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ROUND-THE-CLOCK TRADING: EVIDENCE FROM U.K. CROSS-LISTED SECURITIES

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ABSTRACT

This paper uses transactions data from the London Stock Exchange to characterize the intraday pattern of security prices and trading volume for securities trading on SEAQ. It focuses in more detail on a sample of U.K. firms that are cross-listed on the NYSE. Using additional data from the NYSE-AMEX (ISSM), we compare volatility, volume, and quotes as trading starts in London and then continues in New York. These firms have substantially longer trading hours than most singly-listed stocks, and are also traded in two markets with very different institutional setups. This is shown to have several important implications for theories on intraday behavior of prices, the organization of exchanges, and the general consequences of round-the-clock trading.

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1. Introduction

During the eighties there has been substantial interest in market microstructure and in linkages across financial markets. Several studies of the intraday patterns of stock prices and trading volumes have established a set of stylized facts for firms trading in the United States, particularly those trading on the New York Stock Exchange [NYSE]. The stock market crash of October 1987 spurred interest in how large changes in market indices were propagated around the world. Such interest is more broadly related to the globalization of trading activities, and the related issue of appropriate trading hours for any individual market such as the NYSE.

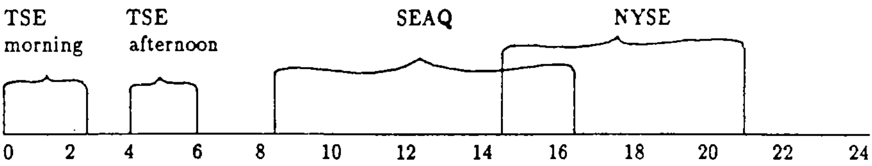
There are three principal objectives of this paper. First, using transactions data from the London Stock Exchange [LSE], we characterize the intraday pattern of security prices for firms trading in the Stock Exchange Automated Quotations [SEAQ] system.[1] Second, we study intraday patterns during both London and New York trading hours for a subsample of U.K. firms that are cross-listed on the NYSE.[2] Third, we use these new results from cross-listed securities to shed light on which of several alternate theoretical hypotheses can explain the empirical intraday behavior of securities prices and trading volume.

Characterizing the intraday pattern of securities prices on SEAQ enables us to distinguish between the patterns of intraday securities prices that are generic, and the patterns which are likely to be exchange-specific. This is particularly interesting since we are comparing two highly liquid markets that differ along several dimensions. SEAQ is a screen-based system with competitive market makers, while the NYSE has continuous floor trading with one specialist per firm. SEAQ has a minimum quote period but no official upper limits on trading hours, while the NYSE has set trading hours. Trading on SEAQ does not start with a call auction, while this is true for NYSE. Finally, and of particular interest for this study, SEAQ trading preceeds and partially overlaps with NYSE trading in a time dimension. Figure 1 illustrates the trading hours for markets in the three major time-zones in Greenwich Mean Time [GMT].[3] Note that the trading hours indicated for SEAQ reflects the minimum time period for which market makers are obliged to post firm two-way quotes.

The Tokyo Stock Exchange opens trading at midnight GMT (9:00 local time) with a call auction followed by the morning session of trading. The market closes between 2:30 (11:30 local time) and 4:00 (13:00 local time) when the second call auction takes place. The afternoon

[1] These data were kindly provided by the Quality of Markets Group at the LSE.
[2] In our sample of 23 cross-listed firms, 3 are listed on the American Stock Exchange [AMEX].
[3] This paper will use the European time-convention, i.e. 3:00 is 3:00 a.m. and 15:00 is 3:00 p.m.

Figure 1. Timeline



Time in Greenwich Mean Time.

session of trading continues until 6:00 (15:00 local time). There is a trading gap between 6:00 GMT and 8:30 when SEAQ opens in London. The minimal trading period for firms quoting in London is between 8:30 to 16:30, though trading takes place both before 8:30 and after 16:30. Finally, at 14:30 GMT (9:30 local time) the NYSE opens in New York with a call auction. Trading is continuous in New York through 21:00 GMT (16:00 local time).[4] Note that this implies that there is a minimal overlap between 14:30 and 16:30 GMT when both SEAQ and NYSE are trading simultaneously.

Studying the sample of firms that are cross-listed on several exchanges will shed light on a number of issues. Exchanges in the U.S. are currently debating if trading should be extended, ultimately potentially approaching the 24-hour trading that is found in foreign exchange markets. The sample of cross-listed firms offers us a unique opportunity to study price and volume patterns of stocks actively trading for a substantially longer time period during the day than any individual stock market is open. Such evidence is valuable for both policy makers and exchange officials in their efforts to make informed decisions about potential extension of trading hours. Second, given that a firm has chosen to cross-list its shares on a foreign exchange, its next concern is to attract foreign investors. One important pre-requisite for broad interest in a stock is that it is liquid, i.e. can be bought and sold at low costs, without delay, and with-

[4] NASDAQ was granted permission to launch an early-hours trading system on October 18th, 1991. The hours were 8:30 to 16:00 GMT (3:30 to 9:00 local time), which overlaps with the SEAQ trading hours. Market participants can access the NASDAQ screens from London as well as from the Continent. The trading volume generated has, however, been very small. This lack of interest might be a direct result of the fact that trading volume for U.S. securities on LSE's system for trading foreign securities, the SEAQ International, practically disappeared in 1990-1991. According to Mr. Stephen Wells of the Quality of Markets Group at the LSE, the drop in trading volume coincided with pressure from exchange officials in New York on its members to not execute trades abroad. In fact, the U.S. section for firm quotes was abandoned in early 1991 due to lack of volume. Market-makers now only make indicative prices and trading volume in U.S. securities is less than 0.6 percent of total trading volume on SEAQ International.

out substantially affecting the stock price. Since liquidity is related to transactions-costs, or bid-ask spreads, we will investigate whether the relations between bid-ask spreads and trading volume are the same for U.K. cross-listed firms as for other firms trading in the U.S.? Third, the two markets that we study in this paper have very different characteristics. Since we have intraday data from both markets for a set of cross-listed U.K. shares, we are able to distinguish between the effects on securities prices and trading volume that can be derived from the trading structure itself, and those intraday characteristics which are more generic.

Beyond these descriptive goals, our results are relevant for evaluating competing models of intraday stock price behavior. The U-shaped pattern in volatility of prices, trading volume, and bid-ask spreads which has been shown to characterize U.S. equity markets is conceivably related to three main lines of models that have been advocated to explain intraday prices: information models, inventory models, and models of specialist (market maker) market power. Much current research is based on the information models, which explain high volatility of returns at the beginning and the end of trading in terms of heavy trading by informed investors, and the consequent incorporation of their private information into prices. Our data on cross-listed securities enables us to compare price behavior, such as volatility and bid-ask spreads, across two markets with less than perfectly overlapping trading hours. Specifically, trading in the primary market preceeds and overlaps with trading in the secondary market. Thus, the primary market should facilitate price-discovery in the secondary market.

The paper proceeds as follows. Section 2 presents the methodology by which we will analyze the data and illustrate our results. Section 3 reproduces the stylized facts of NYSE intraday price and volume behavior for our sample and outlines the relevant literature on the information hypothesis. Section 4 characterizes the intraday patterns of securities prices and trading volume for U.K. non-cross-listed stocks, and compares them with the patterns from the U.S. given in Section 3. We focus attention on price and volume characteristics in each of the markets considered of the U.K. firms which are cross-listed on the NYSE in Section 5. Section 6 compares the behavior of stock prices and trading volume for the cross-listed securities across the two markets, namely for U.K. versus U.S. trading. We argue that the results are incompatible with the information hypothesis. Section 7 discusses the implications of our findings both for theoretical modelling of intraday securities prices, and for the policy debates on extension of trading hours and the microstructure of stock exchanges.

2. Data and Methodology

The U.S. data cover S&P 100 firms as well as the American Depositary Receipts [ADRs] of U.K. firms which are cross-listed on the NYSE or AMEX in 1991. We use transactions and quote data for January 1, 1991 through December 31, 1991.[5] Our U.K. data cover firms included in the FT-SE 100 share index on March 10, 1992. The FT-SE 100 comprises the top 100 U.K. companies by market capitalization.[6] According to exchange officials, these firms account for around 60 percent of all trades and about 70 percent of market capitalization on the domestic section of the London Stock Exchange. They are the most liquid stocks trading on the London Stock Exchange, which is why we selected the S&P 100 as a benchmark in the U.S. The period for which we have U.K. transactions data is October 1, 1991 through March 10, 1992. Our data include quotes and quote volumes for all market-makers in these stocks as well as transactions prices and trading volumes.

We use a standardized approach for characterizing the data. We first compute the sample-estimates of five-minute-return variances, average trading volume, and average bid-ask spreads, for each firm and each time-interval during the trading day from the raw intraday data. The return-variances are computed as the variance of five-minute-returns across trading days for a particular time-interval and a particular firm. The averages for trading volume and bid-ask spreads are arithmetic averages across trading days for a particular time-interval and a particular firm. For each subsample j and firm i, $\hat{\sigma}^{2\,j}_{it}$ denotes the variance across trading days of five-minute-returns in time-interval t, $\hat{V}^j_{it}$ is the average (across trading days) number of shares traded in time-interval t, and $\hat{S}^j_{it}$ is the average (across trading days) absolute inside spread *at the start of* time-interval t.

Table 1 reports descriptive statistics of these variables for each subsample. The subsamples are: FT-SE 100 firms which are not cross-listed on the NYSE or AMEX (79 observations); FT-SE 100 firms which are cross-listed on the NYSE or AMEX (23); the ADRs of the U.K. firms which are cross-listed on the NYSE or AMEX (28); and the S&P 100 firms (98). Two of the cross-listed firms have multiple ADRs trading in the U.S. which accounts for the difference in the number of U.K. cross-listed firms across the samples.[7]

The variability of five-minute transactions-returns is lower for the U.S. market than for SEAQ. While the cross-listed firms have a relatively low transaction-variance on SEAQ, the

[5] The data come from the Institute for the Study of Security Markets [ISSM] transactions data base.
[6] There are actually 102 stocks in the index at the time: a list is given in the Appendix.
[7] There are five ADRs traded for Barclays Bank, and two ADRs traded for Royal Bank of Scotland.

variance of their ADRs in the U.S. exceeds that of S&P 100 firms. Mid-point quote-returns are, however, more volatile in the U.S. market than in London. The variances of mid-point quote-returns for the S&P 100 firms are about twice as high as the variance for the U.K. cross-listed firms when trading in New York.

Trading volume in terms of number of shares traded cannot be compared across markets unless one corrects for the number of ADRs issued per share. This is done in Section 6. Cross-listed shares trade roughly twice as many shares as the rest of the FT-SE 100 firms. The corresponding ADRs trade about one fourth as many shares per five-minute interval as S&P 100 firms. Trading frequency show the same pattern within markets as the number of shares traded, but the S&P 100 firms are traded more than twice as often as the FT-SE 100 firms. Cross-listed firms have lower absolute spreads on SEAQ than the rest of the FT-SE 100 firms, while their ADRs have higher absolute spreads than S&P 100 firms in the U.S.

