Institutional Design and Liquidity on Stock Exchanges

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Abstract

This paper analyzes the impact of various institutional features of stock exchanges on their performance in a unified framework. We assemble the institutional design features like organizational structure, trading mechanism, trade-execution system, transparency, degree of market fragmentation, age, and ownership for 51 major exchanges around the world. For these exchanges, representing over 90% of world's market capitalization, their institutional features are linked with various performance measures namely – quoted bid-ask spreads, effective spreads, realized spreads, volatility, and trading turnover. Simultaneous-system-of-equations model is used to account for inter-linkages between the different measures of performance. We find that hybrid systems have lower spreads and volatility than pure limit order systems, which in turn are have lower spreads and volatility than pure dealership systems. Stock exchanges with bid-ask spreads are those that have narrower tick sizes, competitive market makers, electronic limit order book, automatic execution of trades, centralized trading, and enforcement of insider trading laws. The results do not provide any support to the theories that predict better liquidity for monopolistic specialist system, or electronic open limit order book with no dealers. Spreads are directly related to return volatility but inversely related to market capitalization on a global basis. The analysis has important policy implications for security lawmakers implementing fairness and transparency, companies seeking global listings, investors forming trading strategies, and stock exchanges altering their institutional design to increase competitiveness.

Introduction

Stock market trading is witnessing radical changes at the dawn of the new millennium. Rising globalization, deregulation, cross listing, and foreign portfolio investments have made the competition among exchanges greater than ever before. Technological advancements in telecommunications and the Internet are modifying the basic business model of a stock exchange. The important changes in institutional design of exchanges can be categorized as follows:

- De-mutualization: There is an increasing trend towards incorporation of exchanges. For example, exchanges in Sweden, Finland, Denmark, the Netherlands, Italy, Australia, Singapore, Hong Kong, and Canada are now incorporated. This separates ownership from membership. NASDAQ has plans for major re-capitalization that would change its ownership structure.
- "Hybrid" trading systems: Major exchanges of the world have either introduced or proposed "hybrid" trading systems that are a combination of electronic public limit order book and obligatory quotes by market makers. NYSE, already a hybrid system, is introducing an additional internal electronic communication networks (ECN), NASDAQ is proposing 'Supermontosh' limit order book which will also display dealers identity; exchanges in London and Germany (Xetra) have hybrid systems since 1997.
- Automation: Numerous cost effective electronic communication networks (ECN) have appeared and quickly captured a considerable market share of trading volumes[1]. Madoff securities and 4 other investment banks are planning to create "Primex", a fully electronic version of an agency auction. Over 60% of all exchanges have moved from floor-based trading to electronic screen based trading with a provision for automatic execution of trades based on price and time priorities.
- Centralization of Order Flow: There is a wave of mergers among the leading European exchanges, like London and Frankfurt. The stock exchanges of Amsterdam, Brussels and Paris merged in September 2000 to form "Euronext". Similarly all equity trading was centralized to a single exchange in Canada and France in the last decade. The

[1] ECNs captured over 30% of NASDAQ trades and over 4% of NYSE trades within 3 years of their existence.

institutional design implication of these changes is the centralization of fragmented markets. Arnold et. al (1999) show that mergers of U.S. regional exchanges attracted additional market share and lowered bid-ask spreads.

- Decimalization: Leading exchanges of the world like Toronto, NYSE and NASDAQ have moved from pricing in fractions to pricing in decimals.

Even though so many exchanges are striving to bring about sweeping changes in their institutional design, not many studies dwell upon the efficacy of various institutional features of exchange-design in an integrated framework. The goal of this study is to analyze the impact of institutional design characteristics on the performance of 51 major stock exchanges around the world. The institutional features analyzed for each exchange in this paper are organizational structure, trading mechanism, tick-sizes for price quotation and trading, trade-execution system, transparency of the details of the order flow, degree of market fragmentation, exchange-ownership, exchange-age, and shareholders rights. Organizational structure is characterized by the presence of designated market makers[2] and competition between market makers. Trading mechanism and systems are characterized by existence or absence of features like an electronic limit order book, dealers acting as market makers, and provision for automatic execution of trades. Performance of exchanges is gauged by various measures namely, quoted bid-ask spreads, effective spreads, realized spreads, volatility, and trading turnover.

The specific research question addressed in this paper is whether the performance measures vary systematically across exchanges. If yes, then is the variation in spreads arising due to differences in their institutional design? Exchange-design can potentially affect several components of spreads – adverse selection, order processing and inventory costs. We empirically examine what the important exchange-design parameters that affect the competitiveness of an exchange are.

The extensive coverage of 51 exchanges helps in capturing a wide-ranging cross-sectional variation in both performance measures and institutional design measures. This setting

[2] By designated market makers, we mean dealers who are obligated to provide firm quotes at all times at least for a small quantity.

allows us to test several market microstructure theories in a unified framework. Apart from their scientific value, the answers to these questions have policy implications for security lawmakers who want to increase fairness and efficiency of the securities markets. This study is also important for companies, investors and stock exchange managers. The financial markets today have become highly integrated. This has increased the degree of exchange-choice available to the companies that seek listing, and the investors who wish to trade. The comparisons made in this paper have a direct application for optimization of the strategies of such companies and investors. Previous literature has documented various instances where trading is found to be very sensitive to trading costs and market structure. For example, majority of trading in some leading Mexican stocks takes place on NYSE. Similarly, Pagano and Stiel (1996) document that in 1989, French order handling rules made block trades unattractive and majority of block trades in French stocks were executed anonymously on the London SEAQ-International exchange. Only after the liberalization of block trading restrictions did the trading turnover come back to the Paris Bourse. Thus stock exchange owners, promoters and managers would value the analysis presented in this study for improving exchange competitiveness.

Many studies have previously compared the performance of different exchanges within the U.S. Huang and Stoll (1996) discuss the differences in trading mechanisms of NYSE, a hybrid market, and NASDAQ, a dealer market, that may give rise to differences in spreads on the two exchanges, particularly higher spread on NASDAQ. However, such bi-lateral comparisons do not capture all possible exchange-designs. For example neither NYSE nor NASDAQ is a pure limit order book and neither one is incorporated. Another limitation of such comparisons is that these exchanges differ in more than one institutional characteristic like competition between market makers, existence of a limit order book, provision of automatic execution of trades, etc. As a result, the impact of individual institutional features cannot be disentangled. In contrast, the wide cross-sectional variation in institutional features of international stock exchanges used in this study results in a full coverage of exchange-designs and enables us to extricate the incremental impact of each institutional feature on performance of an exchange. This presents an opportunity to test the theoretical predictions about improvement in performance of exchanges due to factors

like absence of market maker (Glosten 1994, Black 1995, Rock 1989 and Stoll 1998), monopoly of specialist (Glosten 1989), fragmentation of marketplace instead of centralization of all trades to a single venue (Biais 1993, Hamilton 1972), reduced ex-ante transparency of the details of order flow (Madhavan 1995), replacement of trading floors with automated electronic order-based trading (Domowitz and Stiel 1998), de-mutualization of ownership (Domowitz and Stiel 1998), and enforcement of insider trading laws (Bhattacharrya and Spiegel 1991).

There are only a handful of cross-border comparisons of exchanges around the world. The main reasons for this are the difficulties in obtaining data and forming a common metric of trading costs across markets. In this paper we try to address some of these difficulties and attempt to search for exchange-designs that provide best liquidity to the investors. In a related study, Domowitz, Glen and Madhavan (2000) use a U.S. global portfolio manager's proprietary panel data from 42 countries from 1996 to 1998 to analyze the interactions between cost, liquidity, and volatility. They find significant cross-sectional variation in total trading costs and composition of these costs. Perold and Sirri (1997) also use order and execution data from a large U.S. institutional asset manager and document significant cross-country variation in costs of equity trading. However, these studies do not directly relate the differences in observed spreads to institutional characteristics.

This study extends these papers in an important way by searching for the evidence on whether the differences in performance measures have their roots in the institutional set-up of the stock exchanges in these countries. Further, unlike the previous studies that consider total cost to US investors, here the costs to local investors are considered. The benefit of this approach is that it gives cleaner estimates of costs and their relationships to institutional structure. The cost estimates are not contaminated by differential treatment that foreign investors receive in most countries. There is also an important methodological difference between this paper and Domowitz et. al (2000) and Perold et. al (1997). They compute implicit cost by taking the difference between transaction price and an indexed

price[3]. In contrast, this study uses the percentage quoted spreads computed as the difference between actual lowest ask price and highest bid price divided by the bid-ask midpoint at the close of each day. We also use percentage effective spreads computed as twice the difference between actual transaction price and quote midpoint divided by quote midpoint at the close of each day. These are likely to be much more accurate representations of costs especially if the intra-day volatility in prices is high. Higher volatility could widen the gap between transaction prices and indexed prices even though the actual spreads at any given point of time may be low[4].

The performance measures i.e. percentage quoted spreads, percentage effective spreads, percentage realized spreads and volatility are computed from bid prices, ask prices, and transaction prices observed at the close of each day for 15 securities[5] with the highest market capitalization on each of 51 stock exchanges. Spreads and depths on all stocks listed on these exchanges are also observed once every month from intra-day trading data available from Bloomberg Financial Services and NYSE's Trades and Quotes (TAQ) data. The details about the institutional features, trading mechanisms and organization of different exchanges are collected from home pages of the exchanges on the World Wide Web, directories, handbooks, reports of capital market institutes and direct correspondence. A simultaneous system-of-equations model is estimated using two-stage least squares (2SLS) methodology. This technique allows for interdependence within the endogenous variables in the model. The endogenous variables are spreads, volatility and turnover. The exogenous or instrumental variables include tick sizes, indicator variables for the institutional features discussed earlier, economic variables and individual stock trading characteristics.

