Transition to electronic trading of Kansas City Board of Trade wheat futures

Samarth Shah and B. Wade Brorsen

Samarth Shah
Graduate Student
Department of Agricultural Economics
Oklahoma State University
421-F Ag Hall
Stillwater, OK 74078
405 744 9801
samarth.shah@okstate.edu

B. Wade Brorsen
Regents professor and Jean & Patsy Neustadt Chair
Department of Agricultural Economics
Oklahoma State University
414 Ag Hall
Stillwater, OK 74078
405 744 6832
Wade.brorsen@okstate.edu

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This study compares liquidity costs and other characteristics of electronic and open outcry hard red winter wheat futures contracts traded on the Kansas City Board of Trade. Liquidity costs are considerably lower in the electronic market than in the open outcry market. A new approach is used to estimate liquidity costs which eliminates bias resulting from splitting of orders in electronic markets. The liquidity costs are still considerably lower after correcting the bias in electronic market. Liquidity costs were higher in after-hours trading as compared to regular trading hours suggesting a negative impact of volume on liquidity costs. Volatility of futures prices and volume per trade are positively related to liquidity costs, while a negative relation is found between daily volume and liquidity costs. Round-number pricing is more prevalent in the open outcry market. Daily volumes were found distinctively higher during the rolling period as a result of Goldman-Sachs Roll. Trade size is larger in the open outcry market.

Key words: bid-ask spread, electronic trading, execution costs, KCBT, liquidity

Introduction

Futures and options exchanges worldwide are shifting from conventional open outcry markets to electronic trading. Reasons for this shift include reduced transaction costs, less trading errors, and increased speed of execution. Electronic trading eliminates the costs of maintaining a physical site for floor trading. As argued by Martens (1998), an open outcry trading system is comparable to a dealership market, in which traders can trade with competing market makers at their publicly announced bids and asks, while an electronic trading mechanism is comparable to a continuous auction system with automatic order matching in which traders communicate only via computer screens. Electronic trading requires an open limit order book, which enhances market transparency, improves dissemination of updated prices, and speeds order execution. Previous works have studied the effects of the migration from open outcry to electronic trading on relative efficiency, execution costs, and informational efficiency and show that an incentive exists for this migration. Examples of such work include Chung and Chiang (2006), Ates and

Wang (2005), Bloomfield, O'hara, and Saar (2005), Aitken, Frino, Hill, and Jarnecic (2004), Tse and Zabotina (2001), Blennerhasset and Bowman (1998), Frino, McInish, and Toner (1998), Martens (1998) and Pirrong (1996). Frank and Garcia (2009) and Bryant and Haigh (2004) attempted to determine the impact of electronic markets on liquidity costs of agricultural commodities futures contracts, but neither of the two studies explicitly measured liquidity costs in electronic markets. None of the previous studies used the same measures to estimate liquidity costs in both electronic and open outcry markets which provide fair comparison between the two markets. The present study estimates and compares liquidity costs in traditional open-outcry market and the new electronic market at Kansas City Board of Trade (KCBT) using Roll's measure and average absolute price deviation as measures of liquidity costs.

The KCBT introduced electronic trading on the CME Globex® platform on January 14, 2008. This shift sought to provide high-speed trade execution, direct market access, and central counterparty clearing to achieve fairness, transparency, and anonymity in trading. At KCBT, both electronic and open-outcry markets co-exist which provides a favorable scenario to compare both markets. A new approach is used to estimate liquidity cost which eliminates bias resulting from splitting of orders in electronic market. The study identifies the impact of different factors such as daily volume, volume per trade, and price volatility on liquidity costs. A probable impact of Goldman-Sachs roll on daily volumes of KCBT open outcry markets is examined and higher trading volumes are found during the roll period. This study also examines the occurrence of round number pricing in both electronic and open outcry markets. The results of this study will help hedgers and speculators understand various aspects of both market environments and aid in their business decisions. The results of this study will also help regulators and exchange management increase fairness and efficiency in the market.

Theory

To compare electronic and open-outcry trading, the first requirement is to understand the execution of the orders in both trading environments. At KCBT, open-outcry trading occurs on a trading floor where members (traders) trade continuously through open outcry. Traders publicly announce bid and ask prices. If a trader finds a bid or ask attractive, the trader simply sells at the bid or buys at the ask price. The transaction price is then made public. Quotes are valid only for a short time. A trader can also request a quote, and then may accept the best price or refuse to trade. When there are multiple traders with the same offer or ask, the buyer or seller can choose with whom to trade. As no official market maker is present on the KCBT floor, an official order book does not exist. Names of traders are not published by the exchange. This information is immediately available only to the people on the floor.

Electronic trading is a continuous auction system with automatic order matching in which traders communicate only via computer screens without revealing their names. If two orders can be matched, then the automatic auction mechanism chooses as matching orders those with the best prices. For multiple identical best bids or asks, the trade is assigned to the order that has been in the system the longest time. Large orders that exceed the limit order of the quote are split up over more quotes according to price and the time the quote entered the system. Information on transaction prices and volumes is published instantaneously in the electronic system. A quote is valid until it is explicitly withdrawn from the system.

