Execution Costs of Market Designs Worldwide During the Global Credit Crisis

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Abstract

We examine how institutional design features of the New York Stock Exchange, NASDAQ, London Stock Exchange, and Tokyo Stock Exchange relate to execution costs during a period of extreme price volatility. The primary trading mechanisms examined in this paper are pure limit order books, hybrid, and dealership markets. Consistent with Aitken et al. [2009], we adopt a multivariate framework incorporating a matching procedure to overcome bias in our sample selection. Our univariate statistics for spreads and volatility highlight the depths to which global equity market collapsed during the height of the global financial crisis. Spreads are shown to increase by 98% and 100% on NASDAQ and the NYSE respectively in the four months following the collapse of Lehman Brothers. Volatility is similarly shown to increase sharply during that same period for all exchanges analysed. Our multivariate results show that the Hybrid market is most effective in reducing costs followed by the composite features of the NYSE, consistent with the theoretical model of Viswanathan and Wang [2002]. The pure LOB mechanism is found to be least effective during the 2007 to 2009 period.

This paper investigates the resilience of alternative market design implementations by the world's leading securities exchanges. From the outset we assume that all participants benefit from reduced execution costs. We seek to address which market design features reduce execution costs and how best to structure a market to cope with extremely high levels of stress such as during the Global Credit Crisis. Literature has yet to reach consensus on the significance of certain design features. For example, many markets are moving towards fully electronic limit order book (LOB) markets yet a strong argument is emerging that hybrid markets are the best trading mechanism as they provide multiple sources of liquidity (Jain [2004]). Similarly, numerous prior studies have established the role of market design as a determinant of execution costs (beginning with Demsetz [1968]). We use a matched sample procedure combined with multivariate regressions to examine four of the five largest exchanges globally, namely, the NYSE, NASDAQ, LSE, and TSE.

No clear consensus on the association between exchange architecture and execution costs has been established in the literature (Ahn et al. [1996] and de Jong et al. [1995]). This may be attributed to two primary reasons. First, the environment that global equity markets compete in is dynamic and rapidly changing in response to advancements in technology and consumer needs. Second, studies examining execution costs across exchanges encounter a fundamental problem in that listed companies across exchanges have differing characteristics. In order to examine the affect of specific institutional design features on execution costs it is essential, therefore, to control for stock specific characteristics. Generally speaking, three approaches have been utilised in existing literature to achieve this: (1) the examination of cross-listed stocks[1]; (2) a matched sampling method pioneered by Huang and Stoll [1996][2]; and (3) a multivariate framework to simultaneously examine a large number of exchanges[3].

Most early studies comparing execution costs across a number of exchanges in order to determine the efficacy of idiosyncratic exchange design features use a *cross-listed stocks method*. Another technique used in exchange execution costs comparison is the *matched sampling* method. Matched sampling involves taking two or more groups of stocks that are listed on different exchanges and pairing them according to a number of characteristics such as market capitalisation, average traded volume and industry. A matching process overcomes much of the selection bias that arises in multi-exchange analysis.

Weston [2000] examines matched-pairs of stocks listed on the NYSE and NASDAQ and find empirical support to the theoretical arguments of Viswanathan and Wang [2002] that hybrid market structures (those with both market makers and public limit orders)

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[1]Such research involves analysing identical stocks trading on two or more exchanges (for example, BHP which is listed on both the London Stock Exchange as well as the Australian Securities Exchange)

[2]We use the word pioneered loosely here with specific reference to the matched sampling method use in market microstructure studies – the matched sampling method may be attributed to Rubin [1979] with his research in biology. This method compares stocks that are relatively similar by matching across a number of categories – typically market capitalisation, trading volume, price level and volatility.

[3] These studies typically incorporate a number of dichotomous variables and control variables to isolate the affects of design on execution costs.

have execution costs relatively lower than markets designed strictly around market makers (dealer markets). Chung et al. [2004] seek to measure the impact of decimalization on execution costs across the NASDAQ and NYSE markets. Their results suggest that the NYSE specialist system offers lower execution costs for small, low volume stocks. NASDAQ's dealer system, on the other hand, is found to offer lower execution costs for large, high volume stocks. Boehmer [2005] extends prior literature by examining not only execution costs but also execution quality and speed on the NYSE and NASDAQ[4]. Execution speed is particularly influential in determining market order flow.

Few studies utilising the matched sampling approach examine execution costs and equity market structures outside of the United States. Venkaratnam [2001] examines execution costs in an automated market versus one with a trading floor – the Paris Bourse and the NYSE respectively and finds that quoted spreads are lower on the Paris Bourse prior to tick size reduction on the NYSE on June 23, 1997. Furthermore, effective spreads on the Paris Bourse are found to be greater than those on comparable NYSE stocks throughout the sample period indicating that human intermediation in the trading process may lower execution costs.

Jain [2004] adopts a multivariate framework to analyse 51 stock exchanges simultaneously[5]. Jain finds that a myriad of design features are all significant in explaining execution costs. In particular, dealer-emphasis systems have higher spreads and volatility when compared to pure Limit Order Book or hybrid systems. Market makers serve an important role in reducing execution costs for less liquid stocks and are particularly important for emerging markets than for their more developed counterparts. Execution costs are positively related to tick size and order fragmentation.

Aitken et al. [2009] adopt a regression-based, multivariate research design integrating a matched-sample method to overcome potential firm selection bias and estimate execution costs for both thickly and thinly traded stocks in 7 of the largest stock exchanges, the NYSE, NASDAQ, LSE, Euronext, Xetra, TSE and ASX. The authors find strong evidence supporting full transparency of the LOB to all market participants. Moreover, Aitken et al. [2009] find the market architecture of the NYSE to be the 'best' in reducing effective spreads. In contrast, the authors' results show that the combination of execution systems employed by the LSE increase spreads across the entire liquidity spectrum. The presence of a trading floor is also found to be statistically significant (the economic impact is, however, relatively small). Similar results are found for realised spreads. The authors conclude that from the sample set of exchanges analysed, the NYSE offers the lowest execution costs while the LSE the largest.

As general conclusions from the literature we present hypotheses regarding market quality effects of the crisis on four representative exchanges with three types of market design. Hybrid refers to those markets that have consolidated Limit Order

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[4] Only one paper focussing on execution quality in these two markets had been published at the time of Boehmer's [2005] analysis.

[5] The largest sample size of any study conducted examining institutional design and execution costs to date.

Book and also dealers or market makers. Pure LOB refers to markets that are have a consolidate LOB system with no market makers. A market with composite features such as the NYSE combines LOBs with a trading floor and specialists. As such, we propose that:

Hypothesis 1: Execution costs are significantly different across market mechanisms, ceteris paribus.