The main results of the study are as follows. Spreads are directly related to return volatility but inversely related to market capitalization on a global basis. After controlling for these individual stocks' trading characteristics, the exchanges' institutional features

[3] The indexed price used in some previous studies is the weighted average of price of all trades for the day. Alternatively some authors use the average of open, close, high and low price.
[4] For instance in April 2000, yahoo's average quoted spread was 0.03% whereas average volatility was 0.39%.
[5] This covered from a minimum of 22% market capitalization on NYSE to 96.5% on Bermuda.

have significant explanatory power in determining the differences in their performance. There is a strong positive relationship between measures of spread and the relative tick sizes adopted by an exchange. Both quoted and effective spreads as well as volatility are higher in pure dealer systems when compared to those on pure electronic limit order books or hybrid systems. Spreads are lower on exchanges that have such features as provision for automatic execution of trades, presence of a designated market maker, competition between the market makers, a limit order book (LOB), and centralization[6] of all stock-trading activity to a single exchange or system. Spreads and volatility are significantly higher in the emerging markets compared to those in developed markets. Spreads are also higher when there is full transparency of details of order flow including demand and supply schedule. Better shareholder protection rights and enforcement of insider trading laws lower spreads.

Trading intensity, defined as the ratio of annual trading volume to market capitalization, varies significantly with most of the market characteristics in the expected direction. Higher spreads widen the transaction cost band and lower the incentive for trading. Market fragmentation significantly increases turnover. Trading intensity is positively associated with presence of market maker (MM). Enforcement of insider trading laws potentially reduces adverse selection and gives rise to a higher trading turnover.

The remainder of the paper is organized as follows. Section I links the institutional design of a stock exchange to its performance and develops the hypotheses to be tested. Data and summary statistics are presented in Section II. Trading mechanisms of different exchanges are also described in this section. The empirical methodology and results are contained in Section III. Section IV discusses robustness issues, the practical utility of the results, and some limitations of this study. Section V concludes.

[6] Here a market is said to be centralized if all trading in a given stock has to go through a single system/ single venue. When same securities are traded on scattered markets/ multiple exchanges, then the market is fragmented.

I. Hypotheses Development

The primary function of a stock exchange is to provide liquidity in listed securities. The effectiveness of a stock exchange in performing this function can be affected by many of its institutional features. This section contains a brief discussion of the attributes of a stock exchange analyzed in this paper. These are presence of market makers, competition between market makers, existence of an electronic limit order book, centralized versus fragmented market, provision for automatic execution of trades, and ownership of the exchange. The economic environment in which the exchange operates, shareholders rights, insider trading rules, and individual stock characteristics are used as control variables.

The performance of exchanges is measured by quoted spreads, effective spreads, realized spreads, volatility, and trading volumes. Percentage quoted spread on a stock is the difference between the lowest ask and the highest bid price divided by bid-ask midpoint. This is representative of trading cost for the investors because the public is guaranteed to be able to trade at least small amounts at these prices without bearing negotiation costs. A further refinement to this concept is the percentage effective spread which is twice the absolute difference between actual transaction price and the contemporaneous bid-ask mid-point divided by the bid-ask midpoint. This measure is widely used because it accounts for price improvement/dis-improvement in actual trading. We also compute the realized spread, which is twice the signed difference between the closing transaction price and the midpoint of bid-ask quotes at the close of next session. This represents the order processing cost and rents of the suppliers of liquidity, net of adverse selection costs. The use of percentage spreads instead of absolute spreads for each of the three measures makes the comparison between exchanges more sensible because percentage spreads are free of numeraire.

Liquidity can be provided on a stock exchange by a variety of trading mechanisms. In a public electronic limit order book, incoming customer orders are matched based on price and time priorities. In pure dealer systems, the brokers supply liquidity by quoting bid and ask prices at which customers can trade with them. In this study, the exchanges that use a

combination of limit order book and binding dealer quotes are classified as 'hybrid' systems. Yet another mechanism is the periodic call market, also called 'price fixing mechanism', in which orders are accumulated over a period of time and then batch processed at a single price that would maximize volume. The periodic call markets do not have any spreads and are therefore excluded from this analysis. Such exchanges account for trading in less than 5% of the world market capitalization. The theoretical predictions on the relationships of the attributes of a stock exchange with its bid-ask spread performance are discussed below. All null hypotheses are set up in such a way that their rejection implies that the institutional feature under consideration significantly impacts performance measures.

A. *Presence of a Designated Market Maker*

Some exchanges have designated market makers (MMs) who are obliged to supply bid and ask quotes and then act as counter parties for incoming orders by trading on their own account. The rationale behind having market makers is that they improve liquidity when the depth of the order book is not sufficient or lacks synchronization. However, Glosten (1994) predicts that the electronic open limit order book (LOB) provides as much liquidity as possible and any additional competition (another exchange) is either unprofitable or redundant. An interpretation of this is that MMs do not add liquidity beyond that provided by a LOB system. He shows that no trader is worse off and many are strictly better off with an open LOB than with a monopolist specialist. Similarly, Black (1995) predicts that with automated LOBs, dealers will lose money and therefore exchanges will have no market makers. Rock (1989) also suggests that market makers disrupt trading against the LOB and induce second order adverse selection. Stoll (1998) envisages that competition across markets reduces willingness of MMs to stabilize markets and electronic trading reduces the importance of MMs even in dealer markets. Thus, most of these theoretical models envisage little role for a MM. The only exception is Seppi (1997) who predicts that a hybrid specialist/limit order market provides better liquidity to small investors than the pure LOB. In his model, the specialist undercuts the public limit orders book due to price and public priority, thus lowering the transaction costs for small investors. The primary hypothesis tested in this paper is that:

$H1_0$: Presence of designated market makers does not significantly reduce the spreads. In other words spreads are not different on hybrid markets and pure limit order books.

B. *Competition Between Market Makers*

As economic intuition would suggest, Ho and Stoll (1981) show that competition between market makers leads to a more liquid market and narrower spreads compared to those with monopolist market maker. However, Glosten (1989) argues that the institution of a monopolist specialist may decrease small-quantity spreads somewhat by increasing the liquidity of the market. The presence of informed traders forces market makers to widen spreads and reduce liquidity of the markets. While competing risk neutral market makers expect a zero profit on every trade, the monopolist will average his profits across trades. Thus, Glosten (1989) predicts that small-quantity spreads are narrower under a monopolist specialist regime. The second hypothesis analyzes the impact of competition:

$H2_0$: Competition between market makers has no impact on spreads.

C. *Centralized versus Fragmented Markets*

Biais (1993) envisions that the mean spreads are equal in both fragmented and centralized markets but more volatile in the latter. Fragmentation potentially has two opposite effects. On the one hand, it increases competition by increasing the number of dealers, which in turn reduces transaction costs. On the other hand, it splits the trading volume across trading venues and decreases price competition between orders thus decreasing liquidity (Madhavan 1995). Branch and Freed (1977) show that the first effect dominated whereas a NYSE (1973) study shows the opposite. Hamilton (1972) shows that the competitive effect exceeds the fragmentation effect. In a related study, Arnold et. al (1999) empirically show that mergers of U.S. regional exchanges lowered bid-ask spreads. This can be interpreted to imply that too much fragmentation is bad. The issue is still unsettled in the literature. Here the null hypothesis is:

$H3_0$: Spreads are equal in both fragmented and centralized markets.

D. *Ex-Ante Transparency of Market Depth*

Madhavan (1995) predicts that dealers in less transparent (opaque) markets will price more aggressively in early rounds to attract informed traders. The information learned can be used in later rounds to extract profits. In more transparent markets, dealers have no such incentive or opportunity. Pagano and Roell (1996) predict the opposite i.e. increases in both ex-ante and ex-post transparency lower spreads because it reduces the adverse selection problem for the dealers. Flood et.al (1999) and Bloomfield and O'Hara (1999) show in their experimental studies that an increase in transparency of quotes and trades widens spreads especially at the open or before news. However, in their studies, the differences in spreads disappear near the close of the trading round. Transparency can refer to many different information items and it can be ex-post and ex-ante. In this study an exchange is classified as transparent if the complete details of limit orders and quotes[7] are displayed on the brokers' screens. Hence, the results have to be interpreted in this restricted sense.

$H4_0$: Closing spreads on transparent trading systems are equal to those on opaque systems.

E. *Automatic Execution of Trades*

Domowitz and Stiel (1998) suggest that automation substantially reduces both the fixed and the variable costs of providing transaction services. There are tremendous savings in market development costs, distance costs, and order-processing costs when one compares automated systems with the non-automated ones. Pirrong (1995) finds that automated markets are deeper than floor markets.

The flip side is that when trades are executed automatically, the dealers' quotes or public limit orders are like free options that can be picked off selectively by the participants. This increases the degree of adverse selection. However, indirect evidence contrary to this view is provided by Vila and Sandman (1996) in their study of two Japanese exchanges. Coppejans and Domowitz (1997) also show that the adverse selection components were 17% higher on the CME floor, compared to the automated Globex trading system for

[7] This essentially gives a snapshot of the demand and the supply schedules for the stock.

stock index futures. This study empirically examines whether cost efficiency or adverse selection dominates:

$H5_0$: Exchanges with automatic execution of trades experience the same spreads as those with trade-time re-negotiations/ broker intervention.

F. *Ownership of the Exchange*

Domowitz and Stiel (1998) discuss the implications of exchange governance mechanism. Exchanges were traditionally organized as mutual associations owned and operated by member-firm brokers and dealers. Recently the trend is towards incorporation of exchanges. There are also a few exchanges that are owned by government entities. One implication of de-mutualization or government ownership is that the interests of the shareholders dominate. As a result, policies that increase exchange's profits and competitiveness are implemented even if it means a reduction in members' spreads and profits. Incorporation also makes it easier to raise more finances and make continuous technological up-gradations. We test the hypothesis that:

$H6_0$: Spreads on incorporated or government owned exchanges are equal to those on exchanges owned by a mutual association of exchange members.

G. *Legal and Economic Environment: Shareholder Rights and Insider Trading Laws*

The legal rules of the game are another important determinant of the performance of a stock exchange. Regulation is a two-edged sword. On the one hand, it provides customer protection, financial system integrity and market price integrity. The literature supporting prohibition on insider trading argues that insider trading increases the degree of adverse selection. This forces liquidity providers to widen the bid-ask spreads. Bhattacharya and Spiegel (1991) prove that in the absence of laws against insider trading, spreads would widen to the extent that markets will break down. On the other hand, regulation can impose its own costs. Manne (1966) states that a ban on insider trading would instead reduce the efficiency of the markets and would impede an effective way to compensate managers. Bhattacharya and Daouk (2000) find that enforcement of insider trading laws significantly improves liquidity and reduces cost of capital. The null hypotheses are:

$H7_0$: Enforcement of laws against insider trading has no impact on spreads.

$H8_0$: Better shareholder rights have no significant impact on spreads.