One of the apparent differences between the two trading systems is the limit order book. In electronic trading, traders have access to an anonymous limit order book, while in open-outcry trading, no official limit order book exists. However, identities and the behavior of other traders can be observed on the floor. Another important difference between these two trading systems is the execution of orders. In electronic trading, a large order can be matched with several orders of the limit order book at different prices. On the other hand, in open-outcry trading, an order is sometimes executed at one price only. Therefore, the argument is that large investors get a better deal in open-outcry markets than in electronic markets. Moreover, the electronic market's splits in order matching create downward bias in estimates of liquidity costs when price changes are used for estimating liquidity costs. No previous study of liquidity costs in electronic markets has identified this bias. To eliminate this bias, probable splits in the dataset are identified and aggregated to represent one order and then separate estimates of liquidity costs are calculated.

In heavily traded commodity futures markets such as wheat and corn, although volume per trade is higher in open-outcry markets, total volume and number of trades are generally higher in electronic markets because it facilitates fast order matching and trade execution. Due to this high activity in electronic environment and a quicker dissemination of information, liquidity costs (except possibly for large orders) seem to be lower in electronic trading as compared to the open-outcry system.

Borchardt (2006, p. 13) prior to the opening of side-by-side trading at the KCBT offered this explanation of why large traders would prefer open outcry:

> Personally, I truly believe that the liquidity will still rest in the trading pits during open outcry, but what you may see is that some of the small orders, that are more of a nuisance to the pit than they are a help, may bleed over to the electronic system to be executed. … But, the liquidity will still reside in the pit. When I first came to the exchange back in 1982, you'd go down to the floor, and if someone was trading 10 or 20 contracts, that was a pretty good size. And 50 contracts was huge! Now everybody in the pit will trade 50, and most of them will trade 100, and there is a core group of people down there who will trade 300 to 500 contracts at a time. They're the true liquidity providers, the depth that's needed for the big commercials and for the financial monies that are flowing into the exchange.

Several past studies across different market structures and financial instruments have observed price clustering at round numbers. Price clustering is the preference for some prices over others. Three main hypotheses have been proposed in the literature to explain the clustering of prices: the negotiation hypothesis, the collusion hypothesis, and the attraction hypothesis (Klumpp, Brorsen, and Anderson 2007). According to the negotiation hypothesis, developed by Harris (1991), traders use a limited number of price points to simplify and reduce the cost of negotiation. If less price points are used, negotiations converge rapidly, avoiding frivolous offers and counteroffers. The collusion hypothesis, proposed by Christie and Schultz (1994), argues that clustering is caused by implicit collusion of traders. The attraction hypothesis, also referred to as the natural clustering hypothesis, states that clustering is the result of a psychological preference of some price points (Ascioglu, Comerton-Forde, and McInish 2007). The present study examines price clustering in both electronic and open outcry wheat futures markets. The anonymity of the electronic market likely prevents negotiation of price or collusion. Therefore, if price clustering is observed in the electronic market, it is more likely the result of natural clustering or an attraction to particular numbers. However, in open outcry markets, the trades, especially large orders, can be implicitly negotiated on the trading pit by the floor traders, which might lead to choosing whole numbers. Further, electronic markets have less need for the simplification of round numbers compared to open outcry markets since the bids and offers are often set by computers. Hence, the open outcry market is expected to have more round number pricing.

The three factors expected to affect liquidity costs in both trading systems are daily volume, volatility, and volume per trade. Previous work on liquidity in futures markets finds that liquidity costs and trading volume are negatively correlated while liquidity costs and price variability are positively related (Thompson and Waller 1988; Brorsen 1989; Thompson, Eales, and Seibold 1993; Bryant and Haigh 2004; Frank and Garcia 2009). This effect occurs because in high volume markets, traders trade with little price effect to their transactions. However, in thin markets, the transactions of individual traders may have significant price effects and may therefore result in higher liquidity costs. This result is also one of the reasons why liquidity costs in electronic markets are expected to be lower than those of open-outcry markets. Conversely, in a volatile market, traders, especially intra-day traders, face high risk from holding inventory so they increase their bid-ask spread. Hence, volatility is expected to have a positive relation with liquidity cost. The third factor believed to affect liquidity costs is volume per trade. In the electronic market, high volume orders may not be filled at a single price. In the open outcry market, a scalper may have a higher bid-ask spread for the largest orders.

Data

The intraday prices used in this study are the tick data for hard red winter wheat futures contracts traded at the Kansas City Board of Trade (KCBT 2008). At KCBT, wheat futures contracts are traded with five expiration months: March, May, June, September, and December. The database contains a record of each trade price of the five contracts traded by both open outcry and electronic methods in 2008. Regular trading hours for open outcry trading at KCBT are 9:30 a.m. to 1:15 p.m. Monday through Friday. The electronic market operates during regular trading hours and 6:00 p.m. to 6:00 a.m. Sunday through Friday. One trading day for electronic trading is considered from 6:00 p.m. through 1:15 p.m. of the next day. Daily volumes for each contract in both markets are also used.

