

IMPLICATIONS OF EUROPEAN TRADING FOR THE NEW YORK STOCK EXCHANGE OPEN

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ABSTRACT

We test the hypothesis that a market maker in New York faces a more competitive market for cross-listed European firms trading simultaneously in their home market during overlapping trading hours as compared to U.S. firms which trade mainly in New York. A sample of seventy two European firms is matched with a control group of U.S. firms, under the same industry and with same liquidity. We find that the mean percentage bid-ask spread for the European firms is significantly smaller than that of the U.S. firms for the opening thirty minutes of trading at the NYSE, even after controlling for liquidity and probability of informed trading. When we compare the percentage bid-ask spreads during the NYSE afternoon after the European markets have closed trading, we find no significant difference. This suggests that the U.S. and the European markets are integrated during the period of overlap and synergies exist between trading venues.

INTRODUCTION

Many European firms cross-list their shares on the U.S. stock exchanges. As of January 27th, 2005 there were 195 companies from 20 different European countries cross-listed on the New York Stock Exchange (NYSE). Most of these European firms cross-list their shares on the NYSE in the form of American Depositary Receipts (henceforth ADR). ADR is a derivative instruments backed by home-market ordinary shares. The trend of cross-listing and cross-trading across different equity markets has precipitated a vast body of financial research. The key motivation of most of these studies has been to try and answer the big question: Are the global equity markets integrated or is there evidence of market segmentation? A highly referenced paper in this area has been that of Werner and Kleidon (1996) where they compare a set of U.K. firms cross-listed in the U.S. and a control group of U.K. firms which are not cross-listed in the U.S. Using intraday data they find that, qualitatively, the cross-listed firms do not differ from the locally traded firms in terms of the intraday U shaped price volatility curve- a result one would expect if the markets are segmented.

This result prompted a host of papers amongst which is the one by Lowengrub and Melvin (2000). They use intraday data on a set of German firms and examine the issue of intraday volatility along with volume in a time series setting both before and after the listing date on the U.S. market and find that intraday volatility and volume curves flatten after cross-listing. They conclude that this evidence is consistent with an integrated global trading environment rather than two segmented markets. Eun and Sabherwal (2003) look at the price discovery of Canadian firms on the Toronto Stock Exchange and U.S. exchanges and find that price adjustments due to cross-market information flows take place not only on the U.S. exchange but also on the Toronto Stock Exchange. Grammig, Melvin and Schlag (2004) examine the period of overlap between New York and Germany and find that price discovery for German firms largely occurs in Frankfurt trading. Howe and Ragan (2002) show that the opening volatility of ADRs is lower when the trading of the underlying asset overlaps with the trading of the ADR on the NYSE. In a recent working paper, Moulton and Wei (2004) find that for European firms listed on the NYSE, specialist behavior changes over the day depending upon whether European markets are open or not.

The main idea of this paper is the following. We know that there are many European firms cross-listed as ADRs on the NYSE. When trading opens in New York, for almost two hours there is trading going on

simultaneously in the European markets and the NYSE. Table 1 exhibits the trading hour overlap between NYSE and the fifteen major European stock markets.

Table 1: List of European Stock Exchanges

| Country | Exchange | Hours | Time ahead of New York | Overlap |
|----------------|---------------------------|---------------|------------------------|------------------|
| Austria | Vienna Stock Exchange | 8:30am-5:45pm | 6 hrs | 2 hrs 15 minutes |
| Belgium | Euronext Brussels | 9 am-5:25 pm | 6 hrs | 1 hr 55 minutes |
| Denmark | Copenhagen Stock Exchange | 9 am-5 pm | 6 hrs | 1 hr 30 minutes |
| Finland | HEX Helsinki | 10am-6pm | 7 hrs | 1 hr 30 minutes |
| France | Euronext Paris | 9 am-5:25 pm | 6 hrs | 1 hr 55 minutes |
| Germany | Frankfurt Stock Exchange | 9am-8pm | 6hrs | 4 hrs 30 minutes |
| Ireland | Irish Stock Exchange | 8am-4:30pm | 5hrs | 2hrs |
| Italy | Borse Italiana | 10am-5:40pm | 6 hrs | 2 hrs 10 mins |
| Netherlands | Euronext Amsterdam | 9 am-5:25 pm | 6 hrs | 1 hr 55 minutes |
| Norway | Oslo Bourse | 9am-5pm | 6hrs | 1hr 30 mins |
| Portugal | Euronext Lisbon | 9 am-5:25 pm | 6 hrs | 1 hr 55 minutes |
| Spain | Barcelona Stock Exchange | 8:30am-5:45pm | 6hrs | 2hr 15 mins |
| Sweden | Stockholm Bourse | 9:30am-5:30pm | 6hrs | 2hrs |
| Switzerland | Swiss Exchange | 9am-5:30pm | 6hrs | 2hrs |
| United Kingdom | London Stock Exchange | 8am-4:30pm | 5hrs | 2hrs |

So there is a substitute market open for these European stocks in Europe. Now this story should be true for comparable US stocks too (by comparable we mean stocks in same industry with same liquidity). But empirically, we find that US stocks have a clear home bias in terms of trading. US stocks mainly trade at home even though equal opportunities exist for a European trading. One possible implication, as far as the NYSE market maker (who is dealing with both these stocks) is concerned, is that he faces a more competitive market for the European stocks than the U.S. stocks because of this issue of multimarket trading. The market power of the market maker should, therefore, be reduced for the European firms as compared to the matched U.S. firms. One measure of market power of the market maker in financial markets is the bid-ask spread. So using the simple theoretical background of monopoly versus multimarket trading, we can hypothesize that European stocks will trade at a smaller bid-ask spread than the matched US stocks when markets in the two continents overlap. When trading stops in Europe both sets of stocks should behave same and this difference in bid-ask spread should vanish. We test this theoretical implication. To do that, a sample of seventy two heavily traded European firms is collected and matched with a group of U.S. firms on the basis of industry and liquidity. Table 2 documents the sample of U.S and European firms used in this study.

We then study the high frequency bid and ask quotes for two time periods: the first thirty minutes of trading, from 9:30-10 am, when the trading hours in the NYSE and the European markets overlap and from 2:30-3 pm when only the NYSE is trading and all the European markets have closed. We use high frequency tick-by-tick data from the TAQ (Trade and Quote) database and three months of data from September-November, 2000 and compare the percentage bid-ask spreads between the European and the U.S. firms. Our hypothesis is that, because of competition from overseas home markets during the NYSE morning, the European firms should trade at a smaller bid-ask spread than the U.S. firms. But this difference should vanish during the NYSE afternoon when all the European markets have closed.