H. *Control Variables*

Stoll (2000) relates spreads (s) to individual firms' trading characteristics in the following cross-sectional regression for U.S. stocks listed on NYSE:

$$s = a_0 + a_1 \log V + a_2 \sigma^2 + a_3 \log MV + a_4 \log P + a_5 \log N + e \qquad (1)$$

where s is the stock's proportional quoted spread defined as (ask price – bid price)/P, V is daily dollar volume, σ^2 is the return variance, MV is the log of stock's market capitalization, P is the stock's closing price, N is the number of trades per day and e is the error term. The rationale for these variables is based primarily on order processing and inventory considerations. Increments in trading volume, average size and number of trades, and firm size increase the probability of locating counter-party, thereby reducing risk of accepting inventory. The stock's return-variance measures the risk of adverse price change of a stock added to inventory. Price controls for the effect of discreteness and is an additional proxy for risk because low price stocks tend to be riskier. Stoll (2000) finds that the empirical relationship in (1) is very strong and over 60% of cross sectional variance in spreads in NYSE stocks is explained by the independent variables (Adjusted $R^2 = 0.6688$). His results are also consistent with Demsetz (1968), Stoll (1978), Tinic and West (1974) and Branch and Freed (1977). For the reasons discussed above, trading turnover, log of market capitalization, and volatility of returns are included in the regressions as explanatory variables. Data on number of trades, however, is not available. In order to control for differences in price levels of the stocks in the sample, we also have the relative tick size (tick size expressed as a percentage of price level) as an independent variable in the regressions.

The business environment in developed economies is also different from that in emerging economies. A dummy variable for developed countries is included in the regressions to account for these differences. The performance of a stock exchange can improve or deteriorate with time. For that reason we include the age of a stock exchange as another control variable.

I. *Endogeneity of Volatility*

Volatility is modeled as an exogenous driver of spreads in most studies discussed above. However, volatility of stock returns is itself driven by many factors like evolution of fundamentals, arrival of new information, regional factors, country-specific factors, and the method of organizing trading in the stock exchanges. The latter is the focus of this paper. In this paper returns volatility is included as an endogenous variable in the structural form equations. Madhavan (1992) predicts that prices are more volatile in order-driven (LOB) systems than in quote-driven systems. Madhavan (1995) predicts that market fragmentation results in higher price volatility. He also predicts that price volatility in a market without mandatory trade disclosure (low transparency), is higher compared to that in more transparent markets. In a triangular system of equations, Domowitz, Glen and Madhavan (2000) find that market capitalization, and emerging markets dummy are significant explanatory variables for estimating volatility. The null hypotheses for volatility are:

$H9_0$: Institutional design features like limit order book, centralization, and transparency do not have a significant impact on volatility.

J. *Endogeneity of trading turnover*

Domowitz, Glen and Madhavan (2000) note that higher trading cost will reduce turnover. However the effect of volatility on trading is ambiguous. Higher volatility may induce more trading because it is associated with a greater dispersion in beliefs. Alternatively, risk averse traders may reduce their trading in volatile markets. Here trading turnover i.e. the ratio of dollar trading volume to dollar market capitalization is included as an endogenous variable in the structural form equations.

$H10_0$: Bid ask spread does not have a significant impact on trading turnover.

$H11_0$: Volatility does not have a significant impact on trading turnover.

$H12_0$: Institutional design features like limit order book, centralization, transparency, and automatic execution of trades do not have a significant impact on trading turnover.

II. Data and the Details of Institutional Features

The hypotheses developed in the previous section address multiple issues in the institutional design of stock exchanges. Even though the different exchanges in the U.S. itself provide some diversity in institutional features, the cross-sectional variation across the world markets appears much more promising to test these hypotheses in a unified framework. Accordingly, we have assembled the data on institutional features of 139 major stock exchanges from 110 countries. The major part of this study focuses on 51 of these exchanges for which data on bid-ask spreads are available from the Bloomberg Financial Services archives and NYSE's Trades and Quotes (TAQ) database. These account for roughly 36% of the total number of exchanges. In terms of market capitalization, however, the stock exchanges in the sample represent over 90% of the universe. The daily closing bid ask spreads are analyzed over the period from January 2000 to April 2000. Whereas many market-microstructure studies use trade-by-trade data, our information is restricted to daily closing bid price, ask price, trade price, bid depth and ask depth for each stock. This information is sufficient to test the hypotheses in question. However, intraday pattern in spreads cannot be captured in this study. Moreover, the method of recording closing bid, ask and transaction prices may vary slightly across exchanges. However, such noise is more likely to be random than vary systematically with institutional features. Regardless of the possible tradeoffs involved in the two approaches, this approach is the only one that is feasible given data limitations. Historical intra-day quote data is maintained by only a few exchanges.

Institutional details

The details about the trading mechanisms and organization of different exchanges are collected from various sources including the home pages of exchanges on the World Wide Web. The website of International Federation of Stock Exchanges[8] has links to all stock exchanges. In addition, directories, handbooks, and reports of capital market institutes like the International Financial Review's[9] (IFR) handbook of world stock & commodity

[8] http://www.fibv.com
[9] A London based financial publishing house.

exchanges, are also used. Bloomberg Financial Services also provides a brief profile of exchanges around the world. Wherever the required information was not available in any of these resources, it was obtained through direct correspondence with the exchange officials[10]. Wherever, specific information about a particular institutional feature like automatic execution of trades was not given on the website and could also not be obtained by correspondence, such features were assumed to absent. The broad market data and classifications of markets into developed and emerging are obtained from Morgan Stanley Capital International.

The summary statistics for institutional features along with other details about the stock exchanges are given in Table I. A description of the institutional variables used in the regressions is as follows. The indicator variable 'market-maker' is set to one if the exchange employs designated market makers who are obliged to provide binding bid and ask quotes for some minimum quantity that they are ready to trade at all times[11]. For competition between market makers, we test two conditions. First, the dealers should be able to trade on their own account (not just on behalf of firm client orders) and second, no particular dealer should have privileged access to the order flow like a specialist on NYSE. Wherever, the description of trading given on the websites do not specify that brokers could trade only on behalf of their customers, it is assumed that they could trade on their own account as well. The trading mechanism can be either customer-limit-order driven (lob =1) or dealer-quote-driven (lob=0) or open-outcry (lob=0) system of trading. Hybrid systems have 'lob=1' if an order book is present. Trading is said to be centralized if all trades in any stock in the country are executed at a single venue or passes through a single execution system. On the other hand, if the same stock can be traded on multiple trading venues, we classify the market as a 'fragmented' market. If the details of the order flow like price schedules on the demand side as well as the supply side (bid depth for each price and ask depth for each price) are displayed on brokers' screen then "ex-ante transparency" is set to 1. Provision for "automatic execution" is equal to one if trades are executed automatically based on price/time priorities or if the trades can be executed by

[10] The email address, phone and fax numbers for all stock exchanges are available on the world wide web.
[11] In practice market makers can avoid trading under very exceptional circumstances

hitting the dealers quotes on the screen[12]. 'Owner'=1 if the stock exchange is owned and managed by a mutual cooperative of broker-members. If the exchange is incorporated or is an independent government organization then 'owner'=0. We use Morgan Stanley Capital International's (MSCI) classification of markets as developed (=1) or emerging (=0). Bhattacharya and Daouk (2000) give information in their Table II about the date of first enforcement, which we use to determine whether or not the insider trading laws are enforced in a country. The proxy for shareholders rights are the values of the index generated by La Porta et. al (1996) for different countries.

The remaining market specific and firm specific variables are continuous variables. The importance of stock market in the economy is measured by the ratio of market capitalization of listed firms to the GDP of the country. The ages of all stock exchanges are computed from their establishment year to the year 2000. The total market capitalization (in billions of U.S. dollars) for each exchange is the sum of market capitalization of all firms listed on that exchange. In regressions, the logged value of this market capitalization is used. The turnover figure presented is the ratio of annual value of total trading on the exchange to the total market capitalization of listed companies.

[Insert Table 1 here]

There seems to be a large cross sectional variation between institutional design and set-up of the 139 exchanges in the world. Historically speaking the culture of stock exchanges started over 400 years ago when the oldest stock exchange was started in Germany. The tradition continued for centuries and 60 new financial exchanges came into existence in the last decade. More than 48,000 securities are listed on the 139 exchanges with an average of 345 companies per exchange. The aggregate market capitalization exceeds twenty five trillion dollars. The exchange with highest market capitalization is NYSE with more than $8 trillion. The average annual turnover to market capitalization ratio is 0.741.

[12] For example the small orders execution system (SOES) on Nasdaq.

The institutional features across the 51 exchanges in the sample present an interesting variety. Thirty-seven percent of the exchanges have a designated market maker who supplies binding quotes. There is open competition between market maker on 51% of the exchanges. Only 43% have full ex-ante transparency of order flow. Nevertheless, 78% of exchanges have trading system with automatic execution of trades. Sixty-one percent of the exchanges operate in centralized market and the remaining in fragmented markets. Ownership of exchange is in the hands of broker-members in 63% cases and exchanges are incorporated or a government agency in the remaining cases. Fifty-one percent of the exchanges considered here operate in markets classified as developed markets by Morgan Stanley Capital International.

[Insert Figure 1 here]

Exchanges that use a combination of designated market makers and a limit order book are classified as hybrid exchanges. Figure 1 is a pie chart that shows the proportion of pure call auction (19%), pure dealer markets (19%), pure limit order markets (48%) and hybrid exchanges (14%) among the 139 exchanges. In the sample of 50 exchanges, we have 25% pure dealer markets, 48% pure limit order markets, and 27% hybrid exchanges.

Performance Measures

Next, we compute the performance measures for 51 of these exchanges from bid, ask, and transaction prices at the close of each day. These data are collected from the Bloomberg Financial Services' archives and from NYSE's Trades and Quotes (TAQ) database. The 'all stock' percentage spreads shown in the second column of Table 2 are the average quoted bid-ask spreads across all quoted securities on a particular exchange. The average is over monthly observations during the period from March 2000 to August 2000. Stocks listed on an exchange that are not quoted at all do not enter this computation.

