A Tale of Two Time Zones:
Cross-Listed Stock Liquidity and the Availability of Substitutes

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Abstract

This article examines how liquidity provision and market quality differ for European cross-listed stocks on the NYSE when their home markets are open versus closed. We find that specialist participation and effective spreads are lower in European cross-listed stocks when their home markets are open, a time of day when specialist participation and effective spreads are higher for U.S. domestic stocks, although both types of stocks have higher trading volume and volatility when European exchanges are open. Differences in overnight information build-up and other stock characteristics do not explain these contrasting intraday patterns. Our findings suggest that the availability of substitutes significantly affects liquidity provision and market quality. Our results also provide a richer picture of specialists' intraday activities and suggest that market integration has increased notably since the 1990s.

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Abstract

This article examines how liquidity provision and market quality differ for European cross-listed stocks on the NYSE when their home markets are open versus closed. We find that specialist participation and effective spreads are lower in European cross-listed stocks when their home markets are open, a time of day when specialist participation and effective spreads are higher for U.S. domestic stocks, although both types of stocks have higher trading volume and volatility when European exchanges are open. Differences in overnight information build-up and other stock characteristics do not explain these contrasting intraday patterns. Our findings suggest that the availability of substitutes significantly affects liquidity provision and market quality. Our results also provide a richer picture of specialists' intraday activities and suggest that market integration has increased notably since the 1990s.

1. Introduction

As global equity markets become both more integrated and more competitive, there is growing interest in how cross-listed stocks trade. The cross-listed stocks of 460 companies from 47 foreign countries accounted for 10.5% of New York Stock Exchange (NYSE) trading volume in 2004, with the largest trading share coming from European countries. Most of these companies also trade on their domestic stock exchanges, and many U.S.-based investors view home-market shares as potential substitutes for cross-listed stocks.[1] In most cases, information production is greater when a stock's home market is open.[2] A natural question for investors is how the availability of home-market shares and heightened information production during overlapping trading hours affect cross-listed stock trading. European cross-listed stocks, which have home-market substitutes available for part of each trading day, offer a laboratory in which to study such issues. This article examines empirically how trading activity, liquidity provision, and market quality differ for European cross-listed stocks on the NYSE when their home markets are open versus closed.

This topic is important for both practical and academic reasons. From a practical viewpoint, with 2,300 internationally cross-listed stocks worldwide as of year-end 2002 (Karloyi, 2004), how cross-listed stocks are affected by their home-market counterparts matters to investors as well as to markets where cross-listed stocks trade. From an academic viewpoint, we know relatively little about the interaction between the availability of substitutes, information production, the behavior of liquidity providers,

[1] See, for example, the investor survey by JPMorgan (2003).
[2] See, for example, Grammig, Melvin, and Schlag (2004b) and Menkveld, Koopman, and Lucas (2004).

and market quality.[3] In this study we isolate periods when home-market substitutes are available and information production is greater (overlapping trading hours) and measure the behavior of an important group of liquidity providers (specialists) and the resulting market quality.

We find that both volume and volatility are typically higher for European cross-listed stocks on the NYSE when their home markets are open. Higher volume is probably due to arbitrage activity and order-splitting across the cross-listed and home markets, and together with higher volatility likely reflects increased information production when the home market is open, as documented in Grammig, Melvin, and Schlag (2004b) and Menkveld, Koopman, and Lucas (2004).

The intraday change in availability of home-market substitutes should affect liquidity provision and market quality for European cross-listed stocks. We begin by examining the trading of NYSE specialists, a special group of liquidity providers in NYSE-listed securities. While liquidity is also supplied by floor brokers and traders off the floor who electronically submit public limit orders, specialist trading behavior is particularly interesting given specialists' unique access to order-flow information and their role as liquidity providers of last resort. Furthermore, Corwin (1999) and Coughenour and Saad (2004) show that NYSE specialists have a significant impact on execution costs and liquidity.

Using NYSE specialist trading data, we find that specialist participation and

[3] Related work examines different pieces of this question. For example, trading activity and round-the-clock information production are studied by Barclay and Hendershott (2004), Grammig, Melvin, and Schlag (2004b), and Menkveld, Koopman, and Lucas (2004); specialist activity and market quality are the focus of Bacidore and Sofianos (2002) and Madhavan and Sofianos (1998); relative pricing of cross-listed and home-market stocks is analyzed by Eun and Sabberwahl (2003) and Gagnon and Karolyi (2004); and the relative market quality of cross-listing versus home markets is studied by Menkveld (2004) and Werner and Kleidon (1996).

stabilization rates for European cross-listed stocks increase significantly after their home markets close. In contrast, specialist participation and stabilization rates decrease significantly for a matched sample of U.S. domestic stocks over the same intraday periods. This divergence between the European and U.S. matched samples suggests that specialist behavior is affected by the availability of substitutes, not merely by the intraday volume and volatility changes, since the U.S. matched stocks also have significantly higher trading volume and volatility when European exchanges are open (roughly the first two hours of the NYSE trading day). We also find that quoted depth is significantly higher for European cross-listed stocks on the NYSE when European exchanges are open, again in contrast to the matched U.S. domestic stocks, which have lower quoted depth during those hours.

Theoretical analyses of competing trading venues suggest that market quality could be better or worse for cross-listed stocks when their home markets are also open; see, for example, Parlour and Seppi (2003) and Domowitz, Glen, and Madhavan (1998). We find that quoted spreads, effective spreads, and realized spreads are all significantly lower for European cross-listed stocks when their home-market substitutes are trading. In contrast, the matched sample of U.S. domestic stocks shows higher spreads during European trading hours. This evidence is consistent with enhanced liquidity for cross-listed stocks on the NYSE when their home-market substitutes are also trading.

These findings show that European cross-listed stocks trade differently intraday than matched U.S. domestic stocks in ways that suggest the availability of home-market substitutes affects liquidity provision and market quality. The European results do not seem to be driven purely by trading volume and volatility, which are similar for the U.S.

matched sample. The intraday patterns are even stronger when the beginning of NYSE trading is excluded, suggesting that our results are not due to differences in overnight information build-up between the European cross-listed and U.S. matched stocks. Comparisons to control groups of cross-listed stocks with home-exchange trading hours that fully overlap or do not overlap NYSE trading hours reveal that it is the partial-day availability of substitutes, not other characteristics of cross-listed stocks, that accounts for the European sample's intraday patterns. Furthermore, cross-sectional analysis reveals that the intraday patterns are more dramatic for European stocks whose home-country trading is a larger share of their global trading volume, perhaps making them more attractive substitutes during overlapping trading hours.

To our knowledge this is the first paper to analyze the intraday activity of specialists. In this respect it is complementary to Madhavan and Sofianos (1998), who show that specialist activity varies across stocks inversely with their trading volume; we find that this pattern extends intraday to cross-listed stocks with higher trading volume during overlapping hours. Interestingly, we find no such effect for matched U.S. domestic stocks, suggesting that it is not purely the NYSE volume difference but also the availability of global substitutes that affects specialists' trading behavior. Our paper also complements the work of Bacidore and Sofianos (2002), who show that cross-listed stocks generally experience higher specialist participation and stabilization rates than U.S. domestic stocks. We find that although specialist activity is higher overall for European cross-listed stocks, it is generally lower when the home markets are open and significantly higher when they are closed. This highlights a previously unexplored richness in the specialist's role intraday.

Our market quality results suggest that European and U.S. markets are significantly more integrated now than they were in the early 1990s. In contrast to Werner and Kleidon's (1996) finding that British cross-listed stock spreads decline over the first several hours of trading on U.S. markets, evidencing a separate U-shaped curve in the U.S., we find that European cross-listed stock spreads increase on the NYSE. Although our study does not examine trading in the cross-listed stocks' home markets, our NYSE results are suggestive of greater global integration, which may be due to market structure changes and increased international arbitrage activity during the last decade.[4] Our interpretation that markets are more integrated now is consistent with recent research showing that cross-listing markets and developed home markets are informationally linked and generally exhibit price parity; see, for example, Eun and Sabherwal (2003), Gagnon and Karolyi (2004), and Grammig, Melvin, and Schlag (2004a).

Note that our focus in this study is how the availability of substitutes affects liquidity provision and market quality within one market, rather than how cross-listed stocks trade compared to their home-market counterparts. Our work does not directly address how the simultaneous trading of substitutes in different markets affects market quality globally. For example, although we find that European cross-listed spreads are narrower on the NYSE during overlapping trading hours, they may be even narrower in the home markets when the NYSE is closed.

The organization of the paper is as follows. Section 2 provides background on cross-listed stocks and the theoretical motivation for our analysis. Section 3 discusses the

[4] For example, an electronic limit order book (SETS) was introduced on the LSE in 1997, and public transparency for the limit order book on the NYSE (OpenBook) was introduced in 2002.

data and methodology. Section 4 presents our results and robustness checks. Section 5 concludes and outlines future work.

2. Background

2.1 Cross-listed stocks and home-market stocks as substitutes

Cross-listed stocks and their home-market counterparts represent equity exposure to the same company, and thus may be considered closer substitutes than, for example, the domestic shares of two different companies in the same industry. But home-market and cross-listed shares are distinct securities and are not fully fungible. There are three main types of cross-listed stocks traded on the NYSE, and they differ in how close they are to being fully fungible with their home-market stocks.[5]

Most cross-listed stocks on the NYSE are American Depositary Receipts (ADRs). ADRs are derivative instruments backed by home-market ordinary shares. To create ADRs a depositary bank buys home-market shares, places them with a custodian, and issues new dollar-denominated certificates. The ADR ratio, the number of home-market shares underlying each ADR, is established when an ADR program is initiated. ADRs and home-market shares are not fungible: Different securities are traded in the U.S. and the home market, and a conversion fee is charged to switch between them.

New York Registered Shares (NY shares) are U.S. dollar-denominated certificates issued by (mostly Dutch) companies specifically for the U.S. market. NY Shares represent direct claims on the company; they are not derivative securities like ADRs. But as with ADRs, NY shares are not fungible with home-market shares and holders must pay a conversion fee to switch between them.

[5] For a more detailed discussion of cross-listed securities and their relative fungibility see Foerster and Karolyi (1999) and Pulatkonak and Sofianos (1999).

Global shares are a single class of ordinary shares trading on both the NYSE and the home market. The certificate traded on the NYSE is indistinguishable from that traded on the home market, both represent direct claims on the company, and there are no conversion fees. Nonetheless, Global shares are not fully fungible, since investors buying Global shares on the NYSE (home market) must hold them in U.S. dollars (home currency) and receive U.S. dollar (home currency) dividends. Canadian “ordinaries” were the first cross-listed stocks with this structure, and Canadian companies remain the most numerous issuers of this type of security.