We use regression analysis to estimate the time-of-day-effects, denoted α_t, controlling for firm-effects, denoted β_i. The regressions take the following form

$$\hat{X}_{it} = \sum_{i=1}^{N} D_i\beta_i + \sum_{t\neq\tau} D_t\alpha_t + \epsilon_{it}, \qquad (1)$$

where $\hat{X}_{it} \in \{\hat{\sigma}^2_{it}, \hat{V}_{it}, \hat{S}_{it}\}$, N is the number of firms, $t \in (1,T)$ where T is the number of time-intervals, D_i is a vector of firm dummies, D_t is a vector of time-interval dummies, and ϵ_{it} is an error term. Since we are interested in the pattern of the time-of-day effects, and in particular want to see whether the U-shaped pattern emphasized in other studies of intraday price and volume behavior are present in our data, we eliminate the time-interval τ = 12:30-12:35. The estimated parameters, α_t, are thus deviations from the time-of-day-effect at 12:30-12:35. We will call this time-interval mid-day.

The point-estimate for the level of the time of day effects is recovered in the following fashion. Consider the regression with only time-interval effects which are estimated with coefficients γ_t

$$\hat{X}_{it} = \sum_{t=1}^{T} D_t\gamma_t + \nu_{it}. \qquad (2)$$

The coefficient at mid-day, $\hat{\gamma}_\tau = \sum_{i=1}^{N} \hat{\beta}_i/N$ is the benchmark for the level of the time-of-day effects. We can recover the corresponding levels of the other five-minute-intervals by adding this point estimate to the estimated $\hat{\alpha}_t$, i.e. $\hat{\gamma}_t = \hat{\alpha}_t + \hat{\gamma}_\tau$. For most of our analysis, the actual level of the time-of-day-effects is not important. In our graphical illustrations, the upper and lower 95-percent confidence-intervals will thus refer to the difference between the level at 12:30-12:35 and the level at other times of the day. A significant positive t-statistic indicates that an estimated coefficient is significantly higher than the level at mid-day after controlling for cross-sectional variation attributable to firm effects. In the graphs of the time-of-day-effects, the period τ point-estimate will be marked with a hollow square. The actual point-estimate and its standard error based on the specification in equation (2) will be reported parenthesis in each graph. We also report the F-value for the regressions in equation (1). To conserve space, we do not report the estimated coefficients for the firm effects.

3. Intraday Patterns and the Information Hypothesis

To compare data for the time period of our study with previous empirical studies, we first characterize the intraday pattern of volatility, volume, and spreads for the set of S&P 100 firms which traded on the NYSE during 1991. The results from the regression analysis for this sample of firms are illustrated in Figure 2.

[Figure 2.]

Figure 2a shows the regression results for fitted five-minute transactions-return-are multiplied by 10,000. The solid line represents the fitted values per five-minute interval and the dashed lines are the upper and lower 95-percent confidence-limits. The hollow square indicates the return-variance for the interval 12:30-12:35. Returns are significantly more volatile in the first hour of trading on the NYSE than at mid-day.[8] In addition, variances are significantly higher towards the end of the trading day, resulting in the U-shaped pattern of volatility documented in Wood, McInish and Ord (1985) and McInish and Wood (1987).

Figure 2b gives results corresponding to those in Figure 2a, for variances of returns calculated from the mid-point of bid and ask quotes. Four main results are apparent from Figures 2a and 2b. First, the transactions-variances in Figure 2a show greater intertemporal volatility than the mid-quote variances, which is at least partly attributable to the effects of bid-ask bounce. Second, the transactions-variances in Figure 2a are in general much higher than the mid-quote variances in Figure 2b. Third, both measures show very high return variances at the start of the trading day, which decline rapidly. Fourth, however, the behavior of the variances at close

[8] Returns are calculated starting at 9:34. This is an unintentional correction for delayed open,and will be corrected in the next version of the paper.

of trade differs across the two variance measures. While the transactions-variance increases significantly at close relative to mid-day, the mid-quote variance shows no significant increase at close relative to mid-day.

Figure 2c documents the fitted values for trading volume, measured as number of shares traded per firm, for the S&P 100 firms. Trading volume shows a distinct U-shaped pattern with significantly higher trading volumes at the open and at the close. Figure 2d gives the fitted values for average absolute bid-ask spreads sampled every five minutes. The hook at the very start of the trading day is likely to be due to delayed open.[9] As noted in Brock and Kleidon (1992), spreads are distinctly U-shaped over the day. Spreads are significantly higher from the open to 11:00, and again rise significantly above the mid-day-level during the last 35 minutes of trading.

One explanation for the observed intraday patterns in securities markets comes from the literature on asymmetric information. Building on Kyle (1985), Admati and Pfleiderer (1988) show how trading volume during the day can be endogenized. Assuming that a subset of agents can choose when to trade during the day, they will trade when transactions costs are lowest. Moreover, periods of high trading volume offer informed traders the opportunity to disguise their trades. Admati and Pfleiderer obtain an equilibrium of concentrated trading because, given their assumption of risk neutral informed traders, competition among informed traders reveals enough of their information to make the trading costs to the uninformed *lowest* when the informed are trading most heavily. Consequently, in this model, both informed and uninformed choose to trade simultaneously.

Informed trades convey to the market previously private information, causing higher volatility of prices in periods of high informed trading, which in the concentrated trading model correspond with periods of high trading volume. Admati and Pfleiderer motivate their work by noting the correspondence between periods of high volatility on the NYSE and periods of high volume, as seen in Figures 2a and 2c: returns are more volatile when there is high trading volume at the open and close of trading.

The problem for this information story is the evidence presented in Figure 2d; transactions costs as measured by the bid-ask spread are *high* in the morning and towards the close when volume is high and returns are volatile. Early work by Bagehot (1971) on market microstructure claims: "The smallest spread a market maker can maintain and still survive is inversely related to the average rate of flow of new information affecting the value of the asset in question" (p. 13).

[9] The first spread is the average spread at 9:30.

This is consistent with the evidence in Figures 2c and 2d, if periods of high variance are equated with periods when it is likely that informed traders are in the market; that is, highest spreads coincide with periods of highest informed trading. However, Bagehot's argument implies the opposite relation between transactions costs and informed trading to that given by Admati and Pfleiderer, although both analyses are based on the distinction between informed and uninformed traders.

Bagehot's result is also reached by Subrahmanyam (1989, 1991), who assumes that the informed traders in Admati and Pfleiderer's model are risk averse rather than risk neutral. Subrahmanyam (1989, p. 18) cites Foster and Viswanathan (1989) as showing that the adverse selection component of bid-ask spreads is highest at the beginning of the day, which "contrasts with the model of Admati and Pfleiderer [1988], which predicts that spreads should be *lowest* at the beginning of the day" (emphasis in original). Subrahmanyam interprets this result as consistent with his extension of Admati and Pfleiderer to the case of risk averse informed traders, since then more trading by informed traders results in lower market liquidity and higher costs. To do this, he requires (p. 17) the additional assumption that "more individuals are informed at the beginning of the day than at other times during the day."

If the opening of trading comes after a period of market closure when private information has not been incorporated into prices, this argument suggests that the market maker would raise the bid-ask spread at the open. Price discovery would make returns more volatile at the start of trading than for the rest of the day. However, for this argument to provide a complete explanation of the spread and volatility behavior given in Figures 2a and 2d, Subrahmanyam (and Bagehot) would presumably require that the informed also trade more heavily at close, although the motivation for such behavior is not clear. Moreover, this story does not explain the issue that first attracted Admati and Pfleiderer, namely why trading volume follows the U-shaped pattern shown in Figure 2c, since their concentrated equilibrium is lost if the arguments of Bagehot and Subrahmanyam are accepted. One possibility is that liquidity traders who have no discretion as to when to trade (who constitute one group of traders in the Admati and Pfleiderer model) have exogenous high demand to trade at open and close, although such an assumption would place the explanation for volume outside the scope of these information models.[10]

Our sample of cross-listed securities is particularly valuable for an empirical evaluation of information models. In particular, when trading opens in New York for our sample of

[10]See also Brock and Kleidon (1992), especially Section 4.3.

U.K. stocks trading on the NYSE, these securities have already been trading in London for a minimum of six hours and continue to trade there simultaneously with New York. At the opening of trading in New York, therefore, there is less likelihood of major new information about the economic fundamentals relevant to these firms that is not already incorporated in prices in London. This is particularly true if the investors who are likely to be privately informed, i.e. insiders and institutional investors, have had previous access to the market in London. However, if some informed investors are reluctant to use the London market, and postpone trading until the NYSE open, they could conceivably create higher volatility at the NYSE open as their information is incorporated in prices. If this is the case, however, we should see a contemporaneous increase in volatility of prices in London.

We are thus primarily interested in three features of the intraday patterns for cross-listed securities. First, what is the behavior of these securities in London at the time of the New York opening? Specifically, do spreads and volatility in London increase significantly when the New York market starts trading? Second, do U.K. cross-listed firms in New York behave any differently during NYSE trading than do U.S. firms? That is, do they have high volatility and high spreads at the open and during the period immediately following the open? Finally, is there any significant reaction in spreads and volatility of returns in New York as the London market closes? We now turn to these questions.

4. Intraday Patterns for Firms Trading on SEAQ

In recent years, a substantial amount of research has been produced on the microstructure of stock markets in the United States. Relatively little work has, however, been produced about other major stock markets around the world. Exceptions include studies that use data from international stock exchanges to shed light on two issues: whether a call auction or a continuous market is a more efficient market mechanism; and whether volatility of prices is created by release of public information, by revelation of private information through trading, or simply by noise created through the actual trading process. These studies include Amihud and Mendelson (1989, 1991) who study the markets in Israel and Japan; Barclay, Litzenberger, and Warner (1990) who study Japan; and Amihud, Mendelson and Murgia (1990) who focus on Italy.

Higher frequency intraday data from foreign markets are used by Biais, Hillion, and Spatt (1992), who study the supply of liquidity and the competitive behavior of market participants in the recently introduced electronic limit order book of the Paris Bourse; Pagano and Roell (1990, 1991, 1992), who study intraday data from the Milan Stock Exchange, the Paris Bourse, and the London Stock Exchange for Italian and French firms that are cross-listed in London; and Hamao and Hasbrouck (1993) who find the intraday pattern of volatility, volume and spreads for three securities trading on the Tokyo Stock Exchange to have the characteristic U-shape. Neuberger and Roell (1992) use intraday data from 14 British companies over 6 months (September 1987 to February 1988) to study the components of the bid-ask spreads quoted on SEAQ. To our knowledge, no prior research has documented the intraday behavior of securities prices and volume for U.K. firms trading in London.

