Competition Between Exchanges: Euronext versus Xetra*

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January 2003

Abstract: Exchanges in Europe face increasing competition. Smaller exchanges may come under pressure to cooperate with one of the larger exchanges and adopt its trading system. It is, therefore, important to evaluate the attractiveness of the two dominating continental European trading systems, Euronext and Xetra. Though both are anonymous electronic limit order books, there are important differences in the trading protocols. In this paper we use a matched-sample approach to compare execution costs in Euronext Paris and Xetra. We find that both the effective spreads and its components, the realized spread and the adverse selection component, are lower in Xetra. Differences in market organization - we consider differences in the number of liquidity provision agreements, and differences in the minimum tick size - do not explain the spread differences.

JEL classification: G10, G15

Keywords: Competition between exchanges, bid-ask spread

* We thank participants of the 9th Symposium on Finance Banking and Insurance in Karlsruhe for helpful comments.
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1 Introduction

European exchanges are in a process of consolidation. Banks and institutional investors are putting pressure on exchange officials to decrease transaction costs. The fragmentation of European exchanges has been identified as one source of high transaction costs. Mergers between exchanges and the joint use of trading systems are considered to be part of the solution. As Jacques de Larosiere, former gouverneur of the Banque de France and former president of the European Bank for Reconstruction and Development puts it,[1]

> At national and cross-border level [...] traditional stock markets are being obliged to regroup in order to secure the economies of scale essential if they are to become competitive at European level.

The French Stock Exchange (ParisBourseSBF SA.) has merged with the exchanges in Amsterdam, Brussels and (in 2002) Lisboa to form Euronext. The common trading platform is in operation since 2001. The London-based derivatives exchange LIFFE has joined the Euronext group in 2002. Deutsche Börse AG has merged its derivatives trading subsidiary, Deutsche Terminbörse AG, with the Swiss derivatives exchange SOFFEX to form EUREX, now the world's largest derivatives exchange. Further, Deutsche Börse AG has attempted a merger with the London Stock Exchange in 2000. Although that merger failed, Deutsche Börse AG has succeeded in convincing the exchanges in Austria and Ireland to adopt its electronic trading system Xetra.

Despite this trend towards consolidation, there are still many exchanges in Europe that are independent and operate their own trading system. Sooner or later some of these exchanges may face the decision to join one of the two dominating continental European trading systems.

When making that choice (and leaving aside political considerations), the quality of the market should be a decisive factor. Similarly, major global corporations seeking a continental European listing (or a Euro zone listing) may opt for only one listing and then also have to decide between Xetra and Euronext.

This motivates the present paper. We empirically analyze the execution costs in Xetra and Euronext. Both are electronic open limit order books which share many similarities, but also differ in important ways. Besides differences in the trading systems, there are also differences in the characteristics of the listed companies. In order to trace differences in execution costs back to the design of the trading systems we have to control for stock characteristics.

There are two principal approaches to achieve this. The first is to analyze *identical* stocks traded in both markets, e.g. French stocks which are also traded in Xetra or vice versa. This approach has (among others) been used by Pagano / Röell (1990), Schmidt / Iversen (1993), de Jong / Nijman / Röell (1995) and Degryse (1997) to compare the cost of trading continental European stocks in their home market and in the London-based SEAQ system. The second approach is to compare stocks which are *similar* with respect to those characteristics that determine liquidity. The resulting *matched sample* procedure has been used to compare execution costs on NYSE and Nasdaq (Affleck-Graves / Hegde / Miller 1994, Huang / Stoll 1996, Bessembinder / Kauffman 1997), in electronic and floor-based trading systems (Venkataraman 2001) and in pure limit order books, hybrid systems and dealership markets (Ellul 2002).

The problem with the first approach is that the home market has a natural liquidity advantage (Piwowar 1997). Adopting this approach would most likely yield the result that Euronext Paris offers lower trading costs for French stocks whereas Xetra offers lower costs for German

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[1] The statement was made in a speech at the Brussels Economic Form in May 2002. The manuscript can be downloaded at http://www.asmp.fr/sommair2/section/textacad/larosiere/eurofi.pdf.

stocks. We therefore use a matched sample comparison. Using market capitalization, trading volume and volatility as matching criteria, we form 40 pairs of stocks. Each pair consists of one French stock traded on Euronext Paris and one German stock traded in Xetra. Our approach is similar to Venkataraman (2001) and Ellul (2002). Venkataraman (2001) uses a matched sample approach to compare US stocks listed on the NYSE and French stocks traded in NSC (the predecessor of Euronext Paris). His focus is on comparing floor-based and electronic trading. Ellul (2002) compares French stocks traded on the CAC system (the predecessor of NSC), German stocks traded on IBIS (the predecessor of Xetra) and UK stocks traded on the SEAQ system. These systems differ with respect to the degree of dealer intervention. He finds that spreads in IBIS are the lowest.

Our main results can be summarized as follows. Although there are no significant differences in quoted spreads, effective spreads are lower in Germany. When decomposing the spread into an adverse selection component and the realized spread, we find that both components are lower in Xetra. We then test whether differences in market organization can explain these findings. Specifically, we consider differences in the number of liquidity provision agreements, and differences in the minimum tick size. None of these characteristics helps to explain the higher execution costs in Euronext. Our results thus indicate that investors in the French market are less well protected against informed traders, and that Euronext offers lower operational efficiency.

The paper is organized as follows. In section 2 we provide a detailed description of the trading systems under scrutiny. Section 3 describes the data set and the matching procedure and presents descriptive statistics. Section 4 presents the results. Section 5 offers a concluding discussion.

