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Comparison of Liquidity Costs Between the Kansas City and Chicago Wheat Futures Contracts

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The objectives of this study were to: (*a*) quantify differences in liquidity costs between Kansas City and Chicago wheat futures contracts, and (*b*) identify the factors which influence liquidity in these two markets. Regression results suggest that there are significant differences in liquidity costs between Chicago and Kansas City which are in part due to the lower trading volume at Kansas City. However, there appears to be a significantly higher cost of doing business at Kansas City which is independent of trading volume. The implications of these findings to traders is that transacting is more expensive in Kansas City than in Chicago.

Key words: bid–ask spread, futures markets, liquidity, market makers, thin markets, transactions costs.

Introduction

A key aspect of market performance is the degree of liquidity in a market. Traders in liquid markets trade with little price effect to their transactions. However, in thin markets, the transactions of individual traders may have significant price effects and may therefore result in substantial "transactions costs." Futures markets, in general, are more liquid than cash markets, and therefore may be used for transacting business at lower cost. However, futures markets and futures contracts may differ in their degree of liquidity. Thinner futures markets imply higher transactions costs than more liquid futures markets.

The bid–ask spread is the difference between prices quoted by "market makers" willing to take the opposite position in a transaction initiated either by a market order to sell (at the market maker's bid price) or by a market order to buy (at the market maker's ask price). It is the cost of immediate liquidity incurred when entering or exiting a futures market. It is also the accepted measure of liquidity in both security and futures markets. Market makers in futures markets are referred to as "scalpers" (or sometimes as "locals"). They earn a living by trading at prices separated by the bid–ask spread.

This study examines liquidity costs from the Chicago and Kansas City wheat futures markets to determine which wheat futures contract is more liquid. The Chicago contract takes delivery of hard and soft winter wheats, and some spring wheats. The Kansas City contract takes delivery of hard winter wheat. Trading volume in the Kansas City wheat futures is generally between one-third and one-half the trading volume of the Chicago contract. Earlier studies (Working; Gray; Gray and Peck) suggest that the Chicago wheat futures is a more liquid contract than the Kansas City contract, and that lower liquidity in Kansas City may reduce hedging effectiveness in that market (Wilson). This study attempts to test these assertions by measuring liquidity costs in both markets and comparing them. Regression analysis is used to test other variables that may influence liquidity

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costs. The results of these tests could be helpful to hedgers, speculators, pit traders, and the general public when trying to decide on which wheat futures contract to trade.

Background

Representative works on liquidity in securities markets include: Demsetz; Tinic; Roll; Copeland and Galai; Glosten; Glosten and Milgrom; and George, Kaul, and Nimalendran. Findings suggest that liquidity costs and trading volume are negatively related, while liquidity costs and price variability, size of the market order, and contract value or price are positively related (Demsetz).[1] Studies of liquidity in futures markets are less abundant. Thompson and Waller (1988) propose trading activity (both total and the ratio of scalpers' trading activity to total), price variability, and size of market order as determinants of futures' liquidity. Brorsen and Nielsen consider seasonality and months to contract maturity as well.

The bid–ask spread is an accepted measure of liquidity in security and futures markets. Unfortunately, futures exchanges do not record bid–ask spreads at which trades occurred. Thus, we require other measures of, or proxies for, market liquidity. Two well-known proxies for liquidity costs are employed below.

Roll developed the first liquidity cost proxy based on the estimated covariance of prices (or returns). If markets are informationally efficient, the covariance between price changes is negative and directly related to the bid–ask spread.[2] Roll proposed the following measure of the bid–ask spread.[3]

$$RM_j = 2(-\text{cov}_j)^{.5},$$

where RM_j = Roll's measure of the dollar spread for asset j, and cov_j = serial covariance of price changes for asset j; that is,

$$\text{cov}_j = \sum_{t=3}^{T} \frac{\Delta F_t \Delta F_{t-1}}{T-4}.$$

F_t is the wheat futures price at tick t, $\Delta F_t = F_t - F_{t-1}$, and T is the number of price changes.