Of course bid-ask spreads might also be driven by liquidity and informed trading in a stock. The idea of bid-ask spreads being driven by informed trading follows from the theory that the risk-averse market maker will set bigger bid-ask spreads to compensate for the risk exposure when there is a higher probability of trading with a privately informed trader. This would be especially true during the NYSE morning when we would expect privately informed traders to be more active. To account for that, we

estimate the probability of informed trading (PIN) in our sample using the method of Easley, O’Hara, Kiefer and Paperman (1996).

Table 2: Sample of U.S. and European Firms

| European Firm | Ticker | U.S. Firm | Ticker | Industry |
|---------------------------------------|---------------|----------------------------|---------------|------------------------------|
| Publicis Groupe S.A. | PUB | Harte Hanks. | HHS | Advertising |
| Autoliv Inc. | ALV | Tower Automotive. | TWR | Autoparts |
| Banco Bilbao Viscaya Argentaria. | BBV | Bancorp South. | BXS | Banking |
| Banco Santander Central Hispanio S.A. | STD | Bayview Capital. | BVC | Banking |
| ABN AMRO Bank. | ABN | Cullen/Frost Bankers. | CFR | Banking |
| Allied Irish Banks. | AIB | First Fed Financial Corp. | FED | Banking |
| Barclays Plc. | BCS | Valley National Bancorp. | VLY | Banking |
| Credit Suisse Group. | CSR | Bankatlantic Bancorp. | BBX | Banking |
| Deutsche Bank A.G. | DB | Chittenden Corporation. | CZN | Banking |
| HSBC Holdings. | HBC | M&T Bancorp. | MTB | Banking |
| Sanpaolo IMI. | IMI | Community Bank System. | CBU | Banking |
| UBS A.G. | UBS | Commercial Federal Corp. | CFB | Banking |
| Lloyds TSB Group Plc. | LYG | First Commonwealth. | FCF | Banking |
| Serono S.A. | SRA | Theragenic Corp. | TGX | Biotechnology |
| Vivendi Universal. | V | Hearst Arghyle Television. | HTV | Broadcasting |
| Hanson Plc. | HAN | Ameron International. | AMN | Building materials |
| Luxottica Group. | LUX | Guess Inc et al. | GES | Clothes and Fabrics |
| Alcatel. | ALA | American Tower Corp. | AMT | Communications Technology |
| Siemens A.G. | SI | Cable design Corp. | CDT | Communications Technology |
| Nokia Corporation. | NOK | Corning Inc. | GLW | Communications Technology |
| BASF A.G. | BF | Spartech Corp. | SEH | Commodity Chemicals |
| Bayer A.G. | BAY | Wellman Inc. | WLM | Commodity Chemicals |
| Celanese A.G. | CZ | NL Industries. | NL | Commodity Chemicals |
| Royal Phillips Electronics. | PHG | Harman Intl. | HAR | Consumer Electronics |
| Diageo Plc. | DEO | Brown Forman. | BFB | Distillers and Brewers |
| Endesa S.A. | ELE | Unisource Energy. | UNS | Electric Utilities |
| E.ON G. | EON | CH Energy. | CHG | Electric Utilities |
| Scottish Power UK Plc. | SPI | El Paso Electric. | EE | Electric Utilities |
| Cable and Wireless. | CWP | IDT Corporation. | IDT | Fixed line Communications |
| Deutsche Telekom A.G. | DT | Cincinnati Bell. | CBB | Fixed line Communications |
| France Telecom. | FTE | Sprint Corporation. | SDE | Fixed line Communications |
| TDC A/S. | TLD | Centurytel. | CTLPRA | Fixed line Communications |
| Telefonica S..A. | TEF | BCE Inc. | BCE | Fixed line Communications |
| Groupe Danone. | DA | M&F Worldwide. | MFW | Food Products |
| Cadbury Schweppes Plc | CSG | Ralcorp Holdings. | RAH | Food Products |
| Unilever N.V. | UN | Mccormick &Co. | MKC | Food Products |
| Delhaize Group | DEG | Smart and Final. | SMF | Food Retailers &Wholesellers |
| Natuzzi SPA. | NTZ | Fedders Corp. | FJC | Furnishing and Appliance |
| Royal Ahold. | AHO | Winn Dixie Stores. | WIN | Food Retailers &Wholesellers |
| Aegon N.V. | AEG | CNA Financial. | CNA | Full line Insurance |
| Allianz A.G. | AZ | Horace Mann Educators. | HMN | Full line Insurance |

| European Firm | Ticker | U.S. Firm | Ticker | Industry |
|------------------------------------------|---------------|----------------------------|---------------|------------------------------------|
| AXA. | AXA | Stancorp Financial. | SFG | Full line Insurance |
| Royal and Sun Alliance Insurance Grp Plc | RSA | FBL Financial Grp. | FFG | Full line Insurance |
| Chicago Bridge & Iron Co. | CBI | MasTec Inc. | MTZ | Heavy Construction |
| Adecca S.A. | ADO | Crawford and Company. | CRDB | Industrial Services |
| AMVESCAP Plc. | AVZ | Gabelli Asset Mgt. | GBL | Investment Services |
| ING Group. | ING | Nationwide Fin Services. | NFS | Life Insurance |
| BP Plc. | BP | ConocoPhillips. | COP | Major Oil Companies |
| Royal Dutch Petroleum Co. | RD | Marathon Oil Corp. | MRO | Major Oil Companies |
| TOTAL S.A. | TOT | Unocal. | UCL | Major Oil Companies |
| Alcon Inc. | ACL | Apogent Technology. | AOT | Medical Supplies |
| Rio Tinto. | RTP | Cleveland Cliffs. | CLF | Mining |
| Core labs. | CLB | Carbo Ceramics. | CRR | Oil Drilling |
| Stora Enso. | SEO | Buckeye Tech. | BKI | Paper Products |
| UPM-Kymmene Corporation. | UPM | Schweitzer Mauduit Intl. | SWM | Paper products |
| Aventis S.A. | AVE | Bradley Pharmaceuticals. | BDY | Pharmaceuticals |
| GlaxoSmithKline Plc. | GSK | Pharmaceutical Resources | PRX | Pharmaceuticals |
| Novartis. | NVS | Medicis Pharmaceuticals. | MRX | Pharmaceuticals |
| AstraZeneca Grp. | AZN | Alpharma Inc. | ALO | Pharmaceuticals |
| Elan Corp. | ELN | Mylan Labs. | MYL | Pharmaceuticals |
| Schering A.G. | SHR | KV Pharmaceauticals. | KVB | Pharmaceuticals |
| Wilis Grp. | WSH | Allmerica Financial Corp. | AFC | Property and Casualty Insurance |
| Pearson Plc. | PSO | Coachman Industries. | COA | Recreational Products and Services |
| Carnival Plc. | CUK | Dover Motorsports. | DVD | Recreational Products and Services |
| Infineon Technologies | IFX | Meme Electronic Materials. | WFR | Semiconductors |
| ST Microelectronics N.V. | STM | Fairchild Semiconductors. | FCS | Semiconductors |
| Imperial Chemical Industries Plc. | ICI | Arch Chemicals. | ARJ | Speciality Chemicals |
| Syngenta. | SYT | Rogers Corp. | ROG | Speciality Chemicals |
| SAP A.G. | SAP | Cadence Design System. | CDN | Technology,Software |
| Gallagher Group Plc. | GLH | Standard Commercial Corp | STW | Tobacco |

The first column of the table reports the list of European firms, the second column their NYSE ticker symbol, the third column the matching U.S. firms. The fifth column lists the name of the industry to which the pair of European and U.S. firm in that row belongs. We have used the subgroup classifications under the Dow Jones Global Classification Standard.