2 Equity Trading on Euronext Paris and Xetra

The two trading systems share many similarities. Most importantly, they are both anonymous electronic open limit order books. However, closer inspection reveals that there are a number of potentially important differences. In this section we give a short description of both trading systems. It is complemented by the more detailed information given in Table I.

Insert Table I about here

Euronext is the result of a merger between the exchanges in France, the Netherlands, and Belgium. The trading system goes back to the *Cotation Assisté en Continue* (CAC) system introduced in 1986, later renamed *Nouvelle Systeme de Cotation* (NSC). After the merger in 2001, several changes were implemented to harmonize the trading protocols on the three markets. Liquid stocks are traded continuously from 9.00 a.m. to 5.25 p.m., with call auctions at the open and at the close of trading. The market is fully transparent, with the exception of the hidden part of "iceberg orders". Only a fraction of the volume of these orders (the "peak") is visible on the screen. After execution of the peak, the next, equally-sized, part of the order becomes visible.[2] Crosses and block trades may be negotiated outside the system. The admissible prices for these transactions are restricted by the status of the order book. Reporting requirements assure that they are funneled through the system.

For some less liquid stocks, *liquidity providers* stand ready to increase the liquidity. They have to commit to posting firm two-way quotes. The definition of maximum spreads and minimum depths is part of the agreement with Euronext. *Volatility interruptions* are triggered when the potential transaction price would lie outside a pre-defined range around a reference price.

The trading system Xetra was introduced in November 1997 and replaced the electronic trading system IBIS. Liquid stocks are traded continuously from 9.00 a.m. to 8 p.m. with call auctions at the open, the close, and two intradaily call auctions. The market is fully transparent, again with the exception of the hidden part of iceberg orders. Block trades may be negotiated outside the system. In this case, they are not reported as transactions in Xetra. Deutsche Börse AG also offers a block trading facility (Xetra XXL), an anonymous matching system with closed order book.

Designated sponsors (similar to the Euronext liquidity providers) stand ready to increase the liquidity for less liquid stocks. Finally, as in Euronext, volatility interruptions are triggered when a potential transaction price lies outside of a pre-determined interval.

Despite many similarities, there also differences between the trading systems. These concern the trading hours, the existence of intradaily call auctions, and the rule for cross and block trades alluded to above. Another potentially important point is that Xetra faces competition by the Frankfurt Stock Exchange (a floor-based exchange with a trading system similar to that of the NYSE) and seven small regional exchanges.

There are much more designated sponsors in Xetra than there are liquidity providers in Euronext. This holds both with respect to the number of stocks with a sponsoring or liquidity provision agreement and the number of sponsors or liquidity providers per stock. The requirements for the designated sponsors in Xetra are defined by Deutsche Börse AG for groups of stocks. They are thus not subject to negotiation. Further, Deutsche Börse AG performs rankings of the sponsors and publishes the results in quarterly intervals. Euronext, on the other

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[2] When the total order is not a multiple of the peak volume, the last part is smaller than the preceding parts. A further characteristic of the iceberg orders is that each portion is attached the time stamp of the moment when it becomes visible. The hidden parts therefore loose time priority.

hand, does not specify the requirements for the liquidity providers to the same extent. Regular rankings are performed, but are not published.[3]

The price limits that trigger a volatility interruption are known to Euronext market participants. The respective limits are not known to traders in Xetra. Therefore Xetra market participants are uncertain about whether a certain order will trigger a trading halt or not.

The minimum tick size is different between the two markets. It is always € 0.01 in Xetra.[4] In Euronext, on the other hand, it is € 0.01 only for stocks trading at prices below € 50. It increases to € 0.05 for stocks with prices above € 50, to € 0.1 for stocks with prices above € 100, and to € 0.5 for stocks with prices above € 500.

3 Data and Methodology

We create a matched sample of 40 pairs of stocks where each pair consists of one French stock traded on Euronext Paris and one German stock traded in Xetra. We start by defining an initial sample of stocks from which the 40 pairs are to be drawn. For France, we choose the SFB 250 index and for Germany we choose all constituent stocks of the DAX 100 and the SMAX index.

The matched stocks should be as similar as possible with respect to those characteristics that determine the liquidity. Following the literature (e.g., Huang / Stoll 1996, Bessembinder / Kauffman 1997, Venkataraman 2001) we match on market capitalization, trading volume, and volatility.[5] Market capitalization is as of June 5th, 2002. Trading volume is measured by the

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[3] Euronext does, however, publish average spread and depth figures for instruments. This allows inferences about the performance of the liquidity providers.

[4] There is an exception for stocks trading at prices below € 0.1, a case which is irrelevant in our sample.

[5] The price of a stock is a further determinant of spreads. Higher prices are associated with higher absolute spreads but lower percentage spreads. Therefore, some previous studies have used the price as another matching criterion. However, an important explanation for the relation between prices and spreads is the minimum tick size. As outlined in section 2 Euronext Paris and Xetra differ with respect to the minimum tick

average of the number of shares traded in the period June 2001 - June 2002. Volatility is measured by the standard deviation of daily returns over the same period. The data for the matching procedure was obtained from Datastream.

The matching procedure proceeds as follows. We start with the German sample and identify those French stocks that best match them with respect to the criteria listed above. To that end, we first require that the relative difference in market capitalization *MC* does not exceed the threshold defined by

$$\left| \frac{MC^{XETRA} - MC^{EURP}}{(MC^{XETRA} + MC^{EURP})/2} \right| \leq 0.75 \qquad (1)$$

where the superscript (XETRA and EURP) relates to the market. After this first step, there are several candidate French stocks for each German stock, namely, those that fulfill condition (1) above. For each candidate pair we next calculate the score

$$\sum_{i=1}^{3} \left(\frac{x_i^{XETRA} - x_i^{EURP}}{(x_i^{XETRA} + x_i^{EURP})/2} \right)^2 \qquad (2)$$

where the x_i, $i = 1, 2, 3$, correspond to the matching criteria market capitalisation, trading volume and volatility. For each German stock we then pick the French stock with the smallest score. No French stock is matched to more than one German stock. Therefore, if a French stock is the best match for two (or more) German stocks, we resorted to the second-best matching French stock. This procedure leads to 73 pairs of stocks. From these, we choose our final sample of 40 pairs. We select i) liquid stocks from both markets (i.e., members of the DAX 30 and CAC 40 indices) and ii) pairs with a low score (2).