The other accepted proxy for the bid–ask spread was proposed by Thompson, who suggested the average absolute value of price changes as a direct measure of the average execution cost of trading in a contract. That is:

$$\begin{aligned} TWM_j &= \text{Thompson–Waller proxy for liquidity costs for asset } j, \\ &= \text{average absolute value of price changes, or} \\ &= \frac{\sum_{t=2}^{T} |\Delta F_t|}{T-3}. \end{aligned}$$

The average bid–ask spread, frequency of real price changes across transactions, and size of the average real price change determine the average absolute value of price changes. Applications of the Thompson–Waller measure (*TWM*) are found in Thompson and Waller (1987); Liu and Thompson; and Ma, Peterson, and Sears. A number of different measures of liquidity costs in futures markets are compared in Thompson and Waller (1988).

Objectives and Hypotheses

The first objective of this study is to compare liquidity costs in wheat futures contracts traded on the Chicago Board of Trade to those traded on the Kansas City Board of Trade using intra-day price data from both exchanges. Both the Thompson–Waller measure (*TWM*) and the Roll measure (*RM*) will be used to proxy liquidity costs as manifested in the bid–ask spread. Because the expected return in commodity futures is normally assumed to be zero (Black), no modification of Roll's measure accounting for time variation in expected returns is made.

Another objective of the study is to test whether price variability, volume of contracts traded, and expiration month and exchange effects are significantly related to liquidity costs. The relationship between order size and liquidity costs is not considered empirically because no data are available to test this relationship. The relationship between scalper trading activity and liquidity costs is also not directly considered because, while data to investigate this relationship are available for Chicago (see Thompson and Waller 1988), they are not for Kansas City.

These objectives will help evaluate the following relationships/hypotheses:

- The Chicago wheat futures contract is more liquid than the Kansas City contract. This should be true, at least in part, because of the larger volume of trading in Chicago than in Kansas City, and perhaps in part because of other factors peculiar to each exchange that influence liquidity.
- A determinant of liquidity is price variability, which is measured by the first difference of daily price variance (*DVAR*).[4] This variable reflects the degree of informational uncertainty in the futures market, with increases in price variability associated with increases in uncertainty. It has been shown in past research (e.g., Thompson and Waller 1988) that the more risk a scalper faces trading the bid–ask spread, the more scalpers increase their spread because they see risk as a cost. Thus, positive *DVAR* values reflect increasing uncertainty, which should lead to greater liquidity costs. Hence, *DVAR* is expected to be positively related to liquidity costs.
- A determinant of liquidity is trading volume. Low levels of volume lead to slower rates of inventory turnover for the scalper, which increases the scalper's risk of price change. Additionally, market makers thrive on volume, earning a small return on many transactions under competitive conditions. Thus, in two markets where all other liquidity determinants are equal, the one with lower volume may have higher liquidity costs. However, it is possible, under certain circumstances, that trading volume would be positively associated with liquidity costs. If the availability of market makers is limited, as may be the case in generally thin markets, a temporary increase in trading activity may be associated with increases in liquidity costs because the supply of market-making services is less than perfectly elastic. The natural log of daily trading volume (*LOGVOL*) is used to represent these effects in the analysis because scalpers are considered to be more sensitive to variations in trading volume at lower levels of trading activity than at higher levels.
- A determinant of liquidity is the exchange on which the contract is traded. Aside from differences in trading volume and price variability, differences in liquidity may be attributable to institutional factors peculiar to each exchange, to the price behavior of the different classes of wheat traded on each exchange, to differences in information received at each market, to the risk attitudes of traders at each exchange, and to differences in the composition of traders at each exchange. Moreover, the exchange on which a contract is traded may affect the relationship between price variability and liquidity costs and volume and liquidity costs.
- A determinant of liquidity is the contract month traded. Some contract months may be riskier to trade than others due to inherent uncertainty regarding the contract's equilibrium value upon contract expiration. For example, futures which expire during the growing season may be particularly illiquid due to uncertainties regarding the size of the new crop and the demand for storage between old and new crop years.
- A determinant of liquidity is near versus distant time to maturity. Aside from trading volume effects, the number of months to contract maturity may influence liquidity costs if there is some additional cost or risks to market making in distant contracts. There also may be differences in liquidity costs in the expiration month as compared

Table 1. Observation Month, Contract, and Months to Expiration

	Periods of Observation (1985)					
Contract	January	February	March	April	May	June
	(no. of months)					
March	2	—	0	—	—	—
May	—	—	—	—	0	—
July	—	—	4	3	—	1
September	—	7	—	—	—	—

to other periods of trading in a contract if the greater likelihood of becoming involved in the delivery process makes trading futures more risky and less attractive during the delivery month.

