ESSAYS ON LIQUIDITY COSTS IN FUTURES AND OPTIONS MARKETS

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CHAPTER I

ELECTRONIC VS. OPEN OUTCRY: SIDE-BY-SIDE TRADING OF KCBT WHEAT FUTURES[1]

Abstract

This study compares liquidity costs of electronic and open outcry hard red winter wheat futures contracts traded side-by-side 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 due to splitting of orders in electronic markets. The liquidity costs in the electronic market are still considerably lower after eliminating the bias. 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. Price clustering at whole cent prices is found in the open-outcry market which helps explain its higher liquidity costs. Daily volumes were distinctively higher during the rolling period as a result of Goldman-Sachs Roll, but not enough to explain the higher

[1] This essay also appears as Shah, S., and B.W. Brorsen. 2011. "Electronic vs. Open Outcry: Side-by-Side Trading of KCBT Wheat Futures." *Journal of Agricultural and Resource Economics.* 36(1):48-62. Copyright held by Western Agricultural Economics Association. Included with permission.

liquidity costs in the open outcry market. Trade size is larger in the open outcry market which suggests large traders prefer open-outcry trading.

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. Many agricultural markets now offer side-by-side trading of both open outcry and electronic markets. Users need information about whether to execute orders in the open outcry or the electronic market. Users are likely to prefer the market with lower liquidity costs. A liquidity cost is the cost incurred by buyers and sellers when using a market order to liquidate their positions quickly. For example, a person who desires to immediately sell a contract receives the prevailing bid price while someone wanting to sell immediately would receive the ask price. The difference in price received by an urgent seller and the price paid by an urgent buyer is the liquidity cost.

Previous research has studied the effects of the migration from open outcry to electronic trading on relative efficiency, execution costs, and informational efficiency and mostly favors electronic markets. Examples include Ates and Wang (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). This past research has largely considered financial futures markets rather than agricultural commodity futures markets. Because some aspects of the microstructure of financial futures markets are different from those of commodity futures markets, it is important to investigate if findings about financial futures markets are applicable to agricultural commodity futures markets. For instance, commodity futures markets tend to have much lower trading volumes that are more concentrated among a few large hedgers than in financial futures markets, and have a relatively higher proportion of informed traders[2] (Foster and Viswanathan, 1994). Thus, the automation of trading may have a different impact on liquidity costs in a commodity futures market than in a financial futures market.

Two studies investigated the transition to electronic trading in commodity futures markets. First, Bryant and Haigh (2004) evaluated the impact on liquidity costs of moving from open outcry to electronic trading only– a before and after comparison in two LIFFE commodity futures markets. In contradiction with the findings of previous research in financial futures markets, they found that liquidity costs increased after the LIFFE market moved to electronic trading. Second, Frank and Garcia (2009, 2011) measured the impact of adding an electronic market alternative on liquidity costs in lean hogs and live cattle futures markets. They find that increased electronic trading reduced liquidity costs. There is no consensus about the impact of electronic trading on liquidity costs in commodity futures markets, which motivates further investigation of the issue. The question of whether or not the findings of financial futures markets are applicable to commodity futures markets remains unanswered. None of the studies of commodity markets compared liquidity costs in electronic versus open outcry markets with side-by-side trading.

This study compares liquidity costs in side-by-side trading of electronic and open outcry wheat futures contracts traded at Kansas City Board of Trade (KCBT). The KCBT introduced electronic trading on the CME Globex® platform on January 14, 2008. At KCBT, electronic and open-outcry markets co-exist. Intraday transaction prices are used to estimate

[2] An informed trader possesses information not reflected in the current market price and thus can profit by trading based on that information.

liquidity costs since KCBT does not provide bid-ask quotes for the open outcry wheat futures market and only irregularly provides them for the electronic market. Average absolute price deviation and Roll's (1984) measure that is based on the autocovariance of prices are used as measures of liquidity cost. A new approach is used to estimate liquidity cost in the electronic market that eliminates bias due to splitting[3] of orders in the electronic market. The study identifies the impact of different factors such as daily volume, volume per trade, and price volatility on liquidity costs. To explain the difference in liquidity costs in the electronic and open outcry markets, we also examine the degree of price clustering in the two markets. The potential impact of the Goldman-Sachs roll on the KCBT wheat open outcry market is examined to see if it is likely to explain much of the difference in liquidity costs in the two markets.

Expected Differences in the Two Markets

A key difference in electronic and open-outcry trading is the different order execution rules. 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.

[3] In the electronic market, a large market order is often offset by multiple limit orders (sometimes at different prices). These are reported as multiple transactions and thus the single market order ends up being split. In the open outcry market, a large market order is typically offset by a floor trader taking the other side at a single price.

Electronic trading is a continuous auction system with automatic order matching in which traders communicate only via computer screens without revealing their names. The automatic auction mechanism matches market orders with existing limit orders. For multiple identical best bids or asks, the trade is assigned to the order that has been in the system the longest Unlike the open outcry system, a bid or ask quote is valid until it is explicitly withdrawn from the system. Large market orders will often be offset with multiple limit orders that are selected according to price and the time the quote entered the system. The electronic system will report the single market order as multiple trades if it is offset by more than one limit order.

The electronic market's splitting of market orders due to order matching may create downward bias in estimates of liquidity costs. No previous study of liquidity costs in electronic markets has attempted to account for this bias. To eliminate this bias, probable splits in the dataset are identified and aggregated to represent one order and then estimates of liquidity costs are calculated.

One obvious difference between the two trading systems is the limit order book[4]. 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. Some researchers have argued that this anonymity of market participants in an electronic market increases adverse selection, which causes higher bid-ask spreads (Glosten, 1994; Bryant and Haigh, 2004). Another important difference between the two trading systems is order execution. In electronic trading, a large order can be matched with several orders from the limit order book at different prices. Also,

[4] The limit order book is the record of all unexecuted limit orders.

an electronic market may not have enough orders in the limit order book to offset a large order without a large price impact. Therefore, large trades may have lower liquidity costs in open-outcry markets than in electronic markets.

Prior to the opening of side-by-side trading at the KCBT, Borchardt (2006, p. 13) 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.

Price clustering offers alternative hypotheses about the expected differences in liquidity costs in the two markets. Price clustering is when transactions occur more at some prices than at other prices. Several past studies across different market structures and financial instruments have observed price clustering at round numbers (Klumpp, Brorsen, and Anderson). Market participants tend to use round number prices more frequently than fractions, which results in concentration of transaction prices around round numbers. Several hypotheses have been proposed to explain the clustering of prices: the negotiation hypothesis, the collusion hypothesis, the attraction hypothesis and the economic-cost hypothesis. According to the negotiation hypothesis (Harris 1991), traders use a limited number of price points to simplify and reduce the cost of negotiation. When fewer price points are used, negotiations converge rapidly, which avoids frivolous offers and counteroffers. The attraction hypothesis (Ascioglu, Comerton-Forde, and McInish 2007) suggests clustering is due to psychological preferences for some price points. Gwilym, Clare and Thomas (1998) found a positive relationship between price clustering and bid-ask spreads in LIFFE bond futures and argued that their results generally favored the attraction hypothesis. The collusion hypothesis (Christie and Schultz 1994) argues that clustering is caused by implicit collusion of traders. Christie and Schultz found intense clustering in NASDAQ stocks and observed that even though the minimum price fluctuation at NASDAQ was 1/8 cents, in more than 70 per cent of actively traded stocks the odd eighth quotes were virtually non-existent. They concluded that NASDAQ dealers implicitly colluded to maintain wide spreads. After the results of Christie and Schultz were reported, NASDAQ dealers sharply increased their use of odd-eighth quotes and effective spreads fell almost 50 per cent. The economic cost hypothesis (Kleidon and Willig 1995; Grossman et al. 1997), however, suggests that scalpers have a greater tendency to choose rounded quotations when the economic costs of scalping are high. In particular, when price volatility is high, price clustering allows participants to transact quickly in order to reduce risk (Gwilym, Clare, and Thomas 1998).

Price clustering is more likely in the open outcry market than in the electronic market. The negotiation and collusion hypotheses can only explain price clustering in the open outcry market since the electronic market is anonymous. In open outcry markets, the trades, especially large orders, can be implicitly negotiated on the trading pit by the floor traders. The negotiation hypothesis suggests that such a process might lead to a less fine price grid such as whole cents or half cents. Further, by the economic-cost hypothesis, due to more frequent transactions, scalpers[5] in the electronic market can more easily ascertain the value of their holdings, which would result in less price clustering towards round numbers. The converse can be argued for open-outcry trading. Hence, price clustering, and therefore higher liquidity costs, is expected to be greater in the open outcry market than in the electronic market.

The three factors expected to affect liquidity costs in both trading systems are daily volume, volatility, and volume per trade. Previous research about liquidity costs in futures markets finds that liquidity costs decrease as trading volume increases and liquidity costs increase as price variability increases (Thompson and Waller 1988; Brorsen 1989; Thompson, Eales, and Seibold 1993; Bryant and Haigh 2004; Frank and Garcia 2009). The volume effect implies that the supply of liquidity services is downward[6] sloping (Brorsen 1989). Scalpers benefit from economies of size and these benefits are passed on in the form of lower liquidity costs. The higher volume in the 2008 KCBT electronic market (KCBT 2008) is one reason why liquidity costs in electronic markets are expected to be lower than those of open-outcry markets. Conversely, in a volatile market, holding inventory is risky so traders increase the bid-ask spread to compensate for the increased risk. 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. However, in the open outcry market, a scalper may have a higher bid-ask spread for the largest orders.

[5] Scalpers are extremely short-term traders who profit by selling at a price slightly above the last transaction and buying at a price slightly below the last transaction. Scalpers are the main liquidity providers in futures markets.

[6] This downward sloping supply of liquidity services causes futures exchanges to be natural monopolies. This likely explains why competing futures exchanges do not offer identical contracts.

Data

The intraday prices used 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, July, September, and December. The database contains a record of each trade price of the five contracts traded in both open outcry and electronic markets in 2008. This year had unusually high and volatile prices. While we are not aware of any obvious reason why this volatility would affect electronic and open-outcry markets differently, the results need to be viewed with consideration that the year studied is atypical. The KCBT does not record bid and ask price for open-outcry wheat futures markets but, for its electronic wheat futures market, it provides occasional time stamped bid and/or ask prices. However, there are too few concurrent observed bid and ask prices to produce accurate estimates of liquidity cost. Hence, observed bid-ask spreads are not included. 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 from 6:00 p.m. through 1:15 p.m. of the next day. Daily volumes in number of contracts for each contract in both markets are also from KCBT (2008).

Procedures

The bid-ask spread is an accepted measure[7] of liquidity cost in security and futures markets. If bid and ask prices are recorded, prevailing spread in any market could be directly estimated. However, bid and ask prices are usually not recorded for open-outcry futures

[7] The preferred measure is the effective spread. The effective spread is the absolute value of the trade price minus the midpoint of the most recently quoted bid and ask prices. The liquidity cost on a round turn, which is what we calculate, is then two times the effective spread.

markets, which creates a need for indirect measurement of bid-ask spreads. Various estimators have been developed that estimate bid-ask spreads using commonly available transaction data. Spread estimators developed in the literature have mostly used either the covariance of successive price changes or have employed averages of absolute price changes. The former include Roll's measure developed by Roll (1984) and extensions of Roll's measure such as that proposed by Chu, Ding, and Pyun (1996), which relaxes the assumption of equal probability of trade direction in Roll's measure. Holden (2007) developed a model that uses both serial correlation like Roll's measure and price clustering to estimate the effective spread. The latter type of estimators which employ absolute price changes include average absolute price deviation proposed by Thompson and Waller (1987) and a different average absolute price deviation measure used by Commodity Futures Trade Commission (CFTC). The CFTC measure only includes non-zero price deviations and price changes that are in the opposite direction of the previous change. Smith and Whaley (1994) suggest a method to estimate effective bid-ask spread from transaction data in futures markets that uses first and second moments of absolute price change distribution. Frank and Garcia (2011) used a modified Bayesian approach proposed by Hasbrouck (2004) to estimate bid-ask spread in commodity futures markets and discussed its performance compared to other estimators. For a comprehensive discussion of performance of various spread estimators, readers are directed to Locke and Venkatesh (1997), Bryant and Haigh (2004) and Goyenko, Holden, and Trzcinka (2009).

We are interested in relative behavior of spreads in the two markets rather than individual performance of spread estimators. Considering the objectives of the study and quality of data available, the present study uses only Roll's measure and average absolute price deviation as estimators of bid-ask spread. Moreover, use of these two measures enables comparison of the results of this study with previous studies of Thompson, Eales, and Seibold (1993) and Shah, Brorsen, and Anderson (2009) which used the same measures to estimate liquidity costs in the KCBT wheat futures market.

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 (*RM*) is:

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

where ΔF_t is the change in price at time *t*. Roll's measure is more precise with more frequent observations since most price movements will then be due to bouncing between bid and ask prices rather than changes in equilibrium prices. Thompson and Waller (1987) suggest the average absolute value of price changes as a measure of average execution costs. Average absolute price changes are calculated as

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

The liquidity costs for the five contracts are estimated in both electronic and open outcry futures markets using Roll's measure and average absolute deviations. Each measure is calculated for each day and then averaged for the life of the contract weighted by daily number of trades.

In electronic markets, if the market order is larger than the first-in-line limit order, the large order is split into smaller orders and matched with two or more limit orders sometimes at different prices. This practice results in underestimating liquidity costs when using the above measures. When an order is split, the electronic market data record the transaction as multiple observations even though it is only one market order. 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. We assume that the trades at the same second can only be recorded if they are split. The probability of two orders arriving in the same second is small with the number of trades in the KCBT wheat futures market. All the trades occurring at the same time (same second) 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 using restricted maximum likelihood:

(3) $$L_{mt} = \beta_0 + \beta_1 AV_{mt} + \beta_2 TV_{mt} + \beta_3 V_{mt} + \omega_t + e_{mt},$$

where L_{mt} is liquidity cost of maturity month m on day t, AV_{mt} is volume (number of contracts) per trade, TV_{mt} is volume, V_t is price volatility measured as the difference between highest price and lowest price (range), ω_t is random effect of trading day. The error terms ω_t and e_{mt} are assumed independently distributed normal with mean 0 and variances σ_ω^2 and σ_e^2. Apart from the fixed effects explained by the first three independent variables in the above model, ω_t explains any random effect of day on liquidity cost. If the estimate of σ_ω^2 is zero, the model is equivalent to ordinary least squares. In previous literature, several measures of volatility such as range, variance, and standard deviation of prices were used to determine the impact of volatility on liquidity cost. Variance and standard deviation of intraday prices, however, would measure almost the same thing as our dependent variable. Hence, daily range of prices is used as a measure of volatility in the present study. The daily price range is included to measure the uncertainty about the underlying asset value. Since the dependent variable must be positive, the residuals are not truly normal as assumed, but statistical tests are asymptotically valid as long as residuals are asymptotically normal. Separate regressions are estimated for open-outcry, the electronic market, and the electronic market with aggregate trades. Pooling of data from the open outcry and electronic markets was rejected using a Chow test (F-statistic: 37.75)[8].