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size. Matching on price might eliminate the impact of different minimum tick sizes on transaction costs. We therefore decided not to use the price level as a matching criterion.

The data for the analysis of market quality is compiled from Bloomberg. It contains time-stamped data on best bids, best asks and transaction prices for the 80 sample stocks over the three month period (65 trading days), May 2 through July 31, 2002.[6] Data on the transaction volume is not included. Therefore, we use the number of transactions as proxy for the trading volume.

As noted in section 2, trading hours in Xetra are longer than those on Euronext. Given that spreads in Xetra increase after 5.30 p.m. (when the French market closes), we restrict the analysis to those hours where both markets are open. We further eliminate data from the intradaily call auctions in Xetra.

Table II presents descriptive statistics for the full sample and for quartiles of stocks sorted by market capitalization. The market capitalization of the French and German firms is of the same order of magnitude. There appears, however, to be a systematic pattern for German firms to be larger than their French counterparts in the first three quartiles. The daily average number of transactions, used as a proxy for trading activity, results in a similar picture. It is of the same order of magnitude overall, but, when disaggregated, shows a distinct pattern. Trading activity is higher in Xetra for large firms whereas it is higher in Euronext for small firms. In both markets trading activity declines as we move from large to small cap stocks. This decline is more pronounced in the German market.

Return volatility, measured by the standard deviation of midquote returns, is similar across markets and does not show any discernible pattern across size classes. The last characteristic

[6] We screened the data set for errors by applying a set of filters. Quotes were deleted from the sample when either the bid or the ask price was non-positive, when the spread was negative, when the percentage quoted spread exceeded 10%, and when a quoted price involved a price change since the previous quote of more than 10%.

included in Table II is the average stock price. With the exception of the first quartile, prices in the French market are about twice as high as those in the German market.

The overall impression from Table II thus is that the matching procedure did not result in a sample of stocks that are really similar with respect to all relevant characteristics.[7] This is mainly due to the relatively low number of listed companies in Germany and France (at least as compared to the US). As a consequence, we will have to check whether our results can be explained by a lack of control for relevant firm characteristics.

Insert Table II about here

4 Results

Our first measure of market quality is the percentage quoted half spread, defined as

$$s_{i,t}^{q} = 100\frac{a_{i,t} - b_{i,t}}{m_{i,t}} \tag{3}$$

where *a*, *b* and *m* are the ask price, the bid price and the quote midpoint, respectively. The indices *i* and *t* denote the stock and time. We calculate an average quoted half spread for each stock and each trading day. These daily averages are then used for the analysis. This procedure assures that each stock, irrespective of its trading volume, and each trading day, irrespective of the trading activity on that particular day, receive the same weight in the analysis.

Results are shown in Panel A of Table III. The average quoted half spread in France is 0.4258%. The corresponding value for Germany is 0.4142%. These values are very similar, and they are not significantly different from each other. The distributions of the daily average spreads are skewed in both countries. This is evidenced by the fact that the medians are clearly

[7] Remember, however, that we purposely did not match on price.

lower than the means. They amount to 0.2042 for Euronext and 0.1669 in the case of Xetra. A non-parametric Wilcoxon test reveals that the difference is significant.

We next sort the sample stocks into quartiles by market capitalization. The results are also shown in Panel A of Table III. Here we obtain a more differentiated picture. In both countries quoted half spreads increase as we move towards stocks with lower market capitalization. Average spreads in Xetra are lower than spreads in Euronext only for the first three quartiles. In the group of the smallest stocks the sign of the difference reverses; spreads are significantly higher in Xetra. An analysis of the medians reveals a slightly different picture. Here, spreads in Euronext are lower for groups three and four.

Insert Table III about here

Transactions cluster in periods in which spreads are low. Effective spreads, which relate the transaction price to the quote midpoint in effect prior to the transaction, are thus expected to be lower than quoted spreads. The percentage effective half spread is defined as

$$s_{i,t}^{e} = 100\frac{\left|p_{i,t} - m_{i,t}\right|}{m_{i,t}} \tag{4}$$

Results for the effective spread are shown in Panel B of Table III. Effective half spreads in Xetra are, on average, 0.2876. This is significantly less than the 0.3298 we find for Euronext Paris. If we consider the size quartiles, we find that effective spreads in Xetra are lower than those in Euronext in all four quartiles and significantly so in three. The medians are again unanimously lower than the means. In the two smallest quartiles, median spreads in Euronext are lower than those in Xetra. The differences are, however, insignificant.

The result thus far suggest that spreads in Xetra are lower for liquid stocks whereas there are no pronounced differences (at least if the effective spread is considered) for less liquid stocks.

