MARKET LIQUIDITY AND DEPTH ON FLOOR-TRADED AND E-MINI INDEX FUTURES: AN ANALYSIS OF THE S&P 500 AND NASDAQ 100

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Abstract

This paper aims to examine the market liquidity of regular futures and E-mini futures of CME. The bid-ask spread and market depth are explored to compare the market liquidity of floor-traded futures and electronically traded futures. The bid-ask model consists of a structural equation of bid-ask spread, trading-volume, and price-volatility. This paper finds that E-mini contracts boast superior market liquidity as measured both by bid-ask spread and market depth. This finding indicates that the automated trading market is more efficient in handling orders. Moreover, the mechanism of limited order books facilitates better transparency of information regarding trading prices and volume and the continuous bidding process helps to improve the reduction of liquidity cost.

Key words: market liquidity, depth, S&P 500, Nasdaq 100, E-mini futures.
JEL Classification: G14, C32.

1. Introduction

The advancement of information technology and the ubiquity of the Internet have been dismantling the barriers of individual financial markets around the globe. The most direct blow to the futures markets is the fierce competition from other markets. Therefore, the major futures exchanges around the world spare no efforts to innovate their product offerings as well as to improve their trading systems, in order to maintain their competitiveness.

The adoption of automated trading systems and the launch of mini-instruments have been big innovations from future exchanges over the past years. The majority of future exchanges in Europe and Asia, including EUREX, Euronext, Korean Stock Exchange (KSE), and Tokyo Stock Exchange (TSE) have completely adopted the automated trading system. Some exchanges, such as the Chicago Mercantile Exchange (CME), Chicago Board of Trade (CBOT), and Singapore Exchange (SGX), adopt a side-by-side trading system in which open outcry and automated trading systems co-exist. The pros and cons of the open outcry and automated trading systems are a critical issue for any exchange that is considering switching to the automated trading system from the open outcry system or simply allowing the two systems to co-exist.

According to the studies by Ulibarri and Schatzberg (2003), Aitken et al. (2004), Cheng, Fung and Tse (2005), Fung, Lien, Tse and Tse (2005) and Mizrach and Neely (2006) the spread between bids and offers in automated trading systems is smaller than that of the open outcry systems. In other words, the automated trading system provides better market liquidity compared to the open outcry system. However, Tse and Zabotina (2001) argued that, in contrast to the smaller spread between bids and offers seen in the automated trading systems, open outcry systems have a smaller price error variance. Another argument was made by Kappi and Siivonen (2000) that the spread between bids and offers in open outcry systems is smaller, but the automated trading systems provide better market depth. To sum up, the pros and cons of the open outcry and automated trading systems remain a controversy and there is no uniform conclusion so far.

The index futures markets in the U.S. have retained both electronic and open-outcry trading systems operating simultaneously during regular trading hours. This market mechanism provides a natural experiment to directly compare the liquidity and depth between regular and electronically traded index futures. The current set-up of CME serves as a unique opportunity for this paper to explore the pros and cons of the open outcry and automated trading systems.

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The pros and cons of these two systems can be examined in various perspectives, that is why there are different conclusions. Market liquidity is a widely accepted measurement, while the BAS serves as a major indicator. Our paper follows this convention and examines the BAS and market depth as key indicators. The focus of this paper is on the four index future contracts which are most traded on CME, including regular S&P 500 index futures (hereafter referred to as SP) and regular Nasdaq 100 index futures (hereafter referred to as ND) traded on the open outcry system as well as E-mini S&P 500 index futures (hereafter referred to as ES) and E-mini Nasdaq 100 index futures (hereafter referred to as NQ) traded on the automated trading system. The purpose of this paper is to compare the market liquidity of the open outcry and automated trading systems.

Our research is different from previous studies. Past literature usually resorted to the bid-ask spreads to compare market liquidity of the open outcry and automated trading systems (Kappi and Siivonen, 2000; and Ulibarri and Schatzberg, 2003). Nonetheless, McInish and Wood (1992) believed that if there are considerable discrepancies between the trading volume and price volatility, then a misunderstanding may occur if the average bid-ask spreads of the two markets are used as an indicator of the relative market liquidity. Therefore, they suggested that effects from a relative variable should be taken into account when it comes to examining the difference in market liquidity of these two markets. Although some of the literature pointed out the effects from relevant variables when it comes to comparing the liquidity of these two markets, such as Frino et al. (1998), the possibility of a structural relationship between variables gets ignored and, thus, there is a bias in the estimates of model coefficients. In order to compare the differences in bid-ask spread of E-mini contracts on the automated trading system and regular contracts, we decide to construct a three-equation structural model that consists of trading volume, bid-ask spread, and price volatility. This approach enables this study to take into account the possible structural relationship between variables while, at the same time, to control other factors that affect bid-ask spreads when it comes to the analysis of the differing bid-ask spreads in different markets. It is also possible to discuss the relationship among the trading volume, bid-ask spread, and price volatility as three variables.

The major contribution of this paper lies in the findings that the E-mini contracts traded on the automated trading system boast superior market liquidity to that of the regular contracts on the open outcry system, independent of whether the market liquidity is measured in bid-ask spread or market depth. This finding also indicates that the automated trading system features superior efficiency in the executions of orders. Moreover, the transparency of information regarding trading volume and transaction prices and continuous auctions offered by the automated trading system helps to reduce the liquidity cost.

Secondly, the majority of past literature of market microstructure theory focused its discussions on the relationship of only two out of the three variables, i.e. trading volume, bid-ask spread and price volatility. These discussions include (1) the relationship between trading volume and bid-ask spread, (2) the relationship between trading volume and price volatility, and (3) the relationship between bid-ask spread and price volatility. Some scholars attempted to compare the liquidity of different transaction types of contracts by using bid-ask spreads, but such an approach may lead to an extreme bias conclusion, because differences may reside in the factors that affect bid-ask spreads of the regular and E-mini contracts, such as trading-volume and price volatility. Therefore, this study aims to explore the simultaneously-determined relationship among trading-volume, bid-ask spread, and price volatility based on the Hausman test and then, by constructing three-equation structural equation, further prove that the automated trading system boasts superior market liquidity by demonstrating that E-mini contracts exhibit narrower bid-ask spreads with other affecting factors under control.

The organization of the paper is as follows. Section 2 provides a brief literature review. Section 3 summarizes the econometric methodology. Section 4 describes data sources and empirical results. The conclusion is in section 5.