Procedures

The bid-ask spread is an accepted measure of liquidity cost in security and futures markets. As bid-ask quotes for futures markets are not recorded by the exchange, two proxies of bid-ask spread are used to measure the liquidity costs: Roll's measure and average absolute deviation. According to Roll (1984) if markets are informationally efficient, the covariance between price changes is negative and directly related to the bid-ask spread. Roll's measure is calculated using the following formula:

(1) $$RM = 2\sqrt{-\mathrm{cov}(\Delta F_t, \Delta F_{t-1})},$$

where ΔF_t is the change in wheat price at time *t*. Roll's measure is more precise with more frequent observations since most price movements will be due to scalping rather than to information trades. The other accepted proxy for the bid-ask spread was proposed by Thompson and Waller (1987), who suggest that the average absolute value of price changes as a direct measure of the average execution cost of trading. Average absolute price changes are calculated as

(2) $$\text{Average absolute price change} = \frac{1}{T}\sum_{t=1}^{T}|\Delta F_t|.$$

The liquidity costs for the five contracts are estimated in both electronic and open outcry futures markets using Roll's measure and average absolute mean deviations. Each measure is calculated for each day and then averaged for the life of the contract weighted by daily number of trades. For regression and other analysis in the study, average absolute price deviation is used as the measure of liquidity costs.

In electronic markets, if the market order is larger than available limit orders, the large order is split into smaller orders and matched with two or more limit orders sometimes at different prices. This practice results in biased estimates of liquidity costs when measures such as Roll's measure and average absolute price changes are used to estimate liquidity costs. To overcome this bias, all probable splits in the dataset are identified. In electronic markets, matched trades are time stamped with the precision of seconds. All the trades occurring at the same time (same second) in a day are averaged and treated as a single observation. Then average absolute price deviations are calculated from the reduced dataset and referred to as aggregate average absolute price deviations.

To test hypotheses about factors influencing liquidity costs, the following regression equation is estimated by restricted maximum likelihood:

(3) $$L_{it} = \beta_{i0} + \beta_{i1}AV_{it} + \beta_{i2}TV_{it} + \beta_{i3}V_{it} + \omega_t + e_{it} \quad ,$$

where L_{it} is average absolute price change on day t and maturity month i, AV_{it} is volume per trade on day t, TV_{it} is total volume on day t, V_{it} is price volatility measured as range of price on day t, ω_{it} is random effect of trading day. ω_t and e_{it} are assumed independently distributed normal with mean 0 and variance σ_ω^2 and σ_e^2, respectively. The estimates of σ_ω^2 are all zero and thus the model is equivalent to ordinary least squares. Separate regressions are estimated for open-outcry, the electronic market, and the electronic market with aggregate trades.

Results

Descriptive statistics of number of trades and volumes are in Table 1. Average trades per day for electronic markets are immensely higher than for open-outcry markets. However, average volumes per trade for electronic markets are considerably lower than that of open-outcry markets. The small trade size in the electronic market might be partly due to splitting of large orders with electronic trading. However, as argued by Martens (1998), in electronic markets, risk-averse traders can more easily break up their large orders and place smaller orders at different prices to protect themselves from adverse selection than in open-outcry markets.

Monthly volumes for electronic and open outcry markets are shown in figure 1. The daily volume of the July 2008 contract for electronic and open-outcry contracts is presented in Figure 2. Daily volumes of electronic contracts are higher than those of open outcry contracts throughout the life of the contracts except for a few occasions. Total volume traded in wheat electronic futures markets during 2008 at KCBT was 1,882,302 contracts compared to 1,033,741 contracts in open outcry markets (KCBT 2008). The electronic market had a higher market share and dominated the open outcry market.

The liquidity costs for the five contracts in both electronic and open outcry futures markets are presented in Table 2. The average Roll's measure for electronic markets ranges from 0.28 cents per bushel to 0.88 cents per bushel while for open outcry, it ranges from 1.18 cents per bushel to 2.17 cents per bushel. This result indicates that the electronic market has lower liquidity cost. Shah and Brorsen (2009) estimate the same measures for June 2007 open outcry wheat futures contract. They report Roll's measure of 0.45 cents per bushel and average absolute mean deviation of 0.49 cents per bushel. Thompson, Eales, and Seibold (1993) also estimate the same measures for selected 1985 KCBT wheat contracts. Their estimates of average absolute deviations[1] are 0.26-0.29 cents per bushel for highly traded contracts, but are about double these values for lightly traded contracts such as the March contract during March or the September

[1] The dataset used by Thompson, Eales, and Seibold (1993) only recorded observations when prices changed. When the zero price changes are deleted, our estimates of liquidity costs increase by 42.63 and 46.16 per cent in open-outcry and electronic markets, respectively.

contract in February. Our estimates of Roll's measure and average absolute mean deviation for June 2008 open outcry contract are 1.18 and 1.23 cents per bushels, respectively. The reasons behind higher liquidity costs in 2008, as compared to 2007 for the same contract, are lower volumes, high prices, and high volatility in 2008. The total trading volumes for wheat futures markets in 2007 at KCBT were 4,318,007 contracts with only 3,778,266 contracts in 2008 (KCBT 2008). With the higher prices and higher price volatility in 2008, the risk associated with scalping clearly increased, which resulted in higher liquidity costs.

The average absolute deviations are also considerably lower in electronic markets than in open outcry markets. The average absolute price deviations for electronic markets range from 0.26 to 0.70 cents per bushel. In electronic markets, if no limit order of matching size is available at the time for a large market order, the order matching system splits the large market order and matches it with several smaller limit orders depending upon the size of the market order and available limit orders. The result is several trades at the same time instead of a single trade for the market order. The frequency of the number of trades occurring at the same time in both electronic and open outcry markets is presented in Table 3. The numbers reveal a much higher number of trades occurring at the same time in the electronic market than in the open-outcry market. This result is evidence of the splitting of large orders in the electronic market. To mitigate the bias of average absolute price deviation estimates created by splitting larger orders in the electronic market, aggregate average absolute price deviations are used (Table 2). The estimates of aggregate average absolute price deviation range from 0.33 to 0.89 cents per bushel, which are higher than the non-aggregate trades, but still lower than those for the open outcry market.