4.1 Institutional Background

In October 1986, the SEAQ electronic trading system for equities opened in London. This was part of the market reforms, colloquially referred to as the Big Bang, aimed at scrapping the system of fixed commissions. Exchange members started performing the capacities of both brokers and market-makers (jobbers). The trading system itself was copied from NASDAQ. It was meant to be an alternative to floor trading, but in only three weeks the new system had absorbed practically all the trading volume on the LSE. The SEAQ has competitive market-makers who undertake to quote two-way prices during the minimum quote period [MQP]. In December 1991, there were 25 market-makers active on the domestic SEAQ and 54 market-makers on SEAQ International. The quotes and quote volumes are posted on computer screens. Market-makers also post a quote-window during which time the prices are valid. For heavily traded stocks, i.e. those with a Normal Market Size [NMS][11] above 2,000 (about 900 stocks), a market-maker on SEAQ during our sample period was obliged to enter the price, time and the number of shares involved in the transaction into the public computer system *immediately* for trades up to three times the stock's NMS, and *within 90 minutes* for trades larger than three times the stock's NMS.[12] The computer system [TOPIC] automatically delays the public broadcast of information for large trades, but reports to the LSE (which comprise our data) are supposed to take place without delay.

The SEAQ minimum quote period [MQP] for U.K. firms runs from 8:30 to 16:30 GMT.[13]

[11] NMS is defined as 2.5% of a stock's average daily turnover over the preceeding 12 months.

[12] SEAQ trades in stocks with an NMS of less than 2,000 are published the following day in the Daily Official List (DOL); *Quality of Markets Review - Summer*, (1991), p. 35.

[13] For foreign firms, the MQPs on SEAQ International vary by nationality. Firms from Australia, Austria, Belgium, Holland, Hong Kong, Italy, Malaysia, New Zealand, Portugal, Scandianvia, Singapore, South Africa, and Switzerland have MQPs of 9:30-15:30. French, German, Japanese, Mexican, and Spanish firms have MQPs

Market-makers are allowed to quote outside the MQP, but such quotes are not firm. In practice, the market opens around 8:00 and effectively closes around 17:00. Trades do, however, come in throughout the late evening hours, especially in more liquid stocks. Trades are negotiated over the phone, and a substantial share of the trades are transacted inside the quoted spread.[14] The London market is dominated by institutional investors, and it is perhaps not surprising that larger deals are done at more favorable prices than small ones.

4.2 Intraday Pattern for Non-Cross-Listed FT-SE 100 Firms

There are 79 FT-SE 100 firms which are not cross-listed on the NYSE or AMEX during our sample period.[15] For simplicity, we will henceforth call these the FT-SE 100 firms. We employ the same set of graphs produced for the S&P 100 firms in Section 3 to characterize the intraday pattern of our sample of FT-SE 100 firms. The same definitions of variables apply except where noted. Since trading hours in London extend outside the MQP, we examine the period for which there was regular trading volume, namely 8:00 to 17:00. Note, however, that quotes are not firm outside the MQP, i.e. before 8:30 and after 16:30.

[Figure 3.]

Figure 3a shows the fitted time-of-day-effects for transactions-return variances. Returns prior to 8:20 and in the period 16:25-16:45 are significantly higher than at mid-day. Volatility is generally U-shaped over the day with the largest volatility after the end of the MQP. Note also that the volatility of transactions returns at 12:00-12:05 is significantly higher than at mid-day. Transaction-return-variances are quite noisy due to bid-ask bounce, and the precision gets lower outside the MQP due to infrequent trading.

To verify the U-shaped pattern, we also compute the variances of mid-point quote-returns for each firm and each time-interval. Since there are several competing market-makers per firm simultaneously quoting two-way prices, we first compute the inside spread (touch), i.e. the lowest ask and the highest bid price, minute-by-minute for each firm for each trading day. The five-minute, mid-point-quote-return is then calculated for each time-interval, and its variance

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9:30-16:00, 9:45-15:30, 8:30-15:30, 9:00-15:30, and 10:00-15:30 respectively. Market-makers no longer make firm quotes in U.S. securities on the SEAQ International.

[14]About 35% of bargains in liquid securities were transacted inside the touch, i.e. the best spread quoted, during the first quarter of 1992. See *Stock Exchange Quarterly with Quality of Markets Review - Spring*, (1992), p. 27.

[15]However, some of these might be cross-listed on other foreign exchanges.

for each firm across trading days is computed. The fitted values for the time-of-day-effects for these mid-point quote-return-are displayed in Figure 3b. The pattern is U-shaped, and now the early morning returns are more volatile than those at and after the end of the MQP. The two five-minute intervals after 16:30 have significantly higher quote-return-volatility than the mid-day level, as do several periods throughout the morning, but the volatility at 12:00-12:05 is no longer significant.

Figure 3c reports the fitted five-minute average trading volume per firm. Although firms are not required to start quoting until 8:30, several of the market-makers start trading as early as 7:15. The first observation represents the cumulative value of all trades prior to 8:00. The last observation gives the cumulative trading volume after 16:55. The trading volume has a two-hump-shape rather than a U-shape over the day. In particular, trading volume at 8:30 is not exceptionally high although it is significantly higher than the volume during mid-day. There are spikes in trading volume at 10:00 and at 12:00. According to exchange officials, this is likely to be due to programmed trading of portfolios. We see a tendency for trading volume to fall during between 13:00 and 14:00, and pick up again towards the end of trading.[16] Trading volume for the entire period 14:40 to 16:30 is significantly higher than at mid-day. By far the largest trading volume takes place at 16:25-16:30 which is the end of the MQP, although the market continues trading until well after 17:00.

Finally, Figure 3d documents the fitted average inside spreads. Spreads are seen to be U-shaped over the day, but they fall much faster to their mid-day level than for the sample of U.S. firms reported in Figure 2d.[17] Note that the increase in average spreads takes place *after* the large order-flow occurs at 16:30. Since quotes are not firm outside the MQP, we should not put too much weight on the absolute spreads at such times. The spreads are actually declining over the MQP, and reach their lowest level at 16:25, just before the end of the MQP.

In sum, the FT-SE 100 firms have an intraday pattern of returns and volume that is quite different from the S&P 100 firms. Volatility is generally U-shaped. The late afternoon has the highest volatility when we consider transactions-return-variances, while the morning has the highest volatility when we consider mid-point-quote-variances. Trading volume has a two-hump-pattern rather than a U-shape over the day, and there is not a large concentrated order-flow in the morning in the U.K. Spreads are virtually flat for the entire period where all registered market makers are posting quotes, whereas it is substantially larger in periods when quotes

[16]Notice that "lunch" in the City of London is 13:00-14:00.

[17]Before 8:01, no quotes are posted although transactions (negotiated by telephone) can occur.

are not firm and fewer market makers are posting quotes. The program trading that seems to be going on at 10:00 and 12:00 does not cause increases in spreads. The trades at 12:00 do, however, coincide with high volatility of transactions prices; and while the trades at 10:00 coincide with high volatility of quote mid-point relative to mid-day, the quote volatility from 9:00 to 11:00 is frequently higher than that at mid-day.

5. Cross-Listed Securities

Evidence from the microstructure of quoted prices and actual trades of firms which are cross-listed on several exchanges internationally will shed some light on the currently debated extensions of trading hours in the U.S. Since trading cross-listed firms in a foreign market might be expected to affect prices and volume in the market of primary listing, this evidence will also speak to the competition for trading volume across geographical areas, market structures, and time-zones. Lack of such effects would suggest that securities markets are segmented across geographical boundaries.[18] Cross-listed securities also offer valuable additional information about which of the theories currently proposed to explain the stylized facts for intraday prices and volume on individual (U.S.) markets are consistent with the new international emprical evidence.

5.1 Background on Cross-Listing

Cross-exchange trading, i.e., local trading in cross-listed foreign securities, has increased dramatically since the mid-1980s. Table 2 summarizes some key features about international equity trading, with particular focus on the two markets that we are studying, the NYSE and SEAQ. Gross global cross-exchange trading increased from US$100.7 bn in 1986 to US$763.5 bn in 1991. During the same period, cross-border trading, i.e., trading in securities on a foreign market, went up 63 percent from US$800.8 bn to US$1,320.0 bn. By far the largest market for trading in cross-listed securities is SEAQ International which opened in June 1985 in London. The LSE estimates that the volume of trading in foreign securities during the first half of 1991 roughly equalled that of trading in U.K. firms.[19] This market captured about 65 percent of global cross-exchange trading, according to estimates by Howell and Cozzini (1991, p. 24).

[18] Alexander, Eun, and Janakiramanan (1988) study the impact on cumulative average residuals for 13 Canadian, 10 Japanese, 7 Australian, 2 South African, 1 Danish, and 1 U.K. firm that were listed on U.S. exchanges between 1969 and 1982. Non-Canadian firms were found to have a significant decline in expected returns upon listing in the U.S., supporting the segmentation hypothesis.

[19] *The Economist*, October 26, (1991), pp. 23-24.

Firms from Japan, Germany, and France account for the bulk of such trades.[20] Howell and Cozzinin (1991, p. 24) also report that in 1990, 608 foreign companies were listed in London and the trading volume in these securities corresponded to US$283.5 bn, while there were 95 foreign firms listed on the NYSE with a trading volume of US$80.6 bn.[21] ADRs accounted for 65 percent of trading volume in foreign equities in the U.S. in 1990, and 57 percent of those ADRs are U.K. companies.[22] All the cross-listed firms in our study are traded as ADRs in the U.S.

[Table 2.]

5.2 Literature on Cross-Listed Securities

Forster and George (1992) study opening and closing prices and volume from the NYSE for a sample of cross-listed U.S., U.K., and Japanese firms. The sample period is January 1, 1986, to December 31, 1987. They find that foreign firms listed on the NYSE do not have significantly higher open-to-open return volatility than close-to-close return volatility in New York trading. U.S. firms, however, are found to have a significantly higher volatility of open-to-open returns than of close-to-close returns, and this is true whether or not they are cross-listed in foreign markets. The study also documents that the trading volume for U.S. securities (whether cross-listed or not) is relatively higher at open than at close. The pattern is not similar for foreign firms. Forster and George interpret their results as evidence supporting the hypothesis that the accumulation of orders is responsible for the greater volatility at the open, and not the call auction itself or the pricing behavior of NYSE specialists.

An information-based theoretical model for the effects of cross-listing is developed in Freedman (1990). It predicts that listing in a second market which is open *after* the primary market should result in less volatile prices in the primary market since informed traders have access to a second market in which to trade on information. On the other hand, the recent model in Spiegel and Subrahmanyam (1993) predicts that prices should be more volatile if trading is

[20] Howell and Cozzini (1991, p. 24) estimate that, for 1990, 26.9 percent of the trading volume on the SEAQ International was in Japanese securities, 23.8 percent in German, 11.7 percent in French, 7.9 percent in Dutch, 6.1 percent in Swiss, and 6 percent in Scandinavian securities. U.S. firms accounted for only 4.5 percent of trading on SEAQ International in 1990 and their share has fallen considerably since.