2. Literature Review

TV, BAS, and PV are the three variables that constantly are studied and examined by the market macrostructure theory. McInish and Wood (1992) argued that the TV and PV are the major determinants of the BAS. Nonetheless, we need to take heed of the causal relationships in our discussion of market liquidity. Is it true that TV and PV impact market liquidity and, if so, in what manner? Or, is it that the difference in market liquidity affects TV and PV? What are the implications?

The past literature focused most of their discussions on the relationship between two of the three variables, such as the relationship between TV and BAS, the relationship between TV and PV, and the relationship between BAS and PV. Therefore, we can safely assume that there may exist a correlation among TV, BAS, and PV. Much of the past literature also indicated that there may exist endogenous relationships among any two of the three variables. Therefore, our study decided to simultaneously explore the relationship among all the three variables, i.e. TV, BAS, and PV. Possible structural relationships among these variables will be taken into consideration in order to avoid estimation errors in our modelling parameters. Our discussion on the relationship among these three variables starts with the definition of the cost components of BAS. We believe that order processing cost, adverse information, and inventory carrying cost are the three components for the BAS. In theory, there is an inverse relationship between these three costs and TV.

Wang and Yau (2000) and Ates and Wang (2004) conducted their analysis of the relationship among TV, BAS, and PV as three variables. The three-equation structural model they constructed showed that there exists a positive correlation between TV and PV and an inverse correlation between TV and BAS, with the other variable controlled. At the same time, there exists a positive correlation between PV and BAS, whereas there exists an inverse correlation between lagged 1 period value of PV and TV.

To sum up the above discussions, there may exist an endogenous variable relationship among TV, BAS, and PV. It matters a great deal to the estimates of the three-equation structural model whether these three variables are endogenous. Therefore, we need to determine whether there is an endogenous or exogenous relationship between theese variables. Wang and Yau (2000) used the Hausman test to confirm that there exists a structural determinant relationship among TV, BAS, and PV.

3. Methodologies

3.1. Bid-Ask Spread Estimator

BAS and market depth are the most frequently-used measurements of market liquidity. In this paper, BAS is defined as the estimates of BAS according to the TW bid-ask spread estimator of Thompson and Waller (1988, hereafter TW) and Commodity Futures Trading Committee (hereafter CFTC) BAS estimator.

The TW bid-ask spread estimator is articulated as the follows:

$$\theta_{TW} = \frac{1}{T}\sum_{t=1}^{T}\left|\Delta p_t\right|, \tag{1}$$

where ΔP_t is non-zero price change series.

The trading price changes may be caused by noise trading. On the other hand, trading price changes may be caused by the inflow of new information.

The CFTC[1] BAS estimator is a method put forward by the Commodity Futures Trading Committee (CFTC) of the US to measure BAS. It is a commonly used method in the business. This method is similar to TW estimator, but CFTC estimator takes into account the possible effects on transaction prices from the changes of real prices. Therefore, in theory, the estimators derived will be smaller than TW estimators.

[1] Since CFTC and Thompson and Waller bid-ask spread estimators are highly correlated, we use CFTC method to re-do the analysis and the results are very similar.

3.2. Market Depth

In order to measure the differences in market depth of regular contracts traded on the open outcry market and E-mini contracts traded on the automated trading market, this paper uses the Two-Stage Least Squares (2SLS) regression analysis proposed by Kappi and Siivonen (2000) to measure the market depth based on an interval of 15 minutes. During the first stage, we divide the TV (number of contracts) into ETV and UTV as in the following equations:

$$TV_t = a + \sum_{i=1}^{5} \beta_i V_{t-i} + \sum_{j=1}^{5} \theta_j \left|\Delta P_{t-j}\right| + \sum_{k=1}^{5} \lambda_k \sigma_{t-k} + \varepsilon_t, \quad (2)$$

where TV_t is the actual aggregation of trading-volume at time interval t; Δp_t are the price changes within time interval t; σ_t is the price-volatility within time interval t; ε_t is an error term.

Δp_t refers to price changes, i.e. the difference between the first and last trading prices within each time interval, while σ_t refers to price-volatility, i.e. the difference between the largest and smallest trading prices within each time interval. Relevant factors that may affect TV are taken into account in the measuring of ETV within the first stage. These factors include lagged TV and lagged absolute price change. The fitted value of the estimations based on Equation 2 is ETV and its residual is UTV.

At the second stage, the ETV and UTV computed at the first stage are used to measure the impacts of trading activities on trading prices (including the absolute price changes and PV). The measurement is expressed as the following equation.

$$\left|\Delta P_t\right| = \phi + \delta ETV_t + \gamma UTV_t + \mu UTVPOS_t + \sum_{k=1}^{r} \rho_k \sigma_{t-k} + \eta_t, \quad (3)$$

$$\sigma_t = \vartheta + \varsigma ETV_t + \tau UTV_t + \omega UTVPOS_t + \sum_{k=1}^{s} \varphi_k \sigma_{t-k} + \xi_t. \quad (4)$$

The impacts of ETV and UTV on trading prices may exhibit an asymmetric relationship. The price-change absolute-value equation and PV equation both take into account the expected trading-volume (ETV) and unexpected trading-volume (UTV_t). Both positive and negative values of UTV may also exhibit an asymmetric relationship with impacts on trading prices. Therefore, our model incorporates a positive-valued UTV variable ($UTVPOS_t$) to reflect such heterogeneity. When the UTV exceeds zero, $UTVPOS_t = UTV_t$; when the UTV falls below zero, $UTVPOS_t = 0$. The coefficient of UTV_t indicates the marginal impacts of negative-valued UTV on trading prices. The summation of the coefficients of UTV_t and $UTVPOS_t$ indicates the marginal impacts of positive-valued UTV on trading prices. The second-stage price-change absolute-value and PV equations also take into account the effects of PV in the lagged period.

3.3. Trading-Volume, Bid-Ask Spread, and Price-Volatility

In order to examine the difference in market liquidity of regular contracts traded on the open outcry market and E-mini contracts traded on the automated trading market, this paper resorts to the three-equation structural model constructed by Wang and Yau (2000) and Ates and Wang (2004) in exploring the relationship among TV, BAS, and PV. However, certain modifications are made to the model in order to control factors that affect BAS. This approach makes it possible not only to compare the differences in market liquidity of regular contracts traded on the open outcry market and E-mini contracts traded on the automated trading market, but also to scrutinize the differences in TV and PV of the regular and E-mini contracts. Moreover, this paper aims to investigate the relationship among TV, BAS, and PV as three variables. Among our investigations, the model of S&P 500 index futures is referred to as the SP-ES model and the model of Nasdaq 100 index futures is referred to as the ND-NQ model.