As for liquidity, the more liquid the trading in a stock the smaller the bid-ask spread. We use the consolidated number of trades in a stock as a measure of liquidity. We then compare the percentage bid-ask spreads between the European and the U.S. stocks for the two different time periods of the day, after controlling for the effect of liquidity and the extent of informed trading. Our results show that the European firms trade at a significantly smaller bid-ask spread during the NYSE morning period. During the NYSE afternoon, however, the differences in bid-ask spreads vanish. This indicates that our initial hypothesis is true, the NYSE market maker does face competition from European trading during the NYSE morning. This also indicates that the U.S. and the European markets are integrated during the morning period of overlap.

The paper proceeds as follows. First we discuss the theory of informed trading using an earlier paper by Easley, Kiefer, O'Hara and Paperman, 1996 (henceforth EKOP). Next we discuss the empirical evidence on the bid-ask spread is presented and finally we conclude.

INFORMED TRADING

The bid-ask spreads may also be driven also by the extent of informed trading in a stock. Risk-averse market makers tend to set bigger bid-ask spreads to compensate for the exposure to privately informed traders. So when we test our hypothesis if European stocks trade at a smaller bid-ask spread than U.S. stocks because of market competitiveness, we want to make sure we control for the effect of informed trading, if any. This effect is especially important during the NYSE morning when informed traders are expected to quickly trade on their private information. It is difficult to estimate if there is private information based trading going on in a stock. EKOP (1996) have developed an empirical technique to test for the presence of informed trading in a stock. The idea is to use the information in the trade data to estimate the probability of informed trading. Specifically, they use a continuous time sequential model and develop a likelihood function to use in the estimation. The setup of their model is as follows:

- One risk neutral market maker and many informed and uninformed traders.
- Individuals trade a single risky asset and money with a market maker over $i = 1, \dots, I$ days. Within each trading day time is continuous and is indexed by $t \in [0, T]$.
- Prior to the beginning of each trading day, nature determines whether an information event happens. Information events are independent and occur with probability d . These events are bad news with probability e and good news with probability $1 - e$.
- $(V_i)_{i=1}^I$ are the random variables that give the value of the asset at the end of day I .
- Uninformed buyer and seller order arrivals are Poisson processes and the rate of arrival per minute is κ . Informed buyer and seller order arrivals are also Poisson and the rate of arrival per minute is ϖ . Order imbalance is expected to occur with informed trader activity.
- If a privately informed trader observes a bad signal he sells, if he observes a good signal he buys.
- The market maker is a Bayesian and he updates his belief about an information event by looking at the arrival of trade and rate of trading.

EKOP derives the probability of informed trading as $PIN = \frac{d\varpi}{d\varpi + 2\kappa}$.

They use a structural model to estimate the parameters d, ϖ, κ . The likelihood function is derived as the following:

$$L(B, S | H) = (1 - d) * e^{-\kappa T} \frac{(\kappa T)^B}{B!} e^{-\kappa T} \frac{(\kappa T)^S}{S!} + de * e^{-\kappa T} \frac{(\kappa T)^B}{B!} e^{-(\varpi + \kappa)T} \frac{[(\varpi + \kappa)T]^S}{S!} + d(1 - e) * e^{-\kappa T} \frac{(\kappa T)^S}{S!} e^{-(\varpi + \kappa)T} \frac{[(\varpi + \kappa)T]^B}{B!} \quad (1)$$

Where B = number of buys in a day, S = number of sells in a day, H is the parameter vector. EKOP use the Lee and Ready [1990] algorithm to classify each trade as a buy or sell. The likelihood of observing data $M = (B_i, S_i)_{i=1}^I$ over I days is just the product of the daily likelihoods,

$$L(M | H) = \prod_{i=1}^I L(H | B_i, S_i).$$

For our paper we use this technique to measure the probability of informed trading for our sample of European and U.S. stocks. We use the Lee and Ready technique to classify each trade as buy or sell. Then we maximize the likelihood function and find the parameter estimates and obtain the PIN value for each of our stocks. Each PIN value is a number between 0 and 1. Tables 3A and 3B document the PIN for the entire sample for the two time periods 9:30-10am and 2:30-3 pm respectively.