[21] NASDAQ had more foreign companies listed, 271, but a substantially lower trading volume, US$28.4 bn. AMEX had 67 foreign firms listed and trading volume of US$5.7 bn.

[22] The rest of the trading volume in 1990 was distributed as follows: Netherlands 22, Spain 5, Sweden 4, Japan 3, South Africa 3, Australia 1, and "Other" 5 percent (Howell and Cozzini, (1991), p. 23).

continuous than if trading is interrupted by periods of closure.

Forster and George (1992) report evidence on daytime versus overnight return variances, and overnight variances (defined relative to the U.S. market) are relatively higher for foreign firms than for U.S. firms. If return variances reflect information being incorporated into prices through trading, this would suggest that the majority of information flow takes place when the stock market of primary listing is open. Since cross-listing of U.S. firms seemed to have little effect on the volatility-volume pattern, they also infer that markets are segmented. This seems consistent with Barclay, Litzenberger, and Warner (1990), who find that the day-to-night variance ratios for cross-listed U.S. stocks are virtually identical to those of non-cross-listed stocks. However, Forster and George (1992) also find that cross-listing in London for U.S. firms does not alter the day-to-night variances, while cross-listing in Tokyo significantly decreases the day-to-night variance ratio. Amihud and Mendelson (1991) find the ratios of open-to-open to close-to-close variances to be lower for Japanese companies that are cross-listed in the U.S. than for non-cross-listed companies. They conclude that "the globalization of trading may have a beneficial effect on value discovery" (p. 1788). The evidence is thus inconclusive as to the effect of cross-listing on the volatility and the efficiency of prices.

With an emphasis on the competition between European stock exchanges, Pagano and Roell (1990, 1991, 1992) study French and Italian stocks that are cross-listed on SEAQ International. The focus of these studies has been on the implications of trading structure and transactions costs for the local concentration of volume. In Paris, stocks are traded using *cotation assistee en continu*, CAC, which allows continuous dealing with automated clearing. In Milan, execution of orders is by a traditional batch auction. The studies document that the actual costs for similar trades on the market of primary listing and SEAQ International in London were virtually identical. No arbitrage opportunities due to mis-aligned prices across markets were found. Their evidence moreover indicates that it is primarily the large institutional investors that prefer the London dealer-market. Although there is substantial competition for trading volume in cross-listed securities between exchanges in Europe, the primary auction-markets are still viable but attract primarily smaller investors. U.K. firms which are cross-listed in the U.S. provide evidence on the additional dimension of competition across time-zones. For issues pertaining to the extension of trading hours, this is the relevant concept.

5.3 Intraday pattern for U.K. Cross-Listed Securities in the U.K.

FT-SE 100 firms which are cross-listed in the U.S. are on average more heavily traded on

SEAQ than their non-cross-listed counterparts, as we saw from Table 1. Figure 4 repeats the analysis of the previous sections for the cross-listed firms during U.K. trading on SEAQ.

[Figure 4.]

Figure 4a shows the fitted variances of transactions-returns. Volatility displays the familiar U-shape and is very similar to the results for the non-cross-listed firms. In particular, volatility around 14:30 when New York starts trading these securities is not significantly higher than at mid-day. Figure 4b shows the fitted return-variances calculated from quote-mid-points. The U-shape is pronouced, although the variance of returns at 12:00-12:05 is also significantly higher than at mid-day. The highest variance is for the time-interval 8:35-8:40, and volatility is significantly higher than at mid-day just after the end of the MQP, 16:30-16:35. Again, there is no evidence of sigificantly higher volatility around 14:30 when the NYSE opens.

The pattern of fitted trading volume is shown in Figure 4c. The general pattern of trading volume is the same two-humped-shape as for the non-cross-listed firms. Volume in the period 14:40 to 16:30 is significantly higher than at mid-day. Finally, Figure 4d reports the fitted values for the time-of-day-effects of absolute inside spreads. The pattern of absolute bid-ask spreads for cross-listed firms is the same as for non-cross-listed firms. Spreads are generally declining over the course of the MQP and are in fact significantly lower in the period from 15:30-16:25 than spreads at mid-day.

5.4 Intraday Pattern for U.K. Cross-Listed Securities in the U.S.

Among our FT-SE 100 firms, 20 companies are cross-listed on the NYSE and 3 companies are cross-listed on AMEX. The underlying shares are deposited with a sponsor who issues ADRs priced in US$.[23] In fact, several firms have have multiple ADRs trading in New York. Our sample includes the ADRs for our sample of firms which traded at least 190 of the 251 trading days during 1991, resulting in 28 securities.[24] Howell and Cozzini, (1991, p. 23) report that approximately 13 percent of turnover by value of trades in U.K. cross-listed companies took place in the U.S.

[Figure 5.]

[23] The Appendix indicates which firms are cross-listed.

[24] Courtauld only traded 104 days in 1991, and is excluded from the transactions data analysis.

Figure 5a reports the fitted variances of five-minute-transactions-returns for U.K. firms trading in New York. The volatility estimates are rather noisy due to bid-ask bounce and infrequent trading. Only the volatility of returns at 13:45-13:50 is significantly higher than the volatility at mid-day.[25] Fitted values of variances of mid-point quote returns are reported in Figure 5b. The results in Figure 5b are in general more similar to those in Figure 2b (U.S. S&P 100 firms) than in Figure 4b (U.K. cross-listed firms in U.K. trading), especially the high opening variance and mild increase at close of trading. However, the mid-quote variances in Figure 5b appear somewhat high (relative to mid-day) from open of trade to about 11:30, which coincides with the overlap of trading in London; the S&P stocks do not exhibit this behavior.

The fitted average trading trading volume is given in Figure 5c. The familiar U-shaped pattern in trading volume documented for the S&P 100 firms is present also for cross-listed securities. Order-flow at open and for the time period up to 10:35 is significantly higher than at mid-day, while there is less of a pronounced increase in order-flow towards the close. In fact, it is only the five-minute interval just before the close which has a significantly larger number of shares traded than at mid-day.

Fitted values of average (absolute) bid-ask spreads sampled each five minutes for U.K. cross-listed securities are traced out in Figure 5d. Spreads are significantly higher than at mid-day for the first hour of trading, and significantly lower during the last hour of trading in New York. In contrast to the results for S&P 100 firms in Figure 2d, spreads are thus not U-shaped for U.K. ADRs trading in New York.

6. U.K. Cross-Listed Securities Across Time-Zones

To highlight the interaction across markets, we present graphs describing the intraday pattern of returns, volume, and spreads for our sample of U.K. cross-listed firms in GMT for trading in *both* markets. As shown in Figure 1, there is a 5 hour time shift between London and New York. The number of shares traded in London are translated to ADR-equivalents by dividing the London volume for each firm by the number of underlying shares per ADR. To translate £-spreads into US$ spreads, we first translate (Pence) spreads for each firm each day into US$s using daily exchange rates quoted in London around 17:00 each day (average of bid and ask), and then multiply the resulting US$-spread by the number of underlying shares per

[25] However, note that the first returns (inadvertantly) are calculated from 9:35-9:40, so we are missing the open.

ADR. We do not adjust for changes in exchange rates when comparing the volatility of returns across markets.

[Figure 6.]

In Figure 6a, we see that volatility of returns based on transactions prices in London is not elevated when New York starts trading at 14:30 GMT, and the end of the MQP in London is not associated with significantly higher volatility in New York. Figure 6b shows the results for variances of mid-point quote-returns. Again, the variances in London show no significant increase as New York opens, although in New York the opening variances are very high; and the increased volatility in London at the end of the MQP is not mirrored in increased volatility in New York.

Trading volume across markets is reported in Figure 6c. As noted above, the pattern of trading volume for the cross-listed firms is very similar to the pattern of trading volume for non-cross-listed firms. Interestingly, the ADR-equivalent, average volume in London when New York opens is not much larger than the average ADR volume in New York. Using the intraday pattern for non-cross-listed U.K. firms as a benchmark, it does not seem that SEAQ in London is losing a disproportionate amount of trading volume to New York when both markets are open. Of course, this does not imply that the overall level of trading volume in London is unaffected by the trading activity in New York. Also, the pattern of trading volume for the ADRs of cross-listed firms is similar to that of other NYSE stocks. The main difference is that the significant increase in order-flow at the close in New York is missing for the ADRs.

Finally, we report the spreads in US$ for each market in Figure 6c. The confidence-intervals indicated around the spread in each market are those appropriate for the *level* of spreads. The point-estimates of the spreads in New York are generally higher than those in London, but the difference is not significant taking the standard errors of the levels into account. Note that there is no significant increase in spreads in London as the market in New York for these securities opens. Instead, spreads are falling during this period of the day. This is the case both for cross-listed and non-cross-listed firms. In New York, spreads are also falling during this entire period and there is no significant increase in spreads on the NYSE as the MQP ends in London (16:30 GMT) with high volatility both in transactions prices and quotes.

7. Implications and Conclusions

It is difficult to reconcile this evidence with the information hypotheses discussed above. The U.K. cross-listed securities have been trading for at least 6 hours when the NYSE opens, yet spreads and volume are both high when these firms start trading in New York. Our measure of mid-quote volatility is significantly higher at open in New York for these securities.[26] If volatility is truly higher at the open, and this is caused by the trading activities of informed investors in New York, these investors must be reluctant to trade on their information in London. However, even if markets are segmented in this fashion, we would expect the information content of the trades to affect the contemporaneous volatility of returns in London; but there is no apparent reaction in volatility or spreads on SEAQ in London for cross-listed stocks when the NYSE opens. In fact, spreads are *falling* in London during this period of the day. Further, there is no noticeable impact on prices or volatility in New York when London closes, suggesting that the two markets are indeed fairly segmented. Similar results are reported by Hsieh and Kleidon (1992), who examine quote volume, volatility and spreads for London versus New York traders in the foreign exchange market.

Not only are SEAQ and the NYSE not fully integrated, but their very different market structures appear to result in different intraday patterns in prices and volumes. One might ask which features of the data are directly related to the market mechanism, and which are more generic patterns for securities prices and trading volume. The results in Figure 2 for the S&P 100 in New York confirm previous findings of a close relation between volatility, volume and spreads, with a particularly high (positive) correlation between volume and spreads and a distinctive U-shape in both. These results contrast with those in Figure 3 for the FT-SE 100 in London. In particular, volume is much more complicated, with a general bimodal distribution over the day, and conspicuous spikes at regular intervals (such as 10:00 and 12:00). There is not a consistent pattern of high volume coinciding with high volatility. In the morning, high volatility goes with low volume while the reverse is true in the late afternoon. The pattern of volatility and spreads is also somewhat complicated. Although the high levels of volatility before and after the MQP are associated with higher spreads, the significantly higher transactions volatility at noon does not coincide with higher spreads; however, mid-quote volatility (for non-cross-listed firms) is not elevated at noon, suggesting that program trades may affect transactions prices but not quotes.