The empirical model of this paper is established as the following equations.

$$TV_t = a_0 + a_1 BAS_t + a_2 PV_t + a_3 INT_t + a_4 OI_{t-1} + a_5 TV_{t-1} + a_6 Dummy_t, \quad (5)$$

$$BAS_t = b_0 + b_1 TV_t + b_2 PV_t + b_3 SP_t + b_4 BAS_{t-1} + b_5 Dummy_t, \quad (6)$$

$$PV_t = c_0 + c_1 TV_t + c_2 BAS_t + c_3 TV_{t-1} + c_4 PV_{t-1} + c_5 Dummy_t, \quad (7)$$

where TV_t indicates the aggregated daily trading-volume; TV_{t-1} is TV_t lagged 1 day; BAS_t indicates the estimated average daily *BAS* based on *TW BAS* estimators; PV_t indicates daily *PV*, measured by the difference between the highest and lowest transaction prices within a trading day; INT_t indicates the three-month interest rate of T-bills; OL_{t-1} indicates the open interests of the first lag; SP_t indicates the settlement price of the trading day for future contracts; *Dummy* indicates a dummy variable to control the difference between the regular and E-mini contracts. When *Dummy* = 1, it refers to regular contracts; when *Dummy* = 0, it refers to E-mini contracts.

Equation 5 is the key determinant of TV. In theory, there is an inverse relationship between transaction cost and TV. When the transaction cost is high, profit opportunities get squeezed and market participants will seek alternative instruments thereby offering lower transaction costs. This move will subsequently reduce the trading-volume of the instruments that demand high transaction costs. Among the transaction costs, BAS is the major variable cost component. Therefore, it is expected to exhibit an inverse relationship between TV and BAS.

The changes of reservation prices are the main motivation for speculators to conduct transactions. Speculators adjust reservation prices in accordance with PV; in other words, they use PV as the proxy for changes in reservation prices. In the MDH model, TV and PV are both functions of the information inflow rate, according to Harris (1987), and Tauchen & Pitts (1983). Therefore, there is expected to be a positive correlation between TV and PV.

The changes in the expected positions held by hedgers are another key factor for TV and such changes are determined based on the information available to hedgers. The proxies for the information set within this model are the three-month interest rates of T-bills and unsettled volume in the first lag. The three-month interest rates of T-bills are used to reflect the cost of inventory carrying for spot positions, as a higher interest rate increases the cost of inventory carrying and thus reduces the willingness of hedgers to operate in the futures market. Therefore, an inverse relationship is expected to be between TV and the three-month interest rates of T-bills. Unsettled volume in the first lag reflects the number of contracts outstanding in the first lag. A high level of unsettled volume implies that more trading will happen in the future. Therefore, there is expected to be a positive correlation between TV and unsettled volume in the first lag.

In Equation 5, dummy variables are used to control other factors that affect TV in order to determine whether the differences are significant between the TV of regular contracts traded on the open outcry market and E-mini contracts traded on the automated trading market. If the dummy variables are significantly positive, then it means the TV of regular contracts is obviously larger than that of E-mini contracts. If the dummy variables are negative, then it means the TV of E-mini contracts is larger than that of regular contracts.

Equation 6 is the main determinant of BAS. The increase of TV means that liquidity providers have more opportunities to adjust their inventory positions in order to reduce the price risks they face. Therefore, there is expected to be an inverse relationship between expected BAS and TV.

The changes of transaction prices imply two types of risks to liquidity providers. The first type of risk is non-systematic risk due to under-diversification of asset allocation by the liquidity providers. The second type of risk derives from the implied existence of information traders as signalled by the fluctuations of prices. This situation generates the cost of information asymmetry. This model uses PV as a proxy to measure this type of price risk and, therefore, the relationship between BAS and PV is expected to be positive.

The settlement price of the contract date can be used to control the impacts of the index level on BAS. Bryant and Haigh (2002) indicated that the BAS tends to be maintained at a certain percentage in relation to price levels, so that the cost required per transaction unit is consistent. Therefore, the relationship between anticipated BAS and settlement prices is expected to be positive.

In Equation 6, a dummy variable is used to measure the significance of differences in BAS between the regular contracts traded on the open outcry market and E-mini contracts traded on the automated trading market when other factors that affect BAS are under control. This approach avoids the misinterpretation of comparing the market liquidity of regular contracts and E-mini contracts by directly using BAS. This approach is illustrated by the TV equation in Equation 5.

Equation 7 is the key determinant of PV. The larger the TV is, the better the chance that the price may move to higher or lower levels. The MDH model also predicts that the relationship between anticipated PV and TV is positive.

TV lagged one period is also a factor that affects PV. Admati and Pfleiderer (1988) believed that traders choose the time when the recent TV is larger to conduct transactions. Therefore, the relationship between the anticipated PV lagged one period and TV lagged one period is expected to be positive. The studies on the dummy variable are similar to those on the TV equation and BAS equation and we decide not to repeat them again here.

Bessembinder and Seguin (1993) believed that there is continuity in both TV and PV so their autocorrelation in the first lag should be taken into account. Therefore, the three equations in the model all incorporate lagged variables in order to reflect such continuity.

In constructing the three-equation structural model, this study violates the assumption brought forward by the classical linear regression model, since the model constructed there may have a bi-directional causal relationship between the dependent variable and explanatory variables. In other words, the variables on the right of the equation may not be exogenous variables. Wang and Yau (2000) indicated that if there exists a structural relationship between dependent variable and explanatory variables in the three-equation structural model, then the estimation based on the OLS method will be serious under-estimation. Therefore, it is a must to verify whether the relationship among the TV, BAS, and PV has an endogenous-variable relationship before the model runs any estimation. This paper uses two-stage specification tests of Hausman (1978) to verify whether there exists a structural relationship among TV, BAS, and PV.

In order to solve the structural relationship between variables within the model and to avoid the inconsistency of estimations based on the OLS method, this paper uses the 2SLS to conduct estimations of the model after the verification of a structural relationship of dependent variables and explanatory variables in the equation. This approach eliminates the issue of autocorrelation between explanatory variables and the error term within the model and derives consistent estimations of the model.