Empirical studies show that cross-listed and home-market shares generally trade near price parity, adjusted for conversion costs. Eun and Sabherwal (2003) find that Canadian home-market and cross-listed share prices are cointegrated with equality of prices holding as an equilibrium relation, and Grammig, Melvin, and Schlag (2004a) find similar results for German stocks. In the most comprehensive study to date, Gagnon and Karolyi (2004) examine cross-listed and home-market pairs from 39 countries and find that price discrepancies are small on average, are most extreme in emerging markets, and are generally reversed within one day, suggesting that active arbitrageurs enforce parity.

A recent survey reveals that many institutional investors view cross-listed stocks and home-market stocks as substitutes; see JPMorgan (2003). About a third of the surveyed investors say they would buy either instrument depending on relative liquidity and pricing or are indifferent between the two instruments. The one-third of respondents who prefer home-market stocks cite the broader array of companies available and greater liquidity, while the one-third who prefer cross-listed stocks cite lower holding costs and lower risk, particularly for emerging market stocks.

2.2 Theoretical considerations and predictions

Since many investors view cross-listed and home-market stocks as substitutes, trading in cross-listed stocks should be influenced by whether the home market is open or closed. In the case of European cross-listed stocks, home-exchange trading hours overlap NYSE trading hours. For example, the London Stock Exchange (LSE) is open from 3:00 a.m. to 11:35 a.m. EST (8:00 a.m. to 4:35 p.m. GMT), creating a two-hour-and-five-minute overlap with the NYSE (trading hours 9:30 a.m. to 4:00 p.m. EST). The availability of a home-market substitute for European cross-listed stocks for part of each trading day has several potential implications.

Admati and Pfleiderer (1988) show that traders who can choose when to trade prefer to trade at the same time, leading to volume concentration at certain times of day. Previous empirical research finds that stock trading volume is generally higher at the beginning of the trading day; see, for example, Foster and Viswanathan (1993). During overlapping trading hours cross-listed share volume may also be boosted by arbitrage activity between cross-listed and home-market stocks and order-splitting across markets, behavior modeled in Chowdhry and Nanda (1991), Menkveld (2004), and Pagano (1989), and documented in Menkveld (2004). Thus we expect cross-listed stocks to have higher volume during overlapping trading hours, and we expect this temporal volume concentration to be greater than that for U.S. domestic stocks.

Volatility may also be higher during overlapping trading hours, as studies show that information production and price discovery are greater for cross-listed firms during overlapping trading hours; see, for example, Grammig, Melvin, and Schlag (2004b) and Menkveld, Koopman, and Lucas (2004).

Both volume and volatility differences could affect specialist trading activity in cross-listed stocks intraday. Grossman and Miller (1988) and Glosten (1989) suggest that a specialist should be more active in lower-volume stocks, as he supplies immediacy when buyers and sellers arrive at different times and can monitor market conditions at a lower cost than other potential market participants. The NYSE's public order precedence rules (the specialist's negative obligation) also discourage a specialist from participating when a stock is more active. But the NYSE's price continuity rules (part of the specialist's affirmative obligation) may cause a specialist to be more active when a stock is more volatile, as documented by Panayides (2004). Bondarenko and Sung (2003) predict that even without such a rule a specialist in competition with a public limit order book will participate more when a stock is more volatile, assuming that only the specialist can see the contents of the limit order book.[6] Madhavan and Sofianos (1998) find that specialists participate more in more volatile stocks cross-sectionally, but how specialist activity varies with an individual stock's intraday volatility is an open empirical question. Furthermore, if both volume and volatility are higher for European cross-listed stocks during overlapping trading hours, as we expect, is specialist activity lower (as suggested by the volume hypothesis) or higher (as suggested by the volatility hypothesis)? The answer may lie with the availability of the home-market substitute underlying the volume and volatility changes.

The availability of a home-market substitute for only part of the trading day should produce different intraday patterns in market quality for European cross-listed stocks compared to U.S. stocks and cross-listed stocks that have home-market substitutes

[6] Since the introduction of NYSE's OpenBook in 2002 investors can observe the limit order book, subject to a 5-second delay. Boehmer, Saar, and Yu (2004) find that specialist participation rates decline after the introduction of OpenBook.

trading during all or none of their trading hours. Parlour and Seppi (2003) show that the competition between a pure limit order market (like most European exchanges) and a hybrid market with both a specialist and a limit order book (like the NYSE) can lead to either better or worse market quality than in a hybrid market trading alone.

Hagerty (1991) predicts that spreads should be lower when there are substitute assets available in the same market because investors can choose which asset to trade. This intuition suggests that intermarket competition from home-market shares lowers spreads for cross-listed stocks, as may the larger global pool of traders during overlapping trading hours. If it occurs, we would expect this effect to be increasing in the ratio of home-market to NYSE trading volume.

Alternatively, fragmentation of trading between the home market and the NYSE during overlapping trading hours could deteriorate market quality because of increased fixed costs, inventory holding costs, and adverse selection. For example, Domowitz, Glen, and Madhavan (1998) note that if markets are not perfectly linked informationally, arbitrage traders may reduce market quality by raising the adverse selection risk in the less-informed market. In this case, market quality differences between overlapping and nonoverlapping hours should be related to differences in home-market transparency.

3. Data and methodology

3.1 Sample construction

There are 186 European stocks cross-listed on the NYSE as of year-end 2003, according to the NYSE's Non-U.S. Companies database. We eliminate 18 stocks that do not have information available from CRSP, 16 that have no home market listing ("flag of convenience" stocks), seven whose home market trading hours do not overlap with

NYSE trading hours, three that are newly listed during 2003, three that split, two with changes in their ADR ratios, one whose home country is Argentina, and one with only one trade during the year. The remaining 135 stocks constitute our European cross-listed sample. The sample comprises 122 ADRs, nine New York shares, and four Global shares. On average, 7.2% of the companies' global equity trading volume occurs in the U.S., with a range of less than 1% to more than 99% of global equity trading volume occurring in the U.S. **Figure 1** shows the distribution of the European cross-listed stocks across their 14 home exchanges and the overlap between European and NYSE trading hours. Of the 135 European cross-listed stocks in our sample, 124 have home exchanges whose trading hours overlap NYSE trading hours by at least two hours.

We construct a matched sample of U.S. stocks listed on the NYSE for the 135 European cross-listed stocks. From the universe of U.S. stocks we first eliminate stocks that are cross-listed on European exchanges and stocks that split during 2003. We then use CRSP data to determine a unique match for each stock in our European sample based on NYSE daily price, volatility, and volume during 2003.[7] For each European stock we choose the U.S. stock that minimizes the following:

$$\text{p-score} = \frac{\sum_{i=1}^{3} \left| \left(\frac{X_i^{US}}{X_i^{Eur}} - 1 \right) \right|}{3} ,$$

where X_i^{US} denotes the value of the ith matching variable for the U.S. stock, and X_i^{Eur} denotes the value of the ith matching variable for the European stock. The mean p-score for the matches is 0.14, with a median of 0.11; see Appendix A for details of the matches.

[7] As a robustness check, we also construct a U.S. matched sample using global trading volume in place of NYSE trading volume. Results are qualitatively similar to the main U.S. matched sample and are available on request.

We also construct several control samples of stocks traded on the NYSE. Starting with the NYSE's Non-U.S. Companies database and eliminating stocks that split, change symbol, have no home listing, or are listed for only part of the year, we obtain an Asian sample of 69 stocks, a Canadian sample of 66 stocks, and a Latin American sample of 64 stocks. Finally, we construct a sample of NYSE-listed U.S. stocks that are cross-listed on European exchanges. Of the 75 U.S. stocks cross-listed in Europe in 2003, five split, change symbol, or are cross-listed for only part of the year, and one's home country is Sweden, leaving a sample of 69 U.S. stocks cross-listed in Europe.

We select 40 sample days from the 248 full trading days on the NYSE in 2003. We drop the 25 days on which at least one of the European home exchanges is closed, divide the remaining days into deciles by NYSE total volume, and randomly select four days from each volume decile; see Appendix B for the 40 days selected. Home-exchange holidays and trading hours are determined from exchange websites. None of our sample days fall in the week between the change to daylight savings time in Europe and the U.S.

3.2 Data and measures

Our data are taken from the NYSE's Consolidated Trade (CT), Consolidated Quote (CQ), and Specialist Equity Trade (SPET) files. After filtering these data to remove bad trades and quotes,[8] we construct several measures of trading activity, liquidity provision, and market quality.

[8] We use regular trade records, filtering out cancels, errors, late reports, bunched, bunched sold, and average-price transactions. We also exclude trades with price or size equal to zero and trades with price changes of 20% or more from the previous trade. These filters remove less than 0.3% of the original trade records. We use regular quote records, filtering out quotes that are indicated to be errors, related to special mode conditions, and locked or crossed bid and ask. We also exclude quotes with zero or missing bid or ask prices or depth, quotes that change 20% or more from the previous quote, and quotes whose spread exceeds 20% of the quote midpoint. These filters remove less than 0.1% of the quote records. To reduce the quote data to a manageable size, we drop duplicate quotes within the same second, which eliminates about 10% of the original quote records.

To summarize trading activity during overlapping and nonoverlapping trading hours, we examine each stock's average share volume, number of trades, and intraday volatility. The volatility measure, the intraday relative range volatility, is defined as the five-minute high-low range divided by the last transaction price in the interval. We also calculate the standard deviation of five-minute midquote returns as a robustness check.

To capture liquidity provision we focus on specialist participation and stabilization rates and quoted depth. We define the specialist participation rate as the sum of specialist purchase volume and sale volume, divided by total trading volume (single-counted).[9] The specialist stabilization rate is the sum of specialist purchase volume on downticks and sale volume on upticks, divided by specialist trading volume (purchases and sales). The quoted depth includes displayed liquidity offered by the specialist, floor brokers, and public limit orders, and is calculated as the sum of the depth at the NYSE best bid and best offer, divided by two.

To assess market quality we focus on several measures of spreads. Although each of these is an imperfect measure of liquidity, together they capture many aspects of market quality. We examine quoted, effective, and realized spreads. To control for any effects caused purely by stock price differences, we calculate percentage spreads, that is, dollar spreads normalized by the prevailing quote midpoint (for quoted spreads) or trade price (for effective and realized spreads). The quoted spread is the difference between the best offer and the best bid price; it measures the cost of a round-trip transaction for an investor who buys at the offer and sells at the bid.

[9] The NYSE reports the specialist participation rate as the sum of specialist purchases and sales divided by total purchases and sales (double-counting total volume). We use single-counted volume in the denominator to be consistent with prior work such as Bacidore and Sofianos (2002) and Madhavan and Sofianos (1998).