Results

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). Number of trades and volumes by contract month are in Table 1. Average trades per day in the electronic markets are larger 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. Also, as argued by Martens (1998), traders may trade differently in electronic markets and they could choose to enter several small orders rather than a single large order when trading in the electronic market.

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. The results for the July contract are representative of all five contract months and only the results with the July contract data are presented. Daily volumes of July electronic

[8] When the model was estimated by combining datasets for both markets and using a dummy variable that was equal to zero for the electronic market and one for the open outcry market, the dummy variable had a significant coefficient of 0.77 indicating higher liquidity costs in the open outcry market.

contracts are higher than those of open outcry contracts throughout the life of the contracts except for a few occasions.

The liquidity costs for the five contracts in both electronic and open outcry futures markets are presented in Table 2. The electronic market has substantially lower liquidity cost. The average Roll's measure for electronic markets ranges from 0.26 cents per bushel to 0.78 cents per bushel while for open outcry it ranges from 1.18 cents per bushel to 2.17 cents per bushel. In a study of side-by-side trading in financial futures markets, Pirrong (1998) also found lower liquidity costs in the electronic market. Shah, Brorsen and Anderson (2009) estimated the same measures for the July 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[9] 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 contract in February. Our estimates of Roll's measure and average absolute mean deviation for the July 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 the 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.

[9] 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.

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. 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 first column indicates the number of trades occurring at the same second. The other columns indicate the frequency of those occurrences in the electronic and open outcry markets. For example, the third row in the table indicates that three trades at the same second were observed 23,075 times in the electronic market while three trades at the same second was observed only one time in the open outcry market during 2008. The numbers reveal a much higher number of trades occurring at the same second 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. Notice that most of the trading in the electronic market occurs during the open-outcry trading. The possibility of arbitrage opportunities between the two markets should cause the prices to move together closely. Average liquidity costs at different times of the day are calculated by segmenting total trading hours in one-hour intervals (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 informed traders are more likely to trade at the open and close so that is when more price movements occur. The changes in equilibrium prices during these time periods could cause liquidity costs to be overestimated near the open and close. The electronic market shows greater liquidity costs outside open outcry trading hours, which could be explained by the small volume.

Index funds mimicking the Goldman-Sachs Commodity Index traded substantial long positions during 2008. When the funds rolled 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 the open-outcry market at KCBT. Figure 5 presents average daily volume in the month prior to expiration for the five contracts under investigation. The roll period appears to have higher trading volume compared to the rest of the month, especially the 7th business day. However, no significant difference in liquidity costs is found during the roll period. Hence, the Goldman-Sachs roll does not explain the higher liquidity costs in the open outcry market[10].

At KCBT, wheat contracts are traded in increments 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 indicates 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. Chung and Chiang

[10] The average liquidity costs during the Goldman-Sachs roll period is 0.39 cents higher than those during the non-roll period however, this difference is not significant (t statistic: 0.69).

(2006) also found more price clustering in open-outcry index futures compared to E-mini index futures.

To determine the relationship between liquidity cost, volatility, average volume per trade, and total daily volume of the contract, the model in equation 3 was estimated using restricted maximum likelihood estimation. As a proxy for liquidity costs, both Roll's measure and average absolute price changes were used as dependent variables. The measures produced similar results. However, the regression with average absolute price changes had more observations and thus larger t-values compared to using Roll's measure[11] as the dependent variable. Thus, only the results of the regression with average absolute price changes as dependent variable 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. The negative effect of volume is consistent with higher volumes reducing the risk of holding contracts, which results in lower liquidity costs. A significant positive impact of price volatility on liquidity costs is found in both markets. However, the sensitivity of liquidity cost to price volatility is less in electronic than in open-outcry markets. 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 more risk in holding a larger number of contracts, which results in higher liquidity cost.

[11] With Roll's measure, numbers of observations were low because on several trading days covariances of price changes were positive which resulted in non-real values for Roll's measure. The positive covariance occurred 115 (out of 594) observations for electronic trading and 291 (out of 675) observations for open outcry trading.

Summary and Conclusion

This study sought to determine whether liquidity costs were larger in the open outcry futures market or the electronic futures market. Intraday prices of five hard red winter wheat futures contracts traded on Kansas City Board of Trade 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 0.26 cents per bushel to 0.78 cents per bushel while for open outcry markets it ranges from 1.18 cents per bushel to 2.17 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, but the Goldman-Sachs Roll cannot explain the higher liquidity costs in the open-outcry market. More price clustering is found in the open outcry market which helps explain the higher liquidity costs in the open outcry market. Higher trading volume in the electronic market is one explanation of its lower liquidity costs. 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.

The results clearly show that the electronic wheat futures market has lower liquidity costs for all but the largest traders at KCBT. 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. Those submitting small market orders, however, such as most agricultural producers should prefer the electronic market due to its lower liquidity costs.

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 (92.21)	51	1000.31	23.74 (66.36)
May	93	85.08	45.50 (78.37)	93	610.55	14.12 (42.59)
July	134	167.01	23.67 (13.13)	134	1194.60	3.67 (2.37)
Sep	177	84.60	27.89 (36.94)	85	1417.75	5.24 (5.79)
Dec	241	72.04	33.97 (21.67)	241	991.13	3.62 (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
	1.41	1.31	0.41	0.38	0.52
March	(1.76)	(19.97)	(0.58)	(0.56)	(0.67)
	2.17	2.14	0.78	0.70	0.89
May	(1.61)	(9.03)	(0.80)	(0.29)	(0.37)
	1.18	1.23	0.47	0.41	0.51
July	(0.87)	(9.98)	(0.39)	(0.27)	(0.32)
	1.38	1.35	0.27	0.26	0.33
Sep	(1.79)	(12.25)	(0.18)	(0.12)	(0.15)
	1.56	1.44	0.26	0.30	0.40
Dec	(1.73)	(10.50)	(0.33)	(0.29)	(0.36)

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

Note: The first column indicates number of trades occurring at the same second in the dataset. The other columns indicate the frequency of those occurrences in electronic and open outcry market. For example, the third row in the table indicates that occurrence of three trades at the same second was observed 23,075 times in electronic market while it was observed only one time in open outcry market during 2008.

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

Market	N	Intercept	Range	Volume per Trade	Total Volume	R-squared
Open-outcry	675	0.868 (<0.001)	0.050 (<0.001)	0.040 (<0.001)	-0.0006 (<0.001)	0.309
Electronic	594	1.031 (<0.0001)	0.009 (<0.001)	0.025 (<0.001)	-0.0002 (<0.001)	0.325
Electronic (aggregate)	594	1.110 (<0.001)	0.012 (<0.001)	0.020 (<0.001)	-0.0002 (<0.001)	0.334

Note: values in parentheses are p values. OLS estimation was used to produce R-squared values. All parameters remain significant with low p-values if White's heteroskedasticity-consistent covariance matrix is used to compute standard errors.

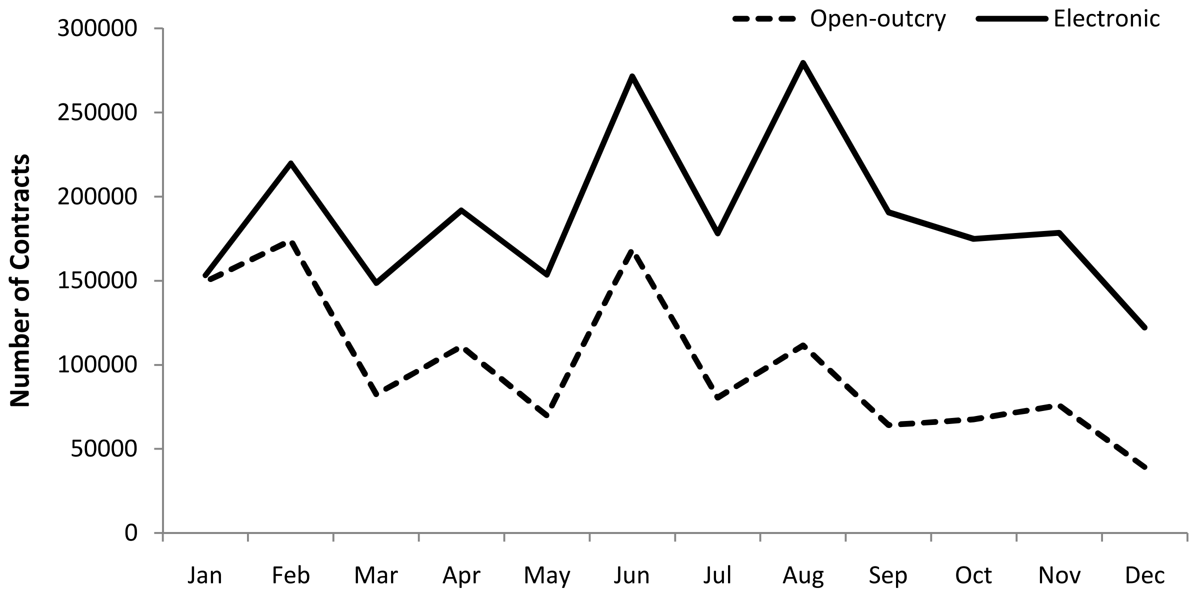

Figure 1. Monthly volume of KCBT wheat futures contract in 2008

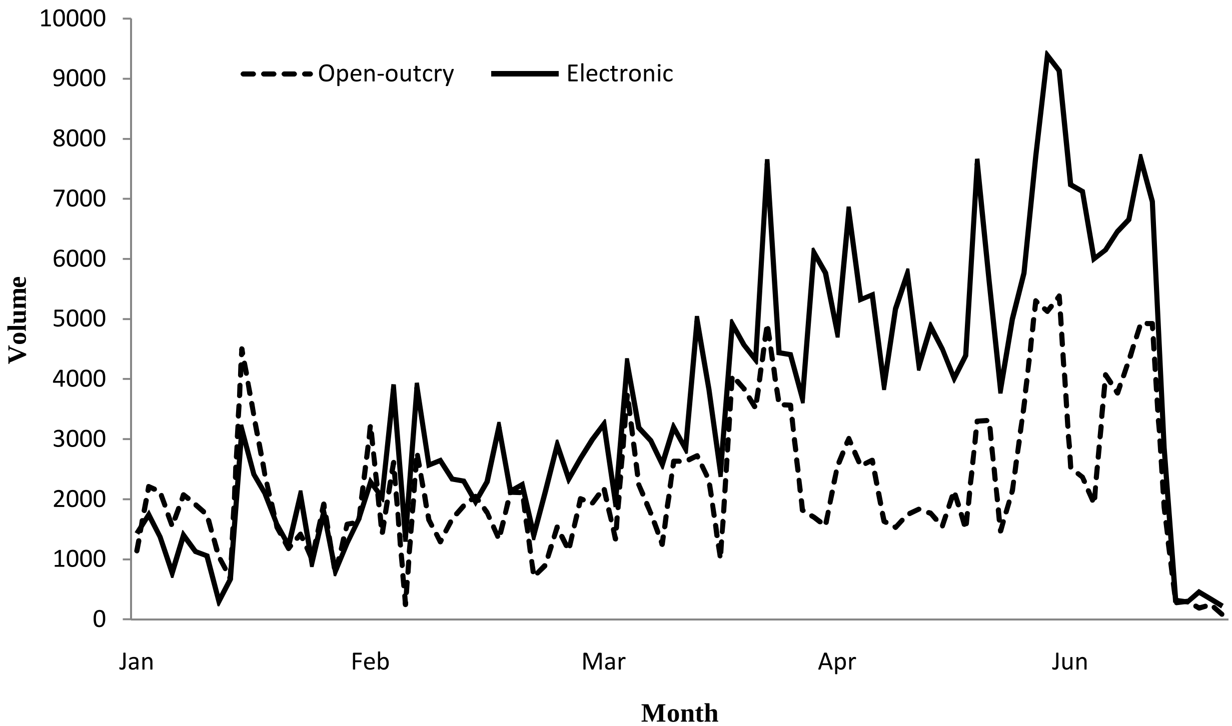

Figure 2. Daily volume of electronic and open-outcry July 2008 wheat futures contracts at KCBT

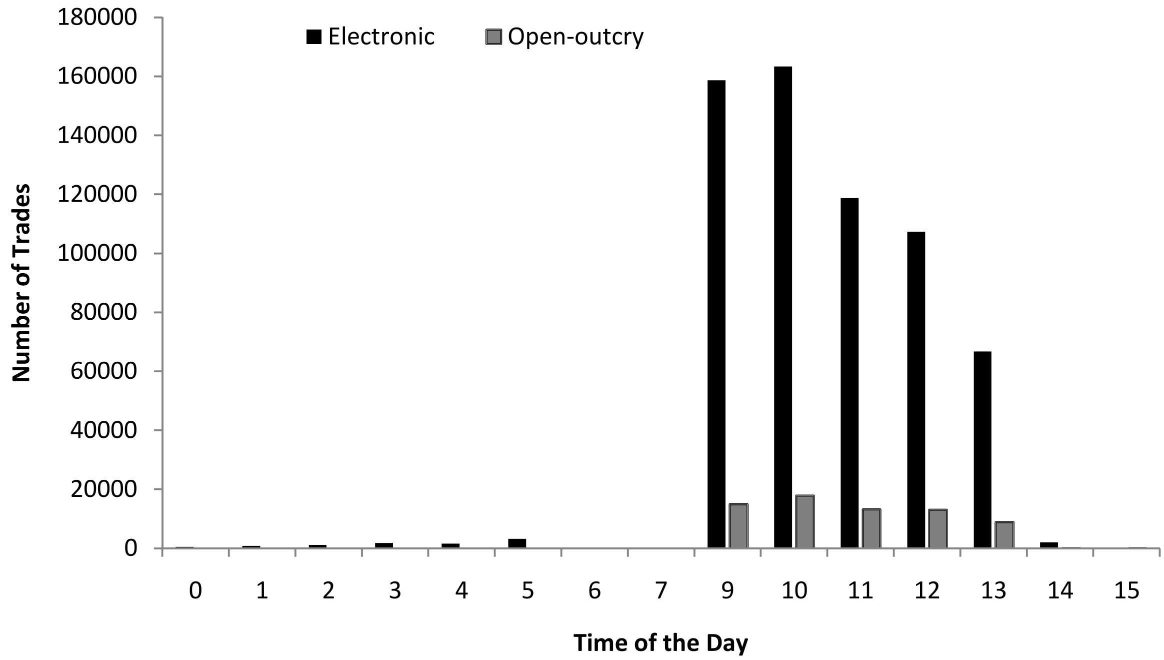

Figure 3. Number of trades at different time of the day at KCBT in 2008
Note: For the open outcry market, the first bar represents 30 minutes of trading and the last bar represents 15 minutes, while the other bars represent one hour of trading.