In addition to the above-mentioned verification of a structural relationship among the variables prior to the estimations run by the model, some steps are taken in order to reduce the quantitative issues associated with time series. First of all, all the variables within the model are converted into log. The advantages are twofold. First, this stabilizes the variance of the error term so that the distribution of the error term will reach a normal distribution. Second, the relationship between dependent variables and explanatory variables within the model can be interpreted by using flexible concepts.

As a unit root of time series data causes a spurious regression, we must conduct the Dickey and Fuller (1981)'s Augmented Dickey-Fuller (hereafter ADF) test on all the variables within the model in order to verify whether there exist unit root phenomena. This will serve as a basis for determining whether the variables need difference in order to eliminate the possibility of spurious regression.

In the SP-ES model and ND-NQ model, the ADF test results show that there exits a unit root in the INT_t and SP_t series. After first differencing (d=1), ∇INT_t and ∇SP_t are both stationary serials. Therefore, during the estimation of the SP-ES model and ND-NQ models, in addition to obtaining the first differencing of INT_t and SP_t, all the remaining variables in the model use level term. In the model estimations, we should consider the possibility of a sequential correlation of error term and heterogeneous variances within the model. We use the procedure of Newey and West (1987) in order to derive consistent estimation values and standard errors for the parameters.

4. Empirical Results

4.1. Data

This study samples regular index future contracts (SP and ND) traded on the open outcry market and E-mini index future contracts (ES and NQ) traded on the automated trading market dating from May 2003 to February 2004, in order to measure and compare their market liquidity.

In order to form a consistent comparison basis, this paper samples RTH timeslot trading data to conduct measurements. RTH refers to the timeslot when the automated trading market and open outcry market run in parallel. The data sample includes Globex Time and Sales Data File on the CME, and volume by Tick Data File. Datastream is also used. Globex Time and Sales Data File and Volume by Tick Data File record data of E-mini contracts and regular contracts, respectively. The intraday entries include monthly data for each transaction price, TV, trading time, and trading contract. This part of the data can be used to estimate BAS and market depth as well as to measure the relationship among TV, BAS, and PV.

On the other hand, as the contracts traded on the same day expire in different months, such a complex situation makes it difficult to conduct an analysis. In order to bypass the effects of contracts that expire in different months, this study samples only nearby contracts that enjoy brisk trading. As investors usually rollover their future contracts, we sample the contracts of the following month in the case when the contracts expired nine days before. In the structural equations, the data source for the number of unsettled future contracts and the interest rates of three-month T-bills is the Datastream database.

4.2. Bid-Ask Spread

Table 1

The descriptive statistics of S&P 500 index future and Nasdaq-100 index futures, from May 2003 to February 2004

	Regular contract		E-mini contract	
	SP	ND	ES	NQ
Average daily trading frequence	2,542	893	51,455	31,480
Average daily trading-volume (contract size)	50,118	12,127	573,066	261,602
Average daily trading-volume (million dollar)	12.9601	1.6366	29.6293	7.0479
Average contract size of one trading	19.7188	13.5839	11.1373	8.3101
Average open interest	621,633	81,362	539,304	255,894
Average contract index level	1,034.37	1,349.51	1,034.06	1,347.06
Average bid-ask spread estimated value (index point)*	0.4909	1.1751	0.2561	0.5121
Average bid-ask spread estimated value (dollar)*	$122.725	$117.51	$12.805	$10.242
Average bid-ask spread over trading dollars of one contract (%)	0.0475%	0.0871%	0.0248%	0.0380%
Standard deviation of bid-ask spread estimated value	0.6477	1.4538	0.0278	0.0441
Average interval time of trading (second)	9.5607	27.2195	0.4723	0.7719
Standard deviation of price change	1.0201	2.0139	0.1514	0.2652
0 Ticks	27.7100%	24.1217%	74.2171%	78.6579 %
1 Ticks	16.5033%	49.0366%	23.4843%	21.2069 %
2 Ticks	26.9704%	20.7243%	2.2490%	0.1134%
More than 2 Ticks	28.8134%	6.1174%	0.0495%	0.0218%

Notes: 1. All the statistic data of the regular trading hour (RTH) of nearby contracts were measured and all the nearby contracts of nine days before expiration were rolling into the following nearby contracts. 2. Bid-ask spread estimators are measured based on CFTC bid-ask spread estimators.

Table 1 summarizes the basic statistics of the four contracts studied in this paper. According to these statistics, E-mini contracts traded on the automated trading market are highly liquid. ES contracts report a daily TV of 570,000 contracts (of the nearby contracts), with 0.47 seconds required to complete each transaction. NQ contracts report a daily TV of 260,000 contracts, with 0.77

seconds required to complete each transaction. Such a short turnover highlights the efficiency advantage of an automated trading system. In addition, the information transparency of limited order books facilitates the provision and consumption of liquidity. Regular contracts traded on the open outcry market report a higher number in each transaction than that of E-mini contracts. SP contracts report an average contract number of 20 per transaction, while the number for ND contracts is 13. The average amount of unsettled volume of regular contracts is far higher than its daily TV, an indicator that market participants of regular contracts are mostly institutional investors funded with large capital. Regular contracts are used as a hedging tool by these investors. This may be due to the fact that an open outcry market offers flexibility to large orders or particular trading strategies.

On the other hand, E-mini contracts traded on the automated trading market report a lower number of contracts per transaction, as they are designed to cater to the needs of retail investors. Moreover, the mechanism of limited order books, perhaps to some degree, helps to reduce losses due to adverse information transaction for limited order providers. Therefore, a trading strategy of placing small orders is employed, according to Tse and Zabotina (2001). The fact that the daily unsettled volume of E-mini contracts is smaller than the daily TV indicates that most of the trading activities are written off on the same day and are from arbitrage.

To sum up the above discussions, there are a large number of differences between regular contracts traded on the open outcry market and E-mini contracts traded on the automated trading market. Therefore, such differences may be clearly reflected in the form of liquidity cost. According to CFTC BAS estimator, the average BAS of E-mini contracts traded on the automated trading market is smaller than that of regular contracts traded on the open outcry market. The average BAS for ES contracts is 0.25 index points, that for SP contracts is 0.49 index points, that for NQ contracts 0.51 index points, and that for ND contracts is 1.17 index points. The study conducted by Kurov and Zabotina (2003), who sampled from January 2001 through June 2001, indicated that the BAS of Nasdaq 100 index futures was larger than that of E-mini contracts. However, the BAS for S&P 500 index futures is smaller than that of E-mini contracts. Apparently, as far as S&P 500 index future contracts are concerned, their BAS rose dramatically during the sample period of this paper.