Figure 3 shows the number of trades by time of day. The open outcry market opens at 9:30 and closes at 1:15. The inverted U shape for number of trades is at least partly due to the length of time periods not being equal. What is striking about figure 3 is how few electronic trades occur outside the hours of operation for open outcry. Average liquidity cost at different times of the day, calculated by segmenting total trading hours in one-hour intervals is presented in Figure 4. The figure shows that liquidity costs are larger in the open outcry market at both the open and the close. Ekman (1992) argues that information traders are more likely to trade at the open and close, and that is when price movements occur. Such changes in equilibrium prices would increase the estimate of liquidity costs. The electronic market shows greater liquidity costs outside regular trading hours, which could explain the small volume.

The Goldman-Sachs index fund traded substantial long positions during 2008. When the fund rolled its positions into the next contract month (Goldman-Sachs Roll 2009), it could have also caused greater price movement, especially at the close. The Goldman-Sachs roll occurs on the fifth through the ninth business day of the month prior to the expiration month in open-outcry market at KCBT. Figure 5 presents average daily volume in penultimate contract months for the five contracts under investigation. The daily volumes on the rolling period are distinctively higher than other business days especially the 5^{th}, 7^{th} and 9^{th} business days.

At KCBT, wheat contracts are traded at prices with precision of 2/8, 4/8 or 6/8 of a cent. Hence, the ending digits after the decimal point of any price can only be 0, 25, 50 or 75. Figure 6 shows the frequency of prices ending in the four possible digits. The figure shows that the clustering of prices to whole numbers is much more prevalent in the open outcry market than in the electronic market. In the open outcry market, almost 78 percent of prices are whole numbers compared to 35 percent in the electronic market. The preference of whole number prices in the wheat open outcry futures market is consistent with the negotiation hypothesis proposed by Harris (1991).

Linear regression is used to determine the relationship between liquidity cost, volatility, average volume per trade, and total daily volume of the contract. The results of the regression for open outcry and electronic markets are presented in Table 4. The results show a significant negative effect of daily volume on the liquidity costs for both electronic and open outcry markets, showing that higher volumes imply less risk of holding contracts resulting in lower liquidity costs. A significant impact of price volatility on liquidity costs is found in both markets. However, the sensitivity of liquidity cost to price volatility is less in the electronic market than in open-outcry. The direction of the effects of total volume and volatility are consistent with findings by Thompson and Waller (1987), Thompson, Eales, and Seibold (1993), and Bryant and Haigh (2004). The average volume per trade shows a positive significant impact on liquidity costs, indicating that traders face risk in holding larger contracts, which results in higher liquidity cost.

Summary and Conclusion

The objectives of this study are to determine and compare liquidity costs in the open outcry futures market and the electronic futures market and determine the factors affecting these liquidity costs. To meet the objectives, intraday prices of five hard red winter wheat futures contracts traded on Kansas City Board of Trade exchange during 2008 are used. Roll’s measure and average absolute price deviations are used to estimate liquidity costs. The average Roll’s measure for electronic markets ranges from 0.53 cents per bushels to 1.43 cent per bushel while for open outcry markets it ranges from 1.23 cents per bushel to 2.71 cents per bushel. Both measures of liquidity costs are considerably lower in the electronic market than in the open outcry futures market. The order matching system in electronic markets splits large orders into smaller orders when the corresponding limit order is for a smaller size, which creates a downward bias in estimates of liquidity costs. After correcting this bias, liquidity costs are still considerably less in the electronic market. Trading volumes are higher in open outcry markets during the Goldman-Sachs Roll period. Most trades in the open outcry market are at whole number prices, but not in the electronic market. Higher trading volume in electronic markets is one explanation of lower liquidity costs in this market. The regression results suggest a negative relation between liquidity costs and daily volume while volume per trade has a positive impact on liquidity costs in both electronic and open-outcry markets.

Except for large orders, liquidity costs are less in electronic futures markets than in open outcry futures markets. The key to continued existence of the open outcry market appears to be its ability to handle large orders. One question is, how can exchanges redesign electronic markets so that they are more attractive to large traders? A move to entirely electronic markets may require the largest orders to be executed off the exchange or may require large traders to take on the role of the scalper and submit a series of smaller orders that are executed sequentially rather than all at once. The results clearly support the use of the electronic market for all but the largest traders.

Table 1. Descriptive Statistics of Wheat Futures Contracts Traded at KCBT in 2008

	Open Outcry			Electronic		
Contract	N	Average Trades per Day	Average Volume per Trade	N	Average Trades per Day	Average Volume per Trade
March	51	132.02	57.33	51	1000.31	23.74
			(92.21)			(66.36)
May	93	85.08	45.50	93	610.55	38.93
			(78.37)			(220.93)
June	134	167.01	23.67	134	1194.60	3.67
			(13.13)			(2.37)
Sep	177	84.60	27.89	85	1417.75	5.24
			(36.94)			(5.79)
Dec	241	72.04	33.97	241	991.13	3.62
			(21.67)			(3.04)

Note: Values in parenthesis are standard deviations. Average volume is number of 5000 bushel contracts.