Data

The intra-day price data used for the analysis are extracted from a Chicago Board of Trade (CBT) Profile Data Set and a similar data set from the Kansas City Board of Trade (KCBT). The price data analyzed are taken from a consecutive record of intra-day prices on a tick basis, where one tick in a wheat futures contract is one-quarter of a cent. Every time a trade occurs at a price different from the last price, a price observation is recorded. Although intra-day data were available from the KCBT on a transaction-to-transaction basis, tick data are analyzed because they are the only form of intra-day price data available from the CBT.

The price data used for this study are described in table 1. Seven sets of intra-day price observations taken from six months of trading are used for analysis. The monthly sets of price observations are taken from January through June of 1985 at different times to contract maturity (0 months, 1 month, 2 months, 3 months, 4 months, and 7 months), and therefore provide a good distribution of trading activity close to and far from maturity. Data for 1985 are evaluated because the only months of data that could be obtained from the KCBT were January through June of 1985.[5] Seven sets of price observations are studied per futures exchange, for a total of 14 observation periods.

Two expiration months were chosen for analysis to analyze the effects on liquidity costs of trading in these characteristically low-volume periods that also include the added risk of becoming involved in the delivery process. Trading in the March contract is analyzed during January and March (the expiration month). The May contract has one observation period—the expiration month. May is also the last contract month traded involving the old crop. The May contract may be particularly risky since new crop supplies are not yet known with certainty and the demand for storage of wheat between old and new crop years is not fully resolved.

The July contract has three observation periods (March, April, and June). Three observation periods were chosen for the July contract because July represents the first "new crop" future in wheat and is generally the contract that attracts the greatest volume of trading. Trading volume in wheat usually peaks between May and July on both exchanges. The September contract has one observation period, February, seven months from maturity. The September contract was chosen for analysis because it is the contract with sufficiently numerous price observations furthest from maturity. It is also the month in which the planting of red winter wheat occurs.

A statistical computer program developed in 1987 by M. L. Waller was used to compute both the Thompson–Waller liquidity cost measure (*TWM*) and the Roll measure (*RM*). Both are calculated using tick data in daily intervals. The mean and standard deviation of daily values of *TWM* and *RM* in terms of hundredths of a cent per bushel, as well as minimum and maximum values for *TWM* and *RM*, are calculated for each monthly

Table 2. Summary Statistics for the 1985 March Wheat Contract Observed in January

Variables	N	Mean	SD	Min.	Max.
Chicago Board of Trade					
RM	21	29.557	5.3343	20.701	39.494
TWM	21	25.083	.12301	25.000	25.336
VOL	21	5,518.3	2,093.5	2,526.00	10,853.0
DVAR	21	486.15	8,521.3	−18,152.0	16,562.0
Kansas City Board of Trade					
RM	16	67.558	91.338	29.370	408.86
TWM	17	27.999	7.9562	25.000	58.621
VOL	17	2,371.4	770.94	1,029.0	4,205.0
DVAR	17	−30.538	4,587.4	−10,343.0	11,266.0

observation period. The mean, standard deviation, minimum and maximum of trading volume (*VOL*), and price variability (*DVAR*) are also calculated for each monthly observation period.