Aitken et al. [2009] conduct a Chow test on a full sample of matched stocks against stocks stratified according to their liquidity profile and find pooling is rejected. Nimalendran and Petrella [2003] further find evidence suggesting that moving from a pure LOB system to a hybrid system with a specialist increases the liquidity of thinly traded stocks on the Italian Stock Exchange. This leads to our next two hypotheses:

Hypothesis 2: Execution costs are not only significantly different across market mechanisms but also liquidity quartiles.

Hypothesis 3: The effect of market mechanisms on execution costs and volatility differs across liquidity quartiles.

Relative realised spreads are a measure of profit made by trading intermediaries such as dealers and specialists see e.g. Stoll [1978]. Hendershott and Jones [2005] also suggest that realised spreads provide an ex post execution cost measure for liquidity demanders. Parlour and Seppi [2001] conjecture that a well structured hybrid market system constitutes an optimal trading mechanism as it encapsulates two sources of liquidity. Multiple sources of liquidity are expected to increase competition among liquidity providers, and as a result, reduce their profit. This leads to the following hypothesis:

Hypothesis 4: Hybrid markets, with their multiple sources of liquidity, reduce relative realised spreads compared to other mechanisms such as pure LOB, ceteris paribus.

Viswanathan and Wang [2002] seek to better understand why small size orders tend to be executed on limit order markets while large orders are executed on dealership systems. They derive a model explaining the circumstances in which investors would prefer to execute on a LOB system as opposed to dealer and hybrid markets and vice versa. They find that all risk-neutral investors prefer a LOB system. Risk-averse investors, on the other hand, prefer a dealership market as long as the number of dealers is sufficiently large. Viswanathan and Wang [2002] further show that for occasions where investors prefer a dealership market, a hybrid system enhances its overall attractiveness. Similarly, they show that as long as the number of market makers is sufficiently large, a hybrid system improves efficiency in a LOB. They conclude that risk-neutral customers prefer to trade in LOB markets instead of in any hybrid or dealership markets. Furthermore, they conclude that risk-averse customers will prefer to trade in a dealership markets over a LOB market when the number of market makers is large and when the order size is large. For risk-averse traders a properly structured hybrid market will dominate both LOB and dealership markets. This leads to our final hypothesis:

Hypothesis 5: Relative volatility is significantly reduced on hybrid market systems compared to pure LOB and dealership systems. Moreover, dealership markets are superior in reducing volatility compared to pure LOB markets.

We propose that if market design matters for execution costs, this impact should be the greatest during crisis. Hence we test these hypotheses during the global financial crisis of 2007 to 2009, investigating matched companies across exchanges representative of different market designs. A similar method is used in Aitken, Cook, deB. Harris and McInish [2009], in addition we incorporate the approach of matched sampling suggested by Davies and Kim [2009] and Liu and Wort [2009]. Further, this paper examines execution costs during the global financial crisis of 2007 through 2009. In addition to providing indications for how to structure a market to cope with stress, this study provides empirical support to many theoretical models that examine the influence of market design on execution costs (for example, see Stoll [1978], Glosten [1994], Viswanathan and Wang [2002]).

The results reveal the depths to which financial markets dropped during the height of the crisis. Across all the stock exchanges examined, we show a sharp spike in volatility and bid ask spreads around the collapse of Lehman Brothers. Moreover, we find that the roots of the rally in equity markets in early to mid 2009 began to develop in February 2009 when most measures of liquidity returned to levels prevalent at the beginning of the crisis. We show that the hybrid market mechanism, featuring a consolidated LOB with dealers, has the lowest relative execution costs followed by the composite features of the NYSE which is an order driven market combining LOBs with a trading floor and specialists. Out of the three market mechanisms, the pure LOB system is found to be the least effective in reducing spreads during levels of stress.

DATA

Intraday trades and quotes data is obtained from the *Thomson Reuters DataScope Tick History* database for the period between 1 April, 2007 and 1 July, 2009. This period encompasses the early warning signs of the upcoming upheaval in the credit markets following a collapse in the sub-prime market. Key events during the broader financial crisis such as the collapse of Lehman Brothers and announcement of fiscal stimuluses by governments around the world are also included. Furthermore, the period encompasses the early days of a global stock market recovery in May 2009. Data is analysed not only as a full sample but also in intervals to in order to more accurately describe the evolution of execution costs during the sample period. The chosen periods are the ‘pre climax’ period (1 April, 2007 to 29 August, 2008), the ‘climax’ period (1 September, 2008 to 31 January, 2009) and the ‘recovery’ period (1 February, 2009 to 1 July, 2009).

As per the matching algorithm employed in this paper, market capitalisation, shares outstanding, closing unadjusted price, and daily volume are obtained for the quarter year prior to our sample period, namely, from 1 January, 2007 to 1, April 2007 for stocks in the NASDAQ Composite Index, FTSE 500, TOPIX Composite[6], and the NYSE All-Research Index[7]. This data is sourced from the *Thomson Reuters Datastream* database. This paper relies on two primary databases, and although, both have a common provider, both do not have perfect congruency in the stocks they cover. As a result, stocks that could not be matched by their International Securities Identifying Number across the two databases were filtered out. Stocks with less than 50 days of trading are also filtered from the sample. The matching procedure performed on all stocks in our sample of four exchanges is outlined in the research design. We randomly select three samples of 120 NASDAQ stocks (split equally from each liquidity quartile) and their counterparts in the other exchanges. This procedure yields 120 matches on the LSE, 120 matches for the TSE, and 120 matches for the NYSE.

Information about exchange design is obtained from official exchange internet websites, exchange rulebooks published by stock exchanges and existing literature (see for example, Comerton-Forde and Rydge [2003] and Aitken [2009]). Country based data is sourced from the World Bank and OECD online databases.

RESEARCH DESIGN

Execution Cost Measures

We utilise execution cost measures quoted spreads, effective spreads and realised spreads, to compare the performance of trading exchanges. We define relative quoted spreads, the instantaneous round-trip execution cost, to be the quoted spread as a percentage of the prevailing quote midpoint:

$$Relative\ Quoted\ Spread = 100x(\frac{Ask_{i,t} - Bid_{i,t}}{Mid_{i,t}}) \qquad Equation\ (1)$$

where $Ask_{i,t}$ is the ask price for the stock *i* at time *t* and $Bid_{i,t}$ is the bid price for the stock at time *t*. $Mid_{i,t}$ represents the midpoint of the quoted ask and bid prices.

Effective spreads may be interpreted as the total price impact of a trade. They measure the non-commission out-of-pocket costs faced by market participants and may be represented as follows:

$$Relative\ Effective\ Spread = 200xD_{i,t}(\frac{Price_{i,t} - Mid_{i,t}}{Mid_{i,t}}) \qquad Equation\ (2)$$

where $D_{i,t}$ represents a trade direction variable (takes a value of 1 for a buy order and negative 1 for a sell order)[8]. $Mid_{i,t}$ (mid-quote price) serves as a proxy for the unobservable inherent asset value and therefore effective spreads may be viewed as the price liquidity providers pay to acquire an asset immediately.