Table 2. Measures of Liquidity Costs (cents/bushel) in Wheat Futures Contracts Traded at KCBT in 2008

	Open Outcry		Electronic		
Contract	Roll's	Average Absolute Price Change	Roll's	Average Absolute Price Change	Aggregate Average Absolute Price Change
March	1.41	1.31	0.46	0.38	0.52
	(21.10)	(19.97)	(20.84)	(18.59)	(17.63)
May	2.17	2.14	0.88	0.70	0.89
	(15.78)	(9.03)	(23.00)	(7.32)	(7.88)
June	1.18	1.23	0.63	0.41	0.51
	(11.31)	(9.98)	(13.70)	(9.25)	(9.45)
Sep	1.38	1.35	0.28	0.26	0.33
	(16.99)	(12.25)	(7.09)	(4.45)	(4.65)
Dec	1.56	1.44	0.29	0.30	0.40
	(15.17)	(10.50)	(11.64)	(9.01)	(9.43)

Note: Values in parenthesis are standard deviations.

Table 3. Frequency of Number of Trades Traded at the Same Time in Wheat Futures Contracts at KCBT in 2008

Number of Trades at the Same Time	Frequency	
	Electronic Market	Open-outcry Market
1	321527	69083
2	73885	137
3	23075	1
4	8915	0
5	3827	0
6	1970	0
7	1019	0
8	577	0
9	318	0
10	191	0
11	120	0
12	88	0
13	49	0
14	39	0
15	24	0
16	15	0
17	14	0
18	10	0
19	5	0
20	1	0
21	1	0
22	1	0
23	1	0

Table 4. Regressions with Average Absolute Price Change as Dependent Variable

Market	N	Intercept	Range	Volume per Trade	Total Volume
Open-outcry	675	0.8681	0.0495	0.0403	-0.0006
		(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)
Electronic	594	1.0311	0.0091	0.0245	-0.0002
		(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)
Electronic (aggregate)	594	1.1197	0.0123	0.0199	-0.0002
		(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)

Note: values in parentheses are p values.