Table 3A: Probability of Informed Trading for 9:30-10 AM

| US Firm | PIN | European Firm | PIN |
|---------------------------|------------|-------------------------|------------|
| Gerber Scientific | 0.428 | ABB Limited | 0.324 |
| Graco Inc | 0.219 | Mettler Toledo | 0.205 |
| Harte Hanks | 0.265 | Publicis Groupe S.A. | 0.785 |
| Tower Automotive | 0.274 | Autoliv Inc. | 0.254 |
| Bancorp South | 0.257 | Banco Bilbao | 0.228 |
| Bayview Capital | 0.401 | Banco Santander Central | 0.311 |
| Cullen/Frost Bankers | 0.189 | ABN AMRO Bank | 0.144 |
| First Fed Financial Corp | 0.295 | Allied Irish Banks | 0.226 |
| Valley National Bancorp | 0.209 | Barclays Plc. | 0.225 |
| Bankatlantaic Bancorp | 0.246 | Credit Suisse | 0.231 |
| Chittenden Corporation | 0.195 | Deutsche Bank | 0.209 |
| M&T Bancorp | 0.138 | HSBC holdings | 0.171 |
| Community Bank System | 0.389 | Sanpaolo IMI | 0.265 |
| Commercial Federal Corp | 0.253 | UBS AG | 0.18 |
| First Commonwealth | 0.523 | Lloyds TSB Group | 0.202 |
| Theragenic Corp | 0.301 | Serono | 0.233 |
| Hearst Arghyle Television | 0.282 | Vivendi Universal | 0.186 |
| Ameron International | 0.33 | Hanson Plc. | 0.471 |
| Guess Inc et al | 0.345 | Luxottica | 0.302 |
| American Tower Corp | 0.171 | Alcatel | 0.125 |
| Cable design Corp | 0.278 | Siemens AG | 0.128 |
| Corning Inc | 0.159 | Nokia Corporation | 0.083 |
| Spartech Corp | 0.34 | BASF AG | 0.186 |
| Wellman Inc | 0.251 | Bayer AG | 0.178 |
| NL Industries | 0.335 | Celanese AG | 0.28 |
| Harman Intl | 0.193 | Royal Phillips | 0.144 |
| Brown Forman | 0.278 | DIAGEO plc | 0.13 |
| Unisource Energy | 0.197 | Endesa SA | 0.288 |
| CH Energy | 0.43 | E ON G | 0.279 |
| El Paso Electric | 0.368 | Scottish Power UK plc | 0.286 |
| IDT Corporation | 0.288 | Cable and Wireless | 0.279 |
| Cincinnati Bell | 0.273 | Deutsche Telekom | 0.188 |
| Sprint Corporation | 0.21 | France Telecom | 0.232 |
| Centurytel | 0.595 | TDC A/S | 0.843 |
| BCE Inc | 0.181 | Telefonica | 0.16 |
| M&F Worldwide | 0.317 | Groupe Danone | 0.111 |
| Ralcorp Holdings | 0.266 | Cadbury Schweppes | 0.196 |
| Mccormick &Co | 0.193 | Unilever | 0.226 |
| Smart and Final | 0.34 | Delhaize Group | 0.293 |
| Fedders Corp | 0.363 | Natuzzi SPA | 0.205 |
| Winn Dixie Stores | 0.155 | Royal Ahold | 0.155 |
| CNA Financial | 0.155 | AEGON | 0.149 |
| Horace Mann Educators | 0.3 | Allianz | 0.222 |
| Stancorp Financial | 0.236 | AXA | 0.193 |
| FBL Financial Grp | 0.18 | Royal and Sun Alliance | 0.263 |
| MasTec Inc | 0.26 | Chicago Bridge&Iron | 0.221 |
| Crawford and Company | 0.693 | Adecca | 0.423 |
| Gabelli Asset Mgt | 0.336 | AMVESCAP Plc | 0.193 |
| Nationwide Fin Services | 0.126 | ING Group | 0.191 |
| ConocoPhillips | 0.131 | BP Plc. | 0.114 |
| Marathon Oil Corp | 0.125 | Royal Dutch Petroleum | 0.168 |
| Unocal | 0.141 | TOTAL S.A. | 0.193 |
| Apogent Technology | 0.226 | Alcon Inc | 0.213 |

| US Firm | PIN | European Firm | PIN |
|---------------------------|------------|----------------------------------|------------|
| Cleveland Cliffs | 0.251 | Rio Tinto | 0.22 |
| Carbo Ceramics | 0.26 | Core labs | 0.319 |
| Buckeye Tech | 0.348 | Stora Enso | 0.216 |
| Schweitzer Mauduit Intl | 0.373 | UPM-Kymmene Corporation | 0.518 |
| Bradley Pharmaceuticals | 0.226 | Aventis | 0.15 |
| Pharmaceutical Resources | 0.137 | GlaxoSmithKline plc | 0.197 |
| Medicis Pharmaceuticals | 0.277 | Novartis | 0.109 |
| Alpharma Inc | 0.114 | AstraZeneca Grp | 0.14 |
| Mylan Labs | 0.152 | Elan Corp | 0.162 |
| KV Pharmaceauticals | 0.578 | Schering Aktiengesellschaft | 0.297 |
| Allmerica Financial Corp | 0.22 | Wilis Grp. | 0.205 |
| Coachman Industries | 0.281 | Pearson plc. | 0.245 |
| Dover Motorsports | 0.535 | Carnival Plc. | 0.286 |
| Memc Electronic Materials | 0.209 | Infineon Technologies | 0.086 |
| Fairchild Semiconductors | 0.133 | STMicroelectronics | 0.647 |
| Arch Chemicals | 0.376 | Imperial Chemical Industries PLC | 0.245 |
| Rogers Corp | 0.374 | Syngenta | 0.365 |
| Cadence Design System | 0.1 | SAP | 0.133 |
| Standard Commercial Corp | 0.376 | Gallagher Group Plc | 0.359 |

The first column of the table reports the list of U.S. firms, the second column their value of probability of informed trading (PIN). The fifth and sixth column reports the matching European firms and the value of probability of informed trading (PIN).

Table 3B: Probability of Informed Trading for 2:30-3 PM

| U.S. Firm | PIN | European Firm | PIN |
|---------------------------|------------|-------------------------|------------|
| Gerber Scientific | 0.414 | ABB Limited | 0.239 |
| Graco Inc | 0.217 | Mettler Toledo | 0.259 |
| Harte Hanks | 0.286 | Publicis Groupe S.A. | 1.000 |
| Tower Automotive | 0.288 | Autoliv Inc. | 0.184 |
| Bancorp South | 0.303 | Banco Bilbao | 0.242 |
| Bayview Capital | 0.432 | Banco Santander Central | 0.258 |
| Cullen/Frost Bankers | 0.185 | ABN AMRO Bank | 0.070 |
| First Fed Financial Corp | 0.302 | Allied Irish Banks | 0.305 |
| Valley National Bancorp | 0.179 | Barclays Plc. | 0.199 |
| Bankatlantic Bancorp | 0.195 | Credit Suisse | 0.209 |
| Chittenden Corporation | 0.199 | Deutsche Bank | 0.277 |
| M&T Bancorp | 0.197 | HSBC holdings | 0.190 |
| Community Bank System | 0.185 | Sanpaolo IMI | 0.095 |
| Commercial Federal Corp | 0.227 | UBS AG | 0.228 |
| First Commonwealth | 0.290 | Lloyds TSB Group | 0.293 |
| Theragenic Corp | 0.280 | Serono | 0.336 |
| Hearst Arghyle Television | 0.254 | Vivendi Universal | 0.188 |
| Ameron International | 0.152 | Hanson Plc. | 0.185 |
| Guess Inc et al | 0.292 | Luxottica | 0.290 |
| American Tower Corp | 0.194 | Alcatel | 0.176 |
| Cable design Corp | 0.243 | Siemens AG | 0.234 |
| Corning Inc | 0.116 | Nokia Corporation | 0.088 |
| Spartech Corp | 0.211 | BASF AG | 0.193 |
| Wellman Inc | 0.252 | Bayer AG | 0.280 |
| NL Industries | 0.191 | Celanese AG | 0.260 |
| Harman Intl | 0.148 | Royal Phillips | 0.123 |
| Brown Forman | 0.168 | DIAGEO plc | 0.379 |
| Unisource Energy | 0.263 | Endesa SA | 0.305 |