Figure 1 and Figure 2 show that there was no drastic fluctuation in the BAS of ES contracts and NQ contracts traded on the automated trading market, as these BAS were largely maintained at the minimum price change unit. This finding is in line with the general perception that both ES contracts and NQ contracts are one tick size markets.

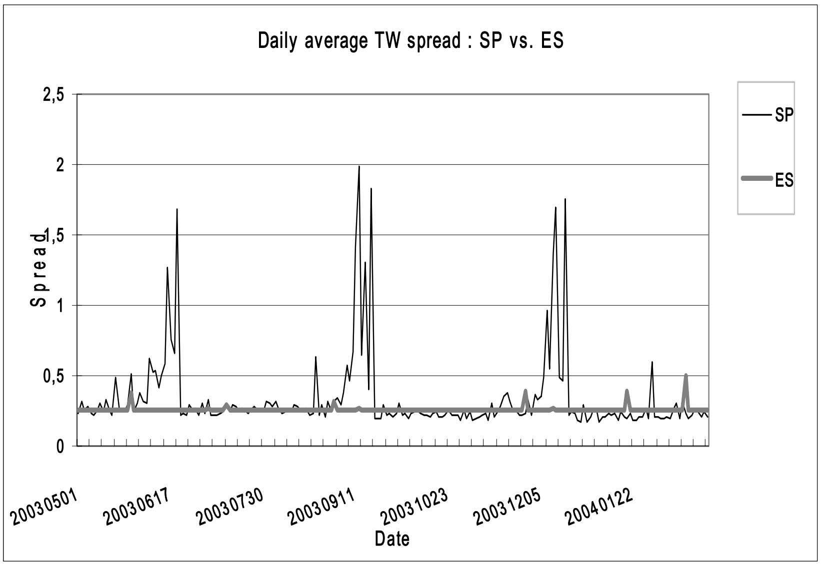

Fig. 1. Average daily bid-ask spread estimators of SP contracts and ES contracts

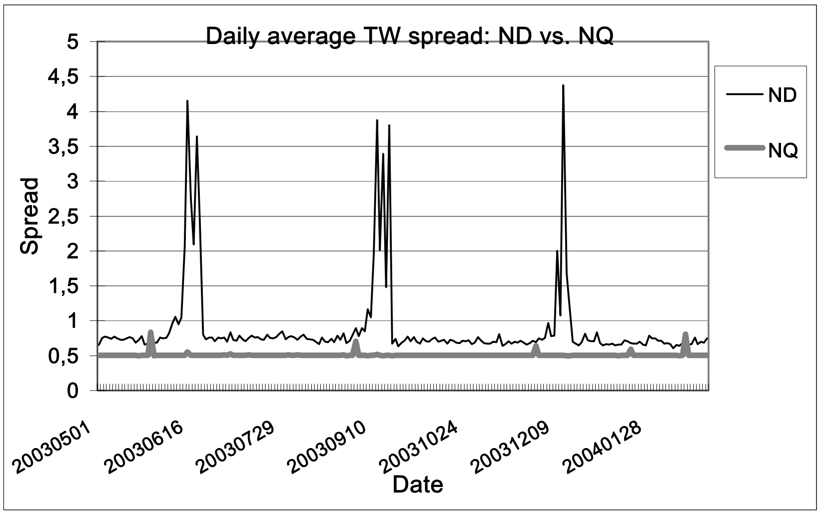

Fig. 2. Average daily TW bid-ask spread estimators of ND contracts and NQ contracts

It also shows that the minimum price change unit may restrict the BAS to levels that are not competitive. As the price change units mostly maintain the same level or change one tick size, ES contracts and NQ contracts are the markets where transaction prices are more continuous. This fact has much to do with the superior information transparency of TV and prices provided by limited orders books and continuous bids.

Compared with E-mini contracts traded on the automated trading market, SP and ND contracts traded on the open outcry market report larger BAS fluctuations.

Approximately 50% of the price changes from SP contracts exceed 2 tick sizes. The majority of price changes of ND contracts fell below 2 tick sizes; however, it is worth noting that 20% of the price changes are 2 tick sizes.

As for the percentage of transaction cost reflected in the form of BAS in relation to the contract value, the cost for regular contracts traded on the open outcry market is significantly higher than that of E-mini contracts traded on the automated trading market. Among them, ND contracts report the highest liquidity cost, with a transaction cost in the form of a BAS of US$117.51 per contract, i.e. 0.0871% of the contract value. Therefore, as far as market liquidity measured by BAS is concerned, E-mini contracts traded on the automated trading market have the upper hand against the regular contracts traded on the open outcry market. This fact indicates the great efficiency of the automated trading system in handling orders and helps to explain the shift of TV from regular contracts to their E-mini counterparts.

4.3. Market Depth

In order to assure the validity of the statistics of the market-depth model, all the variables within the model are tested with the Augmented Dickey-Fuller test (ADF) to verify whether they are stationary, in order to avoid misinterpretations of the model due to a spurious regression. The test results showed that all the variables within the model are stationary, and so we carried out estimations directly by using level values. PV equations consider the effects of auto-correlation in the lag, and so this paper used Akaike's (1973) Akaike Information Criteria (hereafter AIC) to determine the optimal lag. As a result of this operation, which found that a choice of the fifth lag is the most appropriate, this paper uses the effects of the fifth lag.

Table 2

Market depth model – SP contracts and ES contracts

Panel 2A: Absolute value of price change equation						
	Type	Intercept	ETV	UTV	UTVPOS	R^2
SP	PARMS	62.0161**	0.0177**	0.0110*	-0.0019	0.0774
	STDERR	6.3324	0.0026	0.0048	0.0060	
	P-VALUE	<0.0001	<0.0001	0.0229	0.7509	
ES	PARMS	43.0881**	0.0006**	0.0035**	0.0025**	0.3195
	STDERR	3.5443	0.0001	0.0003	0.0004	
	P-VALUE	<0.0001	<0.0001	<0.0001	<0.0001	
Panel 2B: Price-volatility equation						
	Type	Intercept	ETV	UTV	UTVPOS	R^2
SP	PARMS	115.7196**	0.0203**	0.0618**	-0.0488**	0.2935
	STDERR	12.5401	0.0053	0.0096	0.0119	
	P-VALUE	<0.0001	0.0001	<0.0001	<0.0001	
ES	PARMS	87.0982**	0.0012**	0.0066**	0.0019**	0.6130
	STDERR	3.2002	0.0001	0.0003	0.0004	
	P-VALUE	<0.0001	<0.0001	<0.0001	<0.0001	

Note: 1. To facilitate the measurement, the absolute value of price change $|\Delta P_t|$ and price-volatility σ_t are both multiplied by 100. The coefficients of expected trading-volume (ETV), unexpected trading-volume (UTV) and positive-valued unexpected trading-volume (UTVPOS) can be viewed as estimators of market depth. 2. * Significance at the 5% level. ** Significance at the 1% level.