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[6] The composite index for the Tokyo Stock Exchange.

[7] The *Thomson Reuters Datastream* does not include information about the NYSE composite so this index is used as a substitute.

[8] We adopt the Lee and Ready [1991] algorithm to infer trade direction. Consistent with Bessembinder and Kaufman (1997a) and Bessembinder and Kaufman (1997b) we implement an altered version of the original algorithm and use quote delays of 20 seconds.

Effective spreads may be decomposed into two primary components, namely, permanent and temporary. Realised spreads are recognised in Huang and Stoll [1996] as representing the temporary component. They may be interpreted as a market's inherent execution cost as they exclude the effects of the information content of order flow. We calculate a percentage realised spread to measure what liquidity providers earn after accounting for the subsequent price movement:

$$Relative\ Realised\ Spread = 200xD_{i,t}x(\frac{Price_{i,t}-V_{i,t+n}}{Mid_{i,t}}) \quad \textit{Equation (3)}$$

where $V_{i,t}$ represents the quote midpoint 30 minutes after a trade. By benchmarking 30 minutes after the trade we ensure we capture the gains a liquidity provider makes both immediately after the trade as well as after some time has passed.

Volatility

Our primary measure of volatility is calculated as the logarithm of the high trading price for stock *i* on day *t* minus the logarithm of the low price of stock *i* on day *t*:

$$Volatility = (Log\ High\ Trade\ Price_{i,t}) - (Log\ Low\ Trade\ Price_{i,t}) \quad \textit{Equation (4)}$$

Matched Sample Method

Market microstructure studies often incorporate some form of the matched sampling method first introduced in the natural sciences by Rubin [1979]. This paper earlier reviewed several studies incorporating the matching process in their analysis of execution costs across two or more exchanges (for example, see Huang and Stoll [1996], Bessembinder and Kaufman [1997ab], Weston [2000], Venkaratnam [2001] and Boehmer [2005]). Generally speaking, matched sampling involves taking two or more groups of stocks that are listed on different exchanges and pairing them according to a number of characteristics such as market capitalisation, average traded volume and industry.

No consensus exists about the optimal methodological approach to conducting a matched pairs study. Two recent studies - Davies and Kim [2009] and Liu and Wort [2009] - provide a framework for future studies. Davies and Kim [2009], suggest that the optimal approach to creating matched samples is to match firms one-to-one on market capitalisation and share price. In this paper we implement a relatively simple matching algorithm based on market capitalisation, share price and dollar trading volume – the top three characteristics in terms of overall impact on testing power in Davies and Kim [2009]. In sharp departure from matching algorithms used in existing literature (see for example, Huang and Stoll [1996] and Bessembinder [1997ab]), Davies and Kim [2009] provide evidence suggesting that it is better to keep relatively poor matches rather than reduce the sample size. The general approach in current literature is to require matches to occur between firms satisfy some variation of the following condition:

$$\left|2(x_{Ai}^{k} - x_{0j}^{k})/(x_{Ai}^{k} + x_{0j}^{k})\right| < \varepsilon \quad \textit{Equation (5)}$$

where k represents each matching characteristic. Such an approach requires arbitrary selection of a tolerance level – without justification. Davies and Kim [2009] show that unless there is a compelling reason for a predetermined tolerance level then this approach is, in fact, suboptimal. Overall test power is shown on occasion to actually drop when using calliper matching (exclusion of apparent poor matches). This paper will adopt this finding and not place any constraints on the matching algorithm. Stocks with the lowest matching statistic will be chosen regardless of the actual score of the statistic.

The standard approach in existing literature is to adopt a one-to-one matching procedure without replacement. Matching with replacement is best described through example (adapted from Liu and Wort [2009]). Suppose we wish to match stocks on stock exchange ‘A’ with stocks on exchange ‘B’. Assume stock AAA (from A exchange) is matched with stocks C and D (from exchange B). Which stock should AAA be paired with? If the researcher is matching without replacement, a decision will be made to match with *one* of the stocks (let's assume C), following which AAA is removed from the sample. This process is then repeated with the other stock (D) being matched to the next best match from the remaining sample. Matching with replacement allows for AAA to be returned to the sample set and therefore be a candidate for further matches. Matching without replacement ensures greater diversification of the sample size, however, results in increased matching errors. Matching with replacement, on the other hand, increases the idiosyncratic error associated with stocks that are matched with multiple counterparts, however, greatly reduces the average matching error. Liu and Wort [2009], while not suggesting that matching with replacement is always superior, suggest that when the sample size is small or one doesn’t wish to make an assumption that stocks on two exchanges are similar, then matching with replacement may produce more reliable estimation results. Davies and Kim [2009] too find some evidence suggesting that the difference between matching with and without replacement is relatively small. This paper incorporates this finding and adopts a matching with replacement algorithm. This is implemented for a number of reasons. First, we do not wish to make any assumption about the stocks listed on the exchanges considered. In fact, it would be reasonable to assume that stocks listed on the NASDAQ have, generally speaking, quite distinct characteristics to those on the TSE, LSE and, to some extent, the NYSE. Therefore, it would seem that matching would replacement would increase the robustness and accuracy of our results.

We adopt a matched sampling approach this is summarised as follows:

1. Average market capitalisation, share price, and traded dollar volume is obtained for stocks listed on the NASDAQ Composite Index, FTSE 500, TOPIX Composite, and the NYSE All-Research Index for the quarter year prior to our sample period (1 January, 2007 to 1 April, 2007).
2. Stocks on the NYSE, LSE, and TSE are then matched to NASDAQ stocks with replacement using the following statistic:

$$Score = \left(\frac{Price_1 - Price_2}{(Price_1 + Price_2)/2}\right)^2 + \left(\frac{MKTCAP_1 - MKTCAP_2}{(MKTCAP_1 + MKTCAP_2)/2}\right)^2 + \left(\frac{Dollartradevol_1 - Dollartradevol_2}{(Dollartradevol_1 + Dollartradevol_2)/2}\right)^2 \quad Equation\ (6)$$

It is beyond the scope of this paper to analyse all stocks matched. Therefore, after conducting the matching procedure on all stocks in our sample, we randomly select three samples of 120 NASDAQ stocks (split equally from each liquidity quartile) and their counterparts in the other exchanges. This procedure yields 120 matches on the LSE, 120 matches for the TSE, and 120 matches for the NYSE.

Multivariate regression framework

Previous studies examining the significance and influence of institutional design features on execution costs across exchanges using a regression based multivariate research design have all used differing estimation methods (for example, see Domowitz et al. [2002], and Jain [2004]. Most recently, Aitken et al. [2009] utilise a double-log OLS model incorporating several institutional design dichotomous variables to compare execution costs across 7 global equity markets. We adopt a similar approach in this study. We next discuss our method of estimation and describe the models and variables.