| U.S. Firm | PIN | European Firm | PIN |
|---------------------------|------------|----------------------------------|------------|
| CH Energy | 0.296 | E ON G | 0.144 |
| El Paso Electric | 0.219 | Scottish Power UK plc | 0.137 |
| IDT Corporation | 0.327 | Cable and Wireless | 0.395 |
| Cincinnati Bell | 0.240 | Deutsche Telekom | 0.175 |
| Sprint Corporation | 0.437 | France Telecom | 0.315 |
| Centurytel | 0.576 | TDC A/S | 0.750 |
| BCE Inc | 0.251 | Telefonica | 0.278 |
| M&F Worldwide | 0.355 | Groupe Danone | 0.273 |
| Ralcorp Holdings | 0.127 | Cadbury Schweppes | 0.208 |
| Mccormick &Co | 0.249 | Unilever | 0.265 |
| Smart and Final | 0.310 | Delhaize Group | 0.626 |
| Fedders Corp | 0.312 | Natuzzi SPA | 0.338 |
| Winn Dixie Stores | 0.190 | Royal Ahold | 0.207 |
| CNA Financial | 0.212 | AEGON | 0.177 |
| Horace Mann Educators | 0.251 | Allianz | 0.318 |
| Stancorp Financial | 0.175 | AXA | 0.202 |
| FBL Financial Grp | 0.430 | Royal and Sun Alliance | 0.466 |
| MasTec Inc | 0.242 | Chicago Bridge&Iron | 0.256 |
| Crawford and Company | 0.628 | Adecca | 0.471 |
| Gabelli Asset Mgt | 0.274 | AMVESCAP Plc | 0.277 |
| Nationwide Fin Services | 0.113 | ING Group | 0.175 |
| ConocoPhillips | 0.105 | BP Plc. | 0.183 |
| Marathon Oil Corp | 0.160 | Royal Dutch Petroleum | 0.186 |
| Unocal | 0.175 | TOTAL S.A. | 0.183 |
| Apogent Technology | 0.252 | Alcon Inc | 0.229 |
| Cleveland Cliffs | 0.253 | Rio Tinto | 0.261 |
| Carbo Ceramics | 0.210 | Core labs | 0.303 |
| Buckeye Tech | 0.318 | Stora Enso | 0.192 |
| Schweitzer Mauduit Intl | 0.296 | UPM-Kymmene Corporation | 0.180 |
| Bradley Pharmaceuticals | 0.222 | Aventis | 0.191 |
| Pharmaceutical Resources | 0.182 | GlaxoSmithKline plc | 0.183 |
| Medicis Pharmaceuticals | 0.184 | Novartis | 0.187 |
| Alpharma Inc | 0.222 | AstraZeneca Grp | 0.149 |
| Mylan Labs | 0.131 | Elan Corp | 0.144 |
| KV Pharmaceauticals | 0.664 | Schering Aktiengesellschaft | 0.652 |
| Allmerica Financial Corp | 0.179 | Wilis Grp. | 0.202 |
| Coachman Industries | 0.387 | Pearson plc. | 0.286 |
| Dover Motorsports | 0.411 | Carnival Plc. | 0.252 |
| Meme Electronic Materials | 0.208 | Infineon Technologies | 0.238 |
| Fairchild Semiconductors | 0.153 | STMicroelectronics | 0.190 |
| Arch Chemicals | 0.338 | Imperial Chemical Industries PLC | 0.273 |
| Rogers Corp | 0.265 | Syngenta | 0.227 |
| Cadence Design System | 0.177 | SAP | 0.166 |
| Standard Commercial Corp | 0.449 | Gallagher Group Plc | 0.265 |

The first column of the table reports the list of U.S. firms, the second column their value of probability of informed trading (PIN). The fifth and sixth columns report the European firms and the value of probability of informed trading (PIN)

EMPIRICAL EVIDENCE

For our purposes we needed European stocks which are highly liquid and have active trading going on in their home markets in Europe when their ADRs start to trade at the NYSE. The stocks were selected from those European countries whose major stock markets have substantial overlapping trading hours with the NYSE. The major stock exchanges selected were those of the following 15 European countries: Austria,

Belgium, Denmark, Finland, France, Germany, Italy, Ireland, Netherlands, Norway, Portugal, Sweden, Switzerland, Spain and U.K. The sample consists of seventy two heavily traded European stocks from the above list of countries and a control group of U.S. stocks, matched by the consolidated number of trades in 2003 under the same industry. The NYSE uses the Dow Jones Global Classification Standard which divides the firms into 10 economic sectors, 18 market sectors, 51 industry groups and 89 subgroups. Each of the subgroups was examined to pick the European firm and the matched U.S. firm. Table 2 lists the firms. High frequency tick-by-tick bid and offer quotes are used from the NYSE Trade and Quote(TAQ) database which consists of time stamped intraday transactions data for all securities listed on the NYSE and American Stock Exchange (AMEX) as well as NASDAQ National Market System (NMS) and Small Cap issues. The bid and offer quotes and the trades were extracted for the sample for the months of September, October and November, 2003 for the two time periods, 9:30-10 am and 2:30-3 pm. There are 63 trading days in the sample.

Evidence on Bid-ask Spread

The data were sorted and stacked according to each firm, date, time and a variable that identifies each minute of the trading day. Then the percentage bid-ask spread, *perspread*, where $perspread = \frac{Spread}{Midprice}$

is computed for each quote in the dataset. For each firm the mean *perspread* for the entire trading period is computed. So we obtain one mean *perspread* value for each of our firms in both the samples. Table 4A lists the *perspread* values for the sample for the 9:30-10 am period and Table 4B lists the per spread values for the 2:30-3 pm period.

Sample Period 9:30-10 AM

We expected that within each set of U.S. and European firms the mean *perspread* should go down from the less liquid to the more liquid stocks. This is compatible with the intuition that the higher the liquidity, the lower should be the transactions cost, bid-ask spread being a widely used measure of transaction cost. We computed the correlation coefficient between the mean *perspread* and the number of trades for each of the set of European and U.S. firms and found that the correlation coefficient is -0.51771 for the U.S. firms and -0.72960 for the European firms. So the initial evidence suggests that more liquid the stock, smaller the bid-ask spread would be. Focusing on the morning sample, it was also found that the mean *perspread* for the U.S sample is 0.00522027 and the mean *perspread* for the European sample is 0.002976261. So the mean *perspread* for the European sample is smaller than that of the U.S. sample by approximately 23 basis points. The associated P value is 0. Out of each of the pairs of firms it was found that for 17 pairs of firms the European firm has a bigger *perspread* and for the rest of the 55 pairs the U.S. firm has a bigger *perspread*. So overwhelmingly the U.S. firms trade at a bigger bid-ask spread than the European firms.