One way to gain further insights into the reasons for this pattern is to decompose the spread into its components. We follow the procedure used by Venkataraman (2001). The effective half spread is decomposed into an adverse selection component (or price impact) s^a and the realized half spread s^r. The latter has to cover order processing costs and contains any rents the suppliers of liquidity may earn. The two measures are defined as

$$s^a_{i,t} = 100 \cdot D_{i,t} \cdot \frac{\left(m_{i,t+\tau} - m_{i,t}\right)}{m_{i,t}}$$

$$s^r_{i,t} = 100 \cdot D_{i,t} \cdot \frac{\left(p_{i,t} - m_{i,t+\tau}\right)}{m_{i,t}}$$

where $D_{i,t}$ is a trade indicator variable (1 for a buyer-initiated trade, -1 for a seller-initiated trade).[8] The adverse selection component captures the price impact of a trade by measuring the change of the quote midpoint between the time of the transaction, t, and the midpoint at time $t+\tau$. The latter serves as a proxy for the true value of the stock at time $t+\tau$. We choose a value of 5 minutes for τ.[9] The realized half spread captures the revenue of the suppliers of liquidity net of losses to informed traders by relating the transaction price to the midpoint at time $t+\tau$.

The results are shown in Table IV. The adverse selection component (shown in Panel A) is significantly larger in Euronext Paris. This holds for the full sample and for the first three size quartiles. In the smallest quartile the difference has the same sign (i.e., the adverse selection component is larger in Euronext) but is not significantly different from zero. Using the median instead of the mean results in a slightly different picture. The adverse selection component is smaller in Xetra for the full sample and for the first two size quartiles. It is, however, larger (albeit not significantly so) in the last two quartiles.

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[8] A transaction is classified as buyer-initiated [seller-initiated] if the price is above [below] the quote midpoint.

Turning to the realized half spread (Panel B of Table IV) we first note that the realized spreads are generally very low. Despite the low numerical values the realized spreads are, on average, statistically different from zero. More importantly, there are also significant differences between the two markets. The realized spreads are unanimously lower in Xetra. This is true for the full sample, for all size quartiles and irrespective of whether the mean or the median is used.

Insert Table IV about here

The descriptive statistics shown in Table II indicate that the matching procedure does not result in pairs of stocks that are equal with respect to all relevant variables. It is thus possible that the differences in spreads documented above are a consequence of different stock characteristics. To control for these differences we regress the difference in execution costs on the differences in a set of control variables. These are the log of market capitalization, the log of the inverse price, return volatility, and the log of the number of transactions. The model is

$$\Delta s_{i,t}^{j} = \gamma_0 + \gamma_1 \Delta ln\left(MC_i\right) + \gamma_2 \Delta ln\left(1/\overline{P}_{i,t}\right) + \gamma_3 \Delta \sigma_{i,t} + \gamma_4 \Delta ln\left(Notrans_{i,t}\right) + \varepsilon_{i,t} \qquad (5)$$

where

$\Delta s_{i,t}^{j}$: Difference in execution cost measure between French stock *i* and the matched German stock on day *t*. $j \in q,e,a,r$ denotes the measure of execution costs (quoted and effective spread, adverse selection component and realized spread)

$\Delta ln\left(MC_i\right)$: Difference in the log of market capitalization between French stock *i* and the matched German stock

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[9] Results of previous research (e.g. Huang / Stoll 1996) imply that the results are insensitive to the choice of τ.

$\Delta ln\left(1/\overline{P}_{i,t}\right)$: Difference in the log of the inverse price between French stock *i* and the matched German stock. $\overline{P}_i$ is the average transaction price of stock *i* on day *t*.

$\Delta\sigma_{i,t}$: Difference in return volatility between French stock *i* and the matched German stock. Volatility is measured by the standard deviation of midquote returns for stock *i* on day *t*.

$\Delta ln\left(Notrans_{i,t}\right)$: Difference in the log of the number of transactions on day *t* between French stock *i* and the matched German stock.

The regression results,[10] shown in Table V, largely confirm our previous findings. The independent variables do have explanatory power, indicating that the matching procedure did not result in a "perfectly" matched sample. The significantly positive constants imply that quoted and effective spreads are significantly larger in Euronext than in Xetra. The same holds true for the adverse selection component and the realized spread.

Insert Table V about here

5 Explaining the differences in transaction costs

As documented in the preceding section, the adverse selection component is higher in Euronext as compared to Xetra. One possible explanation are differences in insider trading legislation and enforcement. However, insider trading legislation in both countries is based on directives of the European Union and, therefore, does not grossly differ. Besides that, insider trading legislation was inacted (and enforced) earlier in France than in Germany (1967 as compared to 1994, see Bhattacharya / Daouk 2002). The index of shareholder rights constructed

by La Porta / Lopez-de-Silanos / Shleifer (1998) is low in both countries, but is even lower in Germany (1 as compared to 2 for France on a scale from 1 to 6). Therefore, neither insider trading legislation nor shareholder protection rights provide an explanation for the differences in execution costs.

We therefore now turn to explanations based on differences in the trading systems. As outlined in section 2, and despite the similarity on a "macro level", there remain important differences in the way trading is organized on the two exchanges. We consider two differences that potentially have an impact on execution costs.

First, minimum tick sizes are different in Euronext and Xetra. The tick size is € 0.01 for all stocks (except those trading at prices below € 0.10) in Xetra. In Euronext, on the other hand, the minimum tick size is € 0.01 for stocks trading at prices below 50, € 0.05 for stocks trading at prices between € 5 and € 100, € 0.10 for stocks trading at prices between € 100 and € 500, and € 0.50 for stocks trading at prices above € 500. As smaller tick sizes may be associated with lower spreads (e.g., Ronen / Weaver 2001), the larger minimum tick size is a possible explanation for the larger spreads in Euronext.

Second, most stocks in Xetra (outside the DAX 30 index) have one or more designated sponsors. In Euronext, the number of stocks with a liquidity supplier is significantly lower. To the extent that the existence of a liquidity provision agreement (i.e., the existence of a sponsor or liquidity provider) increases liquidity, this may be another explanation for the higher spreads in Euronext.

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[10] We used GMM estimation in order to obtain robust standard errors.