The effective spread is defined as:

$$\text{Effective Spread}_t = 2I(P_t - M_t)\ ,$$

where I is an indicator variable that equals one for buyer-initiated trades and negative one for seller-initiated trades, P_t is the trade price, and M_t is the quote midpoint at the time of the trade. We categorize trades as buyer-initiated (seller-initiated) if they occur above (below) the prevailing quote midpoint; trades occurring at the quote midpoint are categorized using the Lee and Ready (1991) algorithm.[10] The effective spread captures the total price impact of a trade.

The realized spread is defined as:

$$\text{Realized Spread}_t = 2I(P_t - M_{t+5})\ ,$$

where M_{t+5} is the quote midpoint five minutes after the trade. The realized spread measures the price reversal after a trade, approximating the liquidity provider's profit net of the trade's price impact.

The difference between the effective spread (what liquidity demanders pay) and the realized spread (what liquidity providers earn) is used as a measure of the information content of a trade. The information content is equal to the signed difference between the quote midpoint five minutes after the trade and at the time of the trade.

4. Results

4.1 Descriptive statistics

Table 1 presents descriptive statistics for the European and U.S. matched samples and four control samples. The averages for the matching variables are similar for the European and U.S. matched samples, suggesting that our procedure was successful in

[10] While possible misclassification of trades could influence our spread estimates, any resulting bias should be less of a concern for comparing differences in spreads intraday and between different stock samples. Indeed, if the bias is constant intraday and across samples, our estimates of differences are unbiased.

finding suitable matches. As a result, the daily dollar volume is also similar for the matched samples, although the lower number of trades per day in the European cross-listed sample evidences a larger average trade size for those stocks. Most of the other cross-listed samples are similar to the European sample in terms of price and activity level. The notable exception is U.S. stocks that have cross-listings in Europe, a group that includes many of the most actively traded NYSE stocks.

4.2 Overlapping versus nonoverlapping trading in European cross-listed stocks

We examine differences in trading activity, specialist activity, and market quality for European cross-listed stocks on the NYSE between trading hours when their home exchange is open (overlapping period) and when their home exchange is closed (nonoverlapping period). The overlapping period for each cross-listed stock extends from the NYSE open at 9:30 a.m. EST until the cross-listed stock's home exchange closes. We define the nonoverlapping period to be an equal-length period beginning immediately after the home exchange closes. For example, for a cross-listed stock whose home exchange is the LSE, the overlapping period is 9:30 a.m. to 11:35 a.m. and the nonoverlapping period is 11:35:01 a.m. to 1:40 p.m. EST. We choose equal-length overlapping and nonoverlapping periods in the spirit of an event study, where our "event" is the daily closing of a cross-listed stock's home exchange. We consider alternative intraday-period definitions in our robustness checks below.

Panel A of **Table 2** compares intraday trading activity for the European and U.S. matched samples, applying the same overlapping and nonoverlapping time periods to each matched pair of stocks. Both samples have higher share volume during overlapping trading hours, but the difference in share volume from the overlapping to the nonoverlapping period for the European sample is about double the difference for the U.S. matched sample. This greater volume difference for European cross-listed stocks supports our expectation that the larger global investor pool, intermarket arbitrage, and order-splitting exacerbate the usual pattern of high morning volume on the NYSE. Volatility is also higher for both samples during the overlapping period, and these results are qualitatively similar for both the intraday relative range volatility reported here and the standard deviation of five-minute midquote returns (not reported; results are available on request).

Panel B of Table 2 analyzes how liquidity provision differs during overlapping and nonoverlapping trading hours. We find that specialist participation and stabilization rates are sharply lower for European cross-listed stocks during overlapping trading hours. These results are economically as well as statistically significant; for example, the average specialist participation rate for European cross-listed stocks during overlapping trading hours is six percentage points lower than during the nonoverlapping period. In contrast, the U.S. matched sample stocks exhibit higher specialist participation and no significant difference in specialist stabilization rates during the overlapping period.

Volatility cannot easily explain the divergence of specialist activity in the two samples, as they both experience similarly higher volatility in the overlapping period. Volume alone is also unlikely to explain the puzzle, as both the European and the U.S. matched samples have significantly higher NYSE volume during the overlapping period. It appears that the existence of substitutes trading in the home market drives the differential specialist activity. If European cross-listed stocks are viewed as active stocks when substitute stocks are available in their home markets and less active stocks when their home markets are closed, specialist activity in European cross-listed stocks is consistent with Glosten's (1989) and Grossman and Miller's (1988) predictions that specialists should trade less in actively traded stocks. Put differently, a specialist's assessment of a stock as "active" versus "less active" may be based on global trading activity, which is much higher for cross-listed stocks during overlapping trading hours.

Intraday changes in quoted depth differ markedly for the two samples. Quoted depth is significantly higher in overlapping than nonoverlapping periods for the European cross-listed stocks, as the participation of arbitrageurs and order-splitters when the home market is open increases the supply of liquidity. In contrast, quoted depth is significantly lower in overlapping than nonoverlapping periods for the U.S. matched sample.[11]

Panel C of Table 2 analyzes how market quality differs during overlapping and nonoverlapping trading hours. If simple volume or volatility differences were driving the market quality changes, both samples should display similar spread patterns since they both have higher volume and volatility during overlapping trading hours. Quoted spreads, effective spreads, and realized spreads for the European cross-listed sample are all significantly lower during the overlapping period than during the nonoverlapping period.[12] These results are consistent with Hagerty's (1991) prediction that spreads should be lower when substitute securities are available and with the predictions of the networking literature that inter-market competition can improve market quality. In

[11] The NYSE's automated quoting system, AutoQuote, was phased in beginning in January 2003, and all stocks were being AutoQuoted by May 27, 2003. AutoQuote automatically updates the inside bid and ask quotes based on the public limit order book, while still allowing the specialist to add his own and floor broker interest to the inside quote. Separating the analysis of quoted depth into the phase-in and fully AutoQuote periods within our sample period produces qualitatively similar results. Results are available on request.

[12] Volume-weighted effective and realized spreads and information content are reported in Table 2. Trade-weighted spreads and information content, not reported, lead to identical inference; results are available on request.

contrast, quoted and effective spreads for the U.S. matched sample are significantly higher during the overlapping period than during the nonoverlapping period, while realized spreads are not significantly different. The information content of trades is not significantly different during overlapping hours in the European cross-listed sample, nor is the mean information content different for the U.S. matched sample.

These findings show that European cross-listed stocks trade very differently intraday compared to matched U.S. domestic stocks. The overall picture that emerges is consistent with our intuition that the availability of home-market substitutes for European cross-listed stocks during part of the U.S. trading day affects liquidity provision and market quality.

4.3 Robustness checks

The results in Table 2 are robust to a number of alternative intraday-period definitions and sample criteria. First, we exclude the beginning of the NYSE trading day to test whether the differences in intraday patterns for European cross-listed and U.S. domestic stocks are due to differences in their overnight information build-up and opening price discovery. When we drop the first 15 minutes of trading, the results are qualitatively similar. When we reduce our intraday periods to 30 minutes before and after the home exchange closes, the results are stronger although the sample is reduced because some stocks do not trade in those periods.

Second, if we define the nonoverlapping period to include the remainder of the NYSE trading day, rather than match the length of the overlapping period, we find qualitatively similar but weaker results. The weaker results appear to be due to well-documented end-of-day trading patterns that affect all stocks and mitigate the differences between cross-listed and U.S. stocks as the nonoverlapping period lengthens. Third, to test whether our results are heavily influenced by trades coinciding with the home exchange's close, we drop the fifteen minutes immediately before and after the home exchange closes; the results are qualitatively similar.

Fourth, we drop the European cross-listed stocks with five or fewer trades per day on average and find that the results are even stronger. Finally, we exclude the European cross-listed stocks with less than two hours of overlapping trading with their home exchanges. We find that the results for the 124 stocks with at least two hours of overlap are even stronger than the full-sample results. Detailed results of robustness checks are available on request.

4.4 Control sample comparisons

To analyze whether the partial-day availability of substitutes or other characteristics of cross-listed stocks account for European stocks' intraday patterns, we examine the intraday trading patterns of other cross-listed stocks, European cross-listed stocks on days when European markets are closed, and U.S. cross-listed stocks.

Figure 2 compares the 124 European cross-listed stocks whose home exchanges close between 11:30 a.m. and 11:45 a.m. EST to the cross-listed samples from Asia, Canada, and Latin America.[13,14] The non-European cross-listed samples generally exhibit intraday patterns of liquidity provision and market quality more similar to the U.S. matched sample than to the European cross-listed sample, although all six samples show similar patterns of intraday trading volume. These comparisons support our interpretation

[13] We limit our comparison to this subsample of 124 stocks in Figure 2 only, in order to facilitate a comparison based on clock time.
[14] For brevity, we graph only four measures in Figures 2 through 4. Graphs of other measures show similar patterns and are available on request.

that the partial-day availability of substitutes for European cross-listed stocks, not merely changes in trading volume or general characteristics of cross-listed stocks, is responsible for their unique intraday patterns.

Figure 3 compares the European cross-listed stocks on days when the European markets are closed to the original sample of days on which both European markets and the NYSE are open. The number of European exchange holidays that are not NYSE holidays in 2003 ranges from two on EuroNext to ten on the Budapest Stock Exchange; the 135 European sample stocks have an average of four non-NYSE home-exchange holidays in 2003. When their home markets are closed, the European cross-listed shares display intraday patterns very similar to the U.S. matched sample. This reinforces our impression that the availability of home-market substitutes for part of the day is a key factor in European cross-listed stocks' distinctive intraday behavior.

Figure 4 compares the European cross-listed stocks to U.S. stocks cross-listed in Europe. If the availability of substitutes is driving the intraday patterns of European cross-listed stocks, we might expect to see similar NYSE trading patterns in U.S. stocks that are cross-listed on European exchanges. In fact, U.S. cross-listed stocks display intraday patterns quite unlike those of the European cross-listed sample, more similar to those of the U.S. matched sample. One possible explanation for this divergence is that U.S. cross-listed stocks are generally much less actively traded in Europe than European cross-listed companies are: On average 2% of global trading for the U.S. cross-listed firms is on European exchanges in 2003, versus 92.8% of global trading for the European cross-listed firms in our sample. This is an issue we explore further in the cross-sectional regression in the next section.