Table 4 A: Percentage Bid-ask spread Analysis for 9:30-10 AM

| U.S. Firm | Perspread | European Firm | Perspread | X |
|--------------------------|-----------|-------------------------|-----------|-----|
| Gerber Scientific | 0.0112014 | ABB Limited | 0.0066126 | US |
| Graco Inc | 0.0017825 | Mettler Toledo | 0.0023529 | US |
| Harte Hanks | 0.0034331 | Publicis Groupe S.A. | 0.0045 | EUR |
| Tower Automotive | 0.0108557 | Autoliv Inc. | 0.001491 | EUR |
| Bancorp South | 0.0033892 | Banco Bilbao | 0.00409 | US |
| Bayview Capital | 0.0038202 | Banco Santander Central | 0.0043657 | EUR |
| Cullen/Frost Bankers | 0.0017393 | ABN AMRO Bank | 0.0015749 | EUR |
| First Fed Financial Corp | 0.0024 | Allied Irish Banks | 0.003946 | US |
| Valley National Bancorp | 0.0025414 | Barclays Plc. | 0.0019518 | EUR |

| U.S. Firm | Perspread | European Firm | Perspread | X |
|---------------------------|------------------|-------------------------|------------------|----------|
| Bankatlantaic Bancorp | 0.0046525 | Credit Suisse | 0.0017884 | US |
| Chittenden Corporation | 0.022499 | Deutsche Bank | 0.00155 | US |
| M&T Bancorp | 0.001163 | HSBC holdings | 0.00063502 | US |
| Community Bank System | 0.0046619 | Sanpaolo IMI | 0.0036868 | US |
| Commercial Federal Corp | 0.0020973 | UBS AG | 0.001186 | US |
| First Commonwealth | 0.006732 | Lloyds TSB Group | 0.0020292 | US |
| Theragenic Corp | 0.0115576 | Serono | 0.0032615 | US |
| Hearst Arghyle Television | 0.0021103 | Vivendi Universal | 0.0018581 | US |
| Ameron International | 0.0046619 | Hanson Plc. | 0.0044619 | US |
| Guess Inc et al | 0.0092812 | Luxottica | 0.0038163 | US |
| American Tower Corp | 0.0037735 | Alcatel | 0.0020248 | US |
| Cable design Corp | 0.0049271 | Siemens AG | 0.0013626 | US |
| Corning Inc | 0.0016237 | Nokia Corporation | 0.00098545 | US |
| Spartech Corp | 0.0053746 | BASF AG | 0.0018222 | US |
| Wellman Inc | 0.006196 | Bayer AG | 0.0021906 | US |
| NL Industries | 0.0071415 | Celanese AG | 0.004662 | US |
| Harman Intl | 0.0016568 | Royal Phillips | 0.0012552 | US |
| Brown Forman | 0.0011459 | DIAGEO plc | 0.00086415 | US |
| Unisource Energy | 0.0040211 | Endesa SA | 0.0034832 | US |
| CH Energy | 0.0047346 | E ON G | 0.0022141 | US |
| El Paso Electric | 0.0050564 | Scottish Power UK plc | 0.0022458 | US |
| IDT Corporation | 0.0031806 | Cable and Wireless | 0.0060163 | US |
| Cincinnati Bell | 0.0053963 | Deutsche Telekom | 0.0020331 | EUR |
| Sprint Corporation | 0.0111713 | France Telecom | 0.002422 | US |
| Centurytel | 0.0080831 | TDC A/S | 0.0088314 | US |
| BCE Inc | 0.0016433 | Telefonica | 0.0018127 | EUR |
| M&F Worldwide | 0.0091046 | Groupe Danone | 0.0021907 | EUR |
| Ralcorp Holdings | 0.0037014 | Cadbury Schweppes | 0.0018732 | US |
| Mccormick &Co | 0.001295 | Unilever | 0.00084575 | US |
| Smart and Final | 0.0142741 | Delhaize Group | 0.0041157 | US |
| Fedders Corp | 0.0142426 | Natuzzi SPA | 0.0073232 | US |
| Winn Dixie Stores | 0.0025971 | Royal Ahold | 0.0029 | US |
| CNA Financial | 0.0026223 | AEGON | 0.0020992 | EUR |
| Horace Mann Educators | 0.004842 | Allianz | 0.0036317 | US |
| Stancorp Financial | 0.0018497 | AXA | 0.0020504 | US |
| FBL Financial Grp | 0.0077774 | Royal and Sun Alliance | 0.0125151 | EUR |
| MasTec Inc | 0.0042873 | Chicago Bridge&Iron | 0.0040511 | EUR |
| Crawford and Company | 0.0167837 | Adecca | 0.0058341 | US |
| Gabelli Asset Mgt | 0.0032635 | AMVESCAP Plc | 0.0041915 | US |
| Nationwide Fin Services | 0.0032628 | ING Group | 0.0018504 | EUR |
| ConocoPhillips | 0.00065312 | BP Plc. | 0.00052596 | US |
| Marathon Oil Corp | 0.0011581 | Royal Dutch Petroleum | 0.00048054 | US |
| Unocal | 0.0014577 | TOTAL S.A. | 0.000797 | US |
| Apogent Technology | 0.002149 | Alcon Inc | 0.0014776 | US |
| Cleveland Cliffs | 0.0052459 | Rio Tinto | 0.0013166 | US |
| Carbo Ceramics | 0.0025212 | Core labs | 0.005312 | US |
| Buckeye Tech | 0.0101558 | Stora Enso | 0.0034648 | EUR |
| Schweitzer Mauduit Intl | 0.0030526 | UPM-Kymmene Corporation | 0.0049122 | US |
| Bradley Pharmaceuticals | 0.0043029 | Aventis | 0.0012985 | EUR |
| Pharmaceutical Resources | 0.0017099 | GlaxoSmithKline plc | 0.00082006 | US |
| Medicis Pharmaceuticals | 0.001419 | Novartis | 0.00085809 | US |
| Alpharma Inc | 0.002843 | AstraZeneca Grp | 0.000152 | US |

| U.S. Firm | Perspread | European Firm | Perspread | X |
|---------------------------|-----------|----------------------------------|------------|-----|
| Mylan Labs | 0.0011831 | Elan Corp | 0.00587 | US |
| KV Pharmaceuticals | 0.0067368 | Schering Aktiengesellschaft | 0.0030094 | EUR |
| Allmerica Financial Corp | 0.0017962 | Wilis Grp. | 0.0019741 | US |
| Coachman Industries | 0.0102348 | Pearson plc. | 0.0055529 | EUR |
| Dover Motorsports | 0.0191393 | Carnival Plc. | 0.0034355 | US |
| Memc Electronic Materials | 0.002989 | Infineon Technologies | 0.0019379 | US |
| Fairchild Semiconductors | 0.0015876 | STMicroelectronics | 0.00090429 | US |
| Arch Chemicals | 0.005199 | Imperial Chemical Industries PLC | 0.004133 | US |
| Rogers Corp | 0.0033578 | Syngenta | 0.0050665 | US |
| Cadence Design System | 0.00141 | SAP | 0.00087785 | EUR |
| Standard Commercial Corp | 0.0095623 | Gallagher Group Plc | 0.0026384 | US |

The first column of the table reports the list of U.S. firms, the second column the NYSE ticker symbols and the third column the mean percentage bid-ask spread for the trading period. The columns four, five and six report the same for the European firms and the seventh column reports the variable "X". If X= "US" ("EUR") it means the U.S.(European) firm in that pair has a higher percentage bid-ask spread. The column header perspread denotes the percentage bid-ask spread.

