for GMM specifications are lag $t-2$ to lag $t-4$ ($t-6$ in P5 and P6) of $LnVolume$, $Market\ Share\ TQ$, $Market\ Share\ TQ^2_{t-1}$ and the average of last quoted spreads lagged one week $Spread\ in\ \%_{t-1}$ in specifications P4 and P6.

Table 10: Difference between Turquoise and Home Markets (Part 1)

Country	Difference Spread in %			
	Mean	*Std.Dev.*	*Min*	*Max*
UK	0.142***	0.102	-0.125	0.477
Germany	0.080***	0.120	0.021	0.592
France	0.008***	0.019	-0.039	0.052
Netherlands	0.031***	0.023	0.003	0.088
Belgium	0.089	0.077*	0.047	0.231
Portugal	0.050*	0.059	-0.031	0.103
Denmark	0.027**	0.011	0.014	0.034
Sweden	0.383***	0.167	-0.019	0.758
Finland	0.165**	0.076	0.108	0.276
Norway	0.147**	0.208	-0.155	0.421
Ireland	-0.129	0.165	-0.444	0.023
Switzerland	0.103***	0.071	-0.117	0.238
Austria	-0.181	0.123	-0.356	-0.091
Italy	0.156***	0.056	0.065	0.286

Country	Difference Trading Volume			
	Mean	*Std.Dev.*	*Min*	*Max*
UK	-2054.58***	4113.00	-30814.70	-116.89
Germany	-1651.87***	1133.75	-4664.14	-290.72
France	-51.60**	148.98	-215.06	788.49
Netherlands	-91.63***	131.63	-269.63	294.34
Belgium	-56.36	115.36	-136.14	110.71
Portugal	-1073.62*	1111.89	-2636.79	-222.13
Denmark	-284.61	349.12	-674.59	-1.16
Sweden	-59.14	401.38	-1333.31	729.23
Finland	-373.29**	177.88	-622.35	-223.48
Norway	-858.61***	312.90	-1293.72	-548.05
Ireland	-13144.99***	5715.30	-19934.74	-6143.06
Switzerland	-27.07	168.64	-330.72	520.23
Austria	-803.17***	246.43	-1070.12	-518.09
Italy	-4591.22***	8459.71	-30721.12	-154.21

The table presents country averages of differences between trading parameters on Turquoise and the primary market. Trading volume stands for average trading volume in shares. Spread in % relates to the best quoted bid-ask spread in percentage terms. Asterisks depict results of one-sided $t-$tests that the spread on Turquoise is higher than on the incumbent exchanges or, respectively, that average trade size is smaller on Turquoise.

Table 11: Difference between Turquoise and Home Markets (Part 2)

	Difference Depth Ask			
Country	*Mean*	*Std.Dev.*	*Min*	*Max*
UK	-8104.23***	19902.13	-141479.30	-277.13
Germany	-1888.88	7632.99	-37711.70	-81.48
France	-2249.61***	2335.71	-10629.82	-308.00
Netherlands	-2223.44***	2223.00	-6907.99	-146.47
Belgium	-1226.57*	965.90	-2633.15	-448.44
Portugal	-10470.28	11928.83	-27810.68	-2537.22
Denmark	-4929.76	6070.76	-11722.71	-34.63
Sweden	-10308.83***	9308.44	-32805.97	9006.04
Finland	-9334.86*	6494.12	-18050.16	-3240.13
Norway	-8582.17***	3740.09	-13570.05	-4860.07
Ireland	-6825.33**	4059.71	-10872.06	-1329.94
Switzerland	-6861.68***	9094.96	-27162.12	-392.73
Austria	-1019.66***	243.46	-1320.54	-724.24
Italy	-8242.17**	18512.06	-89664.47	81.74
	Difference Depth Bid			
Country	*Mean*	*Std.Dev.*	*Min*	*Max*
UK	-9887.72***	28159.25	-209201.50	-295.56
Germany	-1644.33	6392.71	-31624.41	-72.21
France	-2199.03***	2295.30	-11065.50	-285.63
Netherlands	-2305.93***	2308.77	-7344.72	-83.10
Belgium	-1198.06*	824.10	-2386.74	-509.65
Portugal	-9961.76	10188.07	-24632.71	-2954.29
Denmark	-4500.15	5545.78	-10707.09	-32.48
Sweden	-9831.84***	10171.34	-42152.89	7477.23
Finland	-9104.46*	6295.98	-17481.07	-3027.64
Norway	-8052.23***	3471.94	-12582.76	-4530.32
Ireland	-7513.64*	5233.85	-13840.05	-1379.17
Switzerland	-6651.35***	8784.47	-25584.75	-417.62
Austria	-1032.78***	280.78	-1269.65	-633.0 7
Italy	-7996.55**	18683.66	-90944.63	1079.35