The next column presents the average quoted spreads on the top 15 stocks having highest market capitalization on each exchange in 1998 according to the handbook of world and commodities exchanges (1999). The selection is based on exchange of primary listing and therefore cross-listings through ADRs etc. do not get included. We do not apply any price

or data filters that are commonly used in the U.S. studies. Such filters will not have their desired impact in this study. For instance, if all stocks below US$ 5 are excluded from the sample then for many exchanges we will be left with no stocks to analyze. The initial sample size for 51 exchanges is 775 companies. However, we lose 30 companies from six countries[13] in the sample for which the handbook lists only top 10 companies as they cover a substantial portion of the total market capitalization. Further, 56 companies from different exchanges were delisted, merged or acquired. We replace all these companies with the ones that are next in the sequence of descending market capitalization obtained from Bloomberg database. Since ADRs etc. are included, the sample has 765 unique firms with primary listing on the respective exchanges. Thus, there is no overlap due to cross listings. The spreads data on the top 15 pertains to the period January 2000 to April 2000. These stocks represent on an average 60.3% of the total market capitalization of all stocks on each exchange[14].

The quoted percentage spreads are computed as follows for each day:
Quoted percentage spread = (Ask Price - Bid Price)/Quote Midpoint.

Then for each security the spread is averaged across the sample period. Finally, average over the 15 securities in each exchange is taken and presented in Table 2. Effective bid ask spread is computed as the absolute difference between transaction price and quote midpoint divided by the quote midpoint and then averaged across top 15 stocks:

Effective percentage spread = (|Transaction price – Quote midpoint|)/Quote midpoint*2.

Realized spreads are computed as follows:

Realized percentage spread = {(Transaction price – Quote midpoint$_{t+1}$)/Quote midpoint$_t$*2}* inferred trade direction indicator.

where the subscript t indicates current trading day and t+1 indicates next trading day.

[13] Colombia, Estonia, Hungary, Israel, Peru and Poland
[14] However the percentage of market capitalization covered varies from 25% to 86%.

Since there is only one observation per day, it is not possible to compute intraday volatility. Instead, we compute the volatility as the standard deviation of quote midpoints over a period of one month. Use of quote midpoints avoids the bias in volatility computation due to bid-ask bounce. This is then averaged across the sample period and across the 15 securities on each exchange. The trading turnovers in Table 2 are from 1999.

[Insert Table 2 here]

There is a lot of cross-sectional variation in the performance variables too. Table 2 shows that the average value for percentage quoted spreads on all stocks is minimum in China and maximum in Bermuda. NYSE has the lowest percentage quoted and effective spreads on the top 15 securities listed on the exchange. Ukraine has highest quoted and effective spreads followed by Bermuda, Russia and Brazil.

There is an interesting pattern between quoted and effective spreads. Effective spreads are lower than the quoted spreads on 33 exchanges, which indicates that at least some trades are executed inside the quoted spread. However, on the remaining 18 exchanges, the effective spreads are larger than the quoted spreads. This results when the quotes are only indicative but not binding and the prices are sensitive to actual trading. Usually, the quotes are binding only for small trade sizes. When trade size exceeds this minimum depth, the transaction price is likely to fall outside these bounds. The use of just closing (and not intra-day) bid prices, ask prices and transaction prices can potentially introduce measurement errors in effective spreads as there can be a lag between last trade and last quote revision. However, the use of highly active stocks from each exchange mitigates this problem to a large extent. For instance in the US, the quoted and effective spreads using closing data from TAQ are similar to those computed in previous studies that use intra-day data.

Volatility of returns is highest in Luxembourg and lowest in Israel for top 15 stocks. Taiwan has the highest trading intensity and Luxembourg has the lowest.

Comparison with other past empirical studies on spreads

The spreads for stock exchanges in developed markets are comparable to those in earlier studies like Perold and Sirri (1997) and Domowitz, Glen, and Madhavan, (2000)[15]. However, for the emerging markets the percentage spreads calculated in this paper are less than half of those reported in the earlier studies. Among the many possible reasons for the differences, the following seem most plausible. First, the focus of earlier studies was the cost faced by a U.S. institutional investor placing orders internationally. Such an investor might face higher market impact cost, greater intermediation costs etc. On the other hand, costs computed here are for the local investors trading at the respective exchanges. Second, the data used in this paper represent a more recent period when stock markets are developing at a fast pace in the emerging markets. Third, this study uses spreads on the 15 most active stocks in each market, whereas in the previous studies, institutional investors might be investing in less active stocks. Finally, the implicit costs in those studies are based on the difference between transaction price and a weighted average price. Here the computations are based on quoted bid-price, quoted ask price, and transaction price reported at the close of the market every day.

The quoted percentage spreads on top 15 stocks on these exchanges are also comparable with individual stock market studies. Huang and Stoll (1996) find that absolute spreads on large stocks are $0.132 on NYSE and $0.223 on NASDAQ. The numbers in this study are $0.151 and $0.354 respectively[16]. The 146 basis points spread for UK for the top 20 stocks compares to 104 basis point *'touch'* computed in Hansch, Naik, and Viswanathan (1998). This difference can be partially explained by fact that their calculation is based on full days' trading data unlike the closing bid-ask quotes used for this study. Madhavan, Richardson and Roomans (1997) find a U-shaped pattern in spreads during the day i.e. spreads are higher during open and close than during the rest of the day. For the Paris Bourse, the spread of 0.234% is close to 0.300% in Biais, Hillon, and Spatt (1995) [17].

[15] These studies report one-way costs which correspond to half of the 2-way round trip cost presented in this paper.
[16] Based on spread of 0.20% and average price of $76.60 on NYSE and 0.52% and $66.77 on NASDAQ.
[17] Their paper finds average spreads of 9 times the tick size when tick size is 0.1. The price range of such stocks is FF 100 to 500 for which I have taken the average of FF300.

Lehmann and Modest (1994) [18] and Hamao, and Hasbrouck (1995) [19] report average bid-ask spread of 0.817% and 0.83% respectively for the Tokyo Stock Exchange, both of which are comparable to 0.799% in this paper.

III. Empirical Methodology and Tests

The quoted percentage spreads and effective percentage spreads are computed from daily closing bid and ask prices on the top 15 securities on each exchange for every trading day between January and April 2000. The sample period is divided into four monthly periods. Monthly values of average quoted spread, effective spread and volatility are created for each stock in the sample. These monthly values are then used as dependent variable. Monthly values are required to compute the volatility of stock returns because only one transaction price for each day is available. This procedure also reduces the measurement error due to random day-to-day fluctuation in spreads. Apart from other possible reasons such randomness is also induced by price discreteness resulting from tick size. Using daily values can be problematic because if the model predicts spreads less than the minimum price variation (or any spread not falling on the specified price grid) on the exchange, then we may not observe such values. This averaging procedure has been widely used in the literature for example in Stoll (2000), and Titman and Wessels (1988). Using this procedure, the initial sample of 71,112 daily observations results in a monthly sample size of 3,060 records (firm-months).

An unconditional comparison of average spreads across different market structures is presented in Table 3. Broadly speaking, the institutional structure of the market has a perceptible impact on the performance measures. Both spreads and volatility are highest in pure-dealership markets and lowest in hybrid markets. Hybrid markets have designated market makers who provide dealer quotes in conjunction with a public limit order book. Spreads and volatility are higher on emerging markets compared to those on developing markets.

[Insert Table 3 here]

[18] For largest decile stocks listed on Tokyo
[19] for 3 stocks in their sample

The differences in spreads described in panel A of Table 3 are statistically and economically significant. In order to ensure that the differences are not being driven by concentration of one exchange type in developed or emerging markets, we conducted a two-way analysis by splitting the sample of exchanges between and developed and emerging markets as shown in panel B and panel C respectively. The pure dealer markets in both developed and emerging economies have higher spreads and volatility compared to pure limit order books or hybrid markets. Next, we carry out a three-way analysis by splitting each of panels B and C into two sub-categories namely centralized and fragmented locations of trading. The results of the three-way analysis are shown in Figures 2 and 3.

[Insert Figures 2 and 3 here]

The three market mechanisms are shown on z-axis, the different market classifications are on x-axis, and performance measures are on the y-axis. Panels 2a, 2b, and 2c present quoted spreads, effective spreads and realized spreads respectively. Similarly, in figure 3 the three-way analysis is based on transparency of details of the order flow. The rankings between market mechanisms in these three-way classifications are not as assertive as the 1-way and 2-way classification. However, in most market classifications, hybrid markets and pure limit order books have lower spreads and volatility and dealer markets have the highest.

Finally, we need to account for the possibility that these differences may result from a combination of institutional features and individual stock trading characteristics. In order to simultaneously analyze the incremental impact of each institutional feature while controlling for firm specific characteristics, we need to perform a regression analysis. Furthermore, advanced econometric techniques also make it possible to model inter-dependencies between the performance measures.

Section I discussed a number of attributes of the stock exchanges that may in theory affect their performance in terms of spreads. In that section, endogeneity of spreads, volatility

and turnover are also outlined. In order to account for the inter-dependencies in performance measures we need to use simultaneous system-of-equations model. This application is developed in detail in the context of cross-country comparison of trading costs by Domowitz, Glen and Madhavan (2000). The endogenous variables are spreads, volatility and turnover. The exogenous or instrumental variables include indicator variables for presence of market makers, competition between market makers, presence of limit order book, market centralization or fragmentation, transparency of details of order flow, automatic execution of trades, ownership of exchange, enforcement of insider trading laws and an index of shareholders rights. The system of equations is as follows:

$$\text{pqspread}_{it} = \alpha + \beta_0 \text{ tick} + \beta_1 \text{ mcap}_t + \beta_2 \text{ mmkr} + \beta_3 \text{ mcomp} + \beta_4 \text{lob} + \beta_5 \text{ frag} + \beta_6 \text{ transp} + \beta_7 \text{auto} + \beta_8 \text{ develop} + \beta_9 \text{ right} + \beta_{10} \text{ insider} + \beta_{11} \text{ stdev}_{it} + \beta_{10} \text{ age} + \varepsilon_{it} \quad (2)$$

$$\text{pespread}_{it} = \alpha + \beta_0 \text{ tick} + \beta_1 \text{ mcap}_t + \beta_2 \text{ mmkr} + \beta_3 \text{ mcomp} + \beta_4 \text{lob} + \beta_5 \text{ frag} + \beta_6 \text{ transp} + \beta_7 \text{auto} + \beta_8 \text{ develop} + \beta_9 \text{ right} + \beta_{10} \text{ insider} + \beta_{11} \text{ stdev}_{it} + \beta_{10} \text{ age} + \varepsilon_{it} \quad (3)$$