[26] It is possible that our measure of transactions-volatility fails to find a significantly higher volatility in the morning due to the omission of the first five minutes of trading.

Figure 7 invites us to speculate on the effects of competition on spreads for SEAQ. The thicker line represents volume, while the dashed line is the inside spread for the U.K. cross-listed firms. During the MQP, there are between 10 to 15 market-makers for each firm posting quotes.[27] The period between 8:00-8:30 which is characterized by high spreads has low volume. Spreads increase again in the late afternoon. This increase in spreads takes place *after* the large order-flow at 16:30. A more careful look at the data reveals that very few market-makers are quoting in the system in the early morning and late afternoon. A tentative conclusion is that the competition between market makers intensifies in periods of high volume, producing a negative correlation between volume and spreads.[28] Figure 7b shows that spreads are actually falling over virtually the entire period in which market makers are required to quote firm two-way prices. The figure also clarifies the relation between spreads and volume by cutting off the periods outside the MQP, thus amplifying the scale of the inside spreads. There is a clear inverse relationship between spreads and volume.

[Figure 7.]

Periods of relatively low competition for market making services on the NYSE are also accompanied in general by high spreads. The NYSE structure gives specialists special privileges in setting opening and closing prices, and competition from limit orders is disadvantaged at those times. Stoll and Whaley (1990) and Brock and Kleidon (1992) link market power by specialists to higher spreads at open and close (or to implicit spreads inferred from opening prices). We note a potential distinction between SEAQ and the NYSE, since there is no barrier to entry to multiple market makers outside the MQP on SEAQ, but there are institutional features of the NYSE that may result in non-competitive returns from high spreads at open or close.

Some of our findings are puzzling at present, and require more analysis. Perhaps the most striking is the behavior of spreads on the NYSE for cross-listed U.K. securities. While the S&P 100 confirms previous findings of U-shaped spreads (Figure 2d), the cross-listed firms in Figure 5d show continually declining spreads over the trading day. We are currently following up this

[27] Pagano and Roell (1990) observe a similar pattern for French securities traded on the SEAQ International and interpret it as a response to the competition from the Paris Bourse, p. 104. Based on our results, this could just as well be due to increased competition among market-makers on SEAQ International.

[28] Reiss and Werner (1993) study the competition between market makers on SEAQ and NASDAQ in greater detail.

finding to see if it is attributable to the lower volume of these cross-listed stocks versus the S&P 100 (compare Figures 2c and 5c). Another possible explanation is that one source of demand for trading at close is by funds that attempt to match an index (see Brock and Kleidon, 1992, p. 459), and this demand may not exist for cross-listed securities. As Figure 5c shows, volume for cross-listed securities does not increase as significantly at the close as for the S&P 100 firms.

Additional interesting issues arise concerning the nature of spreads in dealer markets such as SEAQ versus the auction market of the NYSE. In both markets, a substantial fraction of trades occur between the inside quotes; but on SEAQ small trades tend to pay the full spread and large block trades occur between the quotes, in contrast with the NYSE. Figure 7 documents spikes in SEAQ volume at various times throughout the day, with no reaction in spreads, which may have implications for the degree of segmentation within the U.K. market between retail and institutional trading.

Since London's SEAQ is similar in structure to NASDAQ, a natural extension of our work is to investigate whether a similar pattern in spreads, volatility, and trading volume emerges for NASDAQ. Recent evidence on NASDAQ is provided by Chan, Christie and Schultz (1993), who find that inside spreads are falling throughout the trading day, while volatility of mid-point quote-returns as well as trading volume are distinctly U-shaped. Combined with our results for cross-listed securities trading simultaneously on SEAQ and the NYSE, this suggests that the structure of markets, in particular the degree of competition between market makers, may have very significant implications for observed characteristics of transactions prices, volumes and quotes.

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Table 1. Descriptive Statistics

Means are calculated per firm and per five-minute-interval.

Variable	Number of obs	Time-int.	Firms	Mean	Std.Dev.	Minimum	Maximum	Std Err. of Mean	TSSE
*Variances of Returns (*10000)*									
Transactions									
FT-SE100	7914	108	79	0.5530	0.6804	0.0000	10.7197	0.0077	6083.27
U.K. Cross-Listed in U.K.	2385	108	23	0.3904	0.4558	0.0000	6.6967	0.0093	858.85
U.K. Cross-Listed in U.S.	1836	78	27	0.1728	0.4298	0.0000	8.3322	0.0100	393.85
S&P100	7644	78	98	0.1345	0.3599	0.0084	4.2380	0.0041	1128.33
Quote Mid-Points									
FT-SE100	8532	108	79	0.0034	0.0101	0.0000	0.3222	0.0001	0.9614
U.K. Cross-Listed in U.K.	2484	108	23	0.0042	0.0109	0.0000	0.2126	0.0002	0.3416
U.K. Cross-Listed in U.S.	2212	79	28	0.0145	0.0285	0.0000	0.5832	0.0006	2.2660
S&P100	7742	79	98	0.0289	0.0833	0.0000	4.4331	0.0009	60.1966
Trading Volume									
Shares									
FT-SE100	8611	109	79	15153.35	17844.4	0.00	504716.4	192.30	4.7189E+12
U.K. Cross-Listed in U.K.	2507	109	23	31225.40	36921.2	0.00	869057.2	737.39	5.8605E+12
U.K. Cross-Listed in U.K. (ADRs)	*2507*	*109*	*23*	*6691.91*	*6962.8*	*0.00*	*93966.9*	*139.06*	*2.3376E+11*
U.K. Cross-Listed in U.S. (ADRs)	2133	79	27	1639.15	3739.3	0.00	46014.7	80.96	3.5542E+10
S&P100	7742	79	98	6477.65	6681.5	63.35	123193.2	75.94	6.7043E+11
Frequency									
FT-SE100	8611	109	79	0.99	1.0018	0.0000	6.5000	0.0108	17077.77
U.K. Cross-Listed in U.K.	2507	109	23	1.97	1.6036	0.0000	10.4600	0.0320	16136.96
U.K. Cross-Listed in U.S.	2133	79	27	1.11	2.8450	0.0000	33.1440	0.0616	19875.39
S&P100	7742	79	98	4.08	3.9580	0.1520	36.7570	0.0450	249988.38
Bid-Ask Spreads									
Absolute Spreads									
FT-SE100 (Pence)	8412	107	79	4.4737	3.7905	1.0963	63.6842	0.0413	289202.22
U.K. Cross-Listed in U.K. (Pence)	2454	107	23	3.6892	1.5520	1.2798	10.0000	0.0313	39306.82
U.K. Cross-Listed in U.K. (US$)	*2454*	*107*	*23*	*0.2865*	*0.1370*	*0.0055*	*1.0565*	*0.0028*	*247.53*
U.K. Cross-Listed in U.S. (US$)	2212	79	28	0.2879	0.1400	0.1021	0.8813	0.0030	226.71
S&P100 (US$)	7742	79	98	0.2200	0.1828	0.1264	2.3125	0.0021	633.33
Percentage Spreads									
FT-SE100	8412	107	79	0.0119	0.0053	0.0052	0.0462	0.0001	1.4264
U.K. Cross-Listed in U.K.	2454	107	23	0.0095	0.0048	0.0035	0.0379	0.0001	0.2784
U.K. Cross-Listed in U.S.	2212	79	28	0.0116	0.0090	0.0030	0.0428	0.0002	0.4754
S&P100	7742	79	98	0.0058	0.0041	0.0016	0.0346	0.0000	0.3924

Table 2. International Equity Trading 1986-1991.

Adapted from Howell and Cozzini (1991), Figures 24, 28, and 29.

	1986	1987	1988	1989	1990	1991[1]
Foreign firms listed (No.)						
NYSE	63	67	76	86	95	105
SEAQ International	584	597	585	599	608	625
Trading volume (US$bn)						
NYSE	NA	75.4	53.4	67.4	80.6	87.9
SEAQ International	NA	89.8	72.1	135.8	283.5	530.2
Global Gross Equity Flows (US$bn)[2]						
Cross-Border	800.8	1,344.4	1,212.6	1,598.1	1,441.2	1,320.0
Cross-Exchange	100.7	508.6	342.6	582.9	873.9	763.5

1. Data from 1991 for foreign firms listed and trading volume come from *Stock Exchange Quarterly*, January-March, (1992) (translated into US$ using the spot exchange rate on 12/31/91 (£/$ = 0.5345)) while the numbers for global flows come from Howell and Cozzini (1992) as reported by *The Economist*, October 10, (1992), p. 101.

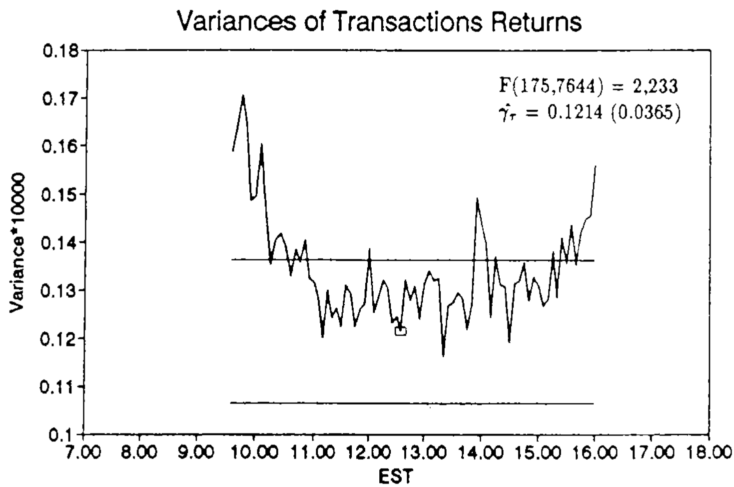
2. Global gross equity flows refers to the sum of purchases and sales of stocks for both cross-exchange trading, i.e. trading in foreign securities on a domestic exchange, and cross-border trading, i.e. trading by foreigners in domestic securities.