4.4 Cross-sectional analysis

Table 3 examines how intraday changes in specialist participation rates and effective spreads vary across European cross-listed stocks using a cross-sectional regression of the 135 stocks, with each stock's averages calculated across the 40 sample days. Unfortunately, the small sample size severely limits the power of our tests. **Table 4** attempts to increase power through a pooled regression of the 135 stocks on the 40 sample days.[15] Most coefficient estimates have the same sign in the cross-sectional and pooled regressions but are significant only in the pooled analysis. Recall that the average participation rate and effective spread differences for overlapping minus nonoverlapping trading periods are negative for the European cross-listed stock sample (see Table 2). Thus a negative coefficient suggests a greater difference and a positive coefficient suggests a smaller difference.

We find that stocks with a higher percentage of global trading taking place in Europe (%TradeEurope) exhibit more negative specialist participation rate and effective spread differences, and the coefficient estimates are significant in the pooled regression. This is consistent with the intuition of Hagerty (1991): Stocks that trade more in their home market may have a stronger substitution effect on their cross-listed counterparts, leading to a more negative overlapping – nonoverlapping difference.

Tables 3 and 4 suggest that home exchange affects participation rate differences, with British stocks (LSE) showing more negative and German stocks (DB) showing less negative participation rate differences, after controlling for other stock characteristics.[16]

[15] The total number of observations used in the pooled regression, 4,725, is less than 135 times 40 because not all stocks trade in both periods on every day.
[16] We include as explanatory variables only the three European exchanges with the largest numbers of cross-listed stocks in our sample; other European exchanges have fewer than ten sample stocks each.

These coefficient estimates are significant only in the pooled regression analysis (Table 4). These results may reflect varying degrees of home-market transparency, as suggested by Domowitz, Glen, and Madhavan (1998), although in 2003 all of the European exchanges have highly transparent electronic limit order books. Alternatively, specialists may feel they understand the British market and firms better than the German market and firms because of cultural similarities such as language, exacerbating the home-market substitute effect for British and diminishing it for German cross-listed stocks.

The pooled regression in Table 4 shows that specialist participation rate differences are significantly less negative for two specialist firms, Fleet (FLT) and Spear Leeds & Kellogg (SLK).[17] This suggests that the intuition of Corwin (1999) and Coughenour and Saad (2004) that specialist firms differ in their liquidity provision extends to intraday changes in specialist behavior.

The pooled regression results of Table 4 help to separate the effects of intraday volume and volatility changes on specialist participation rates. Stocks with bigger intraday volume differences have less negative participation rate differences, all else equal, in contrast to the intuition of Glosten (1989) and Grossman and Miller (1988). Stocks with bigger intraday volatility differences also have less negative participation rate differences. Thus although specialist participation is lower overall during the overlapping period, specialists participate more when stocks are more volatile during the overlapping period, consistent with the prediction of Bondarenko and Sung (2003).

Tables 3 and 4 also report coefficient estimates for several control variables; results for the variables of interest are qualitatively similar but explanatory power is

[17] We include indicator variables for only the five largest specialist firms, as the two smaller firms, Performance and Susquehanna, each handle only two of the cross-listed stocks in our sample.

lower when the controls are omitted. As a robustness check, we re-run the analyses with dummy variables for the type of cross-listing (ADR, NY share, or Global share); their coefficients are insignificant. Results of all robustness checks are available on request.

5. Conclusions and future work

We find that the intraday patterns of European cross-listed stocks differ significantly from those of U.S. stocks with comparable daily volume and volatility. Specialists are less active and quoted depth is higher in European cross-listed stocks when their home markets are open, a time of day when specialists are typically more active and quoted depth is lower in U.S. domestic stocks. Market quality also differs notably, with lower spreads for European cross-listed stocks when their home markets are open, when spreads are usually higher for U.S. domestic stocks. The unique patterns of European cross-listed stocks are not explained by differences in intraday volume and volatility, overnight information build-up, or other characteristics of cross-listed stocks.

Our results suggest that the availability of home-market substitutes for European cross-listed stocks during part of the U.S. trading day significantly influences specialist activity. One implication is that there is a richer story behind the general observation that specialists participate and stabilize more in cross-listed than domestic stocks. Although specialists are more active in European cross-listed stocks overall, they supply significantly less liquidity when European markets are open. Future work on specialists' intraday trading patterns may further illuminate how and when specialists enhance the trading process, a question of growing importance to investors and academics as the NYSE revises its trading model to expand electronic trading.

Our finding that cross-listed stocks are more liquid during overlapping trading hours resolves empirically for these stocks the multiplicity of equilibrium liquidity outcomes posed by models such as Parlour and Seppi (2003). Knowing how overlapping trading hours affect the liquidity of cross-listed stocks is valuable to investors choosing when to trade and to markets setting trading hours. Several U.S. markets are currently discussing opening earlier in the morning, which would increase overlapping trading hours for many cross-listed stocks.

Our finding that the short-term information content of trades is unchanged for European cross-listed stocks from overlapping to nonoverlapping trading hours differs from some recent studies of network effects and the temporal consolidation of trades. For example, Barclay and Hendershott (2003, 2004) find that the information content of trades is much higher when trading is less active after-hours. Whether the disparity in our information content results versus Barclay and Hendershott's (2003, 2004) is due to market structure differences between NYSE and Nasdaq, the change in availability of the home-market substitute offsetting the temporal consolidation effects they find, or a fundamental difference between regular/after-hours and overlapping/nonoverlapping hours trade-offs is a question for further study.

This work also offers new evidence of the integration between European and U.S. equity markets. We find that European cross-listed stock spreads are heavily influenced by the availability of close substitutes in the home market, no longer exhibiting the U-shaped pattern that Werner and Kleidon (1996) document as a sign of market segmentation. In the 12 years between Werner and Kleidon's (1996) dataset and ours, global arbitrage activity has increased and most European and U.S. markets have become more transparent. In complementary work, Lowengrub and Melvin (2002) find that after

German stocks cross-list in the U.S. their U-shaped volume and volatility patterns on Xetra flatten. Many empirical and theoretical questions remain, including whether round-the-clock trading of a firm's equity securities diminishes the U-shaped spread patterns in all markets and where the greatest effects occur.

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Table 1: Sample Summary Statistics

This table contains summary statistics for the European cross-listed stock (CLS) and matched U.S. domestic stock samples, as well as four control samples of Asian, Canadian, Latin American, and U.S. cross-listed stocks. The European CLS and U.S. Match stocks are matched based on price, volatility, and volume. All statistics are calculated across sample stocks using NYSE trade data from the NYSE CT database. Sample period is 40 days in 2003.

		European CLS	**U.S. Match**	**Asian CLS**	**Canadian CLS**	**Latin American CLS**	**U.S. CLS**
Price ($)	Mean	24.71	23.30	23.50	22.28	14.90	37.02
	Median	20.45	20.12	19.32	18.82	12.75	33.73
	Min	2.21	2.38	2.22	3.32	1.05	1.80
	Max	92.96	80.92	103.40	69.50	41.89	90.79
Daily High-Low Volatility (%)	Mean	2.04	2.11	2.03	2.21	2.42	2.88
	Median	1.95	1.94	1.81	2.03	2.15	2.36
	Min	0.33	0.55	0.32	0.98	0.46	1.25
	Max	6.09	6.46	7.63	4.93	6.28	29.74
Daily Volume (shares)	Mean	354,782	330,962	336,185	707,978	175,896	3,850,801
	Median	44,415	52,105	62,264	71,528	44,373	2,986,473
	Min	862	1,017	628	2,008	350	25,693
	Max	10,794,705	10,938,285	7,674,543	25,576,263	1,755,755	17,961,713
Daily Dollar Volume ($)	Mean	8,778,779	8,175,803	4,944,810	8,390,742	3,496,884	133,801,993
	Median	960,292	919,577	1,625,990	1,511,736	448,959	96,420,388
	Min	5,374	12,831	24,045	18,995	4,057	283,972
	Max	174,739,069	218,996,302	76,333,579	82,887,443	55,279,139	605,677,607
Daily Number of Trades	Mean	301	402	229	455	143	3,429
	Median	94	130	105	150	33	3,256
	Min	2	3	2	7	2	50
	Max	4,142	5,706	2,064	4,832	1,182	12,554
Sample Size		135	135	69	66	64	69

Table 2: European Cross-listed Stock Trading when Home Market is Open (Overlap) versus Not (Nonoverlap)

We report statistics for the European cross-listed stock sample and the matched U.S. stock sample. The overlapping period is when both the home exchange and the NYSE are open; the nonoverlapping period is the equal-length period immediately following the home-exchange close. Intraday volatility is the 5-minute high minus low price, divided by the last trade price. Participation rate is the sum of specialist buys and sells divided by total trading volume. Stabilization rate is the percent of those trades that occurred on a stabilizing tick (buys on downticks and sells on up-ticks). Quoted depth is the time-weighted average depth at the inside quote. Quoted spread is the offer price minus the bid price, normalized by the quote midpoint and time-weighted. Effective spread is twice the difference between the trade price and the quote midpoint at the time of the trade. Realized spread is twice the difference between the trade price and the quote midpoint five minutes after the trade occurred. Effective and realized spreads are normalized by the trade price and volume-weighted. P-value is calculated from 135 stocks in each sample; stock averages are calculated from 40 days in 2003. Data are from the NYSE CT, CQ, and SPET databases.