$$\text{prspread}_{it} = \alpha + \beta_0 \text{ tick} + \beta_1 \text{ mcap}_t + \beta_2 \text{ mmkr} + \beta_3 \text{ mcomp} + \beta_4 \text{lob} + \beta_5 \text{ frag} + \beta_6 \text{ transp} + \beta_7 \text{auto} + \beta_8 \text{ develop} + \beta_9 \text{ right} + \beta_{10} \text{ insider} + \beta_{11} \text{ stdev}_{it} + \beta_{10} \text{ age} + \varepsilon_{it} \quad (3)$$

$$\text{stdev}_{it} = \delta_0 + \delta_1 \text{ mcap}_t + \delta_2 \text{ mmkr} + \delta_3 \text{ lob} + \delta_4 \text{frag} + \delta_5 \text{ transp} + \delta_6 \text{ auto} + \delta_7 \text{ develop} + \eta_{it} \quad (4)$$

$$\text{trad}_{it} = \alpha_0 + \alpha_1 \text{ mmkr} + \alpha_2 \text{ mcomp} + \alpha_3 \text{ lob} + \alpha_4 \text{ frag} + \alpha_5 \text{ transp} + \alpha_6 \text{ auto} + \alpha_6 + \text{develop} + \alpha_7 \text{ stdev}_{it} + \alpha_8 \text{ age} + \alpha_9 \text{ pqspread}_{it} + \nu_{it} \quad (5)$$

where $pqspread_{it}$ is the percentage quoted spread on security i in month t, $pespread_{it}$ is the percentage effective spread on security i in month t, $pespread_{it}$ is the percentage realized spread on security i in month t, $stdev_{it}$ is the volatility of returns from security i in month

t,and $trad_{it}$ is the trading turnover on the exchange *i* in month *t*. The independent variables are as follows. 'Tick' is the relative tick size expressed as a percentage of average price midpoint for each stock for each month, '$mcap_t$' is the log of market capitalization (in millions of dollars) of the exchange in month *t*, trad is the ratio of trading volume at an exchange to the market capitalization at that exchange, mmkr, mcomp, lob, frag, transp, auto, develop, and insider are indicator variables for presence of MM, competition between MM, limit order book, market fragmentation, transparency of order flow, automatic execution of trades, developed markets, and enforcement of insider trading laws respectively. 'right' is the index of shareholder protection laws and rights from La Porta et. al (1996), and 'age' is the number of years since the establishment of the exchange. These variables are described in more detail in the description of Table 1. ε_{it} , η_{it} , and ν_{it} are the error terms.

The specification is based on the discussion in Section I where various theories linking the organization and structure of stock exchanges to their performance are presented. The system of equations is estimated using the two stage least squares (2SLS) method.

Parameter Estimates and Results of the Tests

The empirical relationship in equation (2) for percentage quoted spreads gives an adjusted R-square of 30.46%. The R-square with percentage effective spread, as dependent variable is 29.85%. These regressions are based on a sample of 3,060 security months obtained from 71,112 daily observations. The regression coefficients are given in Table 4.

[Insert table 4 here]

After controlling for both individual stocks' trading characteristics like return variance and market characteristics like capitalization, the institutional characteristics add significant explanatory power to explaining the differences in spreads across the exchanges. If we rank the indicator variables for the institutional features by the magnitude of their coefficients, relative tick size, competition among market makers, insider trading laws, and automatic execution of trades have the maximum impact in reduction of both quoted and effective spreads. Market fragmentation and excessive

disclosure of details of order flow seems to be widening the spreads. Presence of a limit order book and presence of a designated market maker seem to have a favorable impact on the liquidity. Spreads and volatility are lower in developed markets when compared to those in emerging markets.

Both quoted and effective spreads decrease with the presence of a designated market maker system on the exchanges. The coefficients on these variables are economically significant. For instance, the presence of a designated market maker reduces the effective spreads by 32 basis points. This compares with the minimum percentage effective spread of 9 basis points and average of 219 basis points across all exchanges. The impact of MM competition, limit order book, fragmentation, transparency, and automatic execution respectively is even more dramatic. Complete absence of market makers in the world markets can cost the investors an extra $85 billion on an annual trading turnover of over $15 trillion around the world. These results have the following implications for the null hypotheses.

Designated market maker: $H1_0$ is weakly rejected i.e. the presence of market makers matters for effective spreads but it is not significant for quoted spread. Glosten (1994), and Black (1995), predict insignificant role of market makers in providing liquidity and reducing spreads. The coefficient on presence of market maker is negative.

Competition among market makers: $H2_0$ is rejected i.e. competition between market makers is useful. The fallout of competition between market makers contradicts Glosten (1989) who gives a rationale for why spreads would be narrower under monopolist specialist regime. In fact, competition between market makers helps in lowering the spreads significantly. This finding is consistent with Ho and Stoll (1981).

Market Fragmentation: $H3_0$ is rejected i.e. centralization is better than fragmentation. The results do not provide support to Biais' (1993) theory that mean spreads are equal in both fragmented and centralized markets. Fragmentation potentially has two opposite effects. On the one hand, it increases competition, which in turn reduces transaction cost. On the

other hand, it splits the trading volume across trading venues thus decreasing liquidity. The findings here are consistent with Arnold et. al. (1999) i.e. liquidity suffers due to splitting up of trades across fragmented exchanges.

Transparency of Order Flow: $H4_0$ is rejected i.e. ex-ante increase in transparency of details of order flow widens spreads. Even though Madhavan (1995) predicts wider opening spreads in more transparent markets, the data here pertains to closing spreads. The result here is, therefore, puzzling.

Automatic execution of trades: $H5_0$ is rejected i.e. automation reduces spreads significantly as per Domowitz and Stiel's (1998) claim that both the fixed and the variable costs of providing transaction services are lower in automated exchanges. The savings in market development costs, distance costs, and order-processing costs more than offset the free options problem of stale quotes[20].

Ownership of exchange: $H6_0$ is not rejected i.e. the spreads are not different between incorporated and mutually owned exchanges. Ownership structure was not found to be significant in any of the regressions and therefore dropped as an explanatory variable to reduce the possibility of collinearity. However, the ownership structure may still matter in areas other than spreads like security innovation, technology adoption, volume of trading in the long run etc.

Insider Trading and Shareholder Rights: $H8_0$ cannot be rejected and $H7_0$ is rejected. Shareholder rights and insider trading enforcement have the predicted sign as espoused by Bhattacharya and Daouk (2000). However, the coefficients are significant only for insider trading law enforcement but not for shareholders rights at the traditional 5% significance level.

In line with extant literature, proportional spreads increase with return variance, and decrease with market capitalization. These were used as control variables. Also notice

[20] The informed participants in automatic execution can pick off stale quotes more quickly thus increasing the degree of adverse selection problem.

that coefficients on market maker and limit order book are both positive. This suggests that hybrid systems potentially can do better than pure auction or pure dealer systems. The 2SLS results also show that volatility of returns is lower in LOB systems. It increases with higher ex-ante transparency. Trading volume varies significantly with most of the market characteristics in the expected direction. Higher spreads widen the transaction cost band and lower the incentive for trading. Trading intensity is significantly higher in the emerging markets.

IV. Robustness and Practical Utility of the Results

Different specifications and sub-samples were analyzed to check the robustness of the regression results. Similar results are obtained when OLS regressions are implemented for equations 2 to 5 with White's heteroskedasticity correction. Initially, this study was conducted with only the top 10 stocks from each exchange. Addition of 5 more securities per exchange does not significantly impact the coefficients. The direction and significance of the coefficients are robust to these alternative specifications and sub-samples.

A cursory look at the Table 2 also indicates that outliers in the sample are not driving the results. Consider, for instance, two markets with extremely high spreads – Russia and Bermuda. The Russian exchange has designated market makers and Bermuda exchange employs electronic limit order book. If observations from these countries were driving the results, we would see a positive coefficient on designated market maker and limit order book. This, in fact, is not the case.

[Insert Table 5 here]

The extensive use of dummy variables naturally gives rise to concerns about potential collinearity problems. A correlation analysis is presented in Table 5 to gauge the seriousness of this problem. There are three elements in each cell. These are respectively the correlation coefficients, p-values of significance, and the number of exchanges based on which the correlation is computed. The lower triangular half of the matrix gives

correlation for all 137 exchanges[21] around the world. The upper triangular matrix computes correlation for 51 exchanges for which performance measures are computed. When one considers all 137 exchanges, limit order book has highly significant positive correlation with automatic execution of trades and market transparency. Developed market dummy is also positively correlated with designated market makers and enforcement of insider trading laws. This reflects the fact that most nascent exchanges are pure limit order books with automatic execution of trades and no market makers. However, the more relevant part of the table is the upper triangle with correlations between the market design features of the 45 major exchanges, which form the core of the analysis in this paper. In case of those exchanges the correlations appear to be low enough to justify the use of multiple dummy variables without giving rise to severe multi-collinearity problems.

While interpreting these results it needs to be borne in mind that even though spreads and volatility are the most direct and relevant measure of trading costs for investors, there are other important criteria that investors consider. Depth of market, and informative-ness of prices are other common variables on which the performance of stock exchanges can be analyzed. This is especially important because there is an obvious inverse relationship between spreads and some of these factors like depth. In addition, the results may be affected by the fact that spreads across exchanges are computed on different stocks that carry different levels of adverse information and probably different inventory carrying costs. Moreover, the analysis applies to the stocks with very high market capitalization. These might well be the stocks with substantial investor interest. Nevertheless, the role of institutional features may be more or less important for smaller stocks. Broker commissions, inter dealer trading systems and policies for preferencing of trades may also differ across exchanges. The study tries to control for many of these differences indirectly by using control variables like market capitalization, economic development, shareholders rights, insider trading enforcement, and age of the exchange. Notwithstanding these limitations, the study produces some significant and interesting results.

[21] Two of the 139 exchanges are dropped due to missing data.