Table 3

Market depth model-ND contracts and NQ contracts

Panel 3A Absolute value of price change equation						
	Type	Intercept	ETV	UTV	UTVPOS	R^2
ND	PARMS	127.2966***	0.0666***	0.1531***	0.0192***	0.1253
	STDERR	7.5075	0.0173	0.0261	0.0342	
	P-VALUE	<0.0001	0.0001	<0.0001	0.5742	
NQ	PARMS	112.4695***	0.0054***	0.0160***	0.0069***	0.2918
	STDERR	7.4375	0.0008	0.0013	0.0017	
	P-VALUE	<0.0001	<0.0001	<0.0001	<0.0001	

Table 3 (continued)

	Type	Intercept	ETV	UTV	UTVPOS	R^2
Panel 3B: Price-volatility equation						
ND	PARMS	116.2080***	0.0511**	0.4585***	-0.2748***	0.5170
	STDERR	9.5866	0.0221	0.0333	0.0436	
	P-VALUE	<0.0001	0.0208	<0.0001	<0.0001	
NQ	PARMS	188.3625***	0.0065***	0.0311***	-0.0003	0.6173
	STDERR	6.4503	0.0006	0.0011	0.0015	
	P-VALUE	<0.0001	<0.0001	<0.0001	0.8163	

Notes: 1. To facilitate the measurement, the absolute value of price change $|\Delta P_t|$ and price-volatility σ_t are both multiplied by 100. The coefficients of expected trading-volume (ETV), unexpected trading-volume (UTV) and positive-valued unexpected trading-volume (UTVPOS) can be viewed as estimators of market depth. 2. *** Significance at the 1% level.

Table 2 and Table 3 summarize the estimations of the market-depth models of the four contracts. In both absolute values of the price change equation and price-volatility equation, the coefficients of anticipated TV indicate that all the contracts report significantly positive values of below 1%. This indicates that the changes in anticipated TV do affect price changes. Among them, the anticipated TV of E-mini contracts traded on the automated trading market have a smaller impact on the transaction prices compared with regular contracts traded on the open outcry market. At the same time, coefficients of non-anticipated TV also indicate that all the contracts report significant positive values of below 1%, but their values are all bigger than those of the anticipated TV. This indicates that there exist obviously asymmetric effects to the prices from effects created by the anticipated and non-anticipated TV. Among them, E-mini contracts traded on the automated trading market report a smaller impact from non-anticipated TV to transaction prices than that of regular contracts traded on the open outcry market. This fact indicates that the automated trading market boasts superior market depth. However, the more significant asymmetric effects reported by E-mini contracts imply that the automated trading market sees a more rapid reduction in market depth when there are unexpected shocks to the market.

The positive and negative values of non-anticipated TV have different asymmetric impacts on prices when it comes to different contracts. As far as ND contracts are concerned, the positive valued non-anticipated TV has a larger impact (than that of the negative valued non-anticipated TV) on the absolute values of price changes, but a smaller effect on price changes. This fact indicates that when the TV is lower than the anticipated TV, ND contracts are quicker in recovering from price shocks. As far as NQ contracts are concerned, there is no significant difference in the effect on price changes from either positive valued non-anticipated TV or negative valued non-anticipated TV. As for SP contracts and ES contracts, their asymmetric relationship is completely the opposite from the one observed for ND contracts. The positive valued non-anticipated TV of SP and ES contracts have smaller impacts on the absolute values of price changes than the negative valued non-anticipated TV do, but impose impacts to price changes are larger than the negative valued non-anticipated trading-volume. This finding indicates that both SP and ES contracts are slower in recovering from price shocks when the TV is lower than the anticipated levels.

According to the above analysis, both ES and NQ contracts traded on the automated trading market report a stronger market depth than SP and ND contracts traded on the open outcry market. This finding indicates that the mechanism of limited order books on the automated trading market and the disclosure of information of bids and offers work to enhance the market depth. However, the automated trading market sees a more rapid decline in market depth when there are abrupt shocks to the market. At the same time, there exists a significant heterogeneity in the impacts on prices from anticipated and non-anticipated TV, and such heterogeneity varies in different contracts.

4.4. Trading-Volume, Bid-Ask Spread, and Price-Volatility

Table 4

Hausman's Specification Test – trading-volume equation

Contracts	(1) F Test (Augmented Regression Approach)		(2) χ^2	(3) χ^2
SP-ES	21.2965	(2 , 419)	33.5034***	113.4898 ***
ND-NQ	16.8889 ***	(2 , 419)	42.0386***	3.8010

Notes: 1. As far as the situation 1 is concerned, null hypothesis H0: In the trading-volume equation, both bid-ask spread and price-volatility are exogenous variables. Alternative hypothesis Ha: Nei ther bid-ask spread nor price-volatility are an exogenous variable. As far as the situation 2 is con cerned, null hypothesis H0: In the trading-volume equation, providing that price-volatility is an endogenous variable, bid-ask spread is an exogenous variable. Alternative hypothesis Ha: Bid-ask spread is an endogenous variable. As far as the situation 3 is concerned, null hypothesis H0: In the trading-volume equation, providing that bid-ask spread is an endogenous variable, price-volatility is an exogenous variable. Alternative hypothesis Ha: Price-volatility is an endogenous variable. 2. F statistics are 3.0 and 4.61, respectively when the degree of freedom is (2, ∞) and significant levels α=0.05 and α=0.01. 3. Chi square statistics are 3.48 and 6.63, respectively when the degree of free dom is 1 and significant levels α=0.05 and α=0.01. 4. *** Significance at the 1% level. 5. The numbers in parentheses denote the degree of freedom of the numerators and denominator.