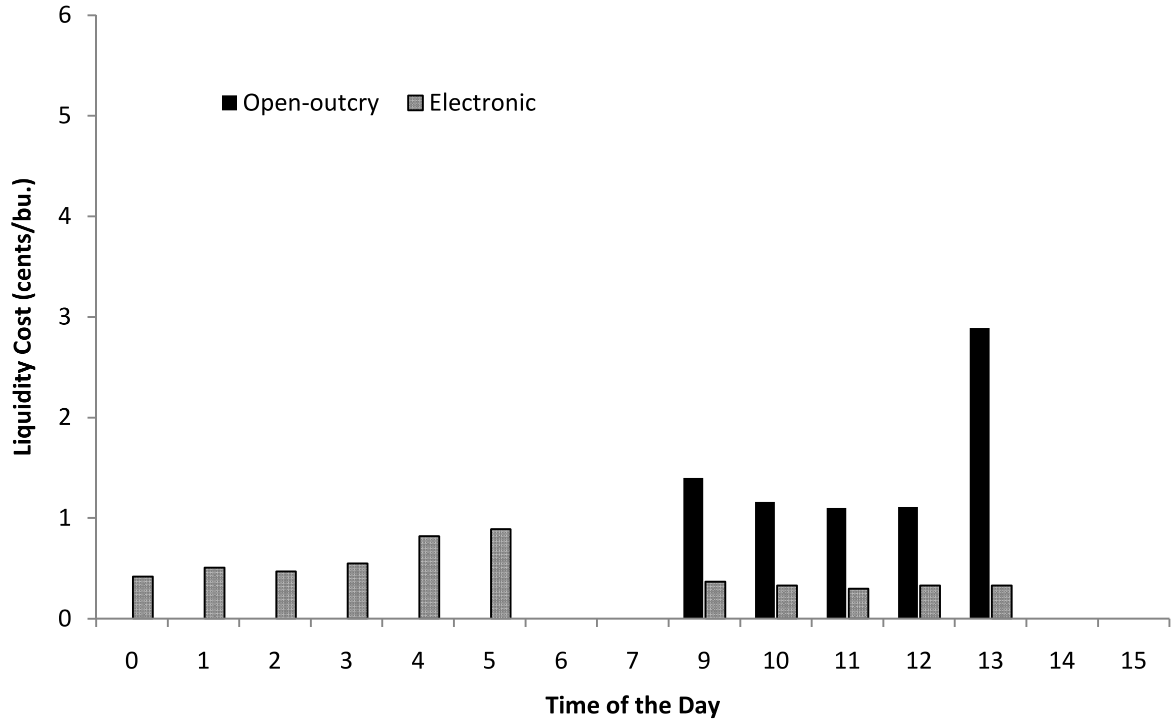

Figure 4. Liquidity cost at different time of the day at KCBT in 2008

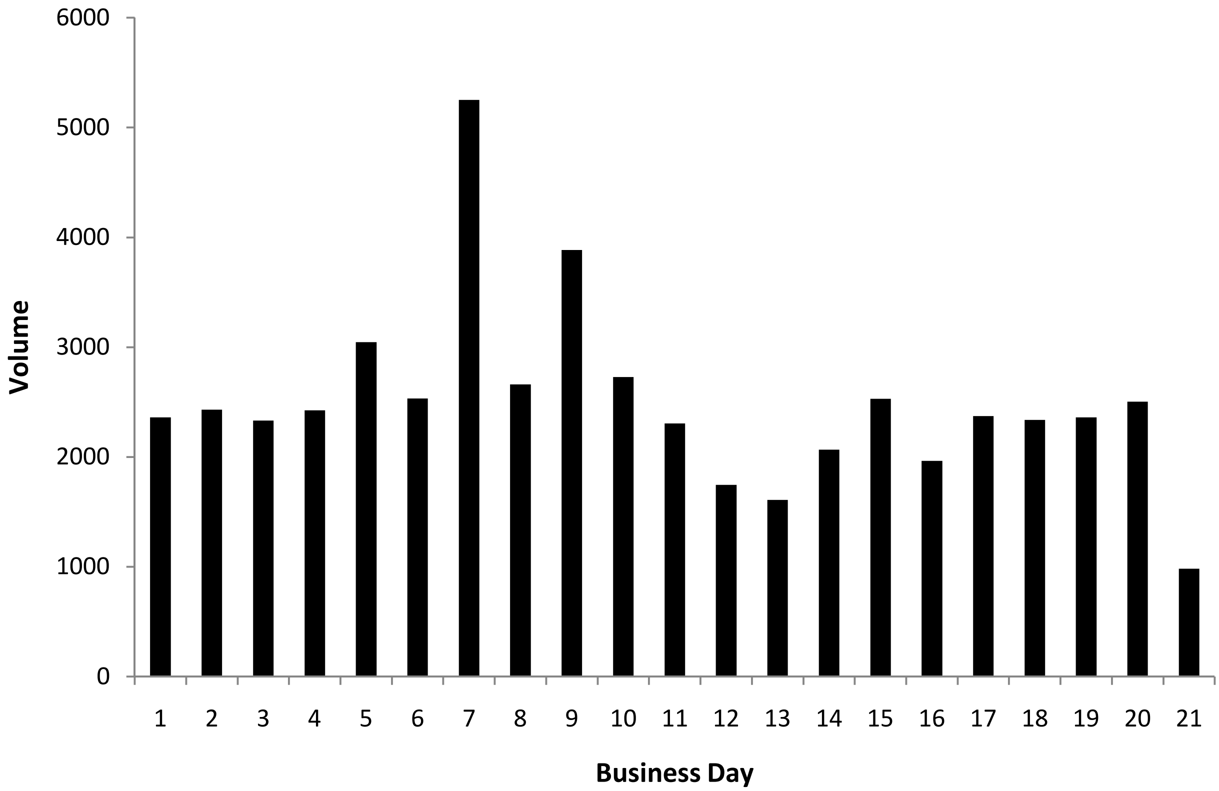

Figure 5. Average daily volume in penultimate (next to last) contract months of KCBT HRW wheat open-outcry contracts in 2008

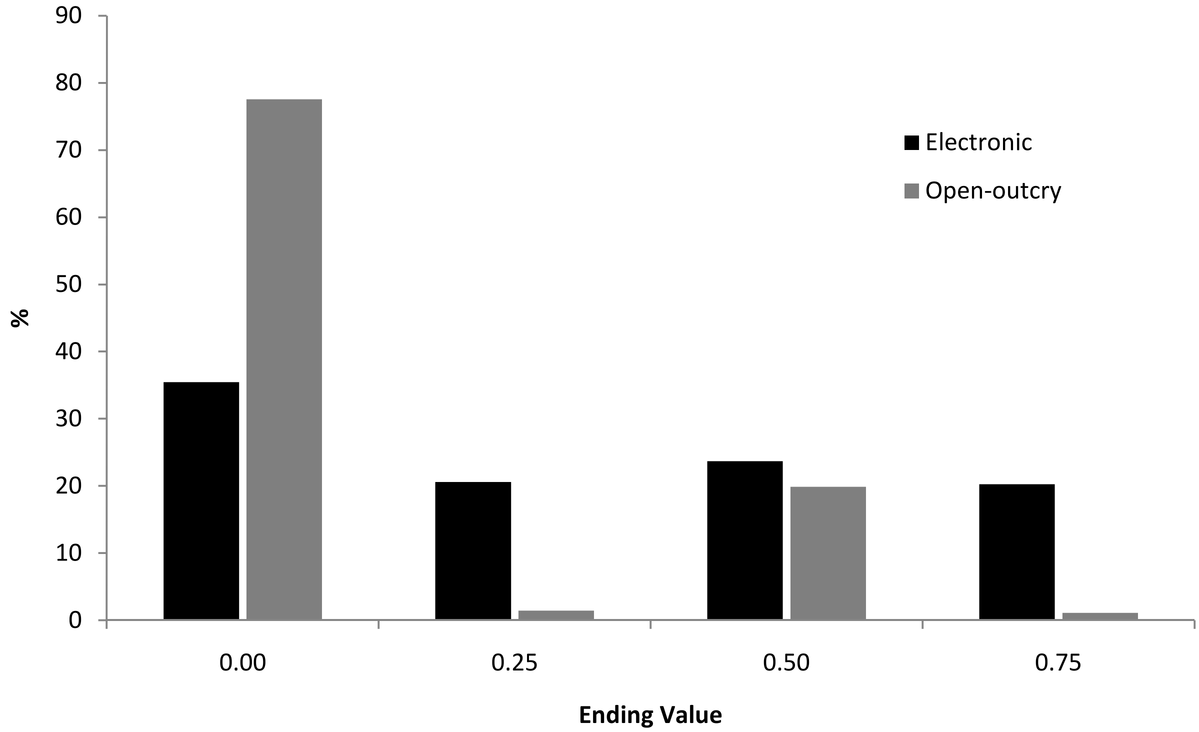

Figure 6. Ending values of trade price in electronic and open outcry markets at KCBT in 2008

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CHAPTER II

LIQUIDITY COSTS IN FUTURES OPTIONS MARKETS

Abstract

Liquidity cost is one of several factors that hedgers should consider when choosing between hedging with a futures contract and hedging with an option contract. While considerable research has estimated liquidity costs of futures trading, there is little comparable research about options markets. This study, for the first time, attempts to determine and compare liquidity costs in options and futures markets. The study also presents a new measure to estimate liquidity costs in options markets based on the Black model. The study uses intraday prices for wheat futures and options contracts traded on Kansas City Board of Trade during 2008-10. Liquidity costs in options markets were estimated using observed bid-ask quotes and the new measure. The average liquidity cost in options market was estimated to be 4.30 cents per bushel using observed bid-ask spreads and it was 4.33 cents per bushel when the new measure was used. Average liquidity costs in the futures market was estimated using eight different measures developed in the literature. The estimates ranged from 1.16 to 1.81 cents per bushel for futures contracts. A positive relation was found between liquidity costs and days to expiration of the option. Moneyness of the options had negligible effect on liquidity cost of the option. The study concludes that liquidity costs in options contracts are considerably higher than liquidity costs in futures contracts.

Introduction

The traditional role of commodity futures and options markets is risk management and price discovery. Producers, processors, and merchants who handle commodities and commodity products use these standardized markets to hedge price risk in underlying cash markets. Futures accounts are marked to market daily and in a volatile market margin calls could quickly deplete a firm's working capital, making it difficult for firms to hold positions in futures market (USDA 2009). Agricultural producers typically dislike the margin calls associated with futures contracts and so they have sometimes been encouraged to consider options as an alternative. Agricultural producers can hedge their cash market risk by buying options. Though hedging with options requires paying premiums upfront, option buyers are not required to maintain a margin account. However, options markets are generally less liquid than futures markets. So, one important consideration in choosing between hedging with futures and options contracts is the relative transaction costs.

Transaction cost is one of several aspects that hedgers should consider when choosing between hedging with a futures contract and hedging with an option contract. On any standardized exchange two elements comprise almost all of the transaction cost – brokerage fees and bid-ask spreads. The difference in price paid by an urgent buyer and price received by an urgent seller is the liquidity cost. Under competitive conditions the bid-ask spread measures the cost of making transactions without delay. A person who desires to immediately sell or buy a contract will, on average, suffer a markdown equal to half of the bid-ask spread. It is necessary to know the size of liquidity costs in both futures and options markets to determine which one to use. Thus, there is a need to answer the question of how much are liquidity costs in futures and options markets?

The answer to this question is important because knowledge of liquidity costs helps hedgers and speculators choose between futures and options markets. All speculators and hedgers, who transact through floor brokers, should know the size of liquidity costs to compare and evaluate available exchanges. Futures exchanges need to know liquidity costs to evaluate new alternatives such as electronic trading. Moreover, knowing liquidity costs can help researchers to account for them while simulating hedging strategies or speculative trading.

While there is considerable research that estimates liquidity costs in agricultural futures markets (Brorsen 1989; Thompson and Waller 1987; Thompson, Eales and Seibold 1993; Bryant and Haigh 2004; Frank and Garcia 2011; Shah and Brorsen 2011), there is little comparable research about options markets. Baesel, Shows, and Thorp (1983) estimated overall cost of liquidity services in listed stock options using trade data of a diversified portfolio of an options hedge fund. Their study provides a limited idea about liquidity costs as it considers a single portfolio hedge fund, which might have been traded differently than a typical options trader. Considering liquidity costs is an important criterion in choosing between futures and options markets and so far no research has attempted to estimate and compare liquidity costs in both markets simultaneously. The purpose of this article is to estimate and compare liquidity costs in options and futures markets. The article uses different measures of effective bid-ask spread in Kansas City Board of Trade (KCBT) wheat futures and options markets and also proposes a new alternative measure of liquidity costs in options markets. Further, the study estimates the effects of factors expected to affect size of liquidity costs in options markets.