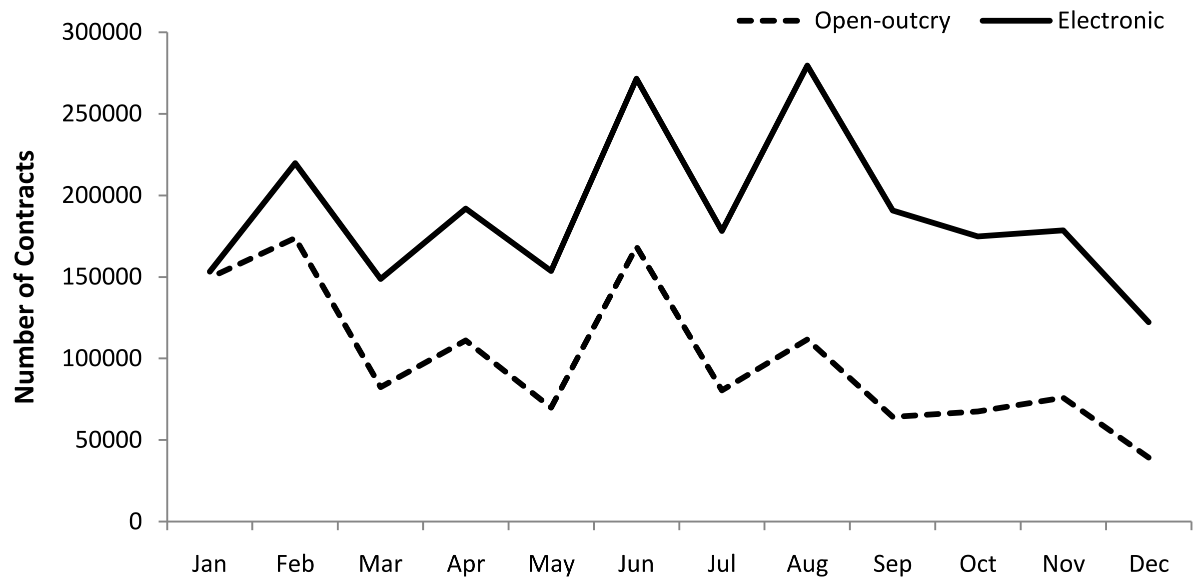

Figure 1. Monthly volume of KCBT wheat futures contract in 2008

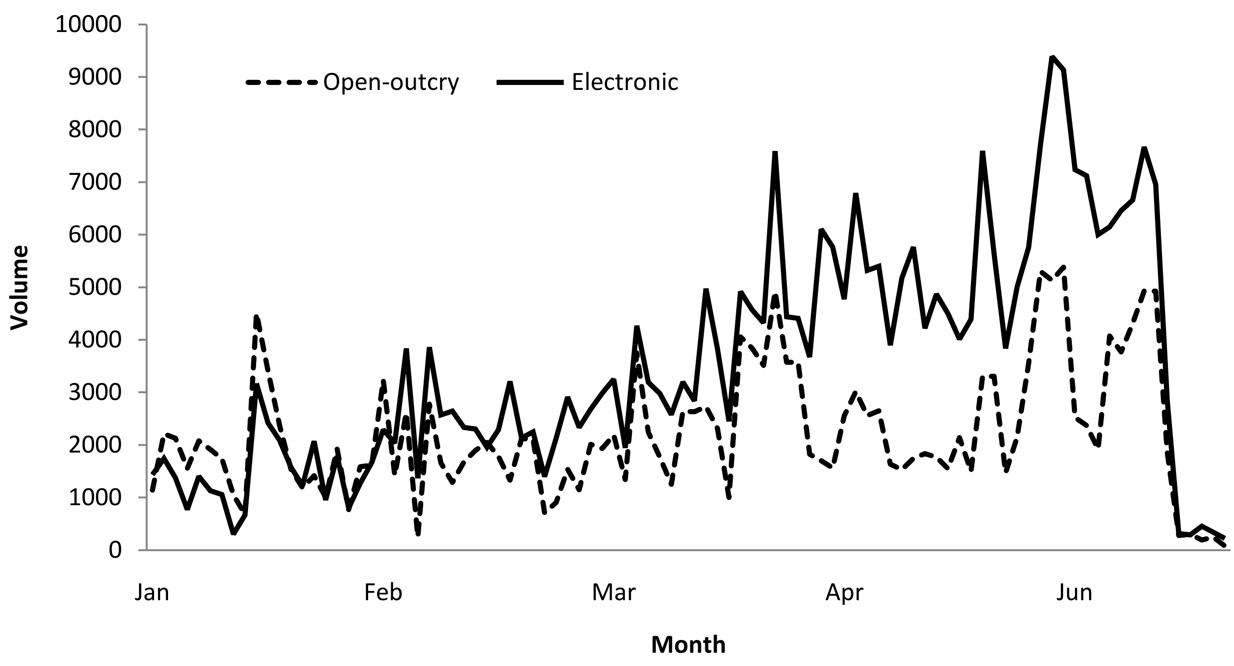

Figure 2. Daily volume of electronic and open-outcry july 2008 wheat futures contracts at KCBT