Results

Summary Statistics

Summary statistics for *RM, TWM, VOL,* and *DVAR* for each observation set on each exchange are presented in tables 2 through 8. Table 2 presents the results from the March contract observed in January, table 3 is the September contract observed in February, table 4 is the March contract observed in March, table 5 is the July contract observed in March, table 6 is the July contract observed in April, table 7 is the May contract observed in May, and table 8 is the July contract observed in June. To broadly characterize the results, one would expect lower liquidity costs, higher trading volumes, and medium changes in variance for tables 2, 5, 6, and 7. The September contract observed in February (table 3), with seven months to maturity, should have high liquidity costs, low volume, and low change in variance. The two expiration months (tables 4 and 7) should have the highest liquidity costs, low volume, and the largest changes in variance. Finally, one would

Table 3. Summary Statistics for the 1985 September Wheat Contract Observed in February

Variables	N	Mean	SD	Min.	Max.
Chicago Board of Trade					
RM	8	19.296	6.0215	10.911	28.398
TWM	17	26.164	1.4714	25.000	29.412
VOL	17	368.41	182.69	72.000	788.00
DVAR	17	33.374	3,961.0	−7,814.1	10,882.0
Kansas City Board of Trade					
RM	14	96.798	73.866	18.898	312.25
TWM	18	54.189	17.163	37.500	112.50
VOL	18	154.00	127.12	18.000	514.00
DVAR	18	133.52	3,823.8	−9,595.2	9,096.8

Table 4. Summary Statistics for the 1985 March Wheat Contract Observed in March

Variables	N	Mean	SD	Min.	Max.
Chicago Board of Trade					
RM	9	20.915	9.0713	6.1512	34.927
TWM	13	27.752	4.5242	25.000	41.087
VOL	13	1,047.3	299.29	522.00	1,593.0
DVAR	13	4,515.9	14,329.0	−6,217.7	49,607.0
Kansas City Board of Trade					
RM	5	113.71	128.33	18.898	326.60
TWM	13	54.957	29.352	25.000	125.00
VOL	13	159.31	188.64	17.000	584.00
DVAR	13	580.23	30,969.0	−73,943.0	75,905.0

expect the CBT to have lower costs and higher volume than the KCBT. Also presented in each table are the number of observations for each set representing the number of days of trading in the contract analyzed, or the number of days for which the Roll measure could be calculated.[6]

A comparison of the mean values of *TWM* and *RM* from each observation set indicates differences in liquidity costs from month to month and between exchanges. One-quarter of a cent, or 25 hundredths of a cent, is the smallest possible tick in wheat futures contracts. Thus, the minimum possible value for *TWM* (representing the lowest possible liquidity cost) is 25, representing $12.50 for a 5,000-bushel contract. Since *RM* cannot be calculated if price changes are positively autocorrelated, values of *RM* must be greater than zero. In general, the *RM* results are consistent with those for *TWM*. However, there are several differences worthy of specific attention. First, it is precisely when liquidity costs are likely to be high that we found problems with positive autocorrelation in the price changes. In tables 3, 4, and 7, the number of days when *RM* could not be calculated ranged from 22% to 64% of the monthly totals. In tables 3 and 4, this led to calculated average *RM*s for CBT of 19 and 21 hundredths of a cent, respectively—the two lowest values of *RM*, when one would expect the largest. On the other hand, the two measures agree on the increased liquidity costs of trading at the KCBT. Also, in months where liquidity costs are expected to be higher (distant contracts and contracts trading during the expiration month), the correlations between *TWM* and the *RM*s which could be calculated are

Table 5. Summary Statistics for the 1985 July Wheat Contract Observed in March

Variables	N	Mean	SD	Min.	Max.
Chicago Board of Trade					
RM	20	26.620	6.9562	9.3113	38.936
TWM	20	25.636	.90796	25.000	28.095
VOL	20	3,019.6	1,722.7	858.00	7,922.0
DVAR	20	135.97	5,249.8	−8,595.2	10,668.0
Kansas City Board of Trade					
RM	16	41.484	15.662	12.127	73.787
TWM	20	29.655	4.5039	25.000	39.394
VOL	20	545.95	258.54	156.00	1,143.0
DVAR	20	254.07	2,745.9	−5,192.5	5,090.9