		Mean				**Median**			
	Sample	**Overlap**	**Nonoverlap**	**Overlap - Nonoverlap**	**p-value**	**Overlap**	**Nonoverlap**	**Overlap - Nonoverlap**	**p-value**
Panel A: Trading Activity									
Share volume	European	124,578	58,832	65,746	0.0000	16,958	9,450	8,008	0.0000
	U.S. Match	96,762	61,944	34,818	0.0009	13,943	9,585	3,526	0.0000
Number of trades	European	87	56	31	0.0000	30	20	10	0.0000
	U.S. Match	114	86	28	0.0000	40	28	11	0.0000
Intraday Volatility (bp)	European	14.5	11.3	3.3	0.0000	12.2	9.4	2.5	0.0000
	U.S. Match	14.2	9.9	4.3	0.0000	11.4	8.0	3.6	0.0000
Panel B: Liquidity Provision									
Participation Rate	European	34.1%	40.3%	-6.2%	<.0001	29.5%	34.9%	-4.2%	<.0001
	U.S. Match	35.8%	32.4%	3.5%	<.0001	31.7%	28.0%	2.9%	<.0001
Stabilization Rate	European	88.6%	92.9%	-4.3%	<.0001	90.5%	95.7%	-3.4%	<.0001
	U.S. Match	91.0%	89.8%	1.2%	0.1125	92.1%	92.5%	0.2%	0.6612
Quoted Depth (shares)	European	1728	1211	517	0.0000	1278	869	398	0.0000
	U.S. Match	849	896	-47	0.0003	618	669	-36	0.0002
Panel C: Market Quality									
Quoted Spread (bp)	European	65.9	83.4	-17.5	0.0000	38.2	46.2	-6.7	0.0000
	U.S. Match	61.9	56.6	5.3	0.0000	36.3	32.9	3.0	0.0000
Effective Spread (bp)	European	50.0	61.1	-11.1	0.0000	32.3	44.8	-6.0	0.0000
	U.S. Match	46.2	41.8	4.4	0.0008	29.7	28.2	3.0	0.0000
Realized Spread (bp)	European	22.0	35.2	-13.2	0.0018	14.2	22.8	-6.5	0.0000
	U.S. Match	19.5	20.8	-1.2	0.4021	11.0	12.2	-0.4	0.4261
Information Content (bp)	European	23.9	26.0	-2.2	0.5958	13.6	14.6	0.3	0.6448
	U.S. Match	23.8	21.3	2.5	0.1947	15.5	11.7	2.3	0.0000

Table 3: European Cross-listed Stock Cross-Sectional Regression Analysis

Differences are calculated as the average during the overlapping period (when both the home exchange and the NYSE are open) minus the average during the nonoverlapping period (the equal-length time period immediately following the home exchange close). Participation rate is the sum of specialist buys and sells divided by total trading volume. Effective spread is twice the difference between the trade price and the quote midpoint at the time of the trade, normalized by the trade price and volume-weighted. Rates and spreads are averaged across 40 days in 2003 and used in the cross-sectional analysis of 135 European cross-listed stocks. Data are from the NYSE CT, CQ, SPET, and Non-U.S. companies databases and from CRSP.

%TradeEurope is a logit transformation of the percentage of the stock's global equity trading volume that occurred in Europe in 2003: log[%TradeEurope/(1-%TradeEurope)]. LSE, EN, and DB are indicator variables set equal to one if the cross-listed stock's home market is the London Stock Exchange, EuroNext, or the Deutsche Börse, respectively, else zero. The specialist firm variables -- BWG (Bear Wagner), FLT (Fleet), LAB (LaBranche), SLK (Spear, Leeds & Kellogg), and VDM (Van der Moolen) -- are indicator variables set equal to one if the cross-listed stock is handled by a specialist from that firm, else zero. Volume (in million shares) is the traded volume. Volatility is the high minus low price, divided by the last trade price in the interval. Quoted spread is the inside quoted spread on the NYSE, normalized by the quote midpoint and time-weighted. Depth (in 100 shares) is the average depth at the inside quotes on the NYSE. Trade size is the average trade size in shares. Log(Price) is the natural logarithm of the daily closing price. Log(Global Market Cap) is the natural logarithm of the the firm's global market capitalization (in $million) as of year-end 2003.

Dependent Variable	**Participation Rate Difference (%)**		**Effective Spread Difference (bp)**	
	Coefficient estimate	p-value	Coefficient estimate	p-value
Constant	-16.59	0.0080	-11.23	0.2371
Home market				
%TradeEurope	-0.65	0.2231	-0.87	0.2860
LSE	-2.94	0.1263	4.46	0.1321
EN	1.33	0.4707	0.52	0.8546
DB	2.44	0.3182	-0.30	0.9363
Specialist firm				
BWG	1.60	0.7263	1.32	0.8509
FLT	5.35	0.2321	6.46	0.3476
LAB	3.11	0.4699	7.28	0.2712
SLK	4.68	0.2680	3.03	0.6403
VDM	3.62	0.4242	13.05	0.0627
Intraday controls				
Volume difference	4.22	0.5073	-2.56	0.7930
Volatility difference	0.12	0.3655	0.99	<.0001
Quoted spread difference	0.11	0.0002	0.13	0.0058
Depth difference	-0.04	0.8149	-0.09	0.7149
Trade size difference	-0.01	0.1713	-0.01	0.3842
Firm controls				
log(Price)	-2.00	0.0860	1.10	0.5364
log(Global Market Cap)	1.78	0.0095	-0.19	0.8575
Adj. R^2	34.9%		31.0%	
Sample Size	135		135	

Table 4: European Cross-listed Stock Pooled Regression Analysis

Differences are calculated as the average during the overlapping period (when both the home exchange and the NYSE are open) minus the average during the nonoverlapping period (the equal-length time period immediately following the home exchange close). Participation rate is the sum of specialist buys and sells divided by total trading volume. Effective spread is twice the difference between the trade price and the quote midpoint at the time of the trade, normalized by the trade price and volume-weighted. Rates and spreads for 40 sample days in 2003 are used in the pooled analysis of 135 European cross-listed stocks. Data are from the NYSE CT, CQ, SPET, and Non-U.S. companies databases and from CRSP.

%TradeEurope is a logit transformation of the percentage of the stock's global equity trading volume that occurred in Europe in 2003: log[%TradeEurope/(1-%TradeEurope)]. LSE, EN, and DB are indicator variables set equal to one if the cross-listed stock's home market is the London Stock Exchange, EuroNext, or the Deutsche Börse, respectively, else zero. The specialist firm variables -- BWG (Bear Wagner), FLT (Fleet), LAB (LaBranche), SLK (Spear, Leeds & Kellogg), and VDM (Van der Moolen) -- are indicator variables set equal to one if the cross-listed stock is handled by a specialist from that firm, else zero. Volume (in million shares) is the traded volume. Volatility is the high minus low price, divided by the last trade price in the interval. Quoted spread is the inside quoted spread on the NYSE, normalized by the quote midpoint and time-weighted. Depth (in 100 shares) is the average depth at the inside quotes on the NYSE. Trade size is the average trade size in shares. Log(Price) is the natural logarithm of the daily closing price. Log(Global Market Cap) is the natural logarithm of the the firm's global market capitalization (in $million) as of year-end 2003.

Dependent Variable	**Participation Rate Difference (%)**		**Effective Spread Difference (bp)**	
	Coefficient estimate	p-value	Coefficient estimate	p-value
Constant	-19.57	<.0001	-3.06	0.2845
Home market				
%TradeEurope	-1.04	0.0003	-0.95	<.0001
LSE	-4.17	0.0002	-0.60	0.4915
EN	0.98	0.3608	-1.58	0.0585
DB	3.56	0.0086	-0.31	0.7677
Specialist firm				
BWG	2.04	0.4393	-0.88	0.6705
FLT	5.91	0.0238	1.78	0.3840
LAB	3.42	0.1714	1.33	0.4978
SLK	4.97	0.0433	-0.26	0.8937
VDM	1.73	0.5123	2.36	0.2515
Intraday controls				
Volume difference	3.60	0.0741	-5.12	0.0012
Volatility difference	0.08	<.0001	0.36	<.0001
Quoted spread difference	0.12	<.0001	0.24	<.0001
Depth difference	-0.10	0.0002	0.02	0.3323
Trade size difference	0.00	<.0001	0.00	0.0002
Firm controls				
log(Global Market Cap)	2.27	<.0001	-0.48	0.0973
log(Price)	-2.16	0.0008	2.29	<.0001
Adj. R^2	10.9%		34.7%	
Sample Size	4,725		4,725	

Figure 1: Comparison of NYSE and European Exchange Trading Hours

Comparison of trading hours for the NYSE versus the 14 European exchanges that are the home exchanges for the 135 European cross-listed stocks. Number of stocks from each home exchange is in parentheses.

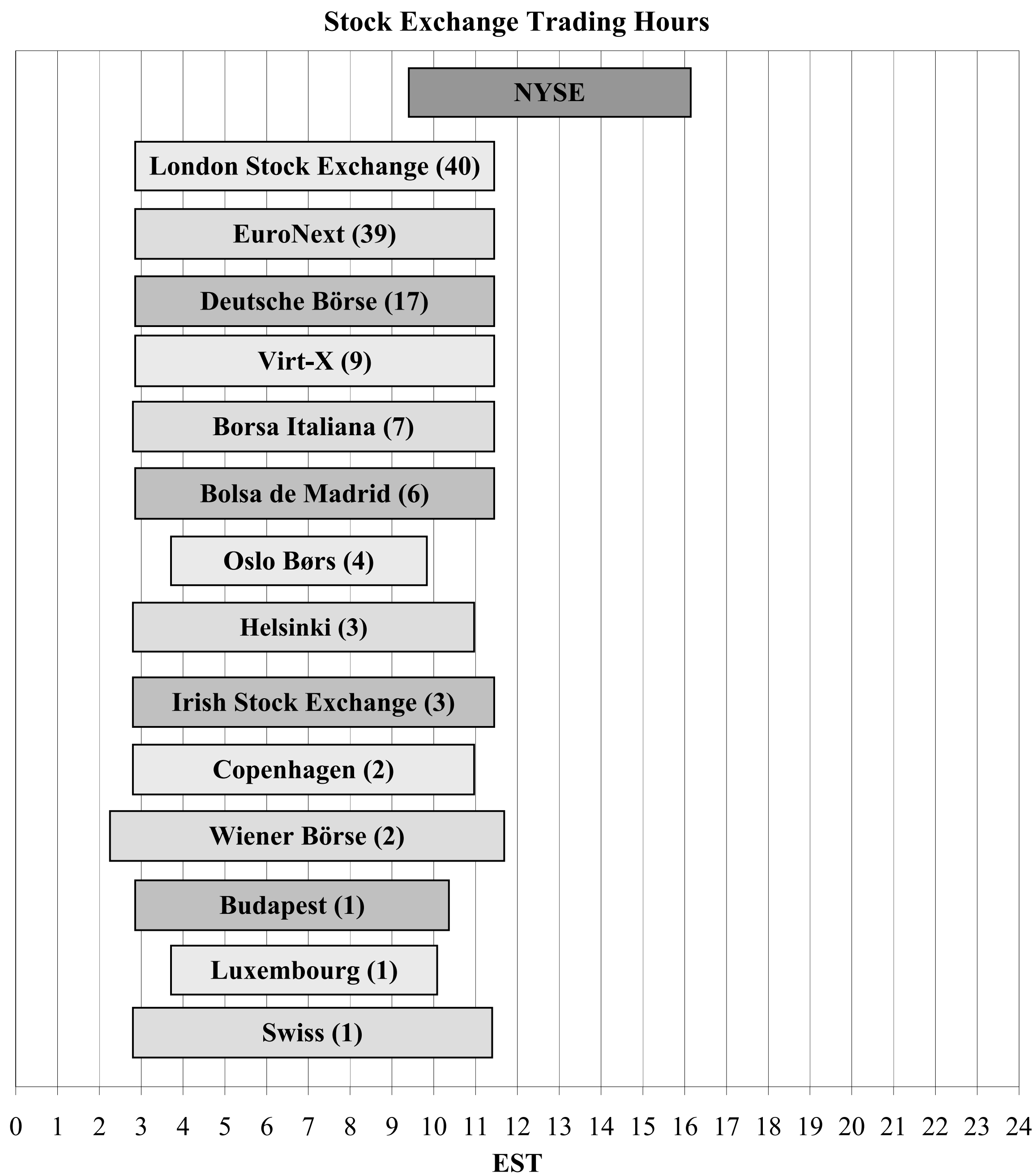


Figure 2: Comparison of European Cross-listed to Other Cross-listed Samples

Average for each 30-minute interval is calculated for each stock across 40 sample days, then averaged across sample stocks. Euro124 is the subset of 124 stocks from original European cross-listed sample that have two or more overlapping trading hours between their home exchanges and the NYSE. In this subsample, all stocks' home exchanges close between 11:30 and 11:45 a.m. EST. USMatch124 is the subset of 124 U.S. stocks matching the European stocks with two or more overlapping trading hours between their home exchanges and the NYSE. AsiaCLS is the sample of 69 Asian cross-listed stocks on the NYSE. CanadaCLS is the sample of 66 Canadian cross-listed stocks on the NYSE. LatAmCLS is the sample of 64 Latin American cross-listed stocks on the NYSE.