In order to control for the effect of these variables we include them as additional explanatory variables in regression (5). The model is

$$\begin{aligned} \Delta s_{i,t}^{j} = \gamma_0 + \gamma_1 \Delta ln\left(MC_i\right) + \gamma_2 \Delta ln\left(1/\overline{P}_{i,t}\right) + \gamma_3 \Delta \sigma_{i,t} + \gamma_4 \Delta ln\left(Notrans_{i,t}\right) \\ + \gamma_5 LP_i + \gamma_6 FR05 + \gamma_7 FR10 + \varepsilon_{i,t} \end{aligned} \tag{6}$$

where

LP_i: Dummy variable which takes on the value 1 when the German stock *i* has a designated sponsor and its French counterpart does not have a liquidity provider[11]

*FR*05, *FR*10: Dummy variables which takes on the value 1 for those French stocks with a minimum tick size of € 0.05 and € 0.10, respectively (i.e., with prices in the range € 50 - 100 and € 100 - 500, respectively). [12]

All other variables are as defined previously. We expect a positive sign for the three additional variables. The difference between the spread measure for the French stock and its German counterpart should be larger when only the German stock has a liquidity provision agreement, or when the tick size of the French stock is larger.

Insert Table VI about here

The results are shown in Table VI. Comparing them to those reported in Table V reveals that the explanatory power of the additional variables is limited, as evidenced by a very modest increase in the R^2's. The sign of the coefficient for the *LP* variable is as expected in three of the four cases (the exception being the realized spread regression), but the coefficient is never

[11] The opposite case does not occur, i.e., there are no pairs of stocks where there is a liquidity provider in Euronext but no designated sponsor in Xetra.

[12] There are no stocks with prices above € 500 in our sample. Therefore, we do not have to include an *FR*50 dummy.

significant. Even more surprising, the coefficients on the tick size dummies are negative, and they are significant in five out of eight cases. Therefore, larger tick sizes in the French market appear to be associated with *smaller*, rather than larger, spread differences. We thus have to conclude that neither the differences in the number of liquidity provision agreements nor the differences in minimum tick size explain the higher execution cost in the French market.

6 Summary and Conclusions

In the present paper we compare execution costs in Euronext Paris to those in Xetra. Both are anonymous electronic limit order books. Though the two systems are similar, there are differences in detail. For example, minimum tick sizes and the degree to which designated market makers are involved in the trading process are different.

To control for different stock characteristics, we construct a matched sample of 40 pairs of stocks. The matching criteria are market capitalization, trading volume, and return volatility. We use this sample to compare quoted and effective spreads, the adverse selection component of the spread, and the realized spread. For liquid stocks (those in the first size quartiles), spreads are lower in Xetra. Most of the difference is explained by the lower adverse selection component. There are, however, also significant differences in realized spreads. For small firms, neither spreads nor the adverse selection component are significantly different in the two markets. We still do find differences in the realized spread, however. The observation that realized spreads are unanimously lower in Xetra indicates that Xetra offers higher operational efficiency. The general finding that spreads are lower in the German market is consistent with the results reported in Ellul (2002) who analyzes the predecessors of the current trading systems, i.e., IBIS and CAC.

We use a regression to analyze whether these results are explained by differences in stock characteristics not eliminated by our matching procedure. The results of the regression analysis confirm the finding that execution costs are lower in Xetra. In an attempt to explain these differences we control for the differing number of liquidity provision agreements and differences in minimum tick size. Both characteristics do not explain the larger execution costs in Euronext.

Our results imply that Xetra is the more efficient trading system. In Euronext, on the other hand, it appears that investors are less well protected against informed traders. Further, the higher realized spreads indicate that the operational efficiency is lower. The search for an explanation for these findings is a promising area for future research.

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Table I: The Trading Systems

	Xetra	**Euronext**
nature of trading system	• Electronic open limit order book	• Electronic open limit order book
trading mechanism by stock groups	• Liquid stocks: call auctions (open, intradaily, close) and continuous trading • Illiquid stocks: call auction	• Liquid stocks: call auctions (open, close) and continuous trading • Less liquid stocks: two call auctions • Least liquid stocks: one call auction
call auctions	• Pre-trading phase with closed book, allows entry and modification of orders • Indicative prices are disseminated • Order imbalance information provided for DAX stocks and stocks with designated sponsors (see below) • Price determination based on volume maximization / order imbalance / reference price • Random price determination time	• Pre-trading phase with partially open (5 best bid and ask prices and the respective quantities are given) book. allows entry and modification of orders • Indicative prices are disseminated • Price determination based on volume maximization / order imbalance / reference price • Random price determination time
admissible order types	• Market, limit, market-to-limit, stop orders • Additional execution conditions admissible: immediate-or-cancel, fill-or-kill • Validity constraints: good-for-day, good-till-date, good-till-cancelled (maximum validity 90 days) • Admissible trading restrictions, e.g. auction only, opening only • Iceberg orders: specify overall volume and peak volume; iceberg orders are not identified in the book; time stamp equal to time at which peak appears on the screen	• Market / Must-be-filled (the latter must be fully executed, only one of these typed is admissible for a given instrument), limit, market-to-limit, stop orders • Additional execution conditions admissible: fill-and-kill, all-or-none, minimum quantity (with fill-or-kill as special case) • Validity constraints: good-for-day, good-till-date, good-till cancelled (maximum validity 365 days) • Iceberg orders: specify overall volume and peak volume; iceberg orders are not identified in the book; time stamp equal to time at which peak appears on the screen • Cross trades and block trades negotiated outside, but funneled through the system (and subject to price restrictions!)