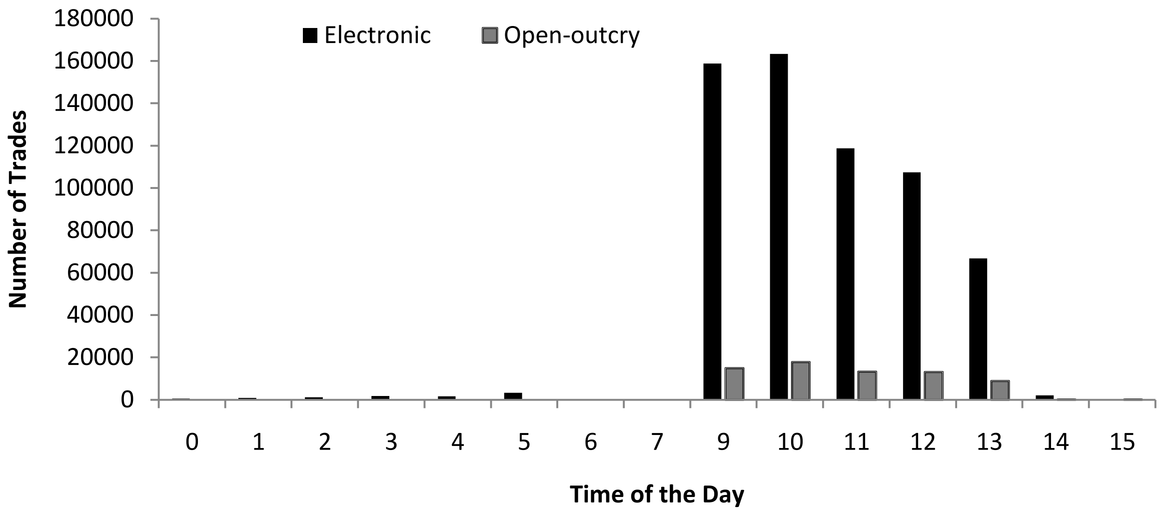

Figure 3. Number of trades at different time of the day at KCBT in 2008

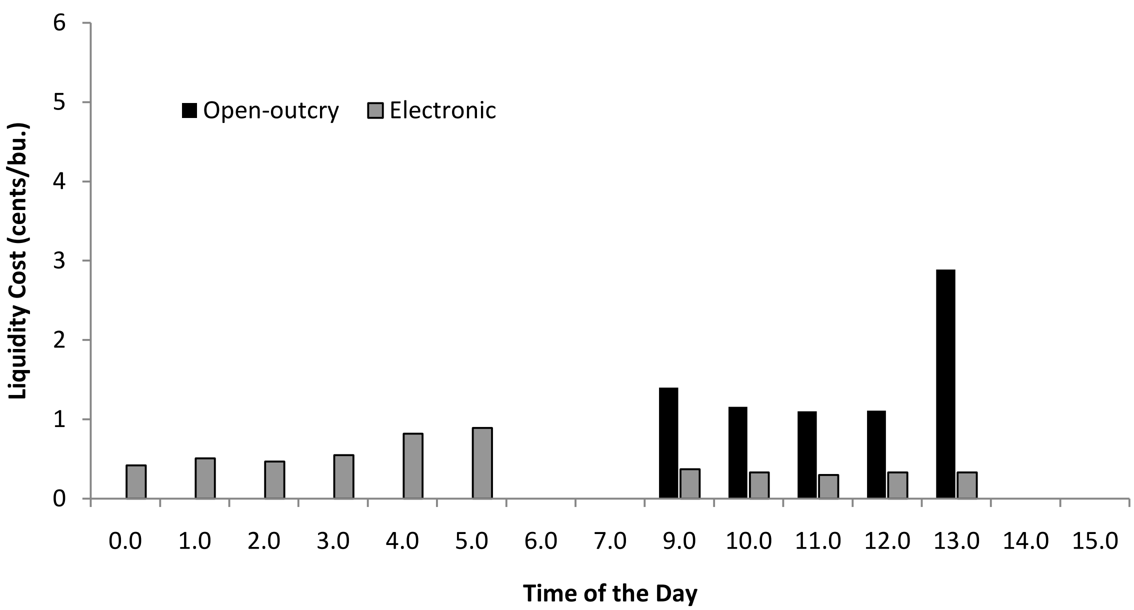

Figure 4. Liquidity cost at different time of the day at KCBT in 2008

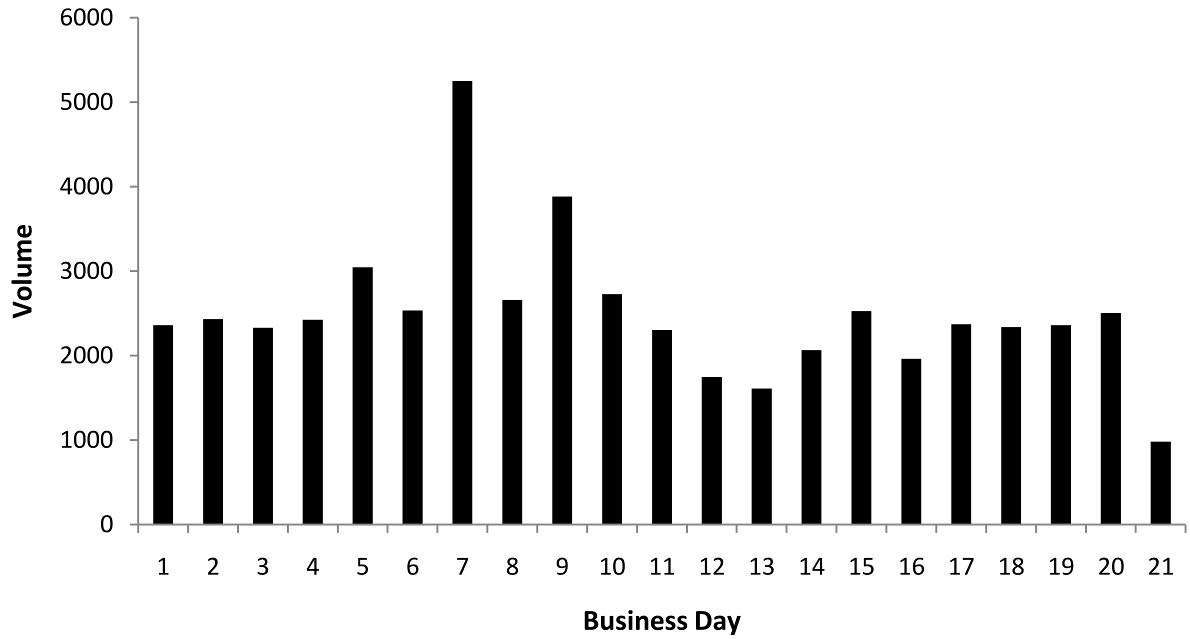

Figure 5. Average daily volume in penultimate contract months of KCBT HRW wheat open-outcry contracts in 2008

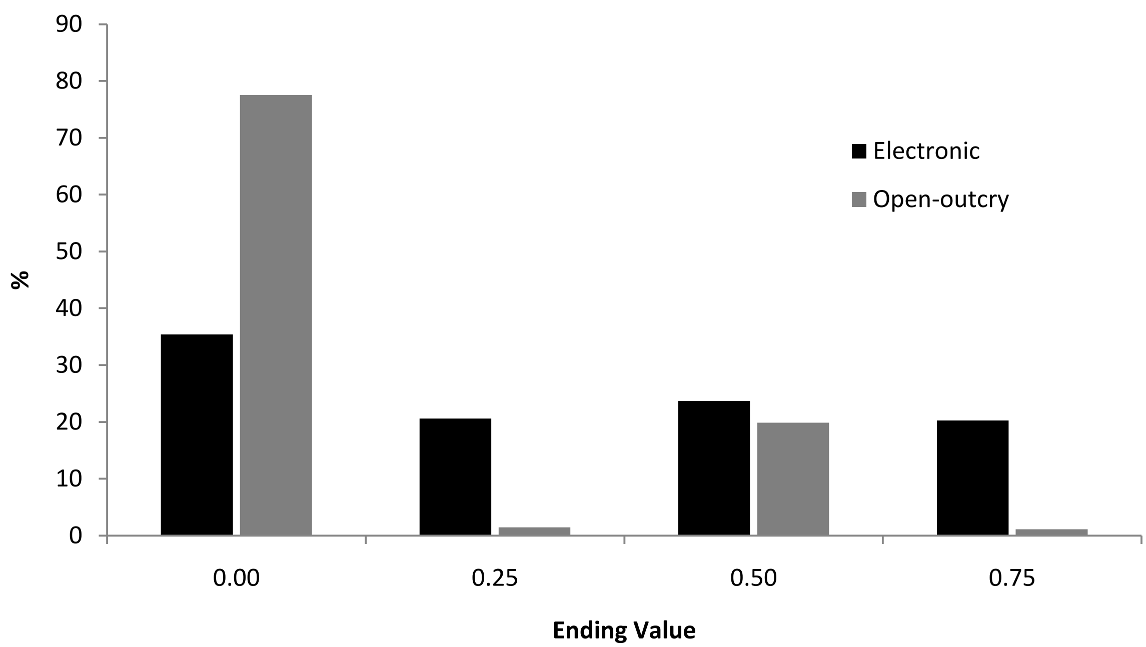

Figure 6. Ending values of trade price in electronic and open out-cry markets at KCBT in 2008