Table 3. Summary Results of Regressions

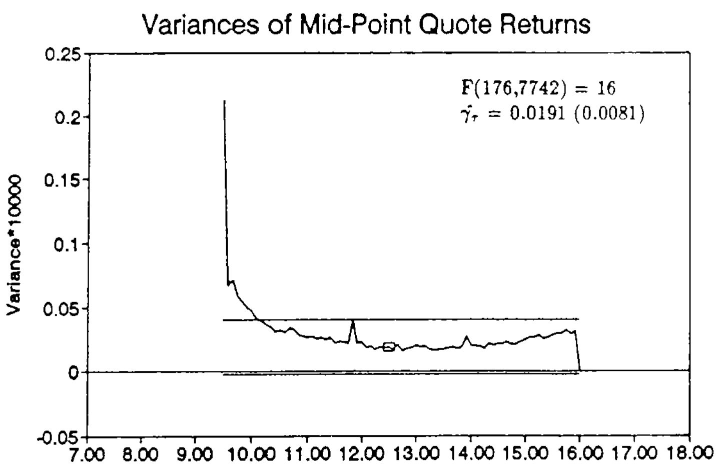
Variable	Number of obs.	Time-int.	Firms	Basic Regression F-value	Basic Regression Adj. R2	Time-effects F-value	Time-effects Adj. R2	Firm effects F-value	Firm effects Adj. R2
*Variances of Returns (*10000)*									
Transactions									
FT-SE100	7914	108	79	144.96	0.77	57 62	0.44	274.56	0.73
U.K. Cross-Listed in U.K.	2385	108	23	51.57	0.73	22.14	0.49	197.20	0.65
U.K. Cross-Listed in U.S.	1836	78	27	8.98	0.31	4.67	0.14	31.61	0.31
S&P100	7644	78	98	2232.80	0.98	13.66	0.11	3858.68	0.98
Quote Mid-Points									
FT-SE100	8532	108	79	24.28	0.34	18.47	0.18	38.32	0.26
U.K. Cross-Listed in U.K.	2484	108	23	20.57	0.51	5.71	0.17	89.17	0.45
U.K. Cross-Listed in U.S.	2212	79	28	23.18	0.52	13.10	0.30	56.01	0.41
S&P100	7742	79	98	15.89	0.25	21.27	0.17	19.21	0.19
Trading Volume									
Shares									
FT-SE100	8611	109	79	121.04	0.72	90.45	0.53	169.52	0.61
U.K. Cross-Listed in U.K.	2507	109	23	57.43	0.75	24.33	0.50	202.29	0.65
U.K. Cross-Listed in U.S. (ADRs)	2133	79	27	116.95	0.85	6.21	0.16	372.24	0.82
S&P100	7742	79	98	368.02	0.89	128.62	0.57	332.25	0.81
Frequency									
FT-SE100	8611	109	79	550.15	0.92	96.66	0.55	691.73	0.86
U.K. Cross-Listed in U.K.	2507	109	23	306.66	0.94	46.21	0.66	706.31	0.87
U.K. Cross-Listed in U.S.	2133	79	27	268.74	0.93	4.28	0.11	941.72	0.92
S&P100	7742	79	98	1224.20	0.97	116.33	0.54	1134.43	0.93
Bid-Ask Spreads									
Absolute Spreads									
FT-SE100 (Pence)	8412	107	79	2063.50	0.98	112.57	0.59	3365.58	0.97
U.K. Cross-Listed in U.K. (Pence)	2454	107	23	2551.83	0.99	146.19	0.86	3776.33	0.97
U.K. Cross-Listed in U.S. (US$)	2212	79	28	11861.05	1.00	115.18	0.80	27819.26	1.00
S&P100 (US$)	7742	79	98	17869.04	1.00	141.38	0.59	19116.68	1.00
Percentage Spreads									
FT-SE100	8412	107	79	10646.83	1.00	414.79	0.84	7366.95	0.99
U.K. Cross-Listed in U.K.	2454	107	23	3715.53	0.99	97.83	0.81	4986.39	0.98
U.K. Cross-Listed in U.S.	2212	79	28	28242.00	1.00	44.64	0.61	55304.34	1.00
S&P100	7742	79	98	40049.46	1.00	198.10	0.67	29161.53	1.00

Figure 2. S&P 100 Firms

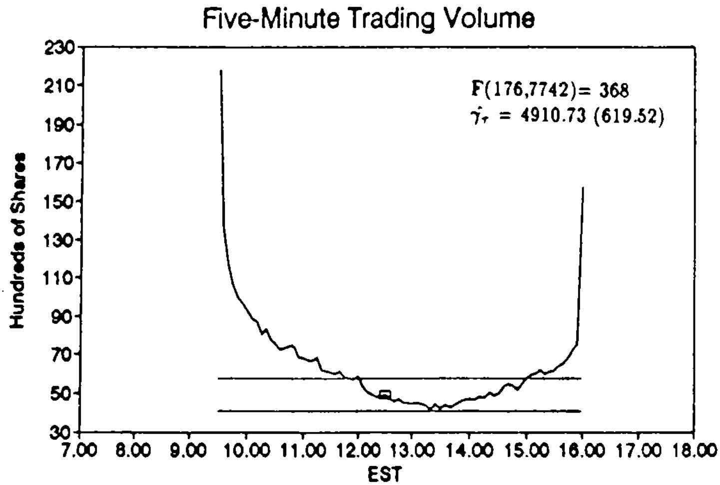
2a.



2b.



2c.


Five-Minute Trading Volume
F(176,7742)= 368
$\hat{\gamma}_\tau$ = 4910.73 (619.52)
Hundreds of Shares
230
210
190
170
150
130
110
90
70
50
30
7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00 15.00 16.00 17.00 18.00
EST

2d.

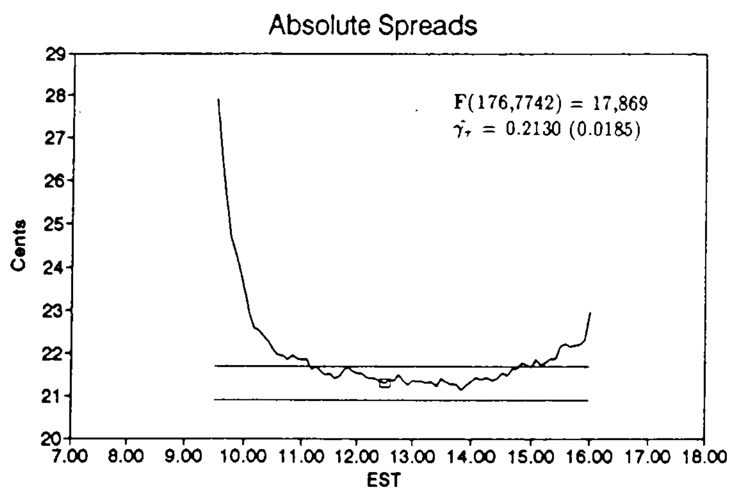
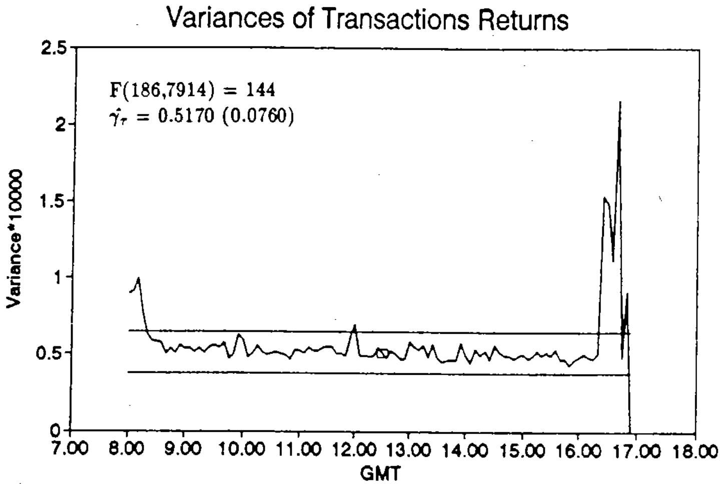
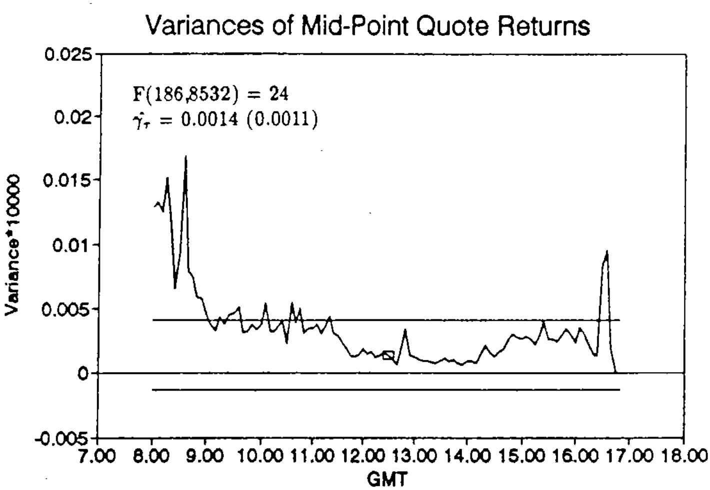

Absolute Spreads
F(176,7742) = 17,869
$\hat{\gamma}_\tau$ = 0.2130 (0.0185)
Cents
29
28
27
26
25
24
23
22
21
20
7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00 15.00 16.00 17.00 18.00
EST

Figure 3. FT-SE 100 Firms

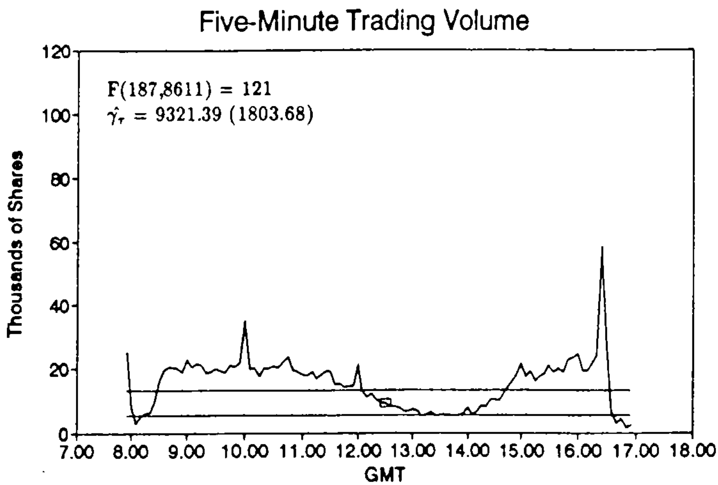
3a.



3b.



3c.


Five-Minute Trading Volume
F(187,8611) = 121
$\hat{\gamma}_\tau$ = 9321.39 (1803.68)
Thousands of Shares
0
20
40
60
80
100
120
7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00 15.00 16.00 17.00 18.00
GMT

3d.