Table I (continued)

	Xetra	**Euronext**
trading hours	• 8.50 a.m. (beginning opening auction) to 8.05 p.m. (end closing auction) • Stocks traded by call auction only: 1.20 - 1.25 p.m. • Xetra XXL (block trading facility): crossings each 15 minutes from 9.30 a.m. to 6.00 p.m.	• Pre-opening 7.15 a.m. • Trading from 9.00 a.m. to 5.25 p.m., closing auction at 5.30 p.m. • Stocks traded by call auction only: 3.00 p.m. for those with a single call, 10.30 a.m. and 4.00 p.m. for those with two calls
priority rules	• Price, time (except hidden parts of iceberg orders)	• Price, time (except hidden parts of iceberg orders)
transparency in continuous trading session	• open book • Exception 1: hidden parts of iceberg orders • Exception 2: liquidity provided by designated sponsors upon quote request	• Open book • Exception: hidden parts of iceberg orders
Anonymity	• Anonymous • Exception: Designated sponsors know identity of quote requesting party	• Anonymous (since 2001; before: broker IDs appeared on the screen)
clearing settlement	• Settlement two workdays after transaction • Central counterparty to be introduced in 2003	• Same-day settlement (in addition, "service de règlement differée" allows delayed settlement, but the delay is only effective in the relation between broker and customer) • Clearnet SA. acts as central counterparty
minimum tick size	• € 0.01 • € 0.001 for instruments with prices below € 0.1	• € 0.01 if price < 50 € • € 0.05 if 50 € ≤ price < 100 € • € 0.10 if 100 € ≤ price < 500 € • € 0.50 if price > 500 €
minimum order size	• 1 share	• 1 share

Table I (continued)

	Xetra	**Euronext**
designated sponsors / liquidity providers	• Mandatory for Neuer Markt (2), SMAX (2) and for admission to the MDAX (midcap) index • Must participate in auctions and volatility interruptions • Minimum quote quantities, maximum spreads (differentiated according to liquidity) and maximum response time specified • Regular performance measurement, published quarterly • Privileges: reduced fees, designated sponsors learn identity of quote-requesting trader	• Not allowed for Euronext 100 stocks • Voluntary for all stocks that qualify for continuous trading and for all stocks traded by call auction only • Mandatory for stocks that the issuer wishes to be traded continuously although the requirements are not met • Recommended (but not mandatory) for small caps • Types: permanent liquidity provider, volatility liquidity provider (all auctions, including those resulting from circuit breakers); auction liquidity provider (for issues traded in auction only) • Liquidity provider is appointed by Euronext • Liquidity provider has to commit to specific size and spread, these must "to the opinion of Euronext have added value for the liquidity and the quality of market in such instrument" (rule 1.2.3) • Size and spreads for each instrument (not each liquidity provider) are published every six months • Monitoring of performance of liquidity providers at least twice a year, but rating are not published

Table I (continued)

	Xetra	**Euronext**
domestic parallel trading venues	• Floor trading on the Frankfurt Stock Exchange and seven regional exchanges • OTC trading • Since September 2002 (after our sample period): Internalization of orders through XetraBest	• No
circuit breakers	• Volatility interruption if potential price outside pre-defined range around reference price 1 (the last determined price) or reference price 2 (last auction price) • The width of the ranges are not disclosed to market participants and are adapted to market conditions • Market order interruption: when market orders exist that are not executable • Trading resumes with call auction • Exchange can suspend trading in case of information events; orders in the system are deleted	• Volatility interruption if potential price outside pre-defined range around static reference price (in general the opening price) or dynamic reference price (in general the last traded price) • Static price range +/- 10%, dynamic price range +/- 2% or +/- 5%, depending on instrument group • Trading resumes with call auction • Exchange can suspend trading in case of corporate events; orders in the system are deleted
handling of block trades	• Specific block trading segment (Xetra XXL) • Matching of orders at the Xetra quote midpoint (i.e., Xetra XXL itself does not contribute to price discovery) • Anonymous, closed order book	• Negotiated outside the order book • In general, price constraints resulting from the status of the book apply • Trades are reported to Euronext and published there

Table II: Sample Description

Panel A: Descriptive statistics

Panel A presents descriptive statistics for the full sample and for subsamples formed according to market capitalization (using the average market capitalization of the pairs as sorting criterion). Market capitalization is as of June 5, 2001. The average daily number of transactions is measured over the sample period. Return volatility is the standard deviation of midquote returns over the sample period. The last column gives the simple average over all transaction prices in the sample.

		market capitalization (million €)	no. of transactions (daily average)	return volatility	average price
all	France	9789.704	892.226	0.126	63.734
	Germany	11767.812	1136.304	0.142	37.589
largest	France	31654.985	2801.003	0.025	74.718
	Germany	37868.773	3389.046	0.025	68.691
second	France	5827.655	562.722	0.064	66.810
	Germany	7345.248	999.882	0.049	28.240
third	France	1391.112	168.730	0.113	53.289
	Germany	1596.956	145.697	0.128	28.467
smallest	France	285.064	27.350	0.310	59.857
	Germany	260.271	10.592	0.372	22.669

Panel B: Sample Stocks

Panel B provides a list of the names of the sample stocks.