Table 4B: Percentage Bid-ask Spread Analysis for 2:30-3:00 PM

| U.S. Firm | Perspread | European Firm | Perspread | X |
|---------------------------|-----------|-------------------------|-------------|-----|
| Gerber Scientific | 0.0010091 | ABB Limited | 0.008576465 | EUR |
| Graco Inc | 0.0012433 | Mettler Toledo | 0.001591212 | US |
| Harte Hanks | 0.0045953 | Publicis Groupe S.A. | 0.000873659 | EUR |
| Tower Automotive | 0.0019991 | Autoliv Inc. | 0.006547056 | EUR |
| Bancorp South | 0.0008353 | Banco Bilbao | 0.002316949 | US |
| Bayview Capital | 0.0031356 | Banco Santander Central | 0.003066669 | EUR |
| Cullen/Frost Bankers | 0.0024092 | ABN AMRO Bank | 0.002789415 | EUR |
| First Fed Financial Corp | 0.0013428 | Allied Irish Banks | 0.001775627 | US |
| Valley National Bancorp | 0.002961 | Barclays Plc. | 0.000840659 | US |
| Bankatlantaic Bancorp | 0.0031099 | Credit Suisse | 0.001094616 | US |
| Chittenden Corporation | 0.006 | Deutsche Bank | 0.00408147 | EUR |
| M&T Bancorp | 0.0026336 | HSBC holdings | 0.002664052 | EUR |
| Community Bank System | 0.002539 | Sanpaolo IMI | 0.004432886 | US |
| Commercial Federal Corp | 0.0028195 | UBS AG | 0.0005872 | US |
| First Commonwealth | 0.0030552 | Lloyds TSB Group | 0.002749376 | EUR |
| Theragenic Corp | 0.0010034 | Serono | 0.004124914 | EUR |
| Hearst Arghyle Television | 0.0026937 | Vivendi Universal | 0.002755641 | EUR |
| Ameron International | 0.0013878 | Hanson Plc. | 0.002380152 | US |
| Guess Inc et al | 0.0008868 | Luxottica | 0.000471316 | US |
| American Tower Corp | 0.0028004 | Alcatel | 0.002644023 | US |
| Cable design Corp | 0.0030788 | Siemens AG | 0.003014056 | EUR |
| Corning Inc | 0.0012939 | Nokia Corporation | 0.00242495 | US |
| Spartech Corp | 0.006263 | BASF AG | 0.001501128 | EUR |
| Wellman Inc | 0.00042 | Bayer AG | 0.00325786 | US |
| NL Industries | 0.0113109 | Celanese AG | 0.005144409 | EUR |
| Harman Intl | 0.0018568 | Royal Phillips | 0.004104 | US |
| Brown Forman | 0.0065276 | DIAGEO plc | 0.00300783 | EUR |
| Unisource Energy | 0.0011638 | Endesa SA | 0.002007695 | US |
| CH Energy | 0.0149562 | E ON G | 0.005626067 | US |
| El Paso Electric | 0.0030378 | Scottish Power UK plc | 0.000626437 | US |
| IDT Corporation | 0.0044605 | Cable and Wireless | 0.00173422 | EUR |
| Cincinnati Bell | 0.0010326 | Deutsche Telekom | 0.004545848 | EUR |
| Sprint Corporation | 0.0015501 | France Telecom | 0.009541478 | US |
| Centurytel | 0.0046059 | TDC A/S | 0.004390942 | US |
| BCE Inc | 0.0115923 | Telefonica | 0.003618708 | EUR |
| M&F Worldwide | 0.0023867 | Groupe Danone | 0.002643699 | US |

| U.S. Firm | Perspread | European Firm | Perspread | X |
|---------------------------|-----------|-----------------------------|-------------|-----|
| Ralcorp Holdings | 0.005692 | Cadbury Schweppes | 0.000763981 | EUR |
| Mccormick &Co | 0.0010919 | Unilever | 0.004277899 | US |
| Smart and Final | 0.0018762 | Delhaize Group | 0.000598956 | US |
| Fedders Corp | 0.0092497 | Natuzzi SPA | 0.005679647 | EUR |
| Winn Dixie Stores | 0.0008523 | Royal Ahold | 0.002159306 | EUR |
| CNA Financial | 0.0013583 | AEGON | 0.004333959 | EUR |
| Horace Mann Educators | 0.0020099 | Allianz | 0.002120634 | EUR |
| Stancorp Financial | 0.0013177 | AXA | 0.002666733 | US |
| FBL Financial Grp | 0.0020905 | Royal and Sun Alliance | 0.002047568 | US |
| MasTec Inc | 0.0060751 | Chicago Bridge&Iron | 0.00115963 | US |
| Crawford and Company | 0.0062644 | Adecca | 0.001226834 | EUR |
| Gabelli Asset Mgt | 0.0005691 | AMVESCAP Plc | 0.005081196 | EUR |
| Nationwide Fin Services | 0.0005573 | ING Group | 0.000673902 | US |
| ConocoPhillips | 0.0011367 | BP Plc. | 0.001036373 | EUR |
| Marathon Oil Corp | 0.00053 | Royal Dutch Petroleum | 0.007632609 | EUR |
| Unocal | 0.0027923 | TOTAL S.A. | 0.006673918 | US |
| Apogent Technology | 0.0009996 | Alcon Inc | 0.000535088 | EUR |
| Cleveland Cliffs | 0.0010419 | Rio Tinto | 0.00936036 | US |
| Carbo Ceramics | 0.0043436 | Core labs | 0.002511999 | EUR |
| Buckeye Tech | 0.0008011 | Stora Enso | 0.000885683 | EUR |
| Schweitzer Mauduit Intl | 0.0020682 | UPM-Kymmene Corporation | 0.003924585 | EUR |
| Bradley Pharmaceuticals | 0.0020663 | Aventis | 0.005506266 | US |
| Pharmaceutical Resources | 0.0083422 | GlaxoSmithKline plc | 0.001110406 | US |
| Medicis Pharmaceuticals | 0.0035381 | Novartis | 0.002804125 | EUR |
| Alpharma Inc | 0.0009415 | AstraZeneca Grp | 0.002532697 | US |
| Mylan Labs | 0.0104231 | Elan Corp | 0.003581138 | US |
| KV Pharmaceuticals | 0.0043261 | Schering Aktiengesellschaft | 0.000825191 | EUR |
| Allmerica Financial Corp | 0.0023074 | Wilis Grp. | 0.004099447 | US |
| Coachman Industries | 0.008962 | Pearson plc. | 0.001165023 | EUR |
| Dover Motorsports | 0.0060444 | Carnival Plc. | 0.007122825 | US |
| Meme Electronic Materials | 0.0012676 | Infineon Technologies | 0.000452386 | US |
| Fairchild Semiconductors | 0.0029978 | STMicroelectronics | 0.000928274 | US |
| Arch Chemicals | 0.0015351 | Imperial Chemical Inds. PLC | 0.0005951 | EUR |
| Rogers Corp | 0.0018954 | Syngenta | 0.003973407 | US |
| Cadence Design System | 0.0018845 | SAP | 0.001285704 | US |
| Standard Commercial Corp | 0.0034847 | Gallagher Group Plc | 0.000819935 | EUR |

The first column of the table reports the list of U.S. firms, the second column the NYSE ticker symbols and the third column the mean percentage bid-ask spread for the trading period. The columns four, five and six report the same for the European firms and the seventh column reports the variable "X". If X= "US" ("EUR") it means the U.S.(European) firm in that pair has a higher percentage bid-ask spread. The column header perspread denotes the percentage bid-ask spread.