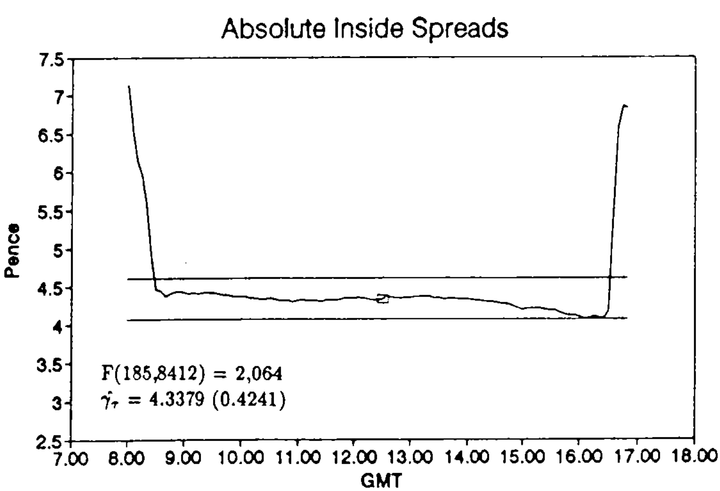
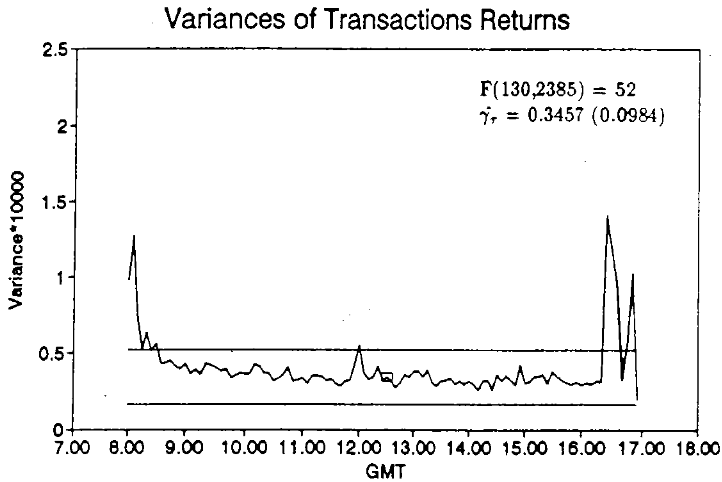
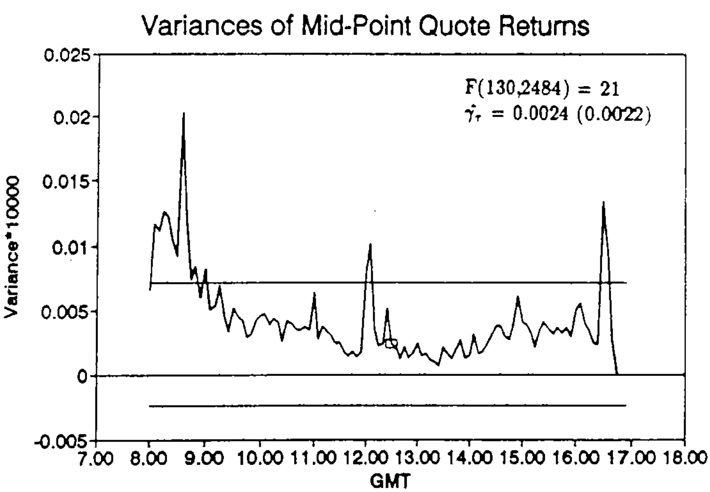

Absolute Inside Spreads
F(185,8412) = 2,064
$\hat{\gamma}_\tau$ = 4.3379 (0.4241)
Pence
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00 15.00 16.00 17.00 18.00
GMT

Figure 4. U.K. Cross-Listed Firms in the U.K.

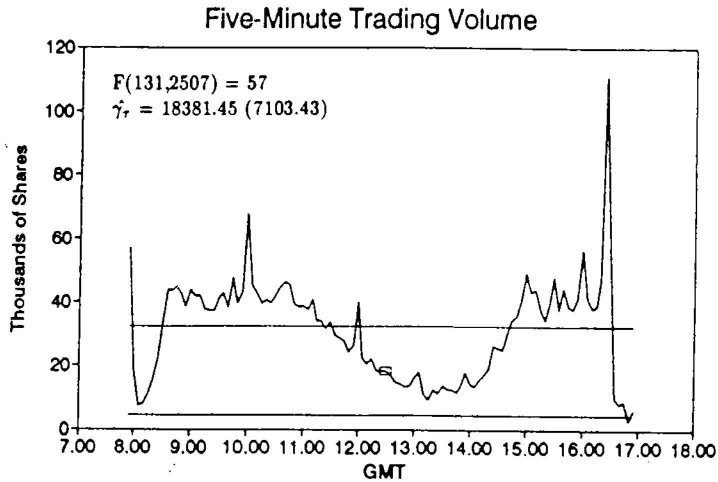
4a.



4b.



4c.


Five-Minute Trading Volume
F(131,2507) = 57
$\hat{\gamma}_\tau$ = 18381.45 (7103.43)
Thousands of Shares
0
20
40
60
80
100
120
7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00 15.00 16.00 17.00 18.00
GMT

4d.

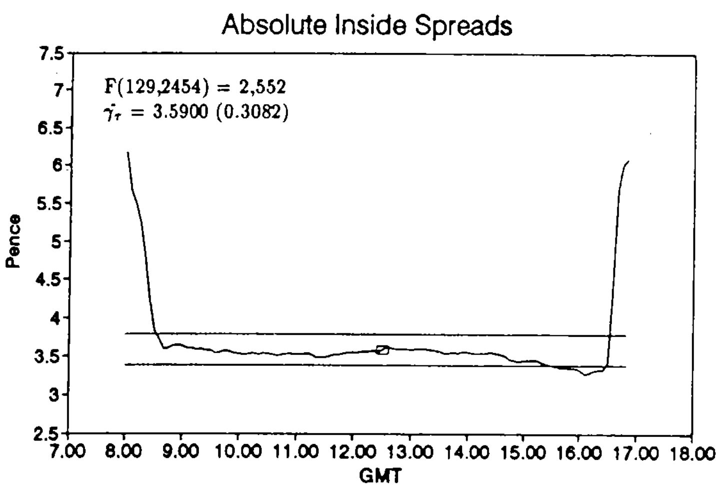
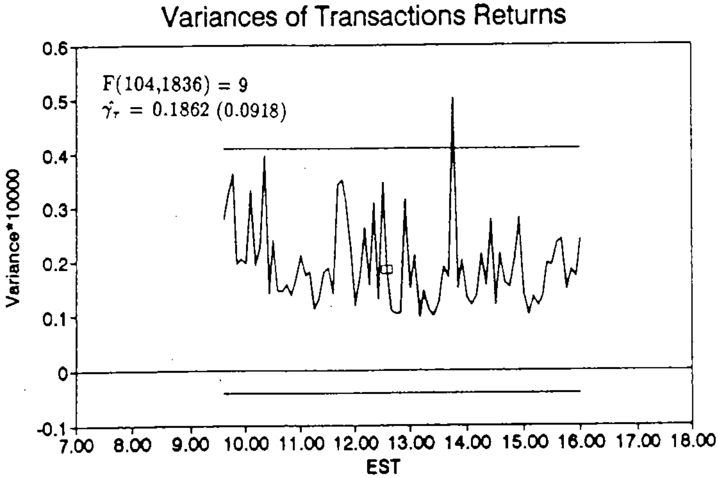
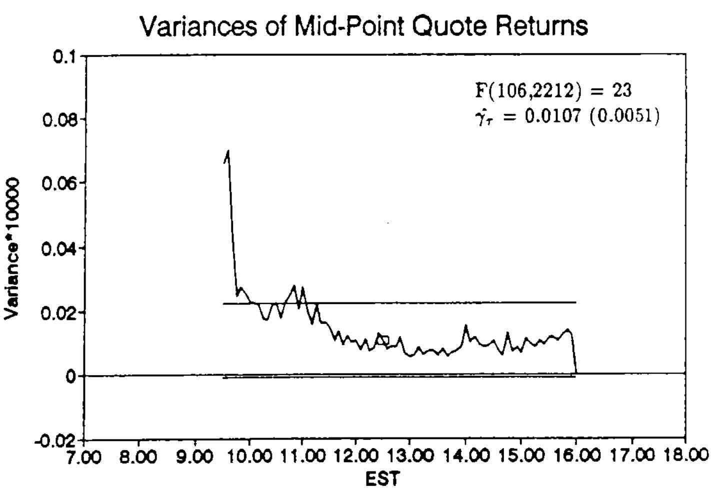

Absolute Inside Spreads
F(129,2454) = 2,552
$\hat{\gamma}_\tau$ = 3.5900 (0.3082)
Pence
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00 15.00 16.00 17.00 18.00
GMT

Figure 5. U.K. Cross-Listed Firms in the U.S.

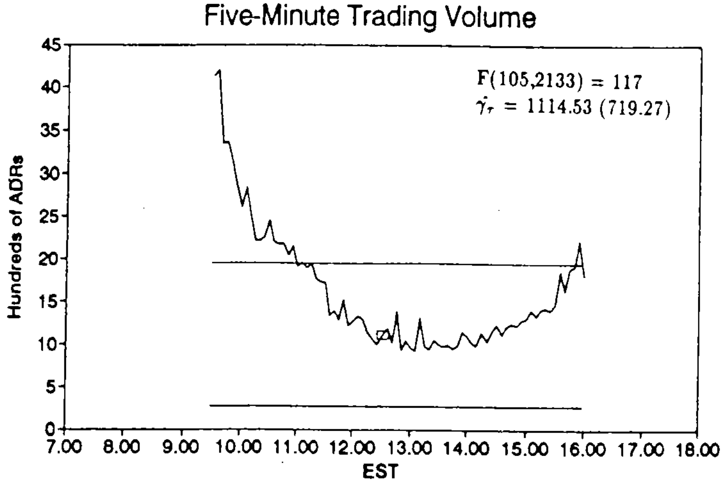
5a.



5b.



5c.


Five-Minute Trading Volume
F(105,2133) = 117
$\hat{\gamma}_\tau$ = 1114.53 (719.27)
Hundreds of ADRs
45
40
35
30
25
20
15
10
5
0
7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00 15.00 16.00 17.00 18.00
EST

5d.