Table 5

Hausman's Specification Test – bid-ask spread equation

Contracts	(1) F Test (Augmented Regression Approach)		(2) χ^2	(3) χ^2
SP-ES	2.2358	(2 , 419)	X[a]	X
ND-NQ	3.9532 **	(2 , 419)	32.5953***	6.6443***

Notes: 1. As far as the situation 1 is concerned, null hypothesis H0: In the bid-ask spread equation, both trading-volume and price-volatility are exogenous variables. Alternative hypothesis Ha: Neither trading-volume nor price-volatility are an exogenous variable. As far as the situation 2 is concerned, null hypothesis H0: In the bid-ask spread equation, providing that trading-volume is an endogenous variable, price-volatility is an exogenous variable. Alternative hypothesis Ha: Price-volatility is an endogenous variable. As far as the situation 3 is concerned, null hypothesis H0: In the bid-ask spread equation, providing that price-volatility is an endogenous variable, trading-volume is an exogenous variable. Alternative hypothesis Ha: Trading-volume is an endogenous variable. 2. F statistics are 3.0 and 4.61, respectively when the degree of freedom is (2, ∞) and significant levels α=0.05 and α=0.01. .3. Chi square statistics are 3.48 and 6.63, respectively when the degree of freedom is 1 and significant levels α=0.05 and α=0.01. 4. ** Significance at the 5% level. *** Significance at the 1% level. 5. The numbers in parentheses denote the degree of freedom of the numerators and denominator. 6. a If the null hypothesis is not rejected, two-step test is not required.

Table 6

Hausman's Specification Test — price-volatility equation

Contracts	(1) F Test (Augmented Regression Approach)	(2) χ^2	(3) χ^2
SP-ES	4.5664** (2 , 419)	144.4304***	3.0175
ND-NQ	0.9370 (2 , 419)	X[a]	X

Notes: 1. As far as the situation 1 is concerned, null hypothesis H0: In the price-volatility equation, both trading-volume and bid-ask spread are exogenous variables. Alternative hypothesis Ha: Neither trading-volume nor bid-ask spread are an exogenous variable. As far as the situation 2 is concerned, null hypothesis H0: In the price-volatility equation, providing that trading-volume is an endogenous variable, bid-ask spread is an exogenous variable. Alternative hypothesis Ha: Bid-ask spread is an endogenous variable. As far as the situation 3 is concerned, null hypothesis H0: In the price-volatility equation, providing that bid-ask spread is an endogenous variable, trading-volume is an exogenous variable. Alternative hypothesis Ha: Trading-volume is an endogenous variable. 2. F statistics are 3.0 and 4.61, respectively when the degree of freedom is (2, ∞) and significant levels α=0.05 and α=0.01. 3. Chi square statistics are 3.48 and 6.63, respectively when the degree of freedom is 1 and significant levels α=0.05 and α=0.01. 4. ** Significance at the 5% level. *** Significance at the 1% level. 5. The numbers in parentheses denote the degree of freedom of the numerators and denominator. 6. a If the null hypothesis is not rejected, two-step test is not required.

Before we conduct the 2SLS estimations on the three-equation structural model, we must clarify the structural relationship between dependent variables and explanatory variables. Table 4, Table 5, and Table 6 summarize whether there exists a structural relationship among the TV equation, BAS, and PV equation, based on the two-step Hausman hypothesis test method. According to these results, for both SP-ES and ND-NQ models, there exist structural relationships in all the equations. Taking for example the TV equation in the SP-ES model, the test result as shown in Table 4 indicates that the BAS should be viewed as an endogenous variable, and the PV should be viewed as an exogenous variable in the TV equation. Therefore, it is necessary to use the 2SLS method to conduct the estimations of the TV equation in order to eliminate the correlated effects of BAS and residual items. (Please refer to Table 4, Table 5, and Table 6 for the structural relationships of other dependent variables and explanatory variables.)

4.4.1. Trading-Volume Equation (TV Equation)

Table 7

Empirical results of trading-volume, bid-ask-spread and price-volatility equations of SP-ES contracts from May 2003 to February 2004

Variable	TV_t			BAS_t			PV_t		
Constant	7.205	***	(4.04)	-2.895	***	(-3.23)	-0.008		(-0.01)
TV_t	---			0.136	**	(2.07)	0.348	***	(3.33)
BAS_t	0.206	***	(5.53)	---			0.103		(1.95)
PV_t	0.438	***	(6.78)	0.203	***	(3.27)	---		
∇SP_t	---			1.870		(0.75)	---		
∇INT_t	2.237		(1.40)	---			---		

Table 7 (continued)

Variable	TV_t			BAS_t			PV_t		
OI_{t-1}	-0.054		(-0.45)	---			---		
PV_{t-1}	0.447	***	(7.60)	---			-0.165	***	(-2.83)
BAS_{t-1}	---			0.552	***	(6.17)	---		
PV_{t-1}	---			---			0.071		(1.38)
$Dummy_t$	-1.418	***	(-8.51)	0.488	***	(2.64)	0.422		(1.79)
$Adj-R^2$	0.92			0.51			0.20		

Notes: 1. Each equation is estimated by the two Stage Least Square (2SLS). 2. Numbers in parentheses are t statistics. ∇ denotes the first difference operator. 3. When *Dummy* = 1, it refers to SP (regular contract); when *Dummy* = 0, it refers to ES (E-mini contract). 4. ** Significance at the 5% level. *** Significance at the 1% level.

Table 8

Empirical results of trading-volume, bid-ask-spread and price-volatility equations of ND-NQ contracts from May 2003 to February 2004

Variable	TV_t			BAS_t			PV_t		
Constant	7.716	***	(3.01)	-1.322	**	(-2.52)	0.947		(0.88)
TV_t	---			0.063		(1.77)	0.282	***	(3.20)
BAS_t	0.145	***	(3.05)	---			0.072	**	(2.24)
PV_t	0.44	***	(5.73)	0.104	**	(2.33)	---		
∇SP_t	---			1.205		(1.05)	---		
∇INT_t	1.28		(0.78)	---			---		
OI_{t-1}	-0.108		(-0.66)	---			---		
PV_{t-1}	0.382	***	(5.61)	---			-0.065		(-1.23)
BAS_{t-1}	---			0.694	***	(7.98)	---		
PV_{t-1}	---			---			-0.126	**	(-2.34)
$Dummy_t$	-2.09	***	(-6.20)	0.371	***	(2.837)	0.614	**	(2.21)
$Adj-R^2$	0.94			0.69			0.15		

Notes: 1. Each equation is estimated by the two Stage Least Square (2SLS). 2. Numbers in paren theses are t statistics. ∇ denotes the first difference operator. 3. When *Dummy* = 1, it refers to ND (regular contract); when *Dummy* = 0, it refers to NQ (E-mini contract). 4. ** Significance at the 5% level. *** Significance at the 1% level.