Measures of Liquidity Costs

In open-outcry commodity futures markets, liquidity is primarily provided by floor traders who readily bid and offer a price for a specific contract. Since the floor traders must make a profit for providing their services the price at which a trade occurs is different from the equilibrium price and in a direction adverse to the hedgers and speculators. Since all trades occur at the bid or ask price of floor traders, the bid-ask spread gives the size of liquidity costs in the market. There are two types of bid ask spreads: quoted spreads and effective spreads. The quoted spread is the difference between floor traders bid and ask price. The effective spread is the difference between the price at which the floor trader buys (sells) a contract and the price at which he subsequently sells (buys) it (Smith and Whaley 1994). The present study mainly focuses on effective spreads since they represent the economic cost to producers of using the standardized exchange.

Various estimators of effective bid ask spreads have been developed. Often bid-ask quotes are not recorded and so bid-ask spreads must be estimated based on the available transaction data. Spread estimators developed in the literature have mostly used either the covariance of successive price changes or averages of absolute price changes. The former type of estimator, originally applied in equity research, was first developed by Roll (1984). According to Roll (1984) if markets are informationally efficient and successive transactions are sale or purchase with equal probability, the covariance between price changes is negative and directly related to the bid-ask spread. Chu, Ding, and Pyun (1996) proposed an extension of the Roll's measure which relaxes the assumption of equal probability of trade direction. Holden (2007) developed a model that uses both serial correlation like Roll's measure and price clustering to estimate the effective spread. The latter type of estimators employ absolute price changes, including average absolute price deviation proposed by Thompson and Waller (1987) and a different average absolute price deviation measure used by the Commodity Futures Trading Commission (CFTC). These two measures assume that the variability in price changes is exclusively due to liquidity costs. Thompson and Waller measure (TWM), as argued by Smith and Whaley (1994), contains real price changes along with bid ask spread. This measure was applied in Thompson and Waller (1988) to study the determinants of liquidity costs in coffee and cocoa futures markets, and was used to compare liquidity costs between two similar markets in Thompson et al. (1988). Ma et al. (1992) used the TWM to study intra-day patterns in spreads and the determinants of spreads for various Chicago Board of Trade (CBOT) contracts. In an attempt to filter out the real price changes in the TWM measure, CFTC uses only nonzero price changes that are in the opposite direction of the previous change. Smith and Whaley (1994) took a different approach to account for real price changes and proposed a method of moments estimator for effective spreads using first and second moments of absolute price change distribution. Recently, Frank and Garcia (2011) used a modified Bayesian approach proposed by Hasbrouck (2004) to estimate bid-ask spread in commodity futures markets and discussed its performance compared to other estimators.

These measures require high frequency data. Roll's measure can yield positive correlation when transactions are infrequent. Similarly, price changes used by the TWM and CFTC measures will be composed largely of changes in equilibrium prices when markets are thin. Generally, agricultural futures markets have enough observations for all the above discussed measures to perform effectively. However, the options markets of agricultural commodities are generally scarcely traded. Due to the small number of transactions per day in the options markets, the spread estimators do not estimate liquidity costs as efficiently as they do in the futures markets. Hence, a new measure of bid-ask spread is required which can effectively estimate the liquidity costs in thin markets. In the present study, we propose a new measure to estimate effective spreads in options markets. The new measure uses the futures option pricing formula proposed by Black (1975).

In open outcry markets, similar to any other exchange traded asset, the price of an option contract bounces between the bid and ask prices of the floor traders. Also, since all transactions occur at either bid or ask prices, the realized price is either higher or lower than the true price depending upon whether a transaction occurs at the ask price or bid price. Hence, on the average, absolute differences between the observed price and the true price of an option should be half of the bid ask spread. Black (1975) proposed a valuation model for options on futures that under the assumptions of no riskless arbitrage and a lognormal distribution, estimates the true price of an option. If a market is efficient and devoid of arbitrage opportunities any deviation of the observed price from the estimated true price captures half of bid-ask spread. We use the Black model to estimate the true equilibrium price of the option. Let π_t be the observed price of an option at time t and $\hat{\pi}_t$ be the estimated true price of the option using the Black formula then, on the average liquidity costs incurred by a trader for a round trip trade can be estimated as

$$2 \cdot E[|\pi - \hat{\pi}|].$$

Unlike previously developed measures of bid-ask spreads, this measure does not require knowing the true price: it rather estimates the deviation around the true price. Hence, as long as the estimation error of the true price is less than half of bid-ask spread this measure produces consistent estimates. Black (1975) defined the price of an option on futures as a function of five variables: strike price of the option, risk free interest rate, time to expiration of the option, underlying futures price, and volatility of the underlying futures price. The strike price, risk free interest rate, time to expiration and underlying futures price are directly observed. However, volatility of the underlying futures price is not observed directly. We use implied volatility from the Black model to estimate volatility of the underlying futures price. The estimation error of the implied volatility is one of the two sources of error in the proposed new measure. The other source of error comes from the staleness of the underlying futures price used in the Black model. Theoretically, the black model requires the underlying futures price at the same time the option price is realized but in practice the underlying futures price is generally not available at the same time of the option transaction. So we are forced to use the most recently transacted futures price. Hence, if the true equilibrium price of the underlying futures contract changes in the interim, the staleness of the futures price affects the estimate of the true option price and consequently affects the proposed measure of liquidity cost. A technique to remove the effect of staleness in futures price and the estimation of the volatility of futures price is developed in this paper.

Previous research examining liquidity costs in futures markets finds that liquidity costs decrease as trading volume increases, and increase as price variability increases (Thompson and Waller, 1988; Brorsen, 1989; Thompson, Eales, and Seibold, 1993; Bryant and Haigh, 2004; Frank and Garcia 2011). The volume effect implies the supply of liquidity services is downward sloping (Brorsen, 1989). Scalpers benefit from economies of size, and these benefits are passed on in the form of lower liquidity costs. Trading volumes for the same commodity in options markets are considerably lower than those in futures markets

(Figure 1). The options markets are also expected to be less liquid than the futures markets because the option market is segmented by puts, calls and varying strike prices in addition to date of maturity. Moreover, options contracts require higher skill for trading as it is more complex in terms of understanding and execution which more or less restrict their use to specialized traders and firms. Liquidity costs in the options market are therefore expected to be higher than those in the underlying futures market.

Data

Kansas City Board of Trade employees overlook the trading pits from an area called "the pulpit." As trading occurs, a "pit reporter" listens intently for prices shouted out by traders in the trading pit and relays them via a headset to a computer terminal operator known as the "data entry operator." The operator enters the prices into a computer. These intraday prices for hard red winter wheat open outcry futures and option contracts are used in the present study. The dataset contains each trade price recorded for open outcry wheat futures and options contracts from January 2008 to December 2010. The underlying asset for options contracts are wheat futures contracts. At KCBT, wheat futures contracts are traded with five expiration months: March, May, July, September, and December and options contracts expire every other month. However, only five options contracts, those with the same expiration months as futures contracts, are considered in the present study due to lack of volume in the other contracts. The KCBT does not record bid and ask price for open-outcry wheat futures markets but, for its open outcry wheat options market, it provides irregular time-stamped bid and/or ask prices. Only the quotes observed at the same time are used to estimate observed bid-ask spreads in wheat options markets. There is a possibility of selectivity bias in using the bid-ask quotes since bid-ask quotes are only reported when no trade occurs. If a trade is less likely to happen given a wide bid-ask spread, bid-ask spreads would overestimate liquidity costs. The measures are computed for each day and then a weighted average is computed so that no changes across days are included. The descriptive statistics of the futures and option contracts are presented in Table 1. For the risk free rate of interest the interest rate on three month U.S. Treasury bills is used (USDT 2011).

Procedures

Liquidity cost in options markets is estimated using bid-ask quotes and a new measure which uses trade price of options. Bid-ask spread is the difference between ask price and bid price observed at the same time. Option liquidity cost can be measured as

$$liquidity\ cost_t = ask_t - bid_t.$$

The second measure of option liquidity cost uses transaction data instead of the bid-ask quotes and is

$$liquidity\ cost_t = 2 \cdot E[|\pi_t - \hat{\pi}_t|]$$

where, π_t is the observed option premium and $\hat{\pi}_t$ is expected premium obtained by Black's formula. For call options, the expected option premium can be obtained as

$$\hat{\pi} = e^{(-r \cdot t)}[F \cdot \Phi(x_1) - S \cdot \Phi(x_2)]$$

and for the put options it can be obtained as

$$\hat{\pi} = e^{(-r \cdot t)}[F \cdot \Phi(-x_1) - S \cdot \Phi(-x_2)]$$

where,

$$x_1 = [\ln(F/S) + (\hat{v}^2 \cdot t)/2]/(\hat{v} \cdot \sqrt{t})$$

$$x_2 = [\ln(F/S) - (\hat{v}^2 \cdot t)/2]/(\hat{v} \cdot \sqrt{t})$$

and

$\Phi(\cdot) =$ standard normal cumulative density function

$F =$ price of underlying futures contract

$S =$ option strike price

$\hat{v} =$ predicted implied volatility (%)

$t =$ time to expiration (days/365)

$r =$ risk-free interest rate (%).

All the parameters in the above model other than the volatility measure — the time to maturity, the strike price, the risk-free rate, and the current underlying price — are observable. To estimate the volatility of the underlying futures, we use implied volatility calculated by inverting the above model and solving for $\hat{v}$ using Newton-Raphson method. Studies on implied volatility have shown that implied volatility can vary with moneyness of the option, time to maturity of the option and also the type of the option. At the money stock options generally predict lower implied volatility compared to deep out of the money options. Similarly, different maturities of the options also affect the predicted implied volatilities. We apply the following regression to filter out the effects of the above discussed factors and use the predicted volatilities from this model to estimate options prices. A different regression is estimated for each option contract. To avoid negative predicted volatilities an exponential relationship between the volatility and the factors was assumed:

(1) $$v_t = \beta_0 + \beta_1 M_t + \beta_2 D_t + \sum_{i=1}^{N} \beta_i T_{it} + e_t$$

where, v_t is implied volatility at time t, M_t is moneyness of the option at time t which is difference between strike price and underlying futures price, T_{it} are fixed effects of trading day, D_t is a dummy variable for type of option which takes value of 1 if it is a call option or 0 if it is a put option. An example estimate of the regression is presented in Table 2. Since the estimate of the volatility of the futures price depends on the above regression, the estimation error of the regression is a source of error in the measure of liquidity cost. As Table 1 shows, the standard error of this regression is small.

The underlying futures prices used in the Black model were the most recent underlying futures price. Hence, the value of option premium is indirectly affected by staleness of the nearest underlying futures price and thus it affects the measure of liquidity cost. The effect of this staleness is removed by estimating the following regression:

(2) $$|\pi_t - \hat{\pi}_t| = \alpha_0 + \alpha_1 S_t + \epsilon_t$$

where S_t is length of time between the observed option transaction and the most recent underlying futures price. If staleness of the futures price is zero, e^{α_0} represents the absolute difference between observed and predicted option premium. Thus, the liquidity costs can be calculated as two times the expected value of the above equation given S_t is zero:

$$\text{liquidity cost} = 2 \cdot \alpha_0.$$

Due to estimation error in the volatility, the estimates of liquidity costs from a new measure are biased upward, but it does produce consistent estimates (sample size must increase for each day since adding days is not enough to achieve consistency).

Liquidity costs in options markets estimated using the new measure are then compared with the liquidity costs in the futures market. Several different measures of spreads have been developed and applied to the futures markets. The properties and limitations of the measures are comprehensively studied in the literature. It has been argued that the different measures produce different estimates of liquidity costs for the same market due to different underlying assumptions (Bryant and Haigh 2004; Frank and Garcia 2011). To make a comprehensive comparison of liquidity costs in options and futures markets we use eight different measures developed in the literature to estimate liquidity costs in the futures market.

According to Roll (1983), if markets are informationally efficient, the covariance between price changes is negative and directly related to the bid-ask spread. Roll's measure (RM) is

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

where, ΔF_t is change in price at time *t*. One assumption of Roll's measure which is generally inappropriate for futures markets is that there is an equal probability of each transaction being buy or sale order (Bryant and Haigh 2004). Choi, Salandro, and Shastri (1988) proposed an extension of Roll's measure which relaxes the assumption of equal probability of a transaction being a buy or sell order. They defined their measure as

$$CSS = \frac{\sqrt{-\mathrm{cov}(\Delta F_t, \Delta F_{t-1})}}{1-\delta}$$

where δ is the conditional probability that the next transaction type (bid or ask) is the same as the current transaction type. If $\delta = 0.5$ the CSS measure reduces to Roll's measure. If there is positive correlation in transaction type with $\delta > 0.5$ the estimates produced by Roll's measure would be a downward biased estimates of the true bid ask spread (Choi, Salandro, and Shastri 1988). Chu, Ding and Pyun (1996) further extended Roll's measure by using two-period (transaction type at $t - 1$ and $t + 1$) conditional probability of the transaction type being bid or ask. Chu, Ding and Pyun measure (CDP) is defined as

$$CDP = \sqrt{\frac{-\text{cov}(\Delta F_t, \Delta F_{t-1})}{(1-\delta)(1-\alpha)}}$$

where α is the conditional probability that the previous transaction type is the same as the current transaction type. When $\alpha = \delta$ the CDP measure reduces to CSS measure and when $\alpha = \delta = 0.5$ it reduces to the Roll's measure. To estimate the probabilities α and δ the transaction types are classified as bid or ask using the tick test suggested by Lee and Ready (1991).

The measures discussed thus far use serial correlation of the price changes to estimate effective spreads in the market. Another measure of liquidity costs that uses absolute price changes is the Thompson and Waller (1998) measure, who suggested the average absolute value of price changes as a direct measure of the average execution cost. The Thompson and Waller measure is

$$TWM = \frac{1}{T}\sum_{t=1}^{T}|\Delta F_t|$$

where, $\Delta \mathrm{F_t}$ are series of non-zero price changes. The Thompson and Waller measure assumes that the bid ask spread is the main determining factor of the price changes and ignores the true price changes. A similar measure used by Commodity Futures Trading Commission

(CFTC) attempts to eliminate the effect of true price changes by removing any price change followed by the same sign. Hence, it considers only non-zero opposite absolute price changes.