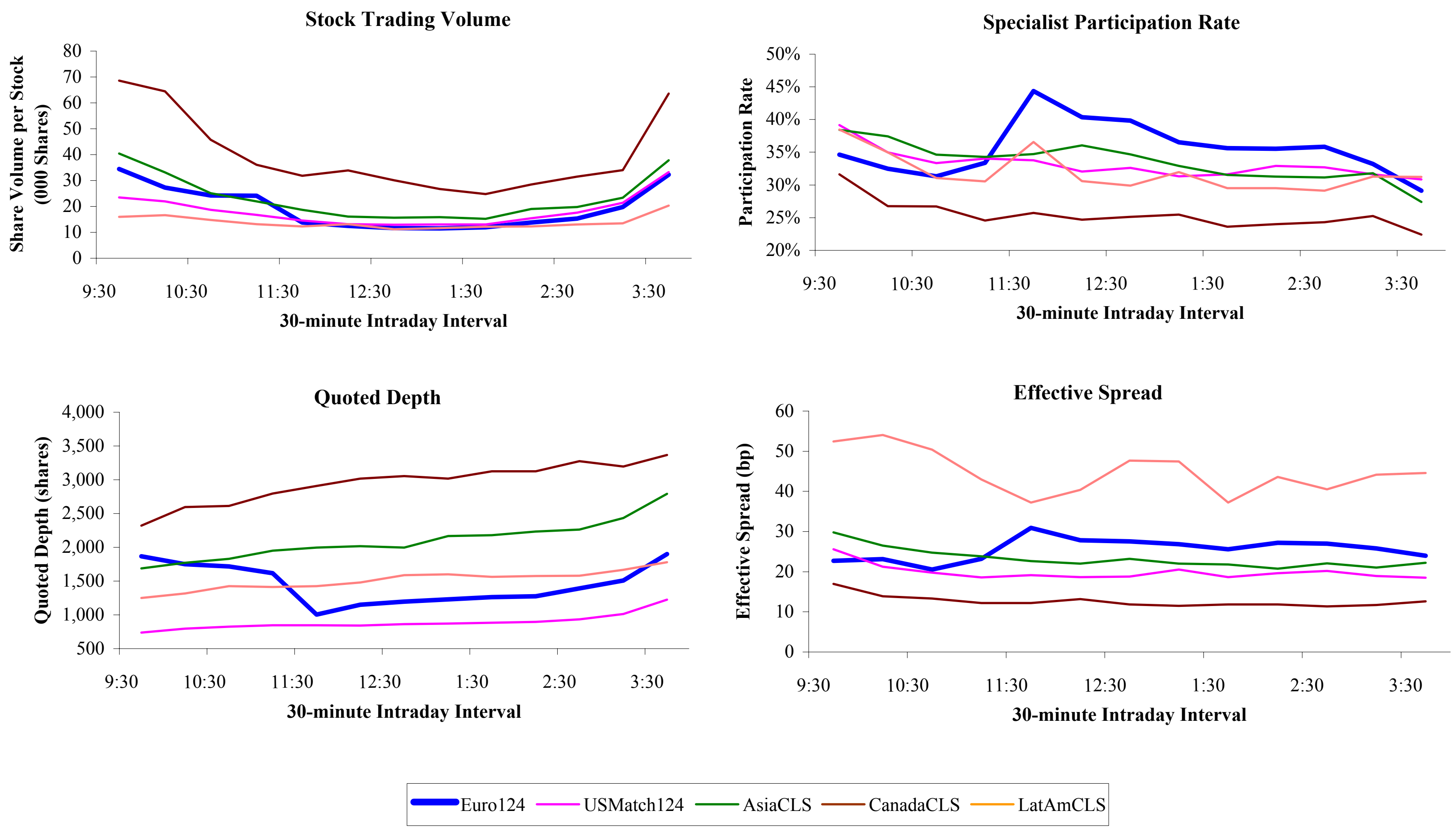


Figure 3: Comparison of European Cross-listed Sample on Days when Home Exchanges are Open versus Closed

Average for each 30-minute interval is calculated for each stock across sample days, then averaged across sample stocks. Euro135_hols is our European cross-listed sample on days when their European home exchanges are closed and the NYSE is open. USMatch135_hols is the U.S. matched sample on days when their matching stocks' home exchanges are closed and the NYSE is open. Euro135_open is the European cross-listed sample on our 40 sample days, when both European home exchanges and NYSE are open. USMatch135_open is U.S. matched sample of 135 stocks on our 40 sample days, when both European home exchanges and the NYSE are open.

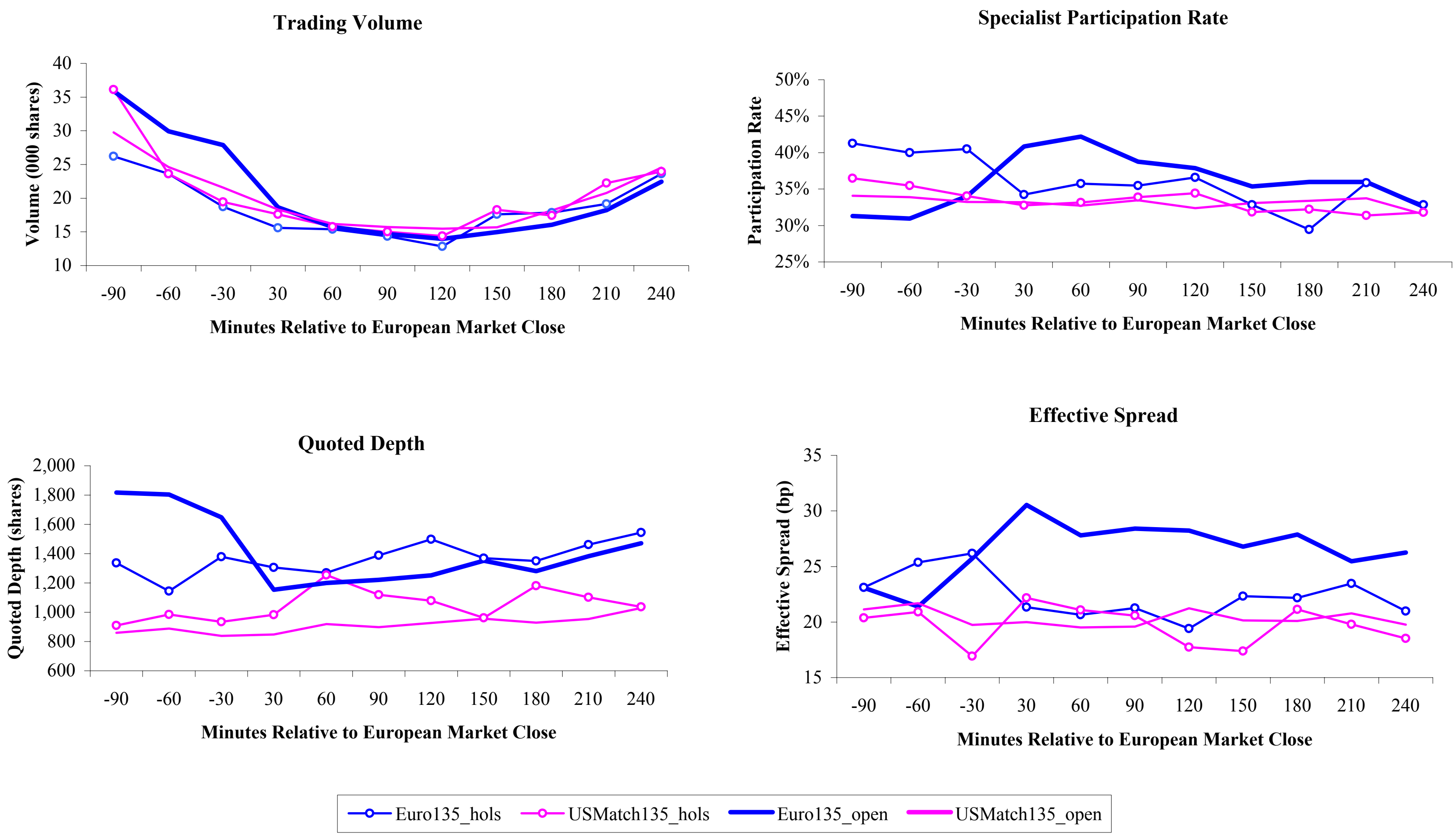
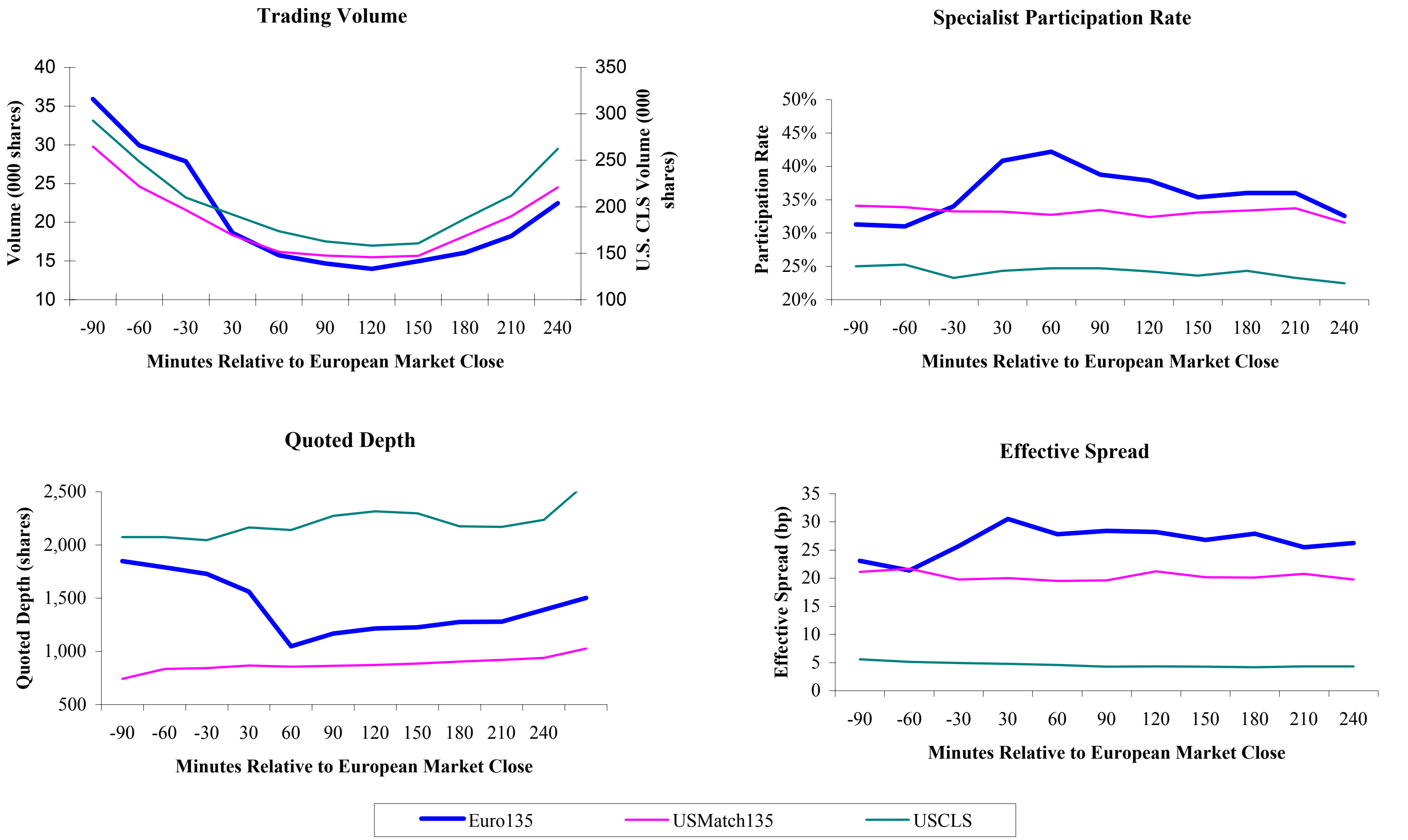