Consistent with previous research we estimate our models using a fixed effects OLS method (see Foucault, Moinas, and Thiessen [2007]). This ensures that some of the heterogeneity across stocks that may be captured otherwise in the coefficients of our parameters is controlled. F-statistics for each of our models confirms that there is unexplained heterogeneity, and so, a panel estimator is the appropriate method to employ rather than simply running pooled OLS. It should be noted that in order to remove any skewness in our data we perform logarithmic transformations of all continuous variables. White's Test for heteroscedasticity is conducted for every regression model run; if heteroscedasticity is detected then the heteroscedasticity-corrected standard errors are used in calculating the t-values and p-values.

Our analysis is conducted during a unique period of turmoil not seen since the Great Depression in global equity markets. The objective of this paper is to isolate the affects of institutional design on execution costs and to draw relevant inferences from the results. Our ability to do so, however, may be limited by the fact that certain exchanges within our sample may have been relatively more affected by the crisis, thus, skewing any data observations we have. In order to correct for this we employ two control variables, namely, daily volatility and volume, as well as several interaction variables that have been found in previous literature to be effective in removing the affects of such shocks (for example, see Foucault et al. [2007]). These two variables were confirmed to be the 'best' control variables after we ran several robustness tests with GDP/per capita, population, market capitalisation, and traded value as alternatives. Use of the GDP/per capita and population variables was found to be ineffective given the dynamic nature of the crisis and delayed reporting of such economic data).

Our model for spreads may be represented as follows:

$$\textit{Trade value weighted effective spread} = \alpha_0 + \beta_1 \, lnVolume + \beta_2 \, ln\_hi\_lo + \beta_3 \, Hyb + \beta_4 Lob + \beta_5 \, LobVolume + \beta_6 \, LobVolatility + \beta_7 \, HybVolume + \beta_8 \, HybVolatility + \varepsilon \qquad \textit{Equation (7)}$$

$$\textit{Trade value weighted relative effective spread} = \alpha_0 + \beta_1 \, lnVolume + \beta_2 \, ln\_hi\_lo + \beta_3 Hyb + \beta_4 Lob + \beta_5 \, LobVolume + \beta_6 \, LobVolatility + \beta_7 \, HybVolume + \beta_8 \, HybVolatility + \varepsilon \qquad \textit{Equation (8)}$$

$$\textit{Trade value relative realised spread} = \alpha_0 + \beta_1 \, lnVolume + \beta_2 \, ln\_hi\_lo + \beta_3 \, Hyb + \beta_4 Lob + \beta_5 \, LobVolume + \beta_6 \, LobVolatility + \beta_7 \, HybVolume + \beta_8 \, HybVolatility + \varepsilon \qquad \textit{Equation (9)}$$

$$\text{Trade value weighted relative realised spread 30 minutes} = \alpha_0 + \beta_1 \ln Volume + \beta_2 \ln\_hi\_lo + \beta_3 Hyb + \beta_4 Lob + \beta_5 LobVolume + \beta_6 LobVolatility + \beta_7 HybVolume + \beta_8 HybVolatility + \varepsilon \quad \text{Equation (10)}$$

$$\text{Time weighted quoted spread} = \alpha_0 + \beta_1 \ln Volume + \beta_2 \ln\_hi\_lo + \beta_3 Hyb + \beta_4 Lob + \beta_5 LobVolume + \beta_6 LobVolatility + \beta_7 HybVolume + \beta_8 HybVolatility + \varepsilon \quad \text{Equation (11)}$$

$$\text{Time weighted relative quoted spread} = \alpha_0 + \beta_1 \ln Volume + \beta_2 \ln\_hi\_lo + \beta_3 Hyb + \beta_4 Lob + \beta_5 LobVolume + \beta_6 LobVolatility + \beta_7 HybVolume + \beta_8 HybVolatility + \varepsilon \quad \text{Equation (12)}$$

In addition to the above model, we estimate the following for our volatility measure:

$$Ln\_Hi\_Lo = \alpha_0 + \beta_3 Hyb + \beta_4 Lob + \beta_5 \ln Num\_trades + \beta_6 LobNumtrades + \beta_8 HybNumtrades + \varepsilon \quad \text{Equation (13)}$$

where ln_hi_lo, lnvolume are the natural logarithms of two firm specific control variables, namely, natural log of high low volatility and natural log of mean daily volume.

HYB and LOB are all dichotomous variables representing trading mechanisms. Specifically, HYB (Hybrid) refers to those markets that have consolidated Limit Order Book and also market makers. This variable will take the value of 1 if this is true, otherwise 0. LOB (pure Limit Order Books) refers to markets that are have a consolidate LOB system with no market makers. This variable will take the value of 1 if this is true, otherwise it will take the value 0. Our base variable refers to those markets that have the composite NYSE features.

RESULTS

Comparative Execution Costs Across Exchanges: Univariate Analysis

We present and analyse the differences in execution costs and volatility using the matched pairs we identified earlier. We present our results in two parts (both of which are further decomposed into additional subsets). The first part looks at execution costs and volatility across the whole sample period, namely, from 1 April, 2007 to 1 July, 2009. Stocks are placed into their respective liquidity quartiles (with quartile 1 representing the most liquid of stocks, while quartile 4 represents the least liquid stocks) and execution costs and volatility is also analysed across these quartiles. We test for difference in mean execution cost (however measured) and volatility using a non-parametric Wilcoxon Signed Rank Test[9]. All tests are performed at the 5% level. The second part examines execution costs across exchanges during the financial crisis. We split the sample period into three periods (based on events that occurred globally during the financial crisis that significantly altered the outlook and performance of markets globally). The first period, from 1 April, 2007 to 29 August, 2008 explores the initial stages of the burgeoning subprime and credit crises. The second period, from 1 September, 2008 to 1 February, 2009 captures what is now widely acknowledged as the ‘eye of

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[9] This is consistent with the suggestions on the optimal matching process by Davies and Kim [2009], who find that the Wilcoxon test produces the strongest and most reliable results compared with a Student *t*-test which, in general, produces similar results but with lower test power.

the storm'. The first two weeks of September include the near collapse of Fannie Mae and Freddie Mac, the collapse of global the investment bank Lehman Brothers, and the near collapse of Merrill Lynch. The third period, from 1 February, 2009 to 1 July, 2009 captures the early days of a general shift in market sentiment and the resulting rally in most global equity markets. Consistent with the first part of our analysis we further decompose this sample to look at results not only for all earlier identified matched pairs but also results stratified by liquidity (as earlier, quartile 1 represents stocks which are the most liquid out of the sample while quartile 4 refers to the least liquid stocks). We test for difference in mean execution cost (however measured) and volatility using a non-parametric Wilcoxon Signed Rank Test. All tests are performed at the 5% level.