	France	Germany
largest	AVENTIS, L'OREAL, SANOFI - SYNTHELABO, CARREFOUR, SOCIETE GENERALE, LVMH, CREDIT AGRICOLE, DANONE, AIR LIQUIDE, Credit Lyonnais	SIEMENS, DAIMLERCHRYSLER, DEUTSCHE BANK, DEUTSCHE TELEKOM, MUNCH.RUCK., E ON, SAP, BAYER, RWE, BAYER.HYPO
second	CASTORAMA DUBOIS, AGF – ASR.GL.DE FRN., CASINO GUICHARD - P, CHRISTIAN DIOR, HERMES INTL., NATEXIS BQ POP, VALEO, REXEL, ATOS ORIGIN, EURAZEO	DEUTSCHE POST, INFINEON TECHNOLOGIES, THYSSENKRUPP, ALTANA, DEGUSSA, LUFTHANSA, PREUSSAG, FRESENIUS MED.CARE, MARSCHOLLEK, SUEDZUCKER
third	SIMCO, RALLYE, GECINA, REMY COINTREAU, NEOPOST, BEGHIN - SAY, SOPHIA, ERAMET, CEREOL, PIERRE & VACANCES	WCM BETEILIGUNG, HANNOVER RUCK., MAN, WELLA AG, HOCHTIEF, CELANESE, IKB DT.INDSTRBK, JENOPTIK, FIELMANN, BERU
smallest	GROUPE BOURBON, SECHE ENVIRONNEMENT, CARBONE - LORRAINE, BOIRON, BRICORAMA, TREDI ENVIRONNEMENT, IMMOBANQUE (SC.FINC), GIFI, EXEL INDUSTRIES	RATIONAL, TECHEM, DIS DT.INDS.SVS., DT.BETEILIGUNG, HOLSTEN BRAUEREI, EDSCHA, MPC MUENCHMAYER CAP, ZAPF CREATION, BOEWE SYSTEC

Table III: Comparison of Bid-Ask Spreads

Panel A: Quoted Half Spreads

This panel shows average quoted half spreads for the sample stocks. The quoted half spread is defined as

$$s_{i,t}^{q} = 100\frac{a_{i,t} - b_{i,t}}{m_{i,t}}.$$

We calculate an average quoted half spread for each stock and each trading days. The figures in the table are based on these daily averages. The first line shows mean and median values for the full sample. Lines 2 through 5 report values for quartiles of stocks sorted by market capitalization.

	mean			median		
	France	Germany	difference t-value	France	Germany	difference z-value
full sample	0.4258	0.4142	0.0116 (0.656)	0.2042	0.1669	0.0373 (4.680)
largest	0.0844	0.0621	0.0223 (8.513)	0.0751	0.0554	0.0197 (16.255)
second	0.2157	0.1303	0.0854 (13.496)	0.1808	0.1128	0.068 (11.669)
third	0.4097	0.3552	0.0545 (2.593)	0.2603	0.3178	-0.0575 (3.360)
smallest	1.0113	1.1312	-0.1199 (2.289)	0.7879	0.8665	-0.0786 (2.954)

Panel B: Effective Half Spreads

This panel shows average quoted half spreads for the sample stocks. The quoted half spread is defined as

$$s_{i,t}^{e} = 100\frac{\left|p_{i,t} - m_{i,t}\right|}{m_{i,t}}.$$

The procedures and the structure of the table are as in Panel A.

	mean			median		
	France	Germany	difference t-value	France	Germany	difference z-value
full sample	0.3298	0.2876	0.0422 (2.888)	0.1627	0.1246	0.0381 (5.582)
largest	0.0763	0.0569	0.0194 (10.613)	0.0661	0.0504	0.0157 (14.805)
second	0.1771	0.1153	0.0618 (11.458)	0.1425	0.0979	0.0446 (9.453)
third	0.3331	0.2950	0.0381 (2.341)	0.2294	0.2470	-0.0176 (1.381)
smallest	0.8710	0.8187	0.0523 (0.926)	0.6524	0.6699	-0.0175 (0.794)

Table IV: The Components of the Bid-Ask Spread

Panel A: Adverse-Selection Component

This panel shows the adverse selection component of the spread for the sample stocks. The effective half spread is decomposed into an adverse selection component (or price impact) s^a and the realized half spread s^r. The two measures are defined as

$$s^a_{i,t} = 100 \cdot D_{i,t} \cdot \frac{\left(m_{i,t+\tau} - m_{i,t}\right)}{m_{i,t}}$$

$$s^r_{i,t} = 100 \cdot D_{i,t} \cdot \frac{\left(p_{i,t} - m_{i,t+\tau}\right)}{m_{i,t}}$$

where Di,t is a trade indicator variable (1 for a buyer-initiated trade, -1 for a seller-initiated trade). The adverse selection component captures the price impact of a trade by measuring the change of the quote midpoint between the time of the transaction, t, and the midpoint at time t+τ. The latter serves as a proxy for the true value of the stock at time t+τ. We choose a value of 5 minutes for τ. The first line of the table shows mean and median values for the full sample. Lines 2 through 5 report values for quartiles of stocks sorted by market capitalization.

	mean			median		
	France	Germany	difference t-value	France	Germany	difference z-value
full sample	0.3261	0.2738	0.0523 (3.243)	0.1580	0.1194	0.0386 (5.756)
largest	0.0760	0.0566	0.0194 (10.648)	0.0657	0.0501	0.0156 (14.842)
second	0.1763	0.1148	0.0615 (11.417)	0.1416	0.0975	0.0441 (9.405)
third	0.3291	0.2934	0.0357 (2.191)	0.2283	0.2464	-0.0181 (1.472)
smallest	0.8974	0.7865	0.1109 (1.580)	0.6329	0.6461	-0.0132 (0.373)

Panel B: Realized Half Spreads

This panel shows the realized half spread for the sample stocks. See the legend for Panel A for details.

	mean			median		
	France	Germany	difference t-value	France	Germany	difference z-value
full sample	0.0010	0.0004	0.0004 (13.539)	0.0005	0.0002	0.0003 (18.192)
largest	0.0002	4.38 E-5	0.0002 (9.202)	0.0002	3.69 E-5	0.0002 (10.704)
second	0.0006	0.0002	0.0004 (13.058)	0.0004	0.0002	0.0002 (13.507)
third	0.0012	0.0006	0.0006 (8.655)	0.0009	0.0005	0.0004 (10.335)
smallest	0.0022	0.0011	0.0011 (6.425)	0.0017	0.0010	0.0007 (7.250)