The practical utility of the results obtained in the previous section depends on several additional factors. When policy makers choose a particular aspect of institutional design, the performance measures discussed above may not be the only criteria. Clayton, Jorgensen, and Kavajecz (2000) find that a country's economic development, the degree of competition, extend of economic freedom, size of economy, availability of technology, and the legal system are important determinants of formation and structure (trading system) of international exchanges. In a multivariate regression analysis section, results of which are not reported here for brevity, we regress each one of the institutional features on the economic, demographic, financial, and geographic factors specific to each country. The most striking result of this analysis is that there are no significant differences between the institutional designs of stock exchanges in the developed markets and emerging markets. The only exception is the ownership of exchange where "incorporated exchanges" are a phenomenon specific to developed markets and bigger markets at the turn of the century. Other than that, the emerging markets have adopted the latest technology, trading structure and market design very swiftly. As one would expect, the number of exchanges increase with number of firms, area of the country, and the GDP.

Conclusions

This paper estimates the impact of institutional factors on the performance of 51 of the world's leading stock exchanges. While these results are not conclusive, they serve to document several empirical relationships between the organization of stock exchanges and the bid-ask spreads on the listed securities with high market capitalization. The paper contributes to empirical literature on market microstructure by testing several theories that could not be tested using data from exchanges in a single country having constant order handling rules, transparency, economic development, and legal environment.

The study shows that after controlling for individual stocks' trading characteristics and some market specific differences, the institutional features of stock exchanges add significant explanatory power in explaining the differences in liquidity on the exchanges. In particular, pure dealer systems have higher spreads and volatility compared to pure limit order systems or hybrid systems. Quoted as well as effective spreads decrease with

the presence of a designated market maker for securities on the exchanges. Spreads further shrink if there is competition between the market makers. Exchanges that maintain a limit order book (LOB) have lower spreads compared to those that do not. Provision of automatic execution of trades, and centralization of all stock trading activity to a single exchange/system both lower the spreads. The institutional characteristics also affect trading volumes and volatility.

Although, many empirical relationships are established, it remains an open question whether the measurement techniques indeed ensures that no confounding economic differences between the markets are left out. The study can be extended in a variety of ways. The scope and number of exchanges, number of securities, periodicity of trading data and number of organizational characteristics can all be expanded for making the tests more precise.

The current study focuses on how stock exchanges can vary their trading characteristics to become more competitive. It is assumed that lower spreads on listed securities will attract both more companies for listing and more investors for trading on the exchange. However, in future studies, additional factors that influence competitiveness can be examined. Depth of market, and informativeness of prices, broker commissions, inter-dealer trading systems, and policies for preferencing of trades are other common criteria on which the performance of stock exchanges can be analyzed. Finally, even though this paper provides insights for government policy makers, exchange owners and management, brokers, companies, and investors, each of these players can view the implications of relationships studied here in a different way. Extensions to this study can focus exclusively on one such player or on interactions between them in a dynamic setting.

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Figure 1.a. Market structure by trading mechanisms of 139 exchanges

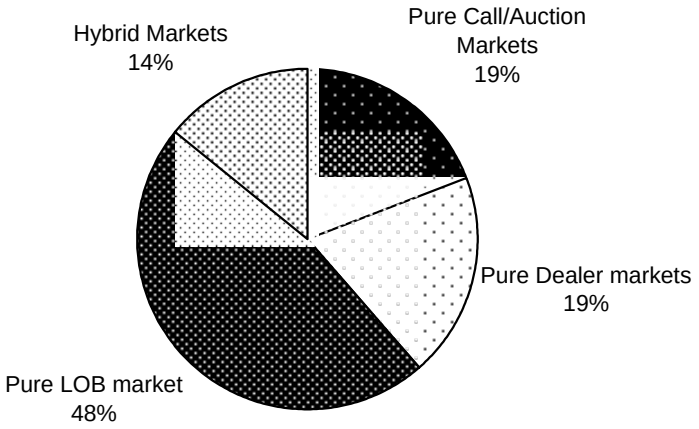

Figure 1.b. Market structure by trading mechanisms of 51 exchanges

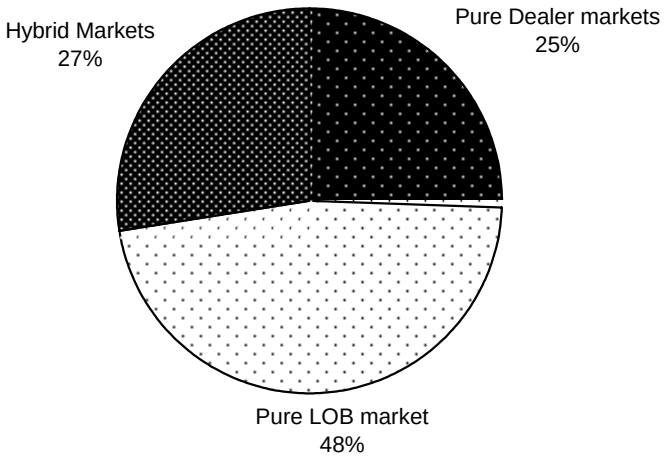

Figure 2: Comparison of spreads and volatility with a three-way classification of 51 ex

Fig. 2a. Quoted Spreads: 3-Way Classification by Trading Mechanism, Economic Development, and Fragmentation

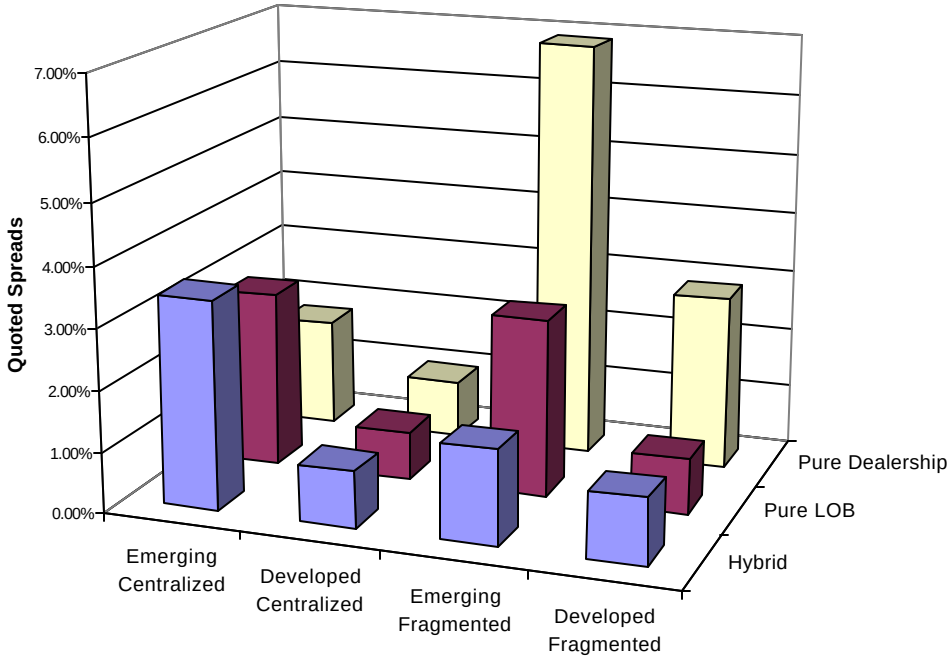

Fig 2 b. Effective Spreads: 3-way Classification by Trading Mechanism, Economic Development, and Fragmentation

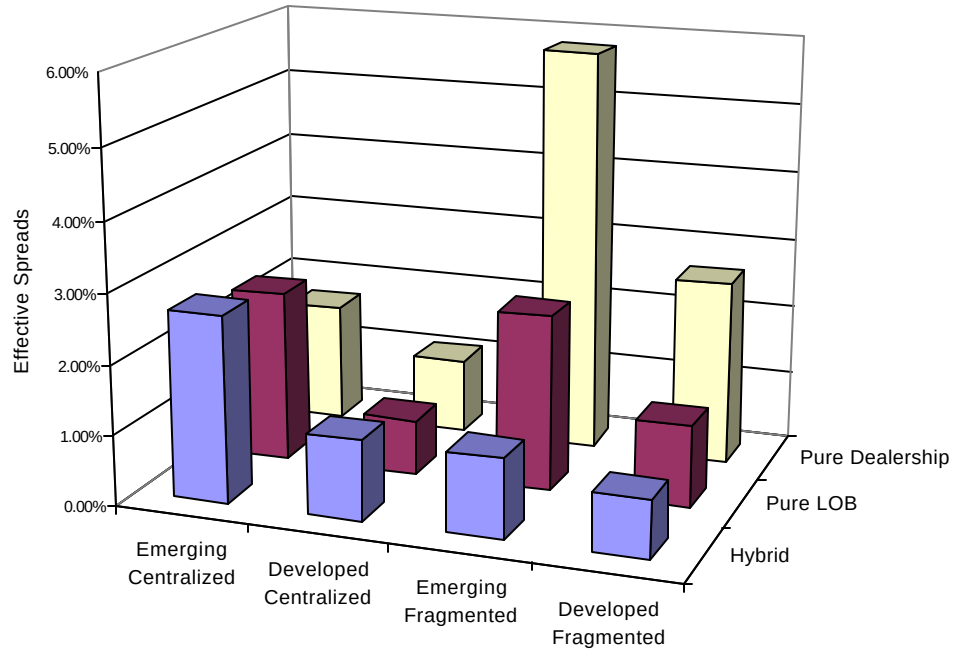

Figure 2 c. Realized Spread: 3-Way Classification by Trading Mechanism, Economic Development, and Fragmentation

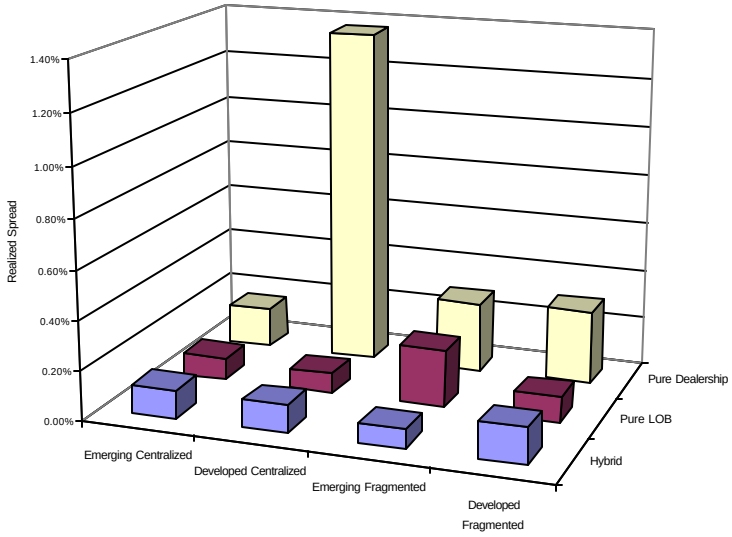

Figure 3: Comparison of spreads and volatility with a three-way classification by transparency