Univariate Results for Spreads – Full Sample by Time Periods

Exhibit 1 presents our univariate results for mean spreads across all three periods using the full sample of matched pairs earlier identified across NASDAQ, LSE, NYSE and TSE. It should be noted that all our continuous variables measuring execution costs have been log transformed. As a result, the interpretation of presented results will be different from what is standard. In Exhibit 1 a relatively high result indicates, in reality, low execution costs. Conversely, a relatively low result is indicative of higher execution costs. This is because the base results (without log transformation) for our presented spread measures lie between 0 and 1. Log transformation of observations between 0 and 1 result in higher values for observations approaching 0 and lower values for observations approaching 1[10].

Panel 1 of Exhibit 1 presents the log of trade value weighted effective spreads across the analysed exchanges. Mean results for trade value weighted effective spreads range from 3.387 in LSE - a hybrid market - to 4.441 in TSE – a pure LOB market. Consistent with previous literature, stocks on the NYSE are found to have comparatively lower effective spreads when compared to matched stocks on NASDAQ (4.077 versus 3.433 respectively).

Similar results are found for log of time weighted quoted spreads (Panel 2). TSE stocks when compared to matched stocks on NASDAQ have significantly lower mean quoted spreads (3.577 versus 2.4 respectively). Consistent with previous literature, we find that mean time weighted quoted spreads are larger on NASDAQ compared to NYSE.

Panel 3 presents our results for the log of trade value weighted relative realised spreads. Consistent with the results above, the pure LOB market of TSE is found to have significantly lower spreads when compared to matched stocks on NASDAQ (relative realised spreads are approximately double on NASDAQ). This is most likely indicative of the increased competition and presumably lower profits for liquidity provision in pure LOB markets. In accordance with or previously presented results and with

[10] It should be noted that we take the absolute value of all results.

existing literature, relative realised spreads are larger on NASDAQ compared to matched NYSE stocks. Similarly, LSE stocks have lower relative realised spreads compared to NASDAQ.

[INSERT EXHIBIT 1 HERE]

Exhibit 2 presents our results for the different measures of spreads during the different stages of the financial crisis. The results[11] paint a rather interesting picture - documenting not only the turmoil and fear that engulfed equity markets globally but also the sharp and somewhat sudden reversal in sentiment towards the second quarter of 2009. Panel 1 of Exhibit 2 shows that the log of trade value weighted effective spreads for NASDAQ stocks increased dramatically - by 29.9 cents (98.9%) - during the climax of the crisis when compared to the initial period analysed. A similarly sharp increase in effective spreads is shown to have occurred for stocks listed on the NYSE – spreads increased by a remarkable 100.1% (29.6 cents). Stocks on the TSE are shown to have effective spreads jump by 46.8% (6.6 cents) during the height of the crisis. Interestingly, our results show that during this same period, stocks on the LSE actually report a *decrease* in effective spreads by 33.1% (14.1 cents). A possible explanation for this is that many of the significant events specific to the United Kingdom occurred prior to our defined crisis period during the various stages of the crisis. These results are consistent with the findings of the full sample. We also report the differences between thickly and thinly traded stocks in our final summary of univariate results.

The difference between *Pre* and *Post* crisis periods in Panel 1 highlights the improvement in effective spreads following the crisis. Universally, spreads are shown to return to levels approximately the same as those prevalent during the initial phase of the crisis (from 1 April, 2007 to 29 August, 2008). NASDAQ stocks, for example, actually show spreads declining to their lowest level in all our sample period in the later phase of the crisis (7.1 cents decrease in mean trade value weighted effective spreads compared to the pre-crisis period).

Panel 2 presents the log of time weighted quoted spreads during the various stages of the financial crisis. The results, similar to those reported in Panel 1, highlight the depths to which global markets (in particular, the NYSE) slumped at the height of the crisis. Quoted spreads increased by 62.3% (2.1 cents) on NASDAQ, 61.2% (3.2 cents) on the LSE, 128.6% (66.8 cents) on the NYSE, and 51.6% (4.9 cents) on the TSE. It should be noted that despite the relatively large increase in time weighted quoted spreads on the NYSE, consistent with literature examining such measures during a more stable period, NYSE spreads are shown to be less (in absolute terms) than those on matched stocks listed on NASDAQ.

Panels 3 presents the log of trade value weighted relative realised spreads during the various stages of the crisis. All exchanges (including the LSE) show spreads increasing during the climax period. Stocks on the NYSE and NASDAQ, once again, are shown

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[11] As earlier, the log transformation of observations lying between 0 and 1 results in a somewhat counterintuitive interpretation of results; a smaller value is indicative of higher costs (however measured) while a higher value indicates lower spreads.

to have the largest deviation in spreads across all periods. Unlike the results for effective spreads (see Panel 1) which return to levels approximately the same as those prevalent in the first period of our analysis, relative realised spreads only recovered marginally. In fact, unlike the distinct shift in effective spreads apparent when comparing the 'recovery' period to the 'crisis' period there is no such shift in relative realised spreads. Relative realised spreads are an ex-post measure of profits to trading intermediaries (see Hendershott and Jones [2005]). The fact that relative realised spreads do not improve greatly following the dislocation that occurs during the climax of the crisis indicates that liquidity providers, generally speaking, continued to face increased adverse selection costs in the markets analysed. It could be also indicative of increased competition for liquidity provision – perhaps resulting from increased dollar traded value as fund managers and institutional investors sought to rebalance their portfolios.

Overall, the results presented in the full sample (Exhibit 1) and the sample split by financial crisis periods (Exhibit 2) provide evidence supporting our first four hypotheses[12]. Specifically, they suggest that execution costs are significantly different across market designs and also significantly different across liquidity quartiles. The results are also consistent with previous literature which show spreads to be greater on the NASDAQ compared to the NYSE and that some execution cost measures indicate that spreads on the LSE are greater than those on NASDAQ (for example, see Huang and Stoll [1996], Aitken et al. [2009]).

[INSERT EXHIBIT 2 HERE]

Univariate Results for Volume and Volatility – Full Sample

We present our results for volume and volatility for the full sample of matched stocks during the entire sample period. Consistent with Hendershott and Jones [2005] we use the daily difference between the logarithm of highest and lowest transaction price as our measure of volatility. Our results are presented in Exhibit 3.

Exhibit 3 Panel 1 shows that the mean log of daily volume is largest on the LSE, followed by NYSE, TSE and then NASDAQ. Exhibit 3 Panel 2 shows that our volatility measure is largest for NASDAQ stocks against all other exchanges. TSE stocks in particular are found to have the lowest comparative volatility when compared to their matched NASDAQ counterparts.