Table 6. Summary Statistics for the 1985 July Wheat Contract Observed in April

Vari-ables	N	Mean	SD	Min.	Max.
Chicago Board of Trade					
RM	19	29.154	4.6317	17.816	36.400
TWM	19	25.273	.38446	25.000	26.356
VOL	19	4,646.7	2,716.3	1,681.0	13,215.0
DVAR	19	−94.422	6,287.9	−12,701.0	11,373.0
Kansas City Board of Trade					
RM	17	39.856	7.3781	26.656	52.780
TWM	20	28.441	3.2312	25.000	37.500
VOL	20	1,059.8	640.84	182.00	2,770.0
DVAR	20	4.1585	2,766.6	−6,457.9	4,160.4

positive and generally large.[7] To simplify presentation of further results, attention will be focused on *TWM,* and will return to *RM* when the relationship between liquidity and other factors is examined in a regression context.

Liquidity costs in several observation months taken from the CBT are close to the minimum value of 25. For Chicago contracts near but not in the expiration month, mean liquidity costs are extremely close (within one hundredth of a cent) to minimum values. Standard deviations of *TWM* for these contracts are also very small—in the neighborhood or less than one hundredth of a cent. *TWM* values from the two expiration months in Chicago differ from the other months analyzed and from each other. Mean liquidity costs for the Chicago March contract observed in March are not much higher than those in the other months analyzed (27 hundredths of a cent), although the standard deviation of *TWM* is much greater (4.5 hundredths of a cent). In contrast, mean liquidity costs for the Chicago May contract observed in May are much higher than those in other months analyzed (over 42 hundredths of a cent), as is the standard deviation of liquidity costs in this month (6.5 hundredths of a cent).

Liquidity costs in all observation months taken from the KCBT are uniformly greater than the comparable months traded in Chicago. None of the mean values of *TWM* in the Kansas City contracts are as close to the minimum value of 25 as are the Chicago values. Standard deviations of *TWM* are also greater for the Kansas City contracts than for the Chicago contracts. The months with the lowest mean liquidity costs in Kansas

Table 7. Summary Statistics for the 1985 May Wheat Contract Observed in May

Vari-ables	N	Mean	SD	Min.	Max.
Chicago Board of Trade					
RM	5	33.556	16.184	13.271	51.769
TWM	14	42.380	6.4641	33.224	53.636
VOL	14	399.29	369.92	101.00	1,354.0
DVAR	14	13,232.0	50,928.0	−26,709.0	179,320.0
Kansas City Board of Trade					
RM	5	123.50	128.23	50.000	350.00
TWM	13	69.112	28.485	40.000	150.00
VOL	13	98.538	132.91	6.000	502.00
DVAR	13	1,244.8	11,477.0	−21,495.0	22,588.0

Table 8. Summary Statistics for the 1985 July Wheat Contract Observed in June

Variables	N	Mean	SD	Min.	Max.
Chicago Board of Trade					
RM	19	33.600	3.3581	29.156	44.175
TWM	19	25.235	.46563	25.000	27.020
VOL	19	3,936.8	1,783.7	1,965.0	7,778.0
DVAR	19	371.81	5,248.7	−13,215.0	10,200.0
Kansas City Board of Trade					
RM	19	41.877	9.0928	27,951	58.943
TWM	19	26.308	1.2824	25.000	29.110
VOL	19	1,782.3	560.39	922.00	3,489.0
DVAR	19	37.800	3,072.3	−5,867.5	4,188.0

City are those close to maturity but not in the expiration month. Liquidity costs for these contracts range between 28 and 30 hundredths of a cent, with standard deviations ranging from approximately 1.3 to 8 hundredths of a cent. Mean liquidity costs in the expiration months and in the contract distant from maturity in Kansas City are more than twice minimum values, ranging from 54 hundredths of a cent to 69 hundredths of a cent, with standard deviations ranging between 17 and 28 hundredths of a cent.

These results indicate that liquidity costs are greater in Kansas City than in Chicago, that liquidity costs are greater in contracts distant from maturity in Kansas City, and that liquidity costs are greater in the expiration month in both Kansas City and Chicago.

There are also differences between Kansas City and Chicago in mean