Hasbrouck(2004) developed a Bayesian estimator of bid ask spreads based on Roll's model:

(3) $$p_t = m_t + cq_t$$

where m_t is the efficient price, p_t is observed transaction price, c is half bid ask spread and $q_t = \{+1\ for\ a\ buy, -1\ for\ a\ sell\}$ is the trade direction indicator so that the ask price is $a_t = m_t + c$, the bid price is $b_t = m_t - c$. The bid ask spread, the difference between a_t and b_t is $2c$. It is assumed that m_t follows a random walk *i.e.* $m_t = m_{t-1} + u_t$ where u_t is identically and independently normally distributed with mean 0 and variance σ_u^2. Taking the first differences in equation (3) we get the following regression model:

(4) $$\Delta p_t = c\Delta q_t + u_t \;\; u_t \sim N(0, \sigma_u^2)$$

where c, the half bid ask spread, is the estimated coefficient in the model. The regression in equation (4) is estimated using Bayesian methods. There are two parameters c and σ_u^2 and T latent data values,$q = \{q_1, q_2, \dots q_T\}$ in equation (4). The full posterior over parameters and latent data is summarized by the distribution function $F(c, \sigma_u^2, q|p)$. Since the closed form representation of the distribution function does not exist, it is characterized by simulation, using Markov Chain Monte Carlo (MCMC) simulation and the Gibbs sampling method. As described in Hasbrouck (2004), the Gibbs sampler is an iterative procedure. Initially, the parameters and latent data are set to any values (subject only to feasibility). Denote these initial values $\{c^{[0]}, \sigma_u^{2[0]}, q^{[0]}\}$. The steps in the first sweep $j = 1$ are:

1. Draw $c^{[1]}$ from $f(c|\sigma_u^{2[0]}, q^{[0]}, p)$

2. Draw $\sigma_u^{2[1]}$ from $f(\sigma_u^2|c^{[1]}, q^{[0]}, p)$

3. Draw $q^{[1]}$ from $f(q|c^{[1]}, \sigma_u^{[1]}, p)$

The sample values of c, q and σ_u^2 are drawn from their full conditional distribution based on observed transaction prices. That is, all parameters and latent data except for the component being drawn are taken as given. The next iteration starts with a draw of $c^{[2]}$ conditional on $\sigma_u^{2[1]}, q^{[1]}$ and p. Repeating this *n* times, a sequence of draws $\{c^{[j]}, \sigma_u^{2[j]}, q^{[j]}\}$ for $j = 1 \ldots n$ are generated. The Gibbs principle ensures that after a sufficient number of samples, the sample distribution converges to $F(c, \sigma_u^2, q|p)$. In the Hasbrouck measure (HAS), a truncated normal prior is used for *c*, producing a conditional distribution of *c* that is truncated and restricted to positive values,

$$c|p \sim N^+\left(\mu_c^{post}, \Omega_c^{post}\right)$$

where, $\mu_c^{post} = Dd$, $\Omega_c^{post} = \sigma_u^2(\Delta q'\Delta q)^{-1}$, $D^{-1} = \Delta q'(\sigma_u^2)^{-1}\Delta q + \left(\Omega_c^{prior}\right)^{-1}$ and $d = \Delta q'(\sigma_u^2)^{-1}\Delta p + \left(\Omega_c^{prior}\right)^{-1} + \mu_c^{prior}$. The positive normal distribution of c imposes non negativity restriction on bid ask spreads. In HAS measure the truncation of the distribution of c influences the mean and variance of the bid ask spread estimates. To circumvent this, Frank and Garcia (2011) modify the HAS measure by using a normal distribution as prior for c and imposing a non-negativity restriction on c by using absolute values of price changes and trade direction. The conditional distribution of c for Frank and Garcia measure (FGM) is

$$c|p \sim N\left(\mu_c^{post}, \Omega_c^{post}\right)$$

where, $\mu_c^{post} = Dd$, $\Omega_c^{post} = \sigma_u^2(|\Delta q|'|\Delta q|)^{-1}$, $D^{-1} = |\Delta q|'(\sigma_u^2)^{-1}|\Delta q| + \left(\Omega_c^{prior}\right)^{-1}$ and

$d = |\Delta q|'(\sigma_u^2)^{-1}|\Delta p| + \left(\Omega_c^{prior}\right)^{-1} + \mu_c^{prior}$. The conditional distributions of σ_u^2 and q for both HAS and FGM measures are

$$\sigma_u^2|p \sim IG(\alpha^{post}, \beta^{post})$$

where, $\alpha^{post} = \alpha^{prior} + t/2$, $\beta^{post} = \beta^{prior} + \sum u_t^2 /2$, with $\alpha^{prior} = \beta^{prior} = 10^{-12}$ and

$$q_t^{post}|p \sim Bernoulli(p_{buy})$$

where, $p_{buy} = e^{(4cp_t)/(\sigma_u^2)}\left(e^{2c(m_{t-1}+m_{t+1})/\sigma_u^2} + e^{(4cp_t)/(\sigma_u^2)}\right)$ is probability that $q = +1$. The priors for c, σ_u^2 and q are $\mu_c^{prior} = 0$, $\Omega_c^{prior} = 10^6$ and $q_t^{prior} \sim Bernoulli(1/2)$.We run 2000 swipes in Gibbs sampler to estimating the full posterior $F(c, \sigma_u^2, q|p)$ out of which first 400 (20%) are burned. We then calculate a sample mean of c and multiply it by two to get the estimate of bid ask spread. To test hypotheses about the factors influencing option liquidity costs, the following regression equation was estimated by maximum likelihood:

(5) $$y_{mt} = \beta_0 + \beta_1 M_{mt} + \beta_2 T_{mt} + \beta_3 D_{mt} + v_m + e_{mt}$$

where, y_{mt} is the new measure of liquidity cost for contract m at time t, M_{mt} is moneyness of the option, T_{mt} is time to maturity of contracts in days, D_{mt} is a dummy variable which takes the value 1 if it is a call option and 0 if it is a put option. The error terms v_m and e_{mt} are assumed independently distributed normal with mean zero and variances σ_v^2 and σ_e^2, respectively.

Results

The aggregate estimates of liquidity costs in KCBT wheat futures and options markets during the sample period of 2007-10 are presented in Table 3. The effective spread estimated using the new measure in the wheat options market is 4.33 cents per bushel. The average observed bid-ask spread is 4.30 cents per bushel. The bid-ask quotes are only reported when no trade occurs. The effective spreads in futures market estimated using eight different measures ranged from 1.16 to 1.81 cents per bushels. The average Roll's measure and Thompson and Waller measure for the wheat futures market are 1.37 cents per bushel and 1.58 cents per bushel, respectively. The result indicates that the option market has much higher liquidity costs. Thompson, Eales, and Seibold (1993) also estimated the same measures for selected 1985 KCBT wheat futures contracts. Their estimates of average absolute deviations 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 contract in February. Our measures are higher because the wheat markets were volatile and spreads were higher during the sample period. Regardless of which measures are used, the liquidity costs in the option markets are at least three times higher than liquidity costs in the futures market.

Total volume traded in wheat futures contracts was considerably higher than volume in options contracts. Figure 1 shows monthly volumes in KCBT wheat open outcry futures and options contracts in 2008-10. Table 1 presents average daily volume and average volume per trade in the two markets. The daily volumes for the futures market are immensely higher than the daily volumes in the option market for all the contracts traded during 2008-10. Previous studies of liquidity costs in commodity markets have found a negative impact of volume on liquidity costs (Thompson and Waller 1987; Thompson, Eales, and Seibold 1993; Bryant and Haigh 2004 ; Shah and Brorsen 2011). Lower volumes in option markets can explain the higher liquidity costs in this market because lower volumes imply more risk of holding contracts resulting in higher liquidity costs. Another explanation of higher liquidity costs in option markets can be higher volume per trade. For all the contracts in the sample period the average volume per trade in the option market was 28.76 contracts compared to

14.82 contracts for the futures market. As argued by Shah and Brorsen (2011), higher volume per trade indicates higher risk in holding the large contracts.

To determine the relationship between liquidity costs in option contracts and moneyness of the option, time to maturity of the option, and the type of option, we estimated the model in equation (5) using restricted maximum likelihood. The new measure was used as the dependent variable in the model. The results are presented in Table 4. A significant positive impact of days to maturity of the option was found on the liquidity cost, which indicates higher risk of holding an option contract farther from maturity. However, there is no strong theoretical justification for the impact of maturity on liquidity costs. Previous studies of Brorsen (1989) and Anderson (1985) found no significant effect of maturity on liquidity costs in grain futures markets. A negligible negative impact of moneyness of the option was found on liquidity costs. Moneyness of the option is the difference between its strike price and the price of the underlying futures. Since, it is only a function of underlying futures price, moneyness is expected to have no impact on the liquidity cost of the option contract. The type of option had a significant impact on liquidity costs. The result indicates that the call options had greater liquidity costs than put options.

Summary and Conclusion

This study presents a new measure for estimating the effective bid-ask spread using time and sales data from option markets. Available measures of spreads in the literature are not effective for the option markets because these markets are very thin. A new measure is proposed which uses the Black option pricing model and implied volatilities along with option transaction prices. The study also estimates and compares liquidity costs in futures and options market simultaneously for the first time. Intraday prices of wheat futures and options contracts traded on the Kansas City Board of Trade during 2008-10 are used. The liquidity cost in the wheat option market is 4.33 cents per bushel. The observed bid ask spread in the option market is 4.30 cents per bushel. The estimated liquidity costs in wheat futures market using eight different measures ranged from 1.16 cents per bushel to 1.81 cents per bushel. A positive relation was found between liquidity costs and days to expiration of the option. Moneyness of the options had negligible effect on liquidity cost of the option. Although, option contracts are often suggested as an alternative to futures contracts to avoid margin calls, it costs more to trade an option. The liquidity costs calculated here assume a round turn in both futures and option markets. Note, however, that a producer using at-the-money options and holding them to expiration would have one-half of the options liquidity cost and then would have half of the futures liquidity cost the half of the time that the option is exercised. Producers should consider that options have higher liquidity cost than futures. Producers should also consider using limit orders rather than market orders when trading options as a possible way to reduce their higher liquidity costs.

Table 1. Descriptive Statistics of Hard Red Winter Wheat Futures and Options Contracts Traded at KCBT in 2008-10

	Options				Futures			
Contract	Trading Days	Trades per Day	Volume per Day	Volume per Trade	Trading Days	Trades per Day	Volume per Day	Volume per Trade
2008								
March	36	16.61	470.92	28.35	37	179.22	3208.78	17.90
May	79	7.47	290.74	38.92	82	95.05	2001.04	21.05
July	119	35.24	557.17	15.81	133	167.23	2208.54	13.21
September	154	7.43	131.65	17.72	162	90.86	1163.20	12.80
December	173	5.03	165.00	32.80	221	76.95	1162.40	15.11
2009								
March	172	4.01	171.63	42.80	145	76.66	1016.15	13.26
May	110	3.14	70.16	22.34	89	69.55	1011.51	14.54
July	284	6.13	117.26	19.13	278	55.53	649.75	11.70
September	147	4.14	97.46	23.54	96	75.85	922.37	12.16
December	179	5.04	140.11	27.80	186	70.57	870.20	12.33
2010								
March	157	3.31	155.74	47.05	137	54.15	881.65	16.28
May	89	1.85	41.51	22.44	73	42.88	739.36	17.24
July	244	3.67	49.45	13.47	139	44.75	651.86	14.57
September	140	4.10	139.77	34.09	70	84.57	946.50	11.19
December	176	5.04	227.43	45.13	135	47.10	891.50	18.93

Table 2. Estimated Parameters of Regression on the Implied Volatility

Variable	Estimate	SE
Intercept	-1.9301	0.0373
Moneyness (cents/bu.)	0.0005	< 0.0001
Calls	0.0793	0.0021
Standard Error of the Regression	0.0114	-

Note: Trading day has a significant fixed effect on volatility (F-statistic = 60.73).

Table 3. Measures of Liquidity Costs (cents/bu.) in Hard Red Winter Wheat Futures and Options Contracts from 2008-10.

	Options			Futures							
	BAS	BASyz	New Measure	RM	CSS	CDP	ABS	TWM	CFTC	HAS	FGM
Liquidity costs	3.59	4.30	4.33	1.37	1.81	1.44	1.24	1.58	1.38	1.16	1.66
Standard error	0.23	0.26	0.14	0.11	0.15	0.12	0.09	0.13	0.13	0.02	0.11

Note: BAS = observed bid ask spread, BASyz = observed bid ask spread including pre-open quotes, RM = Roll's measure, CSS = Choi, Salandro and Shastri measure, CDP = Chu, Ding and Pyun measure, ABS = Absolute price changes, TWM = Thompson and Waller measure, CFTC = Commodity Futures Trading Commission measure, HAS = Hasbrouck measure and FGM = Frank and Garcia measure.

Table 4. Estimated Parameters of Factors Affecting Liquidity Costs (cents/bu.) in Wheat Option Contracts at KCBT with New Measure as Dependent Variable

Variable	Estimate	SE
Intercept	2.7148	2.1649
Moneyness (cents/bu.)	-0.0012	0.0007
Days to expiration	0.0344	0.0018
Calls	1.6861	0.2299

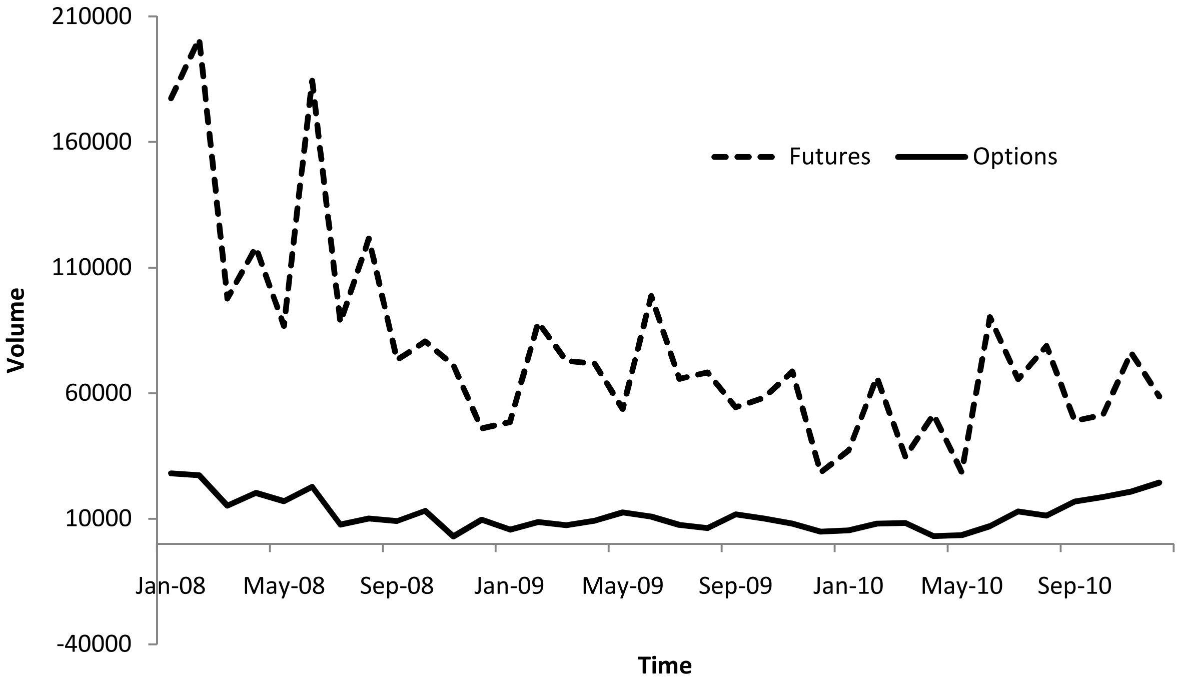

Figure 1. Trading Volume of Open OutcryWheat Futures and Options Contract at KCBT in 2008-10

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APPPENDICES

Appendix Table 1. Measures of Liquidity Costs (cents/bu.) in Hard Red Winter Wheat Futures and Options Contracts in 2008.