[INSERT EXHIBIT 3 HERE]

Exhibit 4 presents spreads after we split our sample further by date and by liquidity quartiles. The results presented show that thinly traded stocks not only have larger spreads but also, generally speaking, experience greater deterioration in liquidity during the climax period of the crisis. The results confirm our *a priori* expectations with volume largest in the most liquid quartile and lowest in the least liquid quartile. This result applies to all of the exchanges examined. We presented results

[12] In unreported analysis we decompose our sample into liquidity quartiles. As expected, the most liquid stocks have the lowest spreads (however measured). The difference in spreads is also reduced across exchanges.

earlier that confirmed our *a priori* expectations based on previous empirical literature and theoretical research that spreads are largest for thinly traded stocks.

Panel 1 of Exhibit 4 presents results for trade value weighted effective spreads across the three time periods (pre-crisis, climax and post-crisis). As with the results shown in Exhibit 2 we show that stocks on the NYSE experienced the greatest deterioration in market quality followed by stocks listed on NASDAQ. Interestingly, stocks in the fourth quartile (least liquid) of the NYSE sample show no improvement in spreads in the period following the climax while stocks in the other liquidity quartiles do. LSE, moreover, is shown (once again) to have been the least affected exchange in terms of percentage decline in effective spreads during the crisis period across all liquidity quartiles. Further, we show that the most liquid stocks on the LSE perform the best relative to all other exchanges – effective spreads decline by 10% during the crisis compared to 55% on NASDAQ, 85.6% on the NYSE, and 40.5% on TSE.

Panel 2 presents similar results for time weighted quoted spreads. Stocks across all liquidity quartiles are shown to perform the best during the climax period on the LSE. Interestingly, while NASDAQ stocks in the first liquidity quartile experience a sharp improvement in spreads in the period following the climax, the least liquid stocks continue to experience a worsening of spreads by 7.7%. We also show that quoted spreads decline the least (during the climax period) across all liquidity quartiles on the only pure LOB market in our sample – TSE. Similar results are found for relative realised spreads (presented in Panel 3).

Similarly, with the exception of two cases, volatility displays a pattern across liquidity quartiles as was expected – volatility increases, albeit marginally, with lower liquid stocks. Moreover, we find evidence suggesting that stocks on NASDAQ are the most volatile when compared to their matched counterparts on the other exchanges.

[INSERT EXHIBIT 4 HERE]

Multivariate Regression Results for Spreads

We present the results from our multivariate analysis of execution costs and their relationship with a variety of institutional design features using the matched stocks previously identified on the NYSE, NASDAQ, LSE, and TSE. The results are presented in two parts. The first part examines our spreads and volatility measures using the entire sample of matched stocks with dichotomous variables introduced for the various market mechanisms and time effect. The second part stratifies our full sample into liquidity quartiles and presents results on the rerun of the original models against this decomposed sample set. This is consistent with previous literature which provides evidence suggesting that the effect of institutional design on execution costs is often a function of stock liquidity.

Multivariate Results for Spreads – Full Sample

We first examine the effect of the market design dummy variables on our measures of execution costs - trade value weighted effective spreads, trade value weighted relative realised spreads, and time weighted quoted spreads. It should be noted that as our model is run using a double logarithmic transformation all parameter coefficients should be interpreted as elasticities. For instance, let us assume the coefficient of β_i(Volume) takes the value 0.05, then it should be interpreted as follows: a 100% increase in Volume will increase spreads by 5.13% (100 x ($e^{0.05}$-1)). Also note that although we consider four exchanges, there are three primary differences (i.e., three distinct dummy variables) in market design. NASDAQ and LSE have been classified as Hybrid Markets, TSE as a pure Limit Order Book market and NYSE, in order to capture its unique composite features, has been assigned a dichotomous variable entitled NYSE Composite Features. To avoid the dummy variable trap our model includes dummy variables for LOB and Hybrid markets. Therefore the interpretation of coefficients refers to the difference compared to the NYSE features.

Exhibit 5 presents the multivariate regression results of the market design dummy variables on our measures of execution costs. The coefficient for the hybrid trading mechanism is significant in explaining all execution cost measures[13]. For instance, having a hybrid market system with both assigned dealers and a LOB - such as the LSE - decreases effective spreads (TVWES) by 50.8% (100 x ($e^{-0.7094}$-1)). This is in accordance with previous literature and Hypothesis 4 which suggests that hybrid markets that incorporate two sources of liquidity providers offer the best execution venue for market participants (for example, see Parlour and Seppi [2001]).

Exhibit 5 also indicates that a pure LOB market mechanism – such as that on the TSE - actually resulted in increased effective spreads during our sample period. Given the increased activity and volatility apparent in markets during our sample period this provides support for Viswanathan and Wang [2002] who find that a properly structured hybrid market will dominate a pure LOB system for risk-averse investors.

Both the LOB and Hybrid trading mechanism are found to be significant in explaining variation in trade value weighted relative effective spreads (TVWRES), and so, provide empirical support for Hypotheses 1 and 2. The results, moreover, reinforce the conclusions reached above. Specifically, hybrid markets are shown to decrease relative spreads by 81.5% (100 x ($e^{-1.6879}$-1)) on average as predicted by Hypothesis 4. A pure LOB system, on the other hand, is shown to increase relative effective spreads by 2971%.

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[13] The execution cost measures are Trade value weighted effective spread (TVWES), Trade value weighted relative effective spread (TVWRES), Trade value weighted relative realised spread (TVWRRS), Trade value weighted relative realised 30 minutes spread (TVWRR30S), Time weighted quoted spread (TWQS) and Time weighted relative quoted spread (TWRQS).

Further, Exhibit 5 presents results for trade value weighted relative realised spreads (TVWRRS) and trade value weighted relative realised 30 minute spreads (TVWRR30S) respectively. The model is run using the same Fixed Effects OLS method used earlier and retains the same independent variables as those used for TVWES and TVWRES (changing only the dependent variable). Therefore, the interpretations for each parameter will continue to be as before. The regression of TVWRRS shows that the hybrid and LOB market structures remain significant in explaining relative realised spreads. The signs of the coefficients of these parameters, negative for the hybrid market dichotomous variable (-1.6764) and positive for the LOB dichotomous variable (1.3648), strengthen the results for TVWES and TVWRES. Our fixed effects model shows that a hybrid market decreases relative realised spreads by 81.3% (100 x ($e^{-1.6764}$-1)). In contrast, pure LOB markets are shown to increase spreads by 291% (100 x ($e^{1.3648}$-1)). This is consistent with the results presented earlier and Hypotheses 1, 2 and 5. Additionally, relative realised 30 minute spreads are 96% (100 x ($e^{-3.2168}$-1)) lower in hybrid markets and 344% (100 x ($e^{1.4906}$-1)) greater in pure LOB markets. Realised spreads are a measure of profit to liquidity suppliers (dealers, specialists and other such participants). A hybrid market incorporates two sources of liquidity and so is expected to generate greater competition among liquidity providers. As a result, profits made by trading intermediaries are expected to be lower compared to a market with only one source of liquidity. The results above, therefore, are consistent with hypothesis 4 and previous literature.