Table V: Regression results

The table reports the results of the regression

$$\Delta s_{i,t}^{j} = \gamma_0 + \gamma_1 \Delta ln\left(MC_i\right) + \gamma_2 \Delta ln\left(1/\overline{P}_{i,t}\right) + \gamma_3 \Delta\sigma_{i,t} + \gamma_4 \Delta ln\left(Notrans_{i,t}\right) + \varepsilon_{i,t}$$

$\Delta s_{i,t}^{j}$ is the difference in the execution cost measure between French stock i and the matched German stock on day t. $j \in q,e,a,r$ denotes the measure of execution costs (quoted and effective spread, adverse selection component and realized spread). $\Delta ln\left(MC_i\right)$ is the difference in the log of market capitalization between French stock i and the matched German stock. $\Delta ln\left(1/\overline{P}_{i,t}\right)$ is the difference in the log of the inverse price; $\overline{P}_i$ is the average transaction price of stock *i* on day *t*. $\Delta\sigma_{i,t}$ is the difference in return volatility, measured by the standard deviation of midquote returns on day *t*. $\Delta ln\left(Notrans_{i,t}\right)$ is the difference in the log of the number of transactions for stock pair *i* on day *t*. The t-values, reported in parentheses, are based on robust standard errors obtained by GMM estimation.

	dependent variable			
	$\Delta s_{i,t}^{q}$	$\Delta s_{i,t}^{e}$	$\Delta s_{i,t}^{a}$	$\Delta s_{i,t}^{r}$
constant	0.1489 (5.78)	0.1081 (6.20)	0.1115 (5.04)	0.000706 (10.23)
$\Delta ln\left(MC_i\right)$	0.3525 (4.39)	0.2213 (3.54)	0.2472 (2.83)	0.000813 (4.08)
$\Delta ln\left(1/\overline{P}_{i,t}\right)$	0.0822 (3.28)	0.0404 (3..46)	0.0284 (2.70)	0.000103 (1.87)
$\Delta\sigma_{i,t}$	0.5182 (2.53)	0.9542 (9.23)	0.9614 (9.07)	0.000703 (1.18)
$\Delta ln\left(Notrans_{i,t}\right)$	-0.1010 (5.42)	-0.0545 (4.64)	-0.0539 (3.83)	-0.000089 (1.83)
R^2	0.23	0.48	0.35	0.03

Table VI: Explaining transaction cost differences

The table reports the results of the regression

$$\Delta s_{i,t}^{j} = \gamma_0 + \gamma_1 \Delta ln\left(MC_i\right) + \gamma_2 \Delta ln\left(1/\overline{P}_{i,t}\right) + \gamma_3 \Delta\sigma_{i,t} + \gamma_4 \Delta ln\left(Notrans_{i,t}\right) + \gamma_5 LP_i + \gamma_6 FR05 + \gamma_7 FR10 + \varepsilon_{i,t}$$

$\Delta s_{i,t}^{j}$ is the difference in the execution cost measure between French stock i and the matched German stock on day t. $j \in q,e,a,r$ denotes the measure of execution costs (quoted and effective spread, adverse selection component and realized spread). $\Delta ln\left(MC_i\right)$ is the difference in the log of market capitalization between French stock i and the matched German stock. $\Delta ln\left(1/\overline{P}_{i,t}\right)$ is the difference in the log of the inverse price; $\overline{P}_i$ is the average transaction price of stock *i* on day *t*. $\Delta\sigma_{i,t}$ is the difference in return volatility, measured by the standard deviation of midquote returns on day *t*. $\Delta ln\left(Notrans_{i,t}\right)$ is the difference in the number of transactions for stock pair *i* on day *t*. LPi is a dummy variable which takes on the value 1 when the German stock, but not its French counterpart, has a liquidity provider. FR05 and FR10 are dummy variables which take on the value 1 for those French stocks with a minimum tick size of € 0.05 [€ 0.10], i.e., with prices in the range € 50 - 100 and € 100 - 500, respectively. The t-values, reported in parentheses, are based on robust standard errors obtained by GMM estimation.

	dependent variable			
	$\Delta s_{i,t}^{q}$	$\Delta s_{i,t}^{e}$	$\Delta s_{i,t}^{a}$	$\Delta s_{i,t}^{r}$
constant	0.2089 (4.58)	0.1445 (4.48)	0.1466 (4.12)	0.000863 (6.49)
$\Delta ln\left(MC_i\right)$	0.3599 (4.35)	0.2291 (3.59)	0.2535 (2.96)	0.000885 (4.24)
$\Delta ln\left(1/\overline{P}_{i,t}\right)$	0.0704 (2.65)	0.0304 (2.29)	0.0196 (1.47)	0.000052 (0.89)
$\Delta\sigma_{i,t}$	0.4985 (2.47)	0.9450 (9.22)	0.9503 (9.08)	0.000696 (1.17)
$\Delta ln\left(Notrans_{i,t}\right)$	-0.1214 (5.54)	-0.0674 (4.42)	-0.0700 (3.29)	-0.000109 (1.90)
LP_t	0.0435 (0.88)	0.0206 (0.62)	0.0348 (0.81)	-0.000096 (0.68)
*FR*05	-0.1634 (4.11)	-0.0916 (3.00)	-0.0997 (2.62)	-0.000235 (1.97)
*FR*10	-0.0389 (0.66)	-0.0586 (1.31)	-0.0479 (0.86)	-0.000396 (2.44)
R^2	0.25	0.49	0.36	0.04