Figure 4: Comparison of European Cross-listed to U.S. Cross-listed Sample

Average for each 30-minute interval is calculated for each stock across 40 sample days, then averaged across sample stocks. Euro135 is the European cross-listed sample of 135 stocks. USMatch135 is U.S. matched sample of 135 stocks. USCLS is the sample of 69 domestic U.S. stocks that are listed on the NYSE and cross-listed on European exchanges.



Appendix A: 135 European Cross-Listed Stocks and U.S. Matches

This table contains summary statistics for each stock in our European cross-listed sample and its matching U.S. stock. The stocks are matched based on price, volatility, and volume, without replacement. Price is the average daily closing price in 2003. Volatility is (Daily high - Daily low)/Closing price, averaged over 2003. Volume is average daily volume on the NYSE in 2003. Market cap, included for descriptive purposes only, is the average daily market capitalization in 2003. P-score is the matching score, calculated as [abs (priceUS/priceEur -1) + abs (volumeUS/volumeEur -1) + abs (volatilityUS/volatilityEur -1)] / 3. Data are from CRSP.

European Cross-Listed Stocks					U.S. Matched Stocks					
Symbol	Price ($)	Volatility (%)	Volume (shares)	Market Cap ($ mn)	Symbol	Price ($)	Volatility (%)	Volume (shares)	Market Cap ($ mn)	p-score
AAA	54.76	1.08	10,300	49.40	WHG	16.19	1.21	9,311	87.75	0.31
ABB	4.08	3.86	228,788	44.48	TYL	5.52	4.13	166,387	232.04	0.23
ABN	18.44	1.97	239,405	1,109.99	HHS	19.14	2.00	192,595	1,713.13	0.08
ADO	11.20	2.51	35,100	81.87	MSC	10.12	2.74	32,574	142.82	0.09
AED	23.96	1.30	13,018	40.82	CPK	22.23	1.47	10,319	123.90	0.14
AEG	11.68	3.02	564,128	1,457.96	IM	12.50	3.00	629,753	1,888.03	0.06
AHM	44.58	1.29	26,498	91.17	FCEA	39.56	1.44	24,847	1,418.49	0.10
AHO	8.18	3.70	1,437,424	445.46	BE	8.52	3.86	1,344,808	1,634.05	0.05
AIB	28.87	1.57	93,625	1,719.39	VLY	27.24	1.46	100,939	2,531.25	0.07
ALA	9.74	3.19	2,101,780	1,314.17	DPH	8.57	2.76	1,980,265	4,797.60	0.11
ALS	3.11	5.37	100,944	22.96	FIX	3.34	4.99	108,466	126.47	0.07
AVE	52.54	1.84	304,342	1,781.45	CYN	49.54	1.65	266,473	2,413.39	0.09
AVZ	13.34	3.44	81,035	127.60	MTN	13.72	3.31	75,314	380.91	0.05
AXA	16.10	2.62	385,090	1,056.05	OLN	17.51	2.57	378,927	1,015.40	0.04
AZ	8.90	3.06	299,048	104.73	IT	9.49	3.19	331,713	478.20	0.07
AZN	40.46	1.95	1,390,880	4,098.28	HRB	43.12	2.19	1,447,937	7,735.71	0.08
BAB	26.84	2.53	57,568	218.29	CDI	26.84	2.38	59,299	520.09	0.03
BAY	21.14	2.67	213,972	257.94	PPD	22.61	2.72	222,299	404.12	0.04
BBV	10.40	2.20	193,400	738.75	EE	11.67	2.26	143,754	572.14	0.13
BCS	29.26	2.17	117,693	719.95	IHP	30.25	2.21	122,132	646.17	0.03
BF	43.81	1.87	105,319	810.71	DSL	43.51	1.83	104,572	1,216.16	0.01
BNG	19.72	1.25	3,982	12.65	MCC	18.11	0.96	3,970	157.96	0.11
BNL	35.37	1.18	2,223	9.04	GEFB	27.47	1.32	1,511	322.32	0.22
BOX	27.00	1.75	19,168	86.44	CPF	26.95	1.79	24,871	431.42	0.11
BP	41.48	1.50	3,289,523	45,270.77	WB	40.60	2.01	3,127,825	54,471.07	0.14
BSY	43.32	1.62	15,676	95.67	TNC	36.60	1.94	15,002	327.96	0.13
BTY	30.38	2.01	72,625	552.96	RLI	31.34	1.92	71,969	784.62	0.03
BUH	5.93	3.70	9,415	7.84	CIX	6.20	1.88	9,988	31.75	0.20
CGA	3.61	6.82	50,392	87.67	BSH	3.58	6.24	48,365	37.31	0.05
CHR	23.28	1.63	9,451	164.18	SCL	24.44	1.71	8,922	217.12	0.05
CLL	11.14	2.63	13,113	35.90	PNNA	14.21	2.44	13,011	199.95	0.12
CSB	33.52	0.88	3,744	33.50	ODC	11.63	1.05	3,646	48.80	0.29
CSG	24.13	1.93	188,027	641.66	VVC	23.10	1.79	192,648	1,587.83	0.05
CSR	27.76	2.05	193,805	342.09	CBT	27.28	2.01	207,689	1,682.30	0.04
CWP	4.95	3.30	253,841	218.71	NR	4.64	4.60	247,200	363.10	0.16
CZ	26.62	2.03	45,956	1,320.95	FRC	28.31	1.94	46,894	386.66	0.04
DA	27.92	1.29	37,724	224.81	TII	27.72	1.58	34,721	476.08	0.10
DB	58.17	2.04	110,262	34,626.99	MTX	47.24	2.01	120,888	951.26	0.10
DCX	34.53	2.15	690,504	35,304.45	EMN	33.43	2.14	718,003	2,587.09	0.03
DEG	32.09	2.04	24,351	368.84	PVR	27.86	1.69	25,834	250.54	0.12
DEO	44.17	1.30	335,144	2,133.81	DLX	42.19	1.68	361,793	2,355.02	0.14
DMH	15.83	1.23	808	2.77	PNN	12.93	1.46	819	43.48	0.13
DT	14.33	2.04	669,275	2,314.79	MGM	13.12	2.54	673,079	3,231.28	0.11
E	77.44	1.27	90,129	570.73	EEP	47.33	1.33	91,018	1,549.22	0.15
EDP	20.80	1.49	7,738	83.40	IAL	21.59	1.34	7,113	91.65	0.07
ELE	14.94	2.06	118,111	677.97	IDC	15.64	2.04	117,490	1,440.77	0.02
ELN	4.87	6.38	4,049,225	1,521.78	RRI	5.16	5.84	2,993,178	1,510.25	0.13
EN	30.85	1.15	13,338	162.70	NPK	31.93	1.34	7,857	217.96	0.20
ENL	22.93	1.90	19,678	77.00	MOV	22.29	1.99	17,089	202.95	0.07
ENO	3.71	2.75	1,410	1.02	TUC	3.98	1.28	5,643	50.46	1.20
EON	49.24	1.86	45,524	723.69	PVA	42.26	1.73	42,474	379.09	0.09
EPC	15.56	1.80	4,256	4.68	TDI	14.87	1.29	4,511	41.74	0.13
ESF	17.03	1.03	33,662	473.46	BBR	17.46	1.36	16,523	110.38	0.29
FIA	7.57	2.73	66,881	117.44	RT	8.04	3.36	68,734	199.43	0.11
FMS	17.60	2.21	36,931	257.26	CAE	18.76	2.03	34,727	219.85	0.07
FTE	24.30	2.18	135,600	77.48	PRA	26.61	2.23	142,009	767.48	0.06
GGY	4.36	3.98	1,842	3.55	HWK	3.24	3.08	5,643	27.73	0.85
GLH	38.21	1.45	35,591	1,965.87	LDR	38.22	1.63	31,232	336.59	0.08
GSK	40.49	1.80	959,899	11,561.16	EOG	40.95	2.12	971,923	4,705.81	0.07
GUC	93.54	0.33	167,061	9,581.36	BFA	80.56	1.01	6,034	2,296.88	1.05