In accordance with Madhavan, Porter and Weaver [2005] we use time weighted quoted spreads to capture overall market liquidity. These results are presented in Exhibit 5 under Time Weighted Quoted Spread (TWQS) and Time Weighted Relative Quoted Spread (TWRQS). The results indicate that TWQS are significantly different from zero. However, in contrast to the results presented earlier, both hybrid markets and pure LOB markets have greater spreads than those apparent in the NYSE market. A hybrid market is found to increase spreads by 450% (100 x ($e^{1.7049}$-1)) and an LOB market by 197% (100 x ($e^{1.0881}$-1)). Similar results are shown for TWRQS.

[INSERT EXHIBIT 5 HERE]

Multivariate Results For Spreads – Split Sample (Liquidity By Quartiles)

Existing literature on market microstructure has provided evidence suggesting that institutional design impacts stocks in different liquidity quartiles in differing ways. Swan and Westerholm [2007], for example, find that greater opacity in market design improves spreads for relatively large stocks while revealing a large part of the LOB serves small to medium sized stocks better. Consequently, we split our stocks into two subsets - a thickly traded sample (those stocks found in the top two liquidity quartiles) and a thinly traded sample (those stocks found in the bottom two liquidity quartile).

Exhibit 6 shows that the composite features of the NYSE (trading floor, circuit breakers and market makers) work best in reducing TVWES for thickly traded stocks (top two liquidity quartiles). A hybrid market increases costs relative to the NYSE by 243%.

Similarly, a pure LOB market increases spreads by 38.34%. The volume control variable indicates that, ceteris paribus, a 100% increase in volume will, on average, result in a 34% increase in spreads. However, the interaction variable for hybrid markets and volume suggests that hybrid markets provide better execution for large volumes with spreads 10.7% lower than the NYSE. Intuitively this has some appeal as hybrid markets offer greater choice to investors in regards to trading mechanism. Pure LOB markets are found to be marginally worse than the NYSE for executing large volumes with spreads 2% greater. Additionally, Exhibit 6 presents results for TVWRES top two liquidity quartiles. Results are similar to those under TVWES top two liquidity quartiles, indicating that the NYSE is structured best to reduce spreads for thickly traded stocks. A hybrid trading mechanism increases relative effective spreads by 179.7% while a pure LOB system increases spreads by 55.8%. Further, Exhibit 6 presents results for TVWES for stocks in the bottom two liquidity quartiles.

Exhibit 7 presents results from our fixed effects model for TVWRRS and TVWRR30S by liquidity quartiles. The top quartile results support the evidence provided in the full sample results – hybrid markets, with their multiple sources of liquidity provision, increase competition and reduce profit available to trading intermediaries (spreads are 99% lower than compared to those on the NYSE). A pure LOB market, on the other hand, increases relative spreads by 81.1%. However, relative spreads for large volume transactions are 20.4% cheaper on LOB systems as indicated by the interaction variable (LOB * Volume).

Exhibit 7 bottom liquidity quartile results provide further evidence supporting prior literature and hypotheses 2, 3 and 4. Once again we show that relative realised spreads are reduced in a hybrid market when compared to the composite features of the NYSE and pure LOB system. Specifically, a hybrid market reduces spreads by 40.70% compared to the NYSE while a pure LOB market increases relative spreads by 253%.

Exhibit 8 presents results for TWQS and TWRQS from our fixed effects model during the financial crisis by liquidity quartiles. The hybrid and LOB dichotomous variables are shown to be significant in explaining quoted spreads. Consistent with previous results, the institutional design of the NYSE is found to be the most effective in reducing execution costs for thickly traded stocks when compared to hybrid and pure LOB markets. Hybrid and pure LOB markets increase time weighted quoted spreads by 401% and 320% respectively.

While in Exhibit 8 we find the NYSE market design to be the most effective in reducing costs for thickly traded stocks, the results in Exhibit 6 TVWES bottom two liquidity quartiles suggest that the hybrid market marginally reduces costs for thinly traded stocks (0.62% lower). Pure LOB markets, however, are shown to increase costs by approximately 80%. Consistent with the results from the thickly traded sample, hybrid markets are the most effective in reducing costs for investors wishing to transact large volumes (3.1% lower than the NYSE). These results are consistent with Nimalendran and Petrella [2003] who find evidence suggesting that moving from a pure LOB system to a hybrid system with a specialist increases the liquidity of thinly traded stocks on the Italian Stock Exchange. The results presented in Exhibit 6 give further credence to our *a priori* belief that the significance and impact of market design on execution costs differs according to stock liquidity (Hypothesis 3).

For Exhibit 8 TWQS thinly traded stocks (the bottom two liquidity quartiles), the unique institutional features on the NYSE, such as the presence of a trading floor and circuit breakers, are shown to be the most effective in reducing quoted spreads. A hybrid market system increases quoted spreads by 354% while the coefficient for the LOB dichotomous variable indicates that such systems increase comparative spreads by 92.5%. Similar results are found for TWRQS. Interestingly, the interaction variables between volume and the hybrid market dichotomous variable and volatility and the hybrid market dichotomous variable suggest that, ceteris paribus, the hybrid market system provides better execution for high volume, high volatility thinly traded stocks transactions when compared to the NYSE and the pure LOB system. This is in accordance with Nimalendran and Petrella [2003].

The results confirm Hypotheses 1, 2 and 3 reinforce the conclusions reached by Aitken et al. [2009] that the effects of market design on execution costs are not uniform across all stocks. Our results confirm that institutional design affects stocks in different liquidity brackets in a varied and complex manner. This has important implications for investors and regulators alike. Regulators may use this information when assessing the likely impact of introducing certain legislation and they could incorporate the findings in any decision making process. Investors and company shareholders too, may also use this knowledge to assist in their execution and listing decisions. Results also provide evidence supporting Viswanathan and Wang's [2002] theoretical model which suggests dealership and hybrid markets, properly structured, are more attractive venues for best execution of large volume transactions – confirming Hypothesis 4.

[INSERT EXHIBIT 6 HERE]
[INSERT EXHIBIT 7 HERE]
[INSERT EXHIBIT 8 HERE]

Multivariate Results for Volatility – Full and Split Samples (Liquidity By Quartiles)

A question of paramount importance for equity markets around the world is – particularly during periods of substantial upheaval in markets such as during the global financial crisis of 2007-2009 - how market architecture contributes to market volatility.

Among others, Biais et al. [1998] and Viswanathan and Wang [2002] demonstrate how the risk preferences of investors determine their ideal execution venue. For example, risk averse investors prefer dealership and hybrid markets. Risk neutral investors, on the other hand, have a preference to execute on pure LOB systems. We investigate the impact of market design on market volatility. We continue to use the multivariate fixed effects regression framework developed earlier, incorporating several control variables in order to isolate the affects of the dichotomous variables that denote the various market designs. Our results are presented in Exhibit 9. It should be noted that the interpretation of the coefficient estimates are as previously described (as elasticities).