Sample Period 2:30-3 PM

Examining the evidence for bid-ask spreads from afternoon data, the mean *perspread* for the U.S. sample is 0.003287 and 0.0029956 for the European sample. So the mean *perspread* for the European sample is smaller than that of the U.S. sample by 3 basis points. The associated P value is 0.4954. Out of each of the pairs of firms it was found that for 35 pairs of firms the European firm has a bigger *perspread* and for the rest of the 37 pairs the U.S. firm has a bigger *perspread*. So the evidence seems to suggest that the pattern of bid-ask spreads for the U.S. and the European firms becomes more homogeneous during the NYSE afternoon than in the morning. We found the correlation coefficient between the mean *perspread* and the number of trades to be -0.0928 for the U.S. sample and -0.0104 for the European sample. The strength of the inverse relation between the bid-ask spread and liquidity that we obtained in the NYSE morning has also diminished during the afternoon.

Cross Sectional Regression on Perspread: 9:30-10 AM

We first examine the hypothesis that during the NYSE morning the European firms trade at a smaller bid-ask spread than the U.S. firms because of the presence of a substitute market. To test this, we ran a cross-sectional regression. The regression is specified as follows. The dependent variable is *perspread*, PS_i . It is regressed on the following dependent variables: Probability of informed trading PIN_i , a dummy d_i that takes the value 1 for a European stock and 0 for a U.S. stock, and the consolidated number of trades, $Trades_i$. The regression is done using White heteroskedasticity-consistent standard errors and covariance. Here i denotes firm. The estimation results are shown in the following regression equation:

$$PS_i = 0.002685 - 0.001976*d_i + 0.010838*PIN_i - 0.00000000317*Trades_i + \varepsilon_i \text{ where } \varepsilon_i \sim N(\xi, \delta^2) \quad (2)$$

(0.0068) (0.0003) (0.0002) (0.0067)

We find some interesting results in this regression. The significantly negative value, 0.001976 of the coefficient on the dummy d_i denotes that, after controlling for informed trading and liquidity, if we switch from a U.S. to a European firm, the value of *perspread* goes down by approximately 20 basis points. The significantly positive coefficient value of 0.010838 on the variable PIN_i suggests that as the value of the probability of informed trading in any stock goes up by 1, the percentage bid-ask spread for that stock goes up by 108 basis points after controlling for the dummy and the number of trades. The significantly negative coefficient on the liquidity measure $Trades_i$ denotes that after we control for informed trading and dummy, percentage bid-ask spread goes down by 7 basis points as we increase the standard deviation of $Trades_i$ by one unit.

Cross sectional regression on Perspread: 2:30-3 PM

The effect on percentage bid-ask spread due to the presence of a substitute market should disappear when the European markets close. The last European market to close trading for our sample is floor trading at the Frankfurt Borse which closes trading at 8 pm local time in Frankfurt. This translates to 2 pm local time in New York. So from 2-4 pm local time in New York only the NYSE is trading. To validate our theory of smaller bid-ask spread in the presence of a substitute market, empirically, we should expect to see the difference in bid-ask spreads between the U.S. and the European firms disappear during the NYSE afternoon when all the European markets have closed. So we estimated the same cross-sectional regression as before using data from the time period 2:30-3pm using White heteroskedasticity-consistent standard errors and covariance. The results of the estimation analysis are shown in the following regression equation:

$$PS_i = 0.003669 - 0.000313*d_i - 0.000906*PIN_i - 0.000000000988*Trades_i + \varepsilon_i \text{ where } \varepsilon_i \sim N(\rho, \psi^2) \quad (3)$$

(0.000) (0.4782) (0.5024) (0.1666)

The results indicate that the coefficient on the dummy is negative, still, but not significant, which suggests that the U.S. and the European firms do not have significantly different percentage bid-ask spreads after we control for liquidity and informed trading. The effect of liquidity and probability of informed trading on the *perspread* is no longer found to be significant. The results of the cross sectional regression for the two periods 9:30-10 am and 2:30-3 pm are documented in Table 5 shown below.

Table 5: Cross Sectional Regressions

| Panel A: Results for 930-10:00 AM | | | | |
|------------------------------------------|--------------------|-----------------------|---------------------|--------------------|
| | Coefficient | Standard Error | t-statistics | Probability |
| <i>Constant</i> | 0.002685 | 0.0068 | 3.502580 | 0.0006*** |
| <i>Dummy</i> | (-)0.001976 | 0.0003 | -3.830808 | 0.0002*** |
| <i>PIN</i> | 0.010838 | 0.0002 | 5.075426 | 0.0000*** |
| <i>Trades</i> | (-)0.00000000317 | 0.0067 | -2.642661 | 0.0092*** |
| R square | <u>0.324213</u> | | | |
| Panel B: Results for 2:30-3:00 PM | | | | |
| | Coefficient | Standard Error | t-statistics | Probability |
| <i>Constant</i> | 0.003669 | 0.000 | 10.02772 | 0.0000*** |
| <i>Dummy</i> | (-)0.000313 | 0.4782 | 0.453134 | 0.6512 |
| <i>PIN</i> | (-)0.000906 | 0.5024 | -1.125026 | 0.2625 |
| <i>Trades</i> | (-)0.00000000098 | 0.166 | -1.000537 | 0.3188 |
| R square | <u>0.009403</u> | | | |

The table summarizes the regression results. The results for the time period 9:30-10 am and 2:30-3pm are presented in Panels A and B respectively. The estimates are followed by the standard error, t statistic and p values. We are using 5% level of significance. The R square value is reported at the end of the table.

CONCLUSION

The study has tried to answer the question of whether the market maker at the NYSE faces more competition for European stocks which have a substitute market open during morning trading hours in New York than for U.S. stocks. This effect of the presence of a substitute market should disappear when all the European markets close trading during the NYSE afternoon. The results from our cross-sectional regression analysis seem to support the hypothesis nicely as percentage bid-ask spreads of European stocks are smaller than that for U.S. stocks in the New York morning. This difference disappears during the New York afternoon when European trading has ended. This indicates that the U.S. and the European markets are integrated during the period of overlap.

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