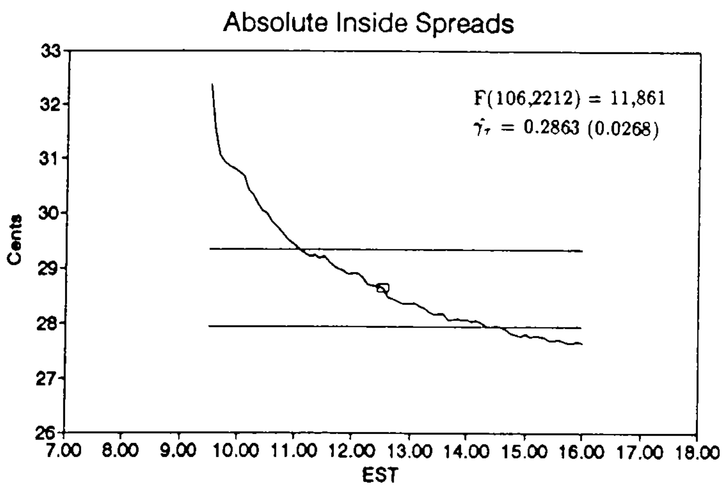
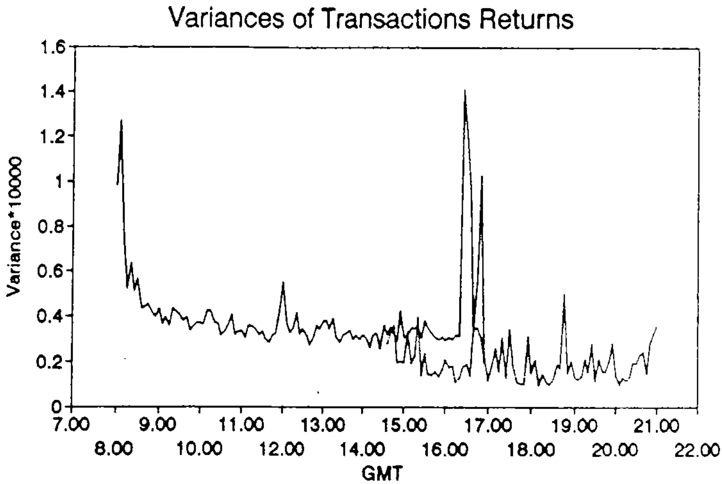
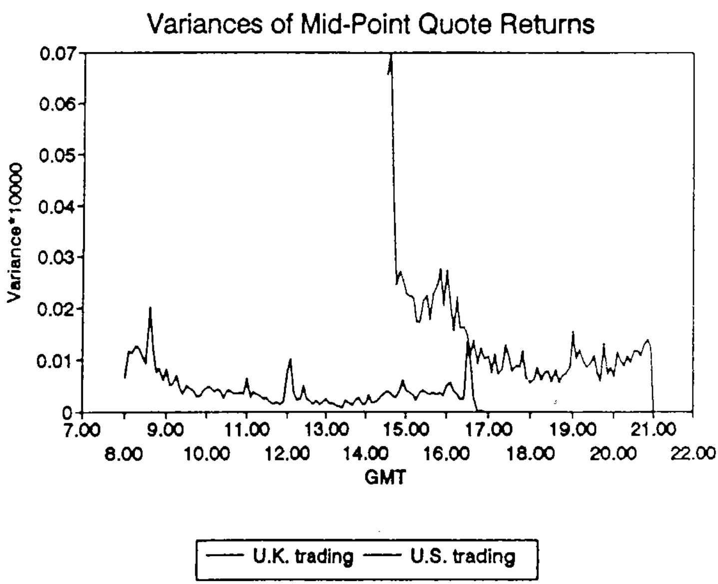

Absolute Inside Spreads
F(106,2212) = 11,861
$\hat{\gamma}_\tau$ = 0.2863 (0.0268)
Cents
33
32
31
30
29
28
27
26
7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00 15.00 16.00 17.00 18.00
EST

Figure 6. U.K. Cross-Listed Firms Across Markets

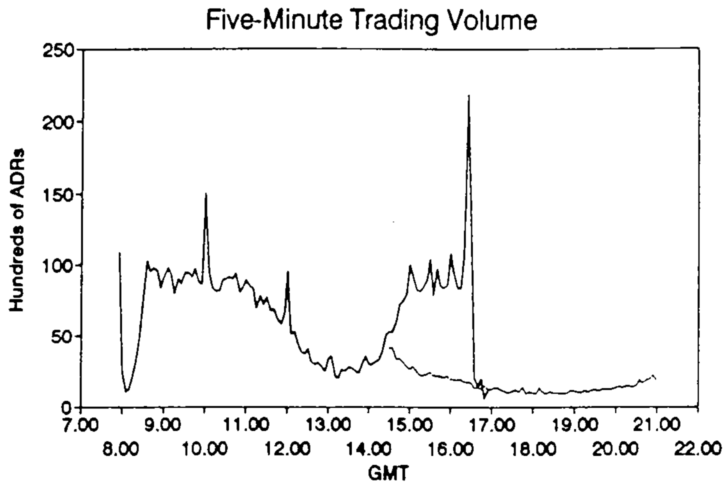
6a.



6b.



6c.


Five-Minute Trading Volume
Hundreds of ADRs
250
200
150
100
50
0
7.00
9.00
11.00
13.00
15.00
17.00
19.00
21.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
GMT

6d.

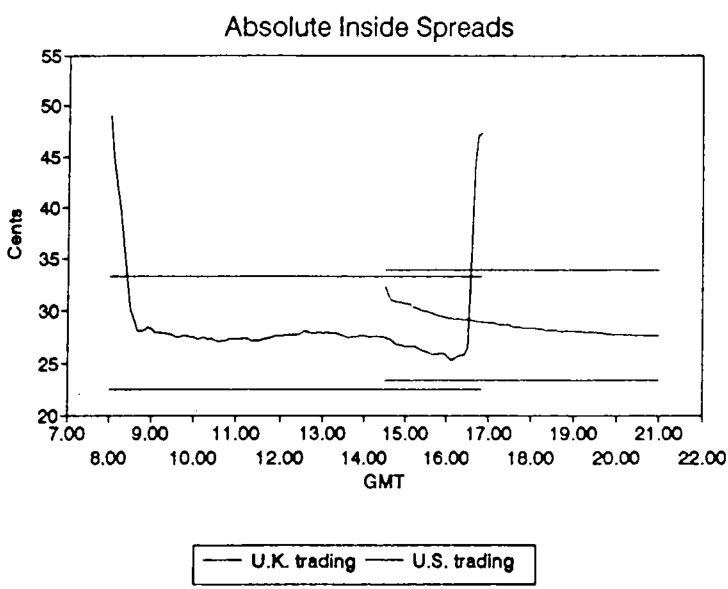
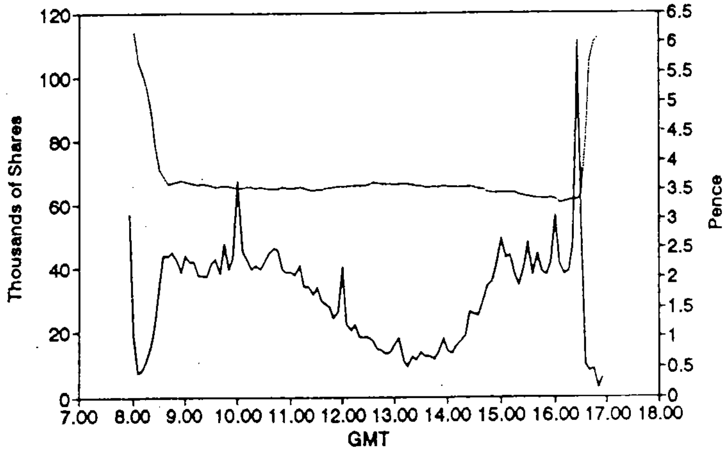
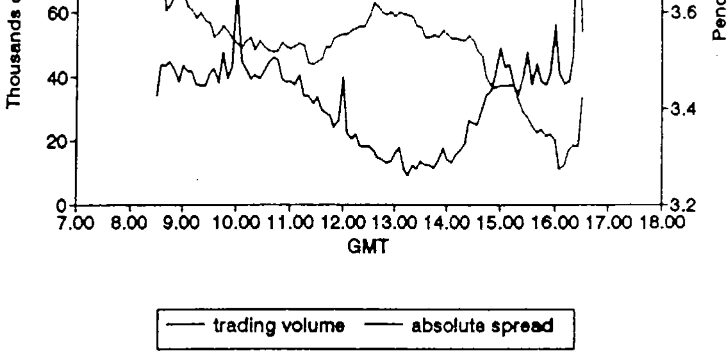

Absolute Inside Spreads
Cents
55
50
45
40
35
30
25
20
7.00
9.00
11.00
13.00
15.00
17.00
19.00
21.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
GMT
U.K. trading
U.S. trading

Figure 7. Spreads and Five-Minute Trading Volume

7a.



7b.



Appendix

FT-SE 100 firms, 1991-1992, (exchange: shares/ADR).[1]

1. Abbey National
2. Allied-Lyons
3. Anglian Water
4. Argyll Group
5. Associated British Foods
6. BAA
7. B.A.T. Industries [AMEX: 1]
8. BET [NYSE: 4]
9. BOC Group
10. BTR
11. Bank of Scotland (Governor & Co.)
12. Barclays [NYSE: 4]
13. Bass [NYSE: 1]
14. Blue Circle Industries
15. Boots Co.
16. British Aerospace
17. British Airways [NYSE: 10]
18. British Gas [NYSE: 10]
19. British Petroleum [NYSE: 12]
20. British Steel [NYSE: 10]
21. British Telecommunications [NYSE: 10]
22. Cable & Wireless [NYSE: 3]
23. Cadbury Schweppes
24. Commercial Union
25. Courtaulds [AMEX: 1]
26. Eurotunnel
27. Enterprise Oil
28. Fisons
29. Forte
30. General Electric Co.
31. General Accident
32. Glaxo Holdings [NYSE: 4]

[1]As of July, 1991 there were 27 U.K. firms cross-listed on the NYSE and 4 U.K. firm cross-listed on AMEX. Of those, 7 are not in the FT-SE 100 index: Attwoods, Beazer, Drug Research Corp. (AMEX), Huntingdon International Holdings, Manpower, Racal Telecom, and Saatchi & Saatchi Co.

33. Grand Metropolitan [NYSE: 2]

34. Great Universal Stores

35. Guardian Royal Exchange

36. Guinness

37. Hanson [NYSE: 5]

38. Hillsdown Holdings

39. Imperial Chemical Industries [NYSE: 4]

40. Inchcape

41. Kingfisher

42. Ladbroke Group

43. Land Securities

44. Laporte

45. Legal & General Group

46. Lloyds Bank

47. Lasmo

48. Lonrho

49. MEPC

50. Marks & Spencer

51. MB-Caradon

52. Midland Bank

53. NFC [AMEX: 5]

54. National Westminster Bank [NYSE: 6]

55. National Power

56. North West Water Group

57. Northern Foods

58. Pearson

59. Peninsular & Orient Steam Navigation Co.

60. Pilkington

61. PowerGen

62. Prudential Corp.

63. RTZ Corp. [NYSE: 4]

64. Rank Organization

65. RMC Group

66. Reckitt & Colman

67. Redland

68. Reed International

69. Rentokil Group

70. Reuters Holdings

71. Rolls-Royce

72. Rothmans International

73. Royal Bank of Scotland Group [NYSE: 8]

74. Royal Insurance Holdings

75. Sainsbury (J)

76. Sears

77. Scottish & Newcastle

78. Scottish Power

79. Severn Trent

80. Shell Transport & Trading Co. [NYSE: 6]

81. Smith & Nephew

82. Smith (W.H.) Group

83. Smithkline Beecham [NYSE: 5]

84. Smithkline Beecham/Smithkline Beckman

85. Sun Alliance Group

86. TSB Group

87. Tarmac

88. Tate & Lyle

89. Tesco

90. Thames Water

91. Thorn EMI

92. Trafalgar House (1)

93. Tomkins

94. Trafalgar House (2)

95. Unilever [NYSE: 4]

96. United Bisquits (Holdings)

97. Vodafone Group

98. Wellcome

99 Whitbread

100. Arjo Wiggins Appleton

101. Williams Holdings

102. Willis Corroon Group [NYSE: 5]