Fig 3 a. Quoted Spread: 3-Way Classification by Trading Mechanism, Economic Development, and Transparency

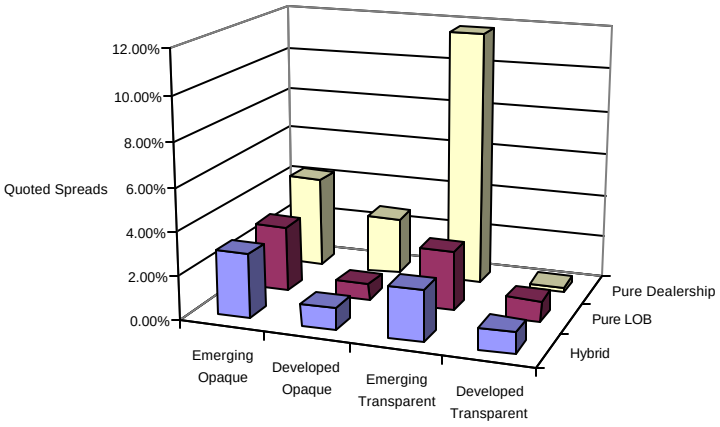

Fig 3 b. Effective Spreads: 3-Way Classification by Trading Mechanism, Economic Development, and Transparency

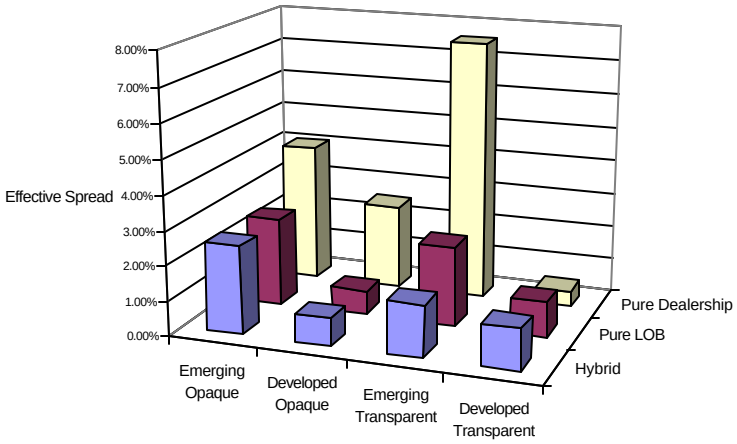

Fig 3 c. Realized Spread: 3-Way Classification by Trading Mechanism, Economic Development, and Transparency

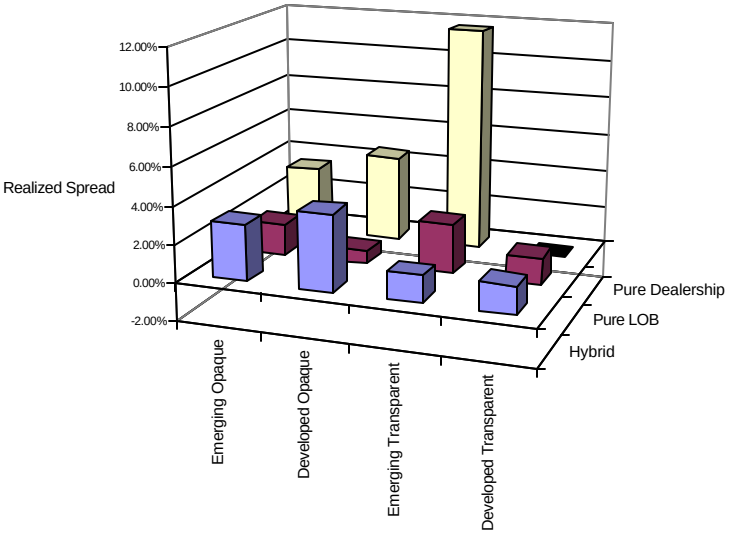

Table 1. Break of 51 exchanges by institutional characteristics

This table shows the number and proportion of exchanges with different institutional features among 51 leading exchanges of the world.

Institutional Feature	Number	Percentage	By Market Capitalization
Pure Dealer Systems	13	25%	17%
Pure Limit order Books	24	47%	25%
Hybrid Systems	14	27%	58%
Centralized Trading	31	61%	31%
Fragmented Trading	20	39%	69%
Full transparency of details of order flow	22	43%	27%
Opaqueness of details of order flow	29	57%	73%
Mutual ownership by brokers	32	63%	79%
Incorporated/ independent ownership	19	37%	21%
Developed Markets	26	51%	92%
Emerging Markets	25	49%	8%
Insider trading laws enforced	34	67%	96%
Insider laws not yet enforced	17	33%	4%
	51	100%	100%

Table 2. Performance measures of 51 major exchanges.

This table shows the average spreads across all quoted stocks based on 7 observations between March and August 2000 on every exchange in the second column (this excludes listed stocks that are not quoted at all). The next column is the average daily closing spread between Jan. and Apr. 2000 on top 15 stocks by market capitalization. Then effective spread, and volatility of returns on these stocks are presented. The trading turnover is based on 1999 data.

Exchange	Top 15 Relative Tick Size (% of Price)	All quoted stocks spread %	Top 15 quoted spread	Top 15 Effective Spread	Top 15 Realized Spread	Top 15 Volatility	Trading Turnover
YEAR	2000	2000	2000	2000	2000	2000	1999
Argentina	0.30%	2.39	1.53%	1.18%	1.22%	0.07%	0.640
Australia	0.19%	2.82	0.69%	0.63%	1.10%	0.07%	0.510
Austria	0.02%	7.36	0.29%	1.18%	1.19%	0.07%	0.330
Belgium	1.55%	2.01	1.03%	1.61%	1.51%	0.11%	0.210
Bermuda	0.58%	24.36	9.33%	7.50%	6.59%	0.15%	0.000
Brazil	1.78%	12.35	7.69%	5.67%	4.57%	0.28%	0.750
Canada	0.15%	5.16	0.55%	0.49%	0.73%	0.15%	0.540
China	0.09%	0.17	0.32%	0.31%	-0.07%	0.12%	1.500
Colombia	0.08%	8.09	3.29%	2.85%	1.15%	0.09%	0.100
Czech	0.02%	2.29	2.79%	1.66%	1.65%	0.09%	1.500
Denmark	0.31%	3.04	1.56%	1.34%	1.22%	0.09%	0.400
Easdaq	0.34%	12.91	6.50%	5.42%	6.29%	0.33%	0.078
Estonia	0.45%	3.85	5.58%	4.69%	5.44%	0.06%	1.390
Finland	0.10%	2.96	0.90%	0.87%	0.77%	0.14%	0.470
France	0.07%	3.60	0.23%	0.34%	1.55%	0.10%	0.580
Germany	0.02%	3.65	0.86%	0.73%	4.83%	0.11%	2.380
Greece	0.06%	1.41	0.78%	1.59%	0.44%	0.10%	0.590
Hong Kong	0.42%	1.81	0.57%	0.55%	0.23%	0.08%	1.180
Hungary	0.08%	6.06	4.85%	2.77%	3.27%	0.09%	2.200
India	0.08%	7.01	0.90%	0.82%	1.28%	0.20%	0.390
Indonesia	1.56%	15.65	4.83%	5.45%	6.18%	0.19%	0.750
Ireland	0.36%	3.94	2.06%	2.56%	1.96%	0.12%	0.610
Israel	0.04%	13.39	0.41%	0.38%	1.96%	0.04%	0.310
Italy	0.16%	1.83	0.78%	1.04%	0.13%	0.12%	0.560
Japan	0.16%	2.13	0.80%	0.72%	1.54%	0.10%	0.390
Korea	0.19%	1.04	0.34%	0.43%	1.06%	0.24%	2.290
Latvia	4.79%	9.19	7.29%	6.12%	6.89%	0.10%	0.250
Luxembourg	0.40%	0.89	1.82%	1.80%	2.19%	2.85%	0.020
Malaysia	0.62%	2.94	0.93%	0.88%	1.04%	0.07%	1.090
Mexico	0.16%	9.46	2.39%	2.22%	0.55%	0.15%	0.340
Netherlands	0.06%	2.11	0.25%	0.46%	-0.07%	0.12%	0.550
New Zealand	0.49%	5.10	1.10%	1.07%	0.11%	0.07%	0.310
Norway	0.44%	3.91	1.52%	1.45%	1.58%	0.07%	0.700
Peru	1.35%	7.34	6.83%	4.34%	2.18%	0.10%	0.250
Philippines	0.85%	6.74	2.29%	2.34%	1.73%	0.10%	0.650
Poland	0.34%	2.01	0.90%	0.86%	0.45%	0.17%	0.610
Portugal	0.08%	1.08	0.57%	0.59%	1.01%	0.08%	0.510
Russia	0.79%	13.77	11.75%	7.58%	11.71%	0.77%	0.230
Singapore	0.58%	8.94	0.81%	0.79%	0.97%	0.07%	0.700
South Africa	0.02%	11.12	0.80%	0.72%	0.06%	0.10%	0.180
Spain	0.07%	8.46	0.41%	0.43%	0.43%	0.05%	1.460
Sweden	0.32%	3.06	0.66%	0.66%	0.75%	0.08%	0.620
Switzerland	0.09%	3.15	0.42%	0.43%	0.63%	0.05%	0.810
Taiwan	0.34%	1.61	0.24%	0.39%	1.63%	0.06%	4.350
Thailand	0.78%	9.46	1.07%	1.11%	1.25%	0.17%	1.070
UK	0.03%	5.21	1.46%	1.25%	0.53%	0.12%	0.420
Ukraine	0.69%	#N/A	12.17%	12.64%	11.24%	0.12%	0.000
US-Amex	1.93%	2.70	2.63%	1.98%	7.10%	0.22%	0.504
US-NASDAQ	0.15%	2.67	0.52%	1.02%	6.64%	0.42%	0.607
US-NYSE	0.12%	0.74	0.20%	0.09%	5.26%	0.12%	0.650
Venezuela	0.18%	19.82	9.30%	7.80%	4.10%	0.36%	0.270
Mean	0.49%		2.51%	2.19%	2.50%	0.19%	0.741
Std. Dev	0.77%		3.12%	2.56%	2.79%	0.40%	0.754
Minimum	0.02%		0.20%	0.09%	-0.07%	0.04%	0.000
Maximum	4.79%		12.17%	12.64%	11.71%	2.85%	4.350

Note: No price filters have been applied as they do not have their standard effect in this study. For instance, if all stocks priced below US$5 are excluded then for some exchanges we will be left with no stocks to analyze.