Contract	ABS	ABSyz	NM	RM	CSS	CDP	ABS	TWM	CFTC	HAS	FGM
March	3.04 (2.05)	3.29 (2.12)	9.49 (0.42)	1.64 (0.42)	2.09 (0.44)	1.65 (0.36)	1.50 (0.31)	2.12 (0.41)	2.06 (0.41)	1.05 (42.00)	1.83 (39.00)
May	5.83 (3.35)	6.42 (3.96)	14.22 (0.63)	1.52 (0.13)	2.05 (0.14)	1.67 (0.12)	1.72 (0.08)	2.36 (0.11)	2.37 (0.11)	1.25 (85.00)	2.72 (81.00)
July	4.64 (3.36)	5.13 (3.56)	10.54 (0.14)	1.03 (0.10)	1.41 (0.11)	1.14 (0.10)	1.18 (0.07)	1.66 (0.09)	1.62 (0.08)	1.01 (131.00)	1.89 (131.00)
September	4.34 (2.63)	5.70 (3.60)	3.94 (0.10)	2.27 (0.25)	3.00 (0.32)	2.49 (0.28)	1.89 (0.12)	2.48 (0.15)	2.14 (0.20)	1.18 (172.00)	2.15 (165.00)
December	4.16 (1.80)	4.95 (3.27)	4.05 (0.11)	1.87 (0.15)	2.50 (0.22)	1.94 (0.15)	1.70 (0.09)	2.24 (0.12)	1.80 (0.09)	1.17 (237.00)	2.09 (227.00)

Note: BAS = observed bid ask spread, BASyz = observed bid ask spread including pre-open quotes, RM = Roll's measure, CSS = Choi, Salandro and Shastri measure, CDP = Chu, Ding and Pyun measure, ABS = Absolute price changes, TWM = Thompson and Waller measure, CFTC = Commodity Futures Trading Commission measure, HAS = Hasbrouck measure and FGM = Frank and Garcia measure.

Appendix Table 2. Measures of Liquidity Costs (cents/bu.) in Hard Red Winter Wheat Futures and Options Contracts in 2009.

Contract	ABS	ABSyz	NM	RM	CSS	CDP	ABS	TWM	CFTC	HAS	FGM
March	4.19	4.79	3.17	1.45	1.95	1.64	1.28	1.61	1.29	1.24	1.67
	(1.86)	(2.56)	(0.09)	(0.12)	(0.20)	(0.16)	(0.07)	(0.09)	(0.06)	(221.00)	(181.00)
May	3.49	4.67	2.22	1.27	1.60	1.40	1.01	1.17	0.88	1.25	1.43
	(1.76)	(2.49)	(0.10)	(0.18)	(0.22)	(0.20)	(0.07)	(0.07)	(0.04)	(166.00)	(112.00)
July	3.55	4.54	3.20	1.89	2.57	2.01	1.61	1.95	1.47	1.24	1.80
	(1.92)	(2.59)	(0.10)	(0.17)	(0.30)	(0.18)	(0.08)	(0.10)	(0.12)	(377.00)	(335.00)
September	3.24	4.25	2.10	0.77	1.00	0.82	0.88	1.09	0.97	1.20	1.31
	(1.78)	(2.64)	(0.06)	(0.08)	(0.10)	(0.08)	(0.05)	(0.05)	(0.05)	(199.00)	(125.00)
December	2.81	3.88	1.93	1.02	1.39	1.10	0.85	1.06	0.94	1.10	1.28
	(1.62)	(2.91)	(0.04)	(0.07)	(0.11)	(0.08)	(0.03)	(0.03)	(0.03)	(301.00)	(228.00)

Note: BAS = observed bid ask spread, BASyz = observed bid ask spread including pre-open quotes, RM = Roll's measure, CSS = Choi, Salandro and Shastri measure, CDP = Chu, Ding and Pyun measure, ABS = Absolute price changes, TWM = Thompson and Waller measure, CFTC = Commodity Futures Trading Commission measure, HAS = Hasbrouck measure and FGM = Frank and Garcia measure.

CHAPTER III

LIQUIDITY COSTS IN FUTURES AND OPTIONS MARKETS AT NATIONAL STOCK EXCHANGE, INDIA

Abstract

This study, for the first time, attempts to determine and compare liquidity costs in options and futures markets traded at the National Stock Exchange of India. Liquidity cost is one of several factors that traders should consider when choosing among the available trading instruments and exchanges. While considerable research has estimated liquidity costs of futures trading, there is little comparable research about options markets. The study also presents a new measure to estimate liquidity costs in options markets based on the Black-Scholes model. The study uses transaction prices for futures and options contracts on S&P CNX Nifty index and high volume stocks traded at National Stock Exchange of India during 2007. The study uses Roll's measure, two extensions of Roll's measure, Thompson and Waller measure and two variants of Thompson and Waller measure to estimate liquidity costs in futures contracts. The same measures as well as the new measure are used to estimate liquidity costs in the options market. Liquidity costs in the futures markets were considerably higher compared to the option markets across all the measures and assets considered in the study. A negative relationship is found between daily volume and liquidity costs. The price of the option has a positive impact on

liquidity costs. The put options had higher liquidity costs than the call options. The study concludes that liquidity costs in options markets are considerably higher than liquidity costs in futures markets.

Introduction

Transaction costs are an important decision variable for an investor to choose among available trading instruments and exchanges. On any standardized exchange the main components of transaction costs are brokerage fees, taxes and liquidity costs. Unlike brokerage commissions and taxes which are explicit, liquidity costs are hidden. The difficulty with which an asset is traded can either be measured in time – how long it takes to trade – or in price – the price concession it takes to trade immediately (Stoll 2000). Liquidity costs are the price concession. Buyer initiated trades are usually made at the ask price and seller initiated trades at the bid price. Thus the difference between the bid price and the ask price is a measure of liquidity cost. For instance, a trader who desires to sell an asset quickly would rather receive the available bid price than run the risk of submitting a limit order that is not executed. Similarly, an eager buyer would pay a price concession and accept the available ask price so that his order is absorbed by the market immediately. Therefore, a trader who desires to immediately sell or buy an asset will suffer a markdown on his realized price in the adverse direction. Such price effects are negatively associated with market liquidity. Traders in liquid markets trade with little price effect to their transactions while in thin markets, the transactions of individual traders may have significant price effects and may therefore result in substantial liquidity costs.

Liquidity costs can affect the profitability of any trade, portfolio or managed fund. With an increase in use of derivative markets for risk management, futures and options contracts have become important tools for traders to hedge their risk. Investors often need to choose between futures and options markets to trade and investors will prefer lower liquidity costs. Increasing use of futures and option contracts suggests a potentially large audience for a study of liquidity costs with these derivatives.

In this paper, liquidity costs are estimated for futures and options contracts traded on listed stocks at National Stock Exchange (NSE), India. NSE of India is a completely order driven electronic market trading futures and options contracts on indexes and securities. With substantial growth in the Indian economy and technological advancements, stock and derivative markets in India have attracted investors globally. There are several studies related to microstructure in emerging futures and options markets. However, microstructure of the derivative markets in India has not been analyzed. Chakrabarty and Jain (2005) studied market microstructure of NSE and estimated liquidity costs in stocks listed on NSE. However, no studies were found that investigate liquidity costs in futures and options markets in India. Increasing interest of global investors in emerging derivative markets of India and lack of research on these markets motivates the present study. This study estimates and compares liquidity costs in futures and options contracts traded on ten high-volume stocks and the major index listed on NSE. Liquidity costs are estimated using two variants of average absolute price deviations and Roll's measure. A new measure is introduced to estimate liquidity costs in options. The study identifies the impact of different factors such as daily volume, volume per trade, price volatility and type of options on liquidity costs. As the liquidity costs directly affect the returns of a portfolio the results of this study are intended to help hedgers and speculators choose between futures and option contracts. Knowledge of liquidity costs can help investors to compare and evaluate available exchanges. Moreover, Knowing liquidity costs can help researchers in accounting for them while simulating hedging strategies or speculative trading. The results will also aid regulators and exchange management in increasing fairness and efficiency of the market.

Trading environment at NSE, data and sample selection

The NSE is mutually-owned by a set of leading financial institutions, banks, insurance companies and other financial intermediaries in India. It is a completely automated limit order market. Price formation in this exchange occurs on its electronic online trading platform known as NEAT (National Exchange for Automated Trading). It adopts the principle of an order driven market in much the same way as Electronic Communication Networks (ECN) operates in the United States. NSE is the first exchange in the world to use satellite communication technology for trading. Its client-server-based trading platform NEAT operates on 2,888 Very Small Aperture Terminals (VSATs) in 365 cities spread all over the country. The exchange currently provides trading in 4 different segments *viz.*, Wholesale Debt Market segment, Capital Market segment, Futures and Options segment and the Currency Derivatives Segment. The Futures and Options segment, which is the focus here, supports an anonymous order driven market, which operates on a strict price/time priority. At any point of time there are only three contract months available for trading, with 1 month, 2 months, and 3 months to expiry. These contracts expire on the last Thursday of the expiry month. If the last Thursday is a trading holiday, the contracts expire on the previous trading day. A new contract is introduced on the next trading day following the expiry of the near month contract. All derivatives contracts at NSE are presently cash settled.

NSE keeps a comprehensive dataset for all the derivative securities traded in the exchange. For each day of trading the dataset contains three types of data: Trade data, Bhav-copy, and snapshot data. The trade data file contains real time information on all trades that take place in each futures and options contract for that day. The Bhav-copy file provides summary information about each security for each trading day including open, close, high, low, settlement prices and daily volume. The snapshots file contains bid ask quotes, which are snapshots of the limit order book at given hours of the day. Unlike the TAQ data, the NSE provides quotes data at various points in time, and not continuously throughout the day. NSE takes a snapshot of the limit order book at five different times of a trading day *viz.* 11 a.m., 12 p.m., 13 p.m., 14 p.m. and 15 p.m. The snapshot data contains all outstanding orders at a particular time of the day. It indicates whether the order is to buy or to sell, its volume and the time at which the order was entered in the system.

Our data set contain the aforementioned three files for each trading day for all futures and options contracts traded at NSE in 2007. Futures and options contracts were traded on 237 stocks and 4 indexes in 2007. While the futures contracts were intensively traded for all the stocks at NSE, the options contracts, especially the put options were thinly traded for most stocks. Futures contracts contributed 90.7 percent of the total trades in the futures and options segment of NSE. Since one of the main objectives of the present study is comparing liquidity costs in the futures and the options markets, having sufficient observations in both the futures and the options contract of a stock is important. To ensure sufficient observations in both futures and options contracts of a stock and to make results presentable, one major index and 10 heavily traded stocks are selected for study. The trading activity in the sample index and stocks is presented in Table 1. The sample covers 39.14 percent of trades in the futures and option segment of NSE.

Methods

In an order driven electronic market, limit orders supply liquidity while market orders demand liquidity. Orders are matched according to the price and time they are entered in the system. Any market order that enters the system is matched with the best available bid or ask price depending on whether it is a sell order or a buy order. Hence, at any point of time the spread between the best ask price and the best bid price represents liquidity in the market. Any trader who uses a market order incurs a cost equal to the difference between available bid and ask price on a round turn trade. There are two types of bid ask spreads: quoted spreads and effective spreads. The quoted spread is the difference between floor traders bid and ask prices. The effective spread is the difference between the price at which the floor trader buys (sells) a contract and the price at which he subsequently sells (buys) it (Smith and Whaley 1994). If bid and ask prices are recorded, liquidity costs can be directly calculated by taking the difference. However, exchanges do not always record observed bid and ask prices. The NSE provides snapshots of the limit order book at five different points in time but not continuously throughout the day. We use snapshot data to estimate observed bid ask spreads and evaluate the indirect measures of bid ask spreads developed in the literature. Various indirect measures of spreads have been developed that use commonly available transaction prices. Spread estimators developed in the literature have mostly used the covariance of successive price changes or have employed averages of absolute price changes. The former type of estimator, originally applied in equity research, was first developed by Roll (1984). According to Roll (1984) if markets are informationally efficient and successive transaction are sale or purchase with equal probability, the covariance between price changes is negative and directly related to the bid-ask spread. Roll's measure (*RM*) has been effectively used in equity markets and is

$$RM = 2\sqrt{-\text{cov}(\Delta P_t, \Delta P_{t-1})}$$

where, ΔP_t is change in the transaction price of a contract at time *t*. The main drawback of Roll's measure is that when there is a positive covariance in successive price changes the formula evaluates to a non real number and the observations for that day need to be discarded. One assumption of Roll's measure which is generally inappropriate for futures markets is that there is an equal probability of each transaction being a buy or sell order (Bryant and Haigh 2004). Choi, Salandro, and Shastri (1988) proposed an extension of Roll's measure which relaxes the assumption of equal probability of a transaction being a buy or sell order. They defined their measure as

$$CSS = \frac{\sqrt{-\text{cov}(\Delta F_t, \Delta F_{t-1})}}{1-\delta}$$

where δ is the conditional probability that the next transaction type (bid or ask) is the same as the current transaction type. If $\delta = 0.5$ the CSS measure reduces to Roll's measure. If there is positive correlation in transaction type with $\delta > 0.5$ the estimates produced by Roll's measure would be a downward biased estimates of the true bid ask spread (Choi, Salandro, and Shastri 1988). Chu, Ding and Pyun (1996) further extended Roll's measure by using two-period conditional probability of the transaction type being bid or ask. Chu, Ding and Pyun measure (CDP) is defined as

$$CDP = \sqrt{\frac{-\text{cov}(\Delta F_t, \Delta F_{t-1})}{(1-\delta)(1-\alpha)}}$$

where α is the conditional probability that the previous transaction type is the same as the current transaction type. When $\alpha = \delta$ the CDP measure reduces to CSS measure and when $\alpha = \delta = 0.5$ it reduces to the Roll's measure. To estimate the probabilities α and δ the transaction types are classified as bid or ask using the tick test suggested by Lee and Ready (1991). The other type of measures used in this study uses average absolute price changes to estimate liquidity costs. Thompson and Waller (1988) suggested the average absolute value of price changes as a direct measure of the average liquidity cost of trading. The Thompson and Waller measure (*TWM*) is

$$TWM = \frac{1}{T}\sum_{t=1}^{T}|\Delta P_t|$$

where, ΔP_t is a series of non-zero price changes. This measure, as argued by Smith and Whaley (1994), contains equilibrium price changes along with bid ask spread. This measure was applied in Thompson and Waller (1988) to study the determinants of liquidity costs in feed grain futures markets, and was used to compare liquidity costs between two similar markets in Thompson et al. (1988). Ma et al. (1992) used the TWM to study intra-day patterns in spreads and the determinants of spreads for various Chicago Board of Trade (CBOT) contracts. In an attempt to filter out the real price changes in TWM measure, Commodity Futures Trade Commission (CFTC) uses only nonzero price changes that are in the opposite direction of the previous change.