HAN	29.29	1.60	14,719	522.47	TRC	31.80	1.89	11,569	459.72	0.16
HBC	62.26	1.04	1,249,912	3,749.01	D	59.65	1.50	1,246,779	18,914.94	0.16
HED	2.14	3.11	21,263	20.50	GOT	2.23	4.11	20,610	28.62	0.13
ICI	10.96	2.85	153,696	296.97	PXP	11.13	2.78	148,182	375.09	0.03
IFX	10.78	3.25	854,372	165.89	KEG	10.02	3.34	840,679	1,295.13	0.04
IMI	18.69	2.18	55,049	221.56	NCS	19.31	2.21	58,304	362.37	0.04
ING	17.92	2.75	494,842	1,611.72	TKR	16.97	2.66	495,953	1,393.85	0.03
IRE	47.50	1.36	12,339	145.92	SKY	30.07	1.34	9,890	252.28	0.19
IST	4.52	3.96	57,742	475.07	CCC	5.77	4.16	61,473	224.87	0.13
ITY	33.55	1.48	16,680	782.83	NMGB	35.24	1.86	17,832	693.98	0.13
KLM	10.65	2.81	71,025	498.64	RGR	10.23	2.61	63,841	275.41	0.07
KPN	7.02	2.16	32,665	54.52	ENC	8.15	2.76	33,789	113.92	0.16
LR	17.03	2.13	23,237	68.03	BRY	17.34	1.64	25,326	367.31	0.11
LUX	13.88	1.95	156,275	1,151.63	PR	12.81	2.00	126,561	696.58	0.10
LYG	27.58	1.97	102,036	258.06	MLI	27.88	2.00	107,703	955.08	0.03
MTA	18.17	1.41	41,767	504.92	INT	24.69	1.59	41,026	264.91	0.17
MX	10.64	1.75	8,104	14.93	LMCB	10.83	1.90	10,320	2,294.63	0.13
NGG	32.79	1.60	30,979	530.38	RUS	33.85	1.54	32,505	695.83	0.04
NHY	48.16	1.08	25,018	672.50	SJI	36.27	1.02	23,858	450.83	0.12
NOK	16.09	2.56	11,598,454	19,888.78	HPQ	19.65	3.14	12,285,909	59,977.19	0.17
NSK	5.41	2.87	6,278	5.92	KT	4.43	1.81	6,211	36.66	0.19
NVO	34.89	1.87	24,132	349.41	WMK	32.82	1.82	20,342	892.50	0.08
NVS	39.07	1.38	677,682	3,860.90	KSE	34.38	1.39	629,372	5,599.41	0.07
OOM	9.35	1.83	21,462	122.03	PIK	8.93	2.31	22,437	111.32	0.12
PFP	7.00	2.01	6,366	33.19	ISH	9.53	2.09	6,261	58.00	0.14
PHG	21.38	2.51	887,995	3,247.71	JWN	22.57	2.46	910,896	3,064.88	0.03
PSO	9.56	2.59	89,571	145.98	DAB	10.35	2.26	78,851	138.32	0.11
PT	7.59	2.55	96,017	457.48	RRA	8.21	3.34	100,062	261.86	0.14
PUB	25.76	1.21	3,823	20.12	CRC	12.45	1.17	4,812	75.19	0.27
PUK	13.58	2.52	31,595	41.69	HZO	13.57	2.62	29,956	208.28	0.03
PV	27.54	0.92	1,684	42.25	JWB	25.12	0.96	1,244	290.78	0.13
RD	44.40	1.29	2,374,321	23,101.93	GIS	45.88	1.49	1,538,177	16,976.16	0.18
REP	15.96	1.55	226,443	1,365.81	NFG	23.18	1.64	244,020	1,874.63	0.19
RHA	6.12	2.97	10,257	13.98	PTC	6.11	2.56	7,775	49.99	0.13
RSA	9.03	3.25	32,843	76.06	TBC	9.15	2.70	31,251	74.15	0.08
RTP	85.67	1.60	86,238	1,493.34	MEG	58.31	1.49	85,414	1,328.62	0.13
RUK	32.27	2.08	31,474	187.46	LG	26.14	2.13	29,672	497.40	0.09
SAP	29.28	2.50	1,967,254	2,495.98	MET	28.72	2.24	2,047,155	20,738.51	0.05
SC	38.49	1.35	345,236	1,848.69	EQT	39.28	1.26	270,692	2,449.85	0.10
SCM	29.63	1.14	19,261	342.34	GMP	21.38	1.03	10,698	105.99	0.27
SCO	5.18	3.34	63,231	1.09	OME	5.58	1.03	71,825	134.61	0.12
SDX	26.05	1.04	1,622	15.15	FCEB	39.75	1.05	829	553.97	0.34
SEO	11.65	2.08	85,356	969.30	PLX	12.97	2.46	94,171	308.91	0.13
SGG	5.13	3.12	10,405	2.92	RGB	4.26	3.17	10,290	41.73	0.07
SHR	45.48	1.68	20,533	85.82	CXP	43.12	1.94	26,321	795.30	0.16
SI	54.79	1.99	271,241	671.34	BWA	64.36	2.01	259,254	1,726.56	0.08
SMVA	4.93	2.98	4,632	13.88	DLW	3.03	2.89	4,782	17.80	0.15
SMVB	5.89	2.50	374	1.73	TNMB	14.12	1.77	692	14.47	0.85
SNY	29.77	1.93	71,319	128.85	TR	31.06	1.86	75,308	1,076.94	0.04
SPI	24.02	1.66	147,922	1,656.49	WGL	26.59	1.65	158,141	1,292.17	0.06
SPM	2.41	5.31	16,282	5.27	HBP	2.68	4.30	17,516	52.36	0.13
SRA	14.80	1.94	167,810	347.83	IDT	17.01	1.89	144,271	915.59	0.11
STD	8.37	2.38	247,662	588.67	OO	10.69	2.94	247,464	728.12	0.17
STM	22.65	2.53	1,830,769	20,380.63	ABS	20.27	2.42	1,886,444	7,504.58	0.06
STO	8.77	2.07	39,497	99.37	MFW	8.79	2.87	42,423	162.94	0.15
SYT	10.92	2.17	101,863	419.25	WMO	11.62	2.97	110,540	599.14	0.17
SZE	16.37	2.46	46,609	61.83	UIC	15.33	2.27	45,369	201.00	0.06
TEF	34.30	1.64	240,676	2,739.19	RCI	34.34	1.75	236,995	1,668.35	0.03
TEM	7.86	1.62	11,903	8.39	SYM	7.03	1.64	14,558	109.10	0.11
TKA	21.56	0.69	1,262	8.33	MKCV	26.12	1.34	1,053	405.93	0.44
TKP	21.72	1.66	6,965	72.94	NYM	22.06	1.80	8,007	211.42	0.08
TKS	15.47	2.03	10,683	143.45	TUG	14.70	1.89	10,440	119.88	0.05
TLD	14.53	2.06	15,201	72.63	DCO	15.31	2.25	15,268	151.10	0.05
TMS	16.82	2.38	18,628	70.60	CPY	16.45	2.50	22,290	132.98	0.09
TOT	74.11	1.38	489,043	5,282.98	ASD	78.75	1.62	475,424	5,694.14	0.09
TP	18.06	1.86	22,518	82.89	CV	20.05	2.02	21,917	237.18	0.07
UBS	54.12	1.42	282,125	2,293.33	UB	45.80	1.63	269,838	6,833.05	0.11
UL	35.24	1.25	203,803	1,218.02	PGL	40.01	1.32	172,401	1,444.83	0.11
UN	58.61	1.19	637,224	33,502.61	KMI	50.75	1.43	592,613	6,213.94	0.14
UU	18.59	1.38	18,612	14.53	STW	17.84	1.76	22,217	241.47	0.17
V	18.09	2.47	489,086	1,657.30	BGP	17.89	2.26	452,176	1,396.16	0.06
VDM	12.11	2.78	138,739	82.16	OIS	12.21	2.90	156,685	593.21	0.06
VE	21.38	2.27	12,113	16.54	SXI	22.73	1.97	13,402	274.85	0.10
VOD	20.15	1.82	3,049,609	14,984.63	MAT	20.36	2.30	2,631,397	8,916.70	0.14
WOS	53.02	0.76	1,518	14.11	SQAB	44.67	1.25	1,197	148.75	0.34

Appendix B: 40 Sample Days in 2003

This table contains the 40 sample days with their NYSE Total daily share volumes and volume deciles in 2003. Days are randomly selected, four from each volume decile, from the 223 NYSE trading days on which all European stock exchanges are open in 2003. Decile 1 is the smallest volume decile, 10 is the largest. Volume data are from NYSE CT database.

Date	NYSE Total Volume	Volume Decile
13-Jan-03	1,345,304,080	5
16-Jan-03	1,460,699,840	8
17-Jan-03	1,331,946,450	5
21-Jan-03	1,286,219,170	4
24-Jan-03	1,506,626,600	9
5-Feb-03	1,397,425,010	6
5-Mar-03	1,288,580,480	4
17-Mar-03	1,661,307,440	10
28-Mar-03	1,202,770,320	2
9-Apr-03	1,264,418,040	3
24-Apr-03	1,463,430,250	8
28-Apr-03	1,249,249,910	3
9-May-03	1,285,446,150	4
12-May-03	1,344,897,480	5
3-Jun-03	1,404,220,120	7
30-Jun-03	1,568,963,480	10
7-Jul-03	1,371,692,180	6
9-Jul-03	1,550,174,380	10
10-Jul-03	1,417,027,250	7
5-Aug-03	1,283,005,120	4
6-Aug-03	1,442,359,330	8
11-Aug-03	1,002,987,140	1
12-Aug-03	1,111,939,320	1
13-Aug-03	1,183,369,690	2
29-Aug-03	936,447,130	1
5-Sep-03	1,427,220,710	7
24-Sep-03	1,534,801,960	9
30-Sep-03	1,487,393,140	9
6-Oct-03	992,653,220	1
8-Oct-03	1,222,982,300	3
20-Oct-03	1,153,566,850	2
21-Oct-03	1,425,392,250	7
22-Oct-03	1,598,229,780	10
5-Nov-03	1,342,075,410	5
10-Nov-03	1,206,715,380	2
2-Dec-03	1,364,866,840	6
3-Dec-03	1,394,266,330	6
4-Dec-03	1,446,290,070	8
18-Dec-03	1,536,180,800	9
22-Dec-03	1,222,970,880	3
Total	**Average**	
40 days	1,342,902,807	