The table presents country averages of differences between trading parameters on Turquoise and the primary market. Depth ask and bid stand for the average ask and bid and volume available at best quotes. Asterisks depict results of one-sided $t-$tests that average quoted depth at the bid or average quoted depth at the ask are smaller on Turquoise.

Table 12: Difference between Quoted and "Effective" Spreads on Turquoise and Home Markets

	Difference Quoted vs. "Effective" Spreads					
	Mean			Median		
	Home Market		Turquoise	Home Market		Turquoise
Country	*Pre*	*Post*	*Post*	*Pre*	*Post*	*Post*
UK	0.381	0.265	-0.750	0.282	0.227	0.206
Germany	0.005	0.007	-0.009	0.004	0.004	8e-04
France	0.004	0.011	-0.010	0.003	0.009	-0.001
Netherlands	0.004	0.005	0.020	0.004	0.004	0.002
Belgium	0.005	0.007	0.005	0.005	0.007	0.009
Portugal	2e-04	2e-04	0.004	2e-04	9e-05	0.003
Denmark	5.602	4.176	9.559	0.064	0.041	0.144
Sweden	0.042	0.214	0.198	0.012	0.010	0.218
Finland	0.002	0.002	0.008	0.002	0.002	0.007
Norway	0.018	0.018	0.071	0.014	0.015	0.036
Ireland	0.006	0.006	0.003	0.004	0.004	0.002
Switzerland	0.035	0.033	0.029	0.020	0.022	0.032
Austria	0.001	-0.004	-2.437	0.001	-0.002	8e-04
Italy	0.004	0.002	0.002	0.003	0.001	0.002

Table 13: Difference between Turquoise and Home Markets: Effective Spreads

	Difference "Effective" Spreads Turquoise vs. Home Markets					
	$2\|P_t - M_t\|$			$\|200(P_t - M_t)/M_t\|$		
Country	*Mean*	σ	*Median*	*Mean*	σ	*Med.*
UK	1.64	8.62	0.40	0.28	0.91	0.08
Germany	0.05	0.14	0.02	0.08	0.06	0.05
France	0.02	0.03	0.02	0.07	0.07	0.05
Netherlands	0.16	0.59	7e-03	0.07	0.07	0.06
Belgium	0.07	0.08	0.05	0.33	0.39	0.14
Portugal	0.01	7e-03	0.01	0.22	0.02	0.22
Denmark	41.31	70.83	0.63	0.31	0.08	0.32
Sweden	0.06	0.08	0.06	0.08	0.07	0.09
Finland	0.02	0.01	0.02	0.18	0.07	0.20
Norway	0.24	0.17	0.20	0.30	0.07	0.28
Ireland	0.02	0.02	0.01	0.09	0.21	0.08
Switzerland	0.09	0.11	0.05	0.18	0.31	0.07
Austria	2.48	4.87	0.06	5.25	10.14	0.33
Italy	3e-03	3e-03	3e-03	0.06	0.05	0.05