There are several other variations of above discussed measures of liquidity costs proposed in the literature. Hasbrouck (2004) estimated Roll's measure using a Bayesian approach in pit traded futures on Chicago Mercantile Exchange. Smith and Whaley (1994) suggest a method to estimate effective bid-ask spread from transaction data in futures markets that uses first and second moments of absolute price changes. The focus of these two studies was open outcry futures markets where market makers play an important role in providing liquidity. Since Roll's measure and average absolute price change measure have been widely used in equity futures markets and since we are interested in relative performance of these measures in futures and options markets at the NSE, we use Roll's measure, TWM measure, and variants of the two measures to estimate liquidity costs in futures markets.

The indirect measures of liquidity costs discussed above are extensively used in stock futures markets (Hasbrouck 2004; Locke and Venkatesh 1997; Laux and Senchack 1992; Roll 1984). However, the indirect measures have not been used to estimate liquidity costs of stock options. Due to the lower volume in options markets, the indirect estimators likely do not estimate liquidity costs as accurately as they do in futures markets. Since, the NSE does not provide continuous observed quote data and we have selected heavily traded stock options we apply the indirect measures of liquidity costs to the stock options in the present study. Further, we propose a new measure of liquidity cost in options markets which uses Black-Scholes formula for pricing option on stocks.

On standardized exchanges, the transaction price of an asset bounces between the bid and ask prices prevailing in the market. Also, since all transactions occur at either bid or ask prices, the realized price is either higher or lower than the true price depending upon whether the transaction occurs at the ask price or the bid price. Hence, on the average, absolute differences between the observed price and the true price of an option should be half of the bid ask spread. Black and Scholes (1973) proposed a valuation model for stock options that under the assumptions of no riskless arbitrage and a lognormal distribution, estimates the true price of an option. If a market is efficient and devoid of arbitrage opportunities any deviation of the observed price from the estimated true price captures half of bid-ask spread. We use the Black-Scholes model to estimate the true equilibrium price of the option. Let π_t be the observed price of an option at time t and $\hat{\pi}_t$ be the predicted true price of the option using Black and Scholes formula then, the liquidity costs incurred by a trader for a round trip trade can be estimated as

$$liquidity\ cost = 2 \cdot E[|\pi_t - \hat{\pi}_t|].$$

$\hat{\pi}_t$ is calculated using the Black-Scholes formula for options. We use a modification of the Black-Scholes model proposed by Hull (2003) to use futures prices instead of using price of the underlying asset. According to Hull (2003), when the market is devoid of arbitrage opportunities and the risk free rate of interest is constant, for an asset providing a continuous dividend yield over the life of futures contract, the futures price of the asset can be given as

$$F_0 = S_0 e^{(r-q)t},$$

where, S_0 is current spot price of the asset, r is risk free rate, q is dividend yield over the life of the futures contract and t is time to maturity of the futures contract. Our sample consists of the most frequently traded futures and options contract at the NSE (see Table 1). Therefore, the assumption of no riskless arbitrage opportunity in the selected futures market is reasonable and the equality in the above equation is likely to hold. If the maturities are the same for both futures and options contracts on the same underlying instrument, which is true for any futures and options contract at the NSE, Hull (2003) derived the following modification of the Merton model that uses futures price of the underlying asset instead of spot price. For call options the true price can be estimated as

$$\hat{\pi} = e^{(-r \cdot t)}[F_0 \cdot \Phi(d_1) - K \cdot \Phi(d_2)]$$

and for put option, it is

$$\hat{\pi} = e^{(-r \cdot t)}[F_0 \cdot \Phi(-d_1) - K \cdot \Phi(-d_2)],$$

where,

$$d_1 = [\ln(F_0/K) + (\hat{v}^2 \cdot t)/2]/(\hat{v} \cdot \sqrt{t}),$$

$$d_2 = d_1 - \hat{v} \cdot \sqrt{t},$$

F_0 is futures price of the underlying asset, K is strike price of the option, r is risk free interest rate, t is time to expiration and $\hat{v}$ is volatility of the underlying asset. The above mentioned model represents option price as a function of five quantities: strike price, risk free interest rate, time to maturity, volatility of the underlying index and the index future price. Since we estimate $\hat{\pi}_t$ using this option pricing model in our proposed measure of liquidity cost, the measure is also a function of these five variables and is affected by variations in them. The first three variables: strike price, risk free interest rate and time to maturity are directly observed. For the present study, strike price and time to maturity are taken from the available dataset for each options contract. The Mumbai Inter-Bank Offer Rate (MIBOR) is used for risk free interest rate. However, the volatility of the underlying index is not directly observed. To estimate the volatility of the underlying futures contracts, we use implied volatility calculated by inverting the above model and solving for $\hat{v}$ using the Newton-Raphson method. Studies on implied volatility have shown that variables such as moneyness of the option, time to maturity of the option and also the type of the option affects the predicted implied volatility. At the money stock options generally predict lower implied volatility compared to deep out of the money options. Similarly, different maturities of the options also affect the predicted implied volatilities. We apply the following regression to filter out the effects of the above discussed factors and use the predicted volatilities from this model to estimate options price.

(1) $$v_t = \beta_0 + \beta_1 M_t + \beta_2 D_t + \sum_{i=1}^{N} \beta_i T_{it} + e_t$$

where, v_t is implied volatility at time t, M_t is moneyness of the option at time t which is difference between strike price and underlying futures price, T_{it} are fixed effects of trading day, D_t is a dummy variable for type of option which takes a value of 1 if it is a call option or 0 if it is a put option. Since the estimate of the volatility of the futures price depends on the above regression, the estimation error of the regression is a source of error in the measure of liquidity cost.

Another source of error for the measure of liquidity cost is the use of the most recent futures price. The Black-Scholes model requires the use of price of the futures realized at exactly the same time the option price is realized. The futures price is generally not available at the same time of the option transaction and we are forced to use the most recent futures price. Hence, if the true equilibrium price of the underlying contract changed in the interim, the staleness of the futures price could affect the accuracy of the estimate of true option price and consequently affect the proposed measure of liquidity cost. The effect of this staleness is removed by estimating the following regression:

(2) $$|\pi_t - \hat{\pi}_t| = \alpha_0 + \alpha_1 S_t + \epsilon_t$$

where S_t is length of time between the observed option transaction and the most recent futures price in seconds and ϵ_t is independently normally distributed with mean 0 and variance σ^2. Since, the expected value of staleness is zero, e^{α_0} represents the absolute difference between observed and predicted option premium. Thus, as defined earlier the liquidity costs can be calculated as two times the expected value of the above equation given S_t is zero:

$$\text{liquidity cost} = 2 \cdot \alpha_0$$

The use of estimated implied volatility and recent futures prices are the two sources of errors in the proposed measure which might overestimate the true liquidity costs. The present study also uses the snapshot data provided by the NSE to estimate observed bid ask spreads. To obtain actual spreads, one needs the bid and ask quotes which can be obtained from the limit order book. The NSE, at this time, does not distribute continuous limit order book data. However, the NSE collects snapshots of the limit order book at five different times of the trading day. The actual spreads were measured as

$$liquidity\ cost_t = ask_t - bid_t$$

where, ask_t and bid_t are price of sell order and buy order respectively of a specific contract observed in a snapshot recorded at time *t*. Generally, there are more than one outstanding buy or sell orders when the snapshot is taken. The highest buy order price was taken as bid_t and lowest sell order price was taken as ask_t. The snapshot data records four types of orders: At the Opening (ATO), stop orders, market orders and limit orders. We drop the ATO, stop orders and market orders from the dataset since the ATO orders are priced based on pre open prices and the stop orders are not active until a specific price is hit during the trading. We observed several buy and sell limit orders with extremely high or low prices. Generally, such extreme observations are dropped out since only the best bid and the best ask prices are considered to calculate observed bid ask spread. However, when there are only few bid and ask prices observed, such extreme observations distort the estimate of bid ask spread. To overcome this problem we only include those contracts where at least 10 bid and ask prices are observed.

A number of variables related to the microstructure of the market have been found to affect liquidity costs. Previous research on futures markets found that liquidity costs and trading volume are negatively correlated (Thompson, Eales and Seibold 1993). High volume reduces risk from holding inventory. Also, higher volume means more likely a non-market maker will enter a limit order. The price of a security is known to have an effect on the spreads in the market (Stoll 2000; Chakrabarty and Jain 2005). To test hypotheses about factors influencing liquidity costs, the following regression equation was estimated by maximum likelihood:

(3) $$y_{mt} = \beta_0 + \beta_2 P_{mt} + \beta_3 V_{mt} + \beta_4 D_{mt} + v_m + e_{mt}$$

where, y_{mt} is average absolute price deviations for day t and contract m, P_{mt} is average price of the day, V_{mt} is daily volume, D_t is a dummy variable which takes the value 1 if it is a call option and 0 if it is a put option, v_m is random effect of contract m. The error terms v_m and e_t are assumed independently distributed normal with mean zero and variances σ_v^2 and σ_e^2, respectively.

Results

Descriptive statistics of the futures and the option contracts on selected stocks and an index are presented in Table 1. The futures contracts are extensively traded compared to the options contracts for all the assets in the sample. Also, the number of trades in call options is considerably higher than with put options. The estimated measures of liquidity costs for futures and options contracts on S&P CNX Nifty index and the average of ten selected stocks are presented in Table 2. The estimates of individual stocks are presented in Appendix I. The average liquidity costs in S&P CNX Nifty futures were INR 0.76 to INR 1.92. The same measures for S&P CNX Nifty call options ranged from INR4.63 to INR 7.79 and for put options they were INR 2.50 to INR 4.83.Thus bid-ask spreads were considerably higher in the options markets, regardless of measure. Similar results were found for the individual stock futures and options contracts considered. However, the difference between the liquidity costs in futures markets was less for individual stocks than for the index. The observed spreads, estimated using snapshot data, also follow the same pattern of higher spreads in the options market than the futures market. The observed spreads in both markets are higher than estimated spreads using the indirect measures. The reason behind higher observed spread might be due to the fact that the snapshot data are only reported five times in a trading day[12]. If a trade is less likely to happen given a wide bid-ask spread, the observed bid-ask spreads would overestimate effective spread in the market. The estimated spreads in the option markets using the new measure are also presented in Table 2. The new measure is used to estimate spreads in the options market. The estimates of the new measure more closely follows the other estimates of spreads in call options compared to the put options. This is because the new measure, in a way, represents the weighted average of the spreads in call and put options combined and in the sample the call options are more frequently traded compared to the put options (Table 1). Moreover, an option with each strike price is considered as a separate asset when these measures are estimated which resulted in loss of data when options on some strike prices were infrequently traded. Since the put options were thinly traded compared to the call options, the loss of data in put options was higher reducing the consistency of the estimates for the put options. The new measure may be more accurate than the other measures since it includes all trades rather than only including trades when the market was active. The result indicates that regardless of which measures are used the liquidity costs in option markets are considerably higher than in futures markets. The result agrees with the results of Shah, Brorsen and Anderson (2009) who compared liquidity costs

[12] We only considered those contracts for which at least 10 bid and 10 ask prices were observed at the time of snapshot. When estimated without applying this rule the observed spreads were estimated about 10-15 times higher.

in wheat futures and options markets. They found that the liquidity costs in options markets were at least three times higher than in the futures markets.

Total volume and volume per trade are presented in Table 3. The total volumes for the futures market are immensely higher than the volumes in the option market for all the assets traded during 2007. To determine the relationship between liquidity costs in option contract, daily volume of the option contracts, price of the option and the type of option, we estimated the model in equation (3) using restricted maximum likelihood. Average absolute price deviations were used as the dependent variable in the model. The results are presented in Table 4. A significant negative impact of daily volume was found on liquidity costs. Previous studies of liquidity costs in futures markets have found a negative impact of volume on liquidity costs (Thompson and Waller 1987; Thompson, Eales, and Seibold 1993; Stoll 2000; Bryant and Haigh 2004 ; Shah and Brorsen 2011). Lower volumes in option markets can explain the higher liquidity costs in this market because lower volumes imply more risk of holding contracts resulting in higher liquidity costs. The price of the option had a significant positive impact on liquidity costs. Chakrabarty and Jain (2005) found the same relationship between stock price and liquidity costs in the capital market segment of the NSE. The result also indicates that liquidity costs in call options were lower compared to the put options which can be explained by the lower volumes in the put options.