Table 3. A. Unconditional comparison of spreads across exchange types

This tables gives an unconditional comparison of average daily closing spreads and volatility on exchanges with different mechanism and institutional features. The bottom of the panel A shows the t-test of differences for 3 different trading mechanisms. Panels B and C are two-way classification of exchanges based on economic development and trading mechanism.

	Top 15 Quoted spread	Top 15 Effective Spread	Top 15 Realized Spread	Top 15 Relative Tick Size
Average	2.31%	2.04%	2.38%	0.47%
Pure Dealership	4.26%	3.71%	4.34%	0.57%
Pure LOB	1.84%	1.64%	1.50%	0.50%
Hybrid	1.53%	1.38%	2.27%	0.32%
Centralized	1.66%	1.52%	1.39%	0.42%
Fragmented	3.37%	2.89%	3.99%	0.54%
Opaque	2.49%	2.25%	2.52%	0.46%
Transparent	2.06%	1.75%	2.18%	0.47%
Incorporated	1.54%	1.52%	1.65%	0.45%
Mutual	2.78%	2.36%	2.83%	0.47%
Emerging	3.62%	3.04%	2.89%	0.63%
Developed	1.11%	1.13%	1.91%	0.32%
t-stat (hybrid-LOB)	-3.33	-3.28	8.49	-5.79
t-stat (hybrid-dealer)	-14.51	-15.28	-8.62	-5.25
t-stat (LOB-dealer)	-14.10	-14.86	-13.83	-1.56
Panel B. Exchanges in Developed Markets				
Pure Dealership	2.24%	2.12%	3.69%	0.21%
Pure LOB	0.83%	0.85%	0.99%	0.36%
Hybrid	0.98%	1.06%	2.31%	0.30%
Panel C. Exchanges in Emerging Markets				
Pure Dealership	5.40%	4.61%	4.71%	0.77%
Pure LOB	2.90%	2.47%	2.03%	0.64%
Hybrid	2.63%	2.02%	2.19%	0.37%

Table 4. Two stage least squares (2SLS) regression results of the triangular model

This table shows the results of regression of the triangular system of equations where percentage quoted spreads, percentage effective spreads, realized spreads, volatility and trading turnover are endogenous variables. These are shown in the columns. The instrumental/ independent variables are in the rows. The analysis is based on 3,060 firm months obtained from 71,112 daily observations between January and April 2000 from 51 exchanges. Coefficients that are significant at 5% level are shown in boldface.

Dependent Variable	**Percent Quoted Spread**			**% Effective Spreads**			**% Realized Spreads**			**Volatility**			**Trading Volume (Intensity)**		
	R-Square	Adj. R-sq		R-Square	Adj. R-sq		R-Square	Adj. R-sq		R-Square	Adj. R-sq		R-Square	Adj. R-sq	
	0.30743	0.30455		0.30145	0.29854		0.17499	0.17155		0.04624	0.04397		0.17076	0.1683	
Instruments	*Coefficient*	*Std. Error*	*t Stat*	*Coefficient*	*Std. Error*	*t Stat*	*Coefficien*	*Std. Erro*	*t Stat*	*Coefficien*	*Std. Erro*	*t Stat*	*Co-efficien*	*Std. Erro*	*t Stat*
Intercept	**0.08363**	**0.00716**	**11.68**	**0.08221**	**0.00600**	**13.7**	**0.03528**	**0.00966**	**3.65**	**0.02107**	**0.00336**	**6.27**	**0.77998**	**0.12164**	**6.41**
Relative Tick Size	**0.98733**	**0.07747**	**12.75**	**0.73958**	**0.06492**	**11.39**	**0.77806**	**0.10454**	**7.44**	**0.15018**	**0.03696**	**4.06**			
Market Capitalization	**-0.00352**	**0.00111**	**-3.18**	**-0.00427**	**0.00093**	**-4.6**	-0.00094	0.00150	-0.63	**0.00102**	**0.00031**	**3.32**			
Market Maker	-0.00049	0.00265	-0.19	-0.00329	0.00222	-1.48	0.00588	0.00357	1.65	**0.00328**	**0.00106**	**3.08**	**0.22581**	**0.03002**	**7.52**
MM Competition	**-0.01346**	**0.00165**	**-8.18**	**-0.01117**	**0.00138**	**-8.09**	**-0.01263**	**0.00222**	**-5.68**						
Limit order book	**-0.00968**	**0.00293**	**-3.31**	**-0.00669**	**0.00245**	**-2.73**	0.00106	0.00395	0.27	**-0.00841**	**0.00128**	**-6.58**	**0.19971**	**0.04278**	**4.67**
Fragmentation	**0.01259**	**0.00278**	**4.52**	**0.01000**	**0.00233**	**4.29**	**0.01739**	**0.00376**	**4.63**	**0.00622**	**0.00115**	**5.42**	**0.15488**	**0.03954**	**3.92**
Transparency	**0.00883**	**0.00193**	**4.58**	**0.00397**	**0.00162**	**2.45**	**0.00635**	**0.00260**	**2.44**	0.00173	0.00106	1.62	**-0.13309**	**0.03157**	**-4.22**
Automatic Execution	**-0.01669**	**0.00252**	**-6.62**	**-0.01434**	**0.00211**	**-6.78**	**-0.02281**	**0.00340**	**-6.7**	0.00211	0.00136	1.55	**0.10318**	**0.03967**	**2.6**
Developed market	-0.00554	0.00352	-1.57	-0.00258	0.00295	-0.87	-0.00161	0.00475	-0.34	**-0.00307**	**0.00121**	**-2.54**	**-0.46242**	**0.03041**	**-15.2**
Shareholder right	**-0.00162**	**0.00059**	**-2.73**	**-0.00137**	**0.00050**	**-2.77**	-0.00130	0.00080	-1.63						
Insider trading law enforced	**-0.01664**	**0.00214**	**-7.76**	**-0.01115**	**0.00180**	**-6.21**	-0.00132	0.00289	-0.46				**0.38845**	**0.03168**	**12.26**
Volatility	0.39612	0.38178	1.04	0.44079	0.31995	1.38	0.90685	0.51521	1.76				**-10.24980**	**3.40638**	**-3.01**
Trading Turnover	0.00383	0.00453	0.85	-0.00087	0.00379	-0.23	**-0.01348**	**0.00611**	**-2.21**						
Age	-0.00002	0.00001	-1.68	0.00001	0.00001	0.53	**-0.00005**	**0.00002**	**-2.72**				-0.00003	0.00020	-0.16
Quoted Spread %													**-3.44194**	**0.77884**	**-4.42**

Table 5. Correlation between institutional features of 51 exchanges.

The table shows correlation between different institutional features. In each cell, the first row gives the correlation coefficient. P-values of significance are given in the second row. The third row is the number of exchanges in the sample based on which the correlation is computed The lower triangular half of the matrix gives correlation for 137 exchanges around the world. The upper triangular matrix shows correlation for 51 exchanges for which performance measures are computed.

	Market Maker	MM Competition	Limit order book	Trans-parency	Automatic Execution	Ownnership	Developed market	Fragment-ation	Insider laws enforced	Shareholder Rights
Market	**1**	0.1066	-0.0146	0.2296	-0.1875	0.0066	0.1877	-0.0375	0.0287	-0.1207
Maker		0.4567	0.9190	0.1051	0.1876	0.9635	0.1872	0.7941	0.8417	0.3989
		51	51	51	51	51	51	51	51	51
MM	-0.0622	**1**	-0.2135	0.0621	-0.1328	0.1368	-0.1769	0.3056	-0.1109	-0.2858
Competition	0.4703		0.1324	0.6650	0.3530	0.3384	0.2142	0.0292	0.4383	0.0421
	137		51	51	51	51	51	51	51	51
LOB	0.0680	0.1908	**1**	0.3278	0.3496	-0.0785	0.1465	-0.3596	0.1591	0.0985
	0.4298	0.0255		0.0189	0.0119	0.5842	0.3051	0.0096	0.2649	0.4917
	137	137		51	51	51	51	51	51	51
Transparency	-0.0116	0.2755	**0.3433**	**1**	0.1680	-0.1477	0.1413	-0.2942	0.1120	-0.2140
	0.8932	0.0011	**<.0001**		0.2387	0.3009	0.3226	0.0362	0.4340	0.1316
	137	137	137		51	51	51	51	51	51
Automatic	-0.1227	0.1602	**0.6606**	0.3102	**1**	-0.1083	0.0580	-0.2623	0.2360	0.1011
Execution	0.1532	0.0614	**<.0001**	0.0002		0.4495	0.6862	0.0630	0.0955	0.4802
	137	137	**137**	137		51	51	51	51	51
Ownership	-0.0041	-0.0127	-0.0627	-0.0613	-0.0227	**1**	-0.3500	0.3697	-0.2868	-0.0680
	0.9624	0.8834	0.4665	0.4766	0.7927		0.0118	0.0076	0.0413	0.6355
	137	137	137	137	137		51	51	51	51
Developed	**0.3468**	-0.0504	0.1593	0.1313	0.1533	-0.2204	**1**	-0.1764	0.2219	0.3529
	<.0001	0.5590	0.0630	0.1270	0.0736	0.0096		0.2155	0.1176	0.0111
	137	137	137	137	137	137		51	51	51
Fragmented	0.1495	0.2612	0.0153	-0.0268	0.0618	0.1725	0.2489	**1**	0.0568	-0.0508
	0.0812	0.0020	0.8594	0.7562	0.4731	0.0439	0.0034		0.6922	0.7232
	137	137	137	137	137	137	137		51	51
Insider Laws	0.2959	-0.2025	0.2334	0.1517	0.1154	-0.0963	**0.4209**	0.0976	**1**	0.3386
Enforcement	0.0015	0.0315	0.0128	0.1088	0.2238	0.3104	**<.0001**	0.3039		0.0151
	137	137	137	137	137	137	137	137		51