References:

Aitken, M. J., A. Frino, A. M. Hill, and E. Jarnecic. (2004). “The impact of electronic trading on bid-ask spreads: Evidence from futures markets in Hong Kong, London, and Sydney.” *Journal of Futures Markets* 24:675-696.

Ascioglu, A., C. Comerton-Forde, and T. H. McInish. (2007). "Price clustering on the Tokyo Stock Exchange." *Financial Review* 42: 289-301.

Ates, A., and G. H. K.Wang. (2005). “Information transmission in electronic vs. open-outcry trading systems: An analysis of U.S. equity index futures markets.” *Journal of Futures Markets* 14:391-419.

Blennerhasset, M. and R. G. Bowman. (1998). “A change in market microstructure: The switch to electronic trading on the New Zealand Stock Exchange.” *Journal of International Financial Markets* 8:261-276.

Bloomfield, R.,M. O’hara, and G.Saar. (2005). “Make or take decision in an electronic market: Evidence on the evolution of liquidity.” *Journal of Financial Economics* 75:165-200.

Borchardt, J.C. (2006). “Kansas City Board of Trade: 150 Years of Commodity Market Evolution.” Western Historical Manuscript Collection, Columbia, MO: University of Missouri. Available at http://web2.umkc.edu/WHMCKC/publications/KIMBALL/CNKPDF/Borchardt-04-19-2006.pdf.

Bryant, H. L., and M. S. Haigh. (2004). "Bid–ask spreads in commodity futures markets." *Applied Financial Economics* 14: 923-936.

Brorsen, B. W. (1989). "Liquidity costs and scalping returns in the corn futures market." *Journal of Futures Markets* 9: 225-236.

Christie, W. G., and P. H. Schultz. (1994). "Why Do NASDAQ market makers avoid odd-eighth quotes?" *The Journal of Finance* 49: 1813-1840.

Chung, H., and S. Chiang. (2006). “Price clustering in E-mini and floor-traded index futures.” *Journal of Futures Markets* 24: 337-357.

Demsestz, H. (1986). "The cost of transacting." *Quarterly Journal of Economics* 82: 33-53.

Harris, L. (1991). "Stock price clustering and discreteness." *The Review of Financial Studies* 4: 389-415.

Ekman, P.D. (1992). “Intraday patterns in the S&P 500 Index futures market.” *Journal of Futures Markets* 12:365-381.

Frank, J., and P. Garcia. (2009). "Bid-ask spreads, volume, and volatility: Evidence from livestock markets." Paper presented at Agricultural and Applied Economics Association Annual Meeting,26-28 July.

Frino, A., T. McInish, and M. Toner. (1998). "The liquidity of automated exchanges: New evidence from German bond futures." *Journal of International Financial Markets, Institutions and Money* 54: 1901-1915.

Goldman-Sachs Roll. (2009). "Roll period." Available at http://www2.goldmansachs.com/services/securities/products/sp-gsci-commodity-index/roll-period.html

Kansas City Board of Trade. (2008). Available at http://www.kcbt.com/historical_data.asp.

Klumpp, J.M., B.W. Brorsen, and K.B. Anderson. (2007). "Producers' preferences for round number prices." *Agricultural Finance Review.* 67:377-385.

Martens, M. (1998). "Price discovery in high and low volatility periods: Open-outcry versus electronic trading." *Journal of International Financial Markets, Institutions and Money* 8: 243-260.

Pirrong, C. (1996). "Market liquidity and depth on computerized and open-outcry trading system: A comparison of DTB and LIFFE Bund contracts." *Journal of Futures Markets* 16:519-544.

Roll, R. (1984). "A simple implicit measure of the effective bid-ask spread in an efficient market." *The Journal of Finance* 39(4):1127-39.

Shah, S. and B. W. Brorsen. (2009). "Liquidity costs in futures options markets." Paper presented at NCCC-134 meeting on Applied Commodity Price Analysis, Forecasting and Market Risk Management, St. Louis, Missouri, 20-21 April.

Thompson, S., J. S. Eales, and D. Seibold. (1993). "Comparison of liquidity costs between the Kansas City and Chicago wheat futures contracts." *Journal of Agricultural and Resource Economics* 18: 185-197.

Thompson, S. R., and M. L. Waller. (1987). "The execution cost of trading in commodity futures markets." *Food Research Institute Studies* 20:141-163.

Thompson, S. R., and M. L. Waller. (1988). "Determinants of liquidity costs in commodity futures markets." *Review of Futures Markets* 7: 110-126.

Tse, Y. and T. Zabotina. (2001). "Transaction costs and market quality: Open-outcry versus electronic trading." *Journal of Futures Markets* 21:713-735.