Summary and Conclusion

This study estimates and compares liquidity costs in the futures and options contracts traded on National Stock Exchange of India. A new measure is proposed which uses the Black-Scholes option pricing model and implied volatilities along with option transaction prices. We also estimate liquidity costs using Roll's measure, Thompson and Waller measure, and four variants of these two measures. Regardless of the measure used, liquidity costs in the options markets are considerably higher compared to the futures markets. Significant negative relationships are found between liquidity costs and daily volume of the asset and liquidity costs and price of the asset. Liquidity costs in put options are higher compared to the call options. Liquidity cost is one of the important decision variables for a trader's choice of trading instrument as well as trading exchange. This study provides results that have broad implications to different market participants such as investors, firms, regulators and exchange management in achieving their goals of highest returns and lowest costs. Futures options have a lower delta than futures contracts and futures options have a lower price. On a percentage basis, liquidity cost in options is even higher than that in futures. One approach that market participants may want to use is to use futures when an immediate trade is desired through a market order, but to consider options when limit orders are used.

Table 1. Number of Trades in Futures and Options Contracts of Selected Index and Stocks Traded at National Stock Exchange, India, 2007.

Contract	Futures	Average trades per day	Calls	Average trades per day	Puts	Average trades per day	Total
S&P NIFTY	26,567,351	106,696	4,673,218	18,768	4,852,828	19,489	36,093,397
RELIANCE	5,382,182	21,615	770,773	3,095	219,522	882	6,372,477
RCOM	4,765,812	19,140	271,268	1,089	38,539	155	5,075,619
SBIN	3,651,332	14,664	262,322	1,054	96,999	390	4,010,653
RPL	3,207,235	12,880	362,027	1,454	68,618	276	3,637,880
TATASTEEL	3,188,444	12,805	326,475	1,311	102,059	410	3,616,978
IDBI	2,783,776	11,180	316,478	1,271	56,757	228	3,157,011
INFOSYSTCH	2,601,182	10,447	270,582	1,087	60,345	242	2,932,109
RNRL	2,399,163	9,635	204,670	822	35,976	144	2,639,809
SAIL	2,232,704	8,967	199,461	801	44,464	179	2,476,629
IFCI	1,620,298	6,507	184,963	743	31,642	127	1,836,903
Selected stocks	58,399,479	234,536	7,842,237	31,495	5,607,749	22,521	71,849,465
% of total trades in sample	35.08	-	70.89	-	93.24	-	39.14
All Stocks	166,476,982	668,582	11,062,823	44,429	6,014,473	24,155	183,554,280

Table 2. Measures of Liquidity Costs (INR) in Selected Stock Futures and Options Markets Traded at the NSE, India in 2007.

		OBS	ABS	TWM	CFTC	RM	CSS	CDP	NM
S&P CNX Nifty	Futures	3.16 (1.33)	0.76 (0.09)	1.18 (0.14)	1.32 (0.15)	1.40 (0.16)	1.92 (0.22)	1.47 (0.17)	-
	Call	7.11 (4.58)	4.63 (0.87)	4.78 (1.52)	4.70 (1.46)	5.76 (1.13)	7.79 (1.58)	5.98 (1.10)	10.61 (4.66)
	Put	3.95 (1.90)	2.50 (0.34)	3.44 (0.66)	3.29 (0.58)	3.26 (0.48)	4.83 (0.75)	3.38 (0.50)	9.98 (3.46)
Selected Stocks	Futures	1.16 (0.36)	0.70 (0.22)	0.86 (0.27)	0.80 (0.24)	1.01 (0.33)	1.24 (0.41)	0.96 (0.31)	-
	Call	1.30 (0.41)	0.90 (0.25)	1.03 (0.29)	1.01 (0.29)	1.11 (0.31)	1.44 (0.41)	1.19 (0.33)	1.95 (0.57)
	Put	1.63 (0.54)	0.98 (0.29)	1.32 (0.38)	1.39 (0.42)	1.24 (0.37)	1.50 (0.46)	1.16 (0.36)	2.38 (0.68)

Note: OBS = observed bid ask spread, ABS = Absolute price changes, TWM = Thompson and Waller measure, CFTC = Commodity Futures Trading Commission measure, RM = Roll's measure, CSS = Choi, Salandro and Shastri measure, CDP = Chu, Ding and Pyun measure, NM = New measure

Table 3. Trading Volumes in Futures and Options Contracts of Selected Index and Stocks Traded at National Stock Exchange, India in 2007.

	Futures		Calls		Puts	
Contract	Total Volume (Million)	Volume per Trade	Total Volume (Million)	Volume per Trade	Total Volume (Million)	Volume per Trade
S&P CNXNifty	7553.92	226.70	1300.43	412.36	1459.31	471.96
RELIANCE	2027.22	317.40	209.08	322.71	55.05	261.79
TATASTEEL	4198.99	850.50	204.30	755.37	28.39	737.81
SBIN	1528.94	406.17	88.87	408.05	30.76	526.68
RPL	12697.59	3917.45	1299.11	3573.45	249.04	3676.77
INFOSYSTCH	2901.82	850.55	257.49	802.18	77.18	773.76
IDBI	8592.47	3128.15	880.88	2909.03	155.27	2908.87
SAIL	466.66	168.17	44.28	186.40	10.12	195.89
RCOM	19997.58	7905.57	1523.83	7369.36	270.00	7504.91
RNRL	6918.69	3028.59	567.56	2874.17	130.03	2887.90
IFCI	19491.91	13288.25	1863.56	12182.06	324.66	12253.01

Table 4. Estimated Parameters of Factors Affecting Liquidity Costs (INR) with Average Absolute Price Deviation as a Dependent Variable in Selected Stock Futures and Options Markets Traded at the NSE, India in 2007.

Variable	Estimate	SE
Intercept	0.5457	0.0548
Price (INR)	0.0303	0.0007
Daily volume	-0.00003	< 0.0001
Calls	-0.2032	0.0236

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APPPENDICES

Appendix Table 1. Measures of Liquidity Costs (INR) in Selected Stock Futures and Options Markets Traded at the NSE, India in 2007.

		OBS	ABS	TWM	CFTC	RM	CSS	CDP	NM
IDBI	Futures	0.29 (0.13)	0.14 (0.11)	0.19 (0.12)	0.20 (0.14)	0.22 (0.17)	0.27 (0.16)	0.21 (0.13)	-
	Call	0.29 (0.09)	0.23 (0.10)	0.26 (0.10)	0.27 (0.14)	0.27 (0.12)	0.36 (0.15)	0.31 (0.13)	0.49 (0.21)
	Put	0.39 (0.21)	0.30 (0.16)	0.37 (0.17)	0.40 (0.21)	0.34 (0.24)	0.37 (0.23)	0.29 (0.18)	0.59 (0.34)
IFCI	Futures	0.15 (0.08)	0.10 (0.07)	0.14 (0.08)	0.14 (0.08)	0.14 (0.10)	0.19 (0.11)	0.15 (0.09)	-
	Call	0.21 (0.10)	0.18 (0.08)	0.23 (0.09)	0.23 (0.11)	0.19 (0.09)	0.31 (0.10)	0.24 (0.10)	0.43 (0.31)
	Put	0.24 (0.19)	0.20 (0.13)	0.34 (0.21)	0.35 (0.23)	0.23 (0.18)	0.26 (0.15)	0.20 (0.12)	0.55 (0.46)
INFOSYS	Futures	2.70 (0.56)	1.96 (0.87)	2.41 (1.04)	2.12 (1.00)	3.19 (1.40)	3.69 (1.56)	2.96 (1.23)	-
	Call	2.97 (0.82)	1.60 (0.45)	2.56 (0.68)	2.49 (0.58)	2.12 (0.58)	2.57 (0.67)	2.19 (0.62)	5.22 (1.46)
	Put	5.15 (1.47)	2.72 (0.91)	3.76 (1.51)	4.07 (1.62)	3.59 (1.60)	4.20 (0.97)	3.36 (1.04)	6.55 (2.64)
RCOM	Futures	0.96 (0.38)	0.61 (0.47)	0.71 (0.48)	0.69 (0.47)	0.85 (0.72)	1.09 (0.96)	0.81 (0.67)	-
	Call	1.08 (0.42)	0.80 (0.52)	0.97 (0.62)	0.87 (0.34)	0.91 (0.49)	1.18 (0.58)	0.99 (0.46)	1.83 (0.92)
	Put	1.50 (0.50)	1.03 (0.43)	1.41 (0.67)	1.46 (0.56)	1.28 (0.63)	1.63 (0.87)	1.11 (0.48)	2.72 (2.15)
RELIANCE	Futures	2.56 (1.91)	1.58 (1.66)	1.93 (1.97)	1.74 (1.46)	2.25 (2.47)	3.01 (3.70)	2.11 (2.22)	-
	Call	2.92 (2.07)	2.02 (1.53)	1.98 (1.28)	2.04 (1.34)	2.79 (2.01)	3.74 (2.62)	2.84 (1.85)	3.88 (2.22)
	Put	2.84 (1.66)	1.64 (1.05)	2.17 (1.52)	2.14 (1.13)	2.05 (1.34)	2.72 (1.64)	1.96 (1.08)	4.60 (3.42)

Note: OBS = observed bid ask spread, ABS = Absolute price changes, TWM = Thompson and Waller measure, CFTC = Commodity Futures Trading Commission measure, RM = Roll's measure, CSS = Choi, Salandro and Shastri measure, CDP = Chu, Ding and Pyun measure, NM = New measure

Appendix Table 2. Measures of Liquidity Costs (INR) in Selected Stock Futures and Options Markets Traded at the NSE, India in 2007.

		OBS	ABS	TWM	CFTC	RM	CSS	CDP	NM
RNRL	Futures	0.39 (0.39)	0.35 (0.43)	0.40 (0.47)	0.41 (0.53)	0.40 (0.50)	0.45 (0.51)	0.36 (0.41)	-
	Call	0.28 (0.22)	0.30 (0.26)	0.33 (0.30)	0.29 (0.22)	0.51 (0.48)	0.47 (0.35)	0.36 (0.26)	0.41 (0.40)
	Put	0.27 (0.20)	0.25 (0.20)	0.31 (0.21)	0.34 (0.25)	0.48 (0.48)	0.34 (0.29)	0.29 (0.26)	0.63 (0.45)
RPL	Futures	0.24 (0.23)	0.11 (0.08)	0.16 (0.10)	0.16 (0.12)	0.15 (0.13)	0.21 (0.14)	0.16 (0.12)	-
	Call	0.27 (0.22)	0.25 (0.23)	0.27 (0.21)	0.26 (0.24)	0.29 (0.27)	0.43 (0.31)	0.34 (0.23)	0.61 (0.61)
	Put	0.28 (0.26)	0.22 (0.21)	0.39 (0.39)	0.40 (0.39)	0.25 (0.24)	0.28 (0.24)	0.21 (0.19)	0.73 (0.74)
SAIL	Futures	0.32 (0.19)	0.17 (0.15)	0.22 (0.16)	0.22 (0.16)	0.23 (0.20)	0.29 (0.22)	0.23 (0.19)	-
	Call	0.43 (0.30)	0.35 (0.24)	0.34 (0.22)	0.36 (0.27)	0.42 (0.29)	0.60 (0.37)	0.51 (0.30)	0.71 (0.40)
	Put	0.46 (0.28)	0.35 (0.26)	0.48 (0.39)	0.50 (0.44)	0.43 (0.43)	0.49 (0.41)	0.43 (0.41)	0.80 (0.55)
SBIN	Futures	2.99 (1.91)	1.37 (0.83)	1.72 (0.99)	1.63 (0.89)	1.80 (1.00)	2.22 (1.40)	1.78 (1.08)	-
	Call	3.40 (2.28)	2.26 (1.49)	2.28 (1.36)	2.28 (1.38)	2.51 (1.55)	3.23 (1.84)	2.81 (1.54)	4.02 (2.01)
	Put	3.68 (2.19)	2.15 (1.37)	2.73 (1.57)	3.07 (1.82)	2.63 (1.83)	3.36 (2.03)	2.65 (1.97)	4.51 (2.53)
TATA STEEL	Futures	0.98 (0.40)	0.61 (0.39)	0.74 (0.46)	0.73 (0.41)	0.84 (0.57)	1.01 (0.64)	0.80 (0.53)	-
	Call	1.16 (0.64)	0.99 (0.59)	1.11 (0.86)	1.00 (0.64)	1.12 (0.71)	1.51 (0.84)	1.28 (0.74)	1.95 (1.34)
	Put	1.47 (0.96)	0.94 (0.64)	1.22 (0.88)	1.19 (0.82)	1.09 (0.73)	1.38 (0.82)	1.09 (0.74)	2.09 (1.29)

Note: OBS = observed bid ask spread, ABS = Absolute price changes, TWM = Thompson and Waller measure, CFTC = Commodity Futures Trading Commission measure, RM = Roll’s measure, CSS = Choi, Salandro and Shastri measure, CDP = Chu, Ding and Pyun measure, NM = New measure

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Scope and Method of Study:

The study comprises three essays about the market microstructure of futures and options markets with the main emphasis on liquidity costs. The first essay determines the impact of the transition to electronic trading at the Kansas City Board of Trade (KCBT) wheat futures market. In this essay liquidity costs are estimated for side-by-side trading of open outcry and electronic wheat futures market at KCBT using intraday transaction prices. Factors such as daily volume, volume per trade, volatility and price clustering are used to explain the difference in liquidity costs in the two markets. The second essay attempts to guide the choice problem that agricultural producers face when selecting between futures and options markets to hedge their cash market position. Liquidity costs in KCBT wheat options and futures market are estimated and a new measure of liquidity costs in options markets is proposed. The third essay deals with the liquidity costs of stock and stock index futures and option markets at National Stock Exchange (NSE) of India. The liquidity costs are estimated using the new measure as well as several other measures previously developed in the literature.

Findings and Conclusions: The main findings of the first essay are that the electronic wheat futures market has lower liquidity costs for all but the largest traders at KCBT. The key to continued existence of the open outcry market appears to be its ability to handle large orders. The second essay concludes that although, option contracts are often suggested to agricultural producers as an alternative to futures contracts to avoid margin calls, it costs more to trade an option. Regardless of the measure used, the liquidity costs in options markets were at least three times higher compared to the futures markets. A similar difference is found between the liquidity costs in stock and stock index futures and option markets at NSE, India in the third essay. The difference is more prominent in stock index futures and options compared to the individual stock futures and options.

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