In the TV equation, there is a positive relationship between BAS (column #2, variable #3) and TV which is statistically significant at the 1% level for both the SP-ES and ND-NQ contracts (0.206 and 0.145). This finding indicates that as liquidity cost increases, TV also rises when other affecting factors are under control. This seems to contradict the expectations in the theory. However, as there exists a structural relationship between BAS and TV, this means that they are determined at the same time and the causal relationship is bi-directional.

In both the SP-ES and ND-NQ contracts, PV (column #2, variable #4) is statistically significant at the 1% level and exhibits a positive relationship with TV. The elasticity of TV with respect to BASs can be found in Table 7 and Table 8 for SP-ES (0.438) and ND-NQ (0.44), respectively. In theory, the rise in PV prompts speculators to adjust reservation prices and hedgers to shift risks, and both effects increase TV. Therefore, the finding of this paper is in line with expectations of the theory.

In order to understand whether there is a significant difference in TV between regular contracts on the open outcry market and E-mini contracts on the automated trading market, we consider dummy variables in our model (column #2, variable #11). The empirical results show that the TV of E-mini contracts on the automated trading market is significantly larger than that of regular contracts traded on the open outcry market (-1.418 and - 2.09). This finding is in line with the statistical data that E-mini contracts have higher TV.

4.4.2. Bid-Ask Spread Equation (BAS Equation)

In the BAS equation, the trading-volume (column #3, variable #2) of the SP-ES model is at the significant level of 5% and is in a positive relationship with the BAS (0.136) when the other factors are under control. The ND-NQ model has also a positive relationship, but is insignificant (0.063). This positive relation is possibly due to the fact that traders of regular contracts interpret the rise in TV as the existence of information providers and so they expand BAS to reduce possible losses.

To market liquidity providers, the increase of PV implies two types of risks, i.e. adverse information risks and non-systematic risks of under-diversifications. As such, they tend to expand BAS to compensate the possible risks. In conclusion, in both the SP-ES model and ND-NQ model, their PV (column #3, variable #4) has a significantly positive relationship with BAS (0.203 and 0.104). Such a finding is in line with expectation of the theory.

According to the above measurements and analysis, the average BAS of regular contracts traded on the open outcry market is larger than that of E-mini contracts traded on the automated trading market when the factors affecting BAS are not under control. However, as there may exist differences in TV, PV, and BAS between regular and E-mini contracts, using their average BAS to examine their market liquidity may cause misinterpretations in comparisons. Therefore, with factors affecting the variances of the TV of regular and E-mini contracts under control, the coefficients of the dummy variables (column #3, variable #11) indicate that the liquidity cost of regular contracts on the open outcry market is significantly higher than that of E-mini contracts on the automated trading market (0.488 and 0.371). This finding is in line with the measurements of BAS as mentioned above.

4.4.3. Price-Volatility Equation (PV Equation)

Wang and Yau (2000) and Ates and Wang (2004) divided the sources of PV into two components, one from the inflow of new information, with TV as the proxy, and the other from the intra-day liquidity, with BAS as the proxy. The more new information there is, the worse the liquidity will be and, therefore, the more volatile the PV becomes. In the price-volatility equation, in both the SP-ES model and ND-NQ model, TV (column #4, variable #2) has a significantly positive relationship with PV (0.348 and 0.282). The larger the TV is, the more obvious the price changes become. This finding is in line with our expectations. At the same time, the BAS (column #4, variable #3) in both the SP-ES model and ND-NQ model exhibit a positive relationship with PV (0.103 and 0.072). This finding is in line with expectations of the theory, which holds that the quality of intra-day liquidity does affect the fluctuations of transaction prices.

Admati and Pfleiderer (1988) believed that there exists a positive relationship between PV lagged one and TV lagged one. As far as the SP-ES model is concerned, during the sample period, the finding turns out to be the opposite of the conclusion reached by Admati and Pfleiderer (1988). However, the finding of the SP-ES model is consistent with the arguments brought forward by Foster (1995) and Wang and Yau (2000). Moreover, the dummy variables of the PV equation (column #4, variable 11) indicate that the ND contracts traded on the open outcry market demonstrate a larger PV (0.614) than the NQ contracts traded on the automated trading market. However, there is no significant difference in PV (0.422) between the SP contracts traded on the open outcry market and their counterpart E-mini contracts traded on the automated trading market.

5. Conclusion

The most commonly-used measurements of market liquidity are market depth and BAS. This study finds that in both the automated trading market and open outcry market, trading activities significantly impact transaction prices. This finding implies that there is room for improvement in determining market depth. Among them, the E-mini contracts traded on the automated trading market exhibit better market depth than the regular contracts traded on the open outcry market. This finding indicates that the mechanism of limited order books and disclosure of bids and offers on the automated trading market provide useful information regarding market depth and help to intensify market depth. In both regular contracts traded on the open outcry market and E-mini contracts traded on the automated trading market, anticipated TV and non-anticipated TV exhibit significant asymmetry in terms of shocks to transaction prices. However, non-anticipated TV exhibits stronger shocks to transaction prices than anticipated TV does. Moreover, there exists a heterogeneity between the shocks to transaction prices, and the shocks from the negative and positive non-anticipated TV. Nonetheless, such heterogeneity varies when different contracts are studied.

According to the TW and CFTC BAS estimator, the average BAS of E-mini contracts traded on the automated trading market is smaller than that of regular contracts traded on the open outcry market. This finding illustrates the advantage of the execution efficiency of order handling under the GLOBEX trading system of CME. Its mechanism of limited order books provides better transparency of information on prices and TV and the characteristics of continuous bidding help to reduce the liquidity cost. Although the anonymous nature of E-mini contracts on the automated trading market may produce adverse selection transactions, such information asymmetry is not apparent in the index futures market. At the same time, investors also have access to a considerable amount of real-time information regarding the market conditions. Therefore, the effects of information asymmetry are smaller in the automated trading market.

However, there exist differences in TV and PV, which are two factors that affect the BAS of the regular contracts and E-mini contracts. Therefore, using BAS to compare the liquidity of these two contracts may cause misunderstandings. The result of the structural equation tests also shows that the effects of E-mini contracts on the automated trading market exhibit a smaller BAS than that of regular contracts on the open outcry market, when the factors that affect BAS are under control. This finding further proves that the automated trading market boasts superior market liquidity.

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