Exhibit 9 presents the results for our full sample of matched stocks. While the parameter coefficients for limit order and hybrid markets are significant the economic impact is shown to be negligible – volatility is 0.06% greater in hybrid markets compared to the NYSE and 0.075% greater in pure LOB markets. Amongst thickly traded stocks (top liquidity quartile firms), pure LOB markets are shown to be significantly negatively related to volatility when compared to the NYSE market while hybrid markets are significantly positively related to volatility. The results for thinly traded stocks (bottom liquidity quartile firms) confirm the results of thickly traded stocks and show that volatility is negatively related to a pure LOB system and positively related to a hybrid system (again relative to the market architecture of the NYSE). All three samples, however, suggest that the economic significance of these market mechanisms in explaining volatility is minor at the best. The interaction term between number of trades and the hybrid market dichotomous variables, however, suggests the hybrid market is most effective in reducing volatility as the number of trades increase. The above results are rather interesting and could be reflective of the general heightened volatility during our sample period (refer to the descriptive statistics earlier presented). These results provide support to Hypothesis 5.

[INSERT EXHIBIT 9 HERE]

Summary of Results

Univariate Results

In Exhibit 10 we present a summary of the univariate results presented earlier and rank each of the market designs against each of our execution cost measures. It should be noted that these univariate results are *not* indicative of the relative benefits of a certain market design over another. Such inferences may only be drawn using the results from the multivariate models employed in this paper.

Exhibit 10 shows that the TSE has the lowest execution costs (however measured) across all liquidity quartiles. Conversely, execution costs are the greatest for NASDAQ stocks. This is generally consistent with pervious literature (for example see Huang and Stoll [1996]). However, in contrast to our results, Aitken et al. [2009] show spreads to be greatest on the LSE. One possible explanation for our disparate results lies with the global financial crisis – our results for volatility and volume earlier, identified the American exchanges as experiences the greatest dislocation during the crisis.

The results are mixed when we decompose our sample into a thickly traded and thinly traded subset (in accordance with Aitken et al. [2009]). While the best and worst performing exchanges may be easily identified (TSE and NASDAQ respectively), it is not clear whether the NYSE or LSE offer lower execution costs for thinly and thickly traded stocks.

[INSERT EXHIBIT 10 HERE]

Multivariate Results

In general, the results from our fixed effects OLS models confirm our hypotheses and are consistent with the majority of existing literature. In Exhibit 11 we present a summary of the results presented earlier and rank each of the market designs against each of our execution cost measures.

We show that the dichotomous variables used to represent market design are significant in explaining execution costs and volatility. Moreover, we show that costs are significantly different across markets. These two findings confirm Hypothesis 1. Specifically, we find that the Hybrid market, for most measures of spreads, is the most effective in reducing costs followed by the composite features of the NYSE (such as trading floor and circuit breaker regulations). The pure LOB mechanism performs the worst during our sample period. The strength of the hybrid market is consistent with the theoretical model of Viswanathan and Wang [2002].

Exhibit 11 Panels B and C confirm hypotheses 2 and 3 and show that execution costs are not only significantly different across markets but the association between market mechanism and execution costs varies across liquidity quartiles. For example, while the composite features of the NYSE are best overall for thickly traded stocks, the hybrid mechanism performs the best overall for thinly traded stocks.

Hypothesis 4, that hybrid markets with their multiple sources of liquidity reduce relative realised spreads (a proxy for profits to trading intermediaries), is strongly confirmed in all three panels of Exhibit 11.

[INSERT EXHIBIT 11 HERE]

CONCLUSION

Studies examining the impact of institutional design on execution costs range from the theoretical models (such as Glosten [1994]) to the pure empirical papers (such as Aitken et. al [2009]). The results from these studies have been mixed. Some of found that the hybrid market performs best as it pools multiple sources of liquidity (Viswanathan and Wang [2002]). Others find that the pure LOB system, which is easily accessible therefore, theoretically increasing the number of liquidity providers, offers the lowest execution costs to investors. This study uses a multivariate regression framework incorporating a matching algorithm to overcome selection bias as evident in existing literature to evaluate the impact of market design on execution costs. Importantly, this study is one of the few papers to examine the influence of market design on execution costs during a time of heightened stress on the trading mechanism; The sample period 1 September 2008 to 1 February 2009 encompasses the start, climax and early recovery from the global financial crisis.

The first section of this paper provided univariate statistics of execution costs and volatility on the NYSE, NASDAQ, LSE and TSE. We find evidence consistent with previous literature. Spreads for stocks on the NYSE are lower than for their matched counterparts on NASDAQ. Spreads for matched stocks on the LSE and TSE are also lower than spreads for their counterparts on NASDAQ. Effective spreads for NASDAQ stocks increase dramatically by 98%. A similar sharp increase is observed for stocks listed on the NYSE (100% increase) and TSE (46.8%). The LSE performs the best of the exchanges examined in this period with conflicting results showing some measures of spreads actually declining during the climax of the crisis. Volatility also is shown to increase sharply during the height of the crisis – increasing by over 20% in the week following the collapse of Lehman Brothers. More generally, spreads are shown to increase by 2 to 3% on all exchanges during our predefined crisis period.

Our multivariate results paint a complex picture. For the full sample of stocks (pooling both thickly traded and thinly traded stocks in our analysis) we find that the hybrid system is most effective in reducing spreads (however measured) during our sample period. The NYSE system, with its unique characteristics such as trading floor and formal rules for circuit breakers, is found to be the second most effective market mechanism. Interestingly, we find the pure LOB system of the TSE performs the poorest out of the designs analysed. Further, in accordance to the theoretical model derived by Viswanathan and Wang [2002], we show that hybrid markets reduced relative realised spreads which are a proxy for profit to trading intermediaries. This suggests that hybrid markets increase competition among liquidity providers placing them under competitive pressure to reduce costs.

Naturally the sample exchanges would have been impacted differently and at different times by the financial crisis. However the impact was to a large extent global and comparing matched companies using the most supported methodology in the literature, we argue that the companies and consequently the exchanges are compared using the same yardstick. We then split our sample into thickly traded and thinly traded subsets and rerun our fixed effects model. Our results show that the affect of market mechanism on execution costs varies according to the liquidity profile of the stock in question. In particular we show that the hybrid market mechanism is highly effective, relative to the other designs analysed, in reducing costs for illiquid stocks. For liquid stocks, we find the most effective market mechanism to be that of the NYSE followed by the pure LOB mechanism. The Hybrid market is shown to increase costs relative to these exchanges for highly liquid stocks.

This paper has important implications for the investment community and regulators alike. The recent financial crisis has engendered a debate among market participants regarding the robustness of the performance of exchanges during volatility episodes. Our conclusions suggest that when market design changes are implemented, exchanges should take into account their impact on trading costs amongst stocks within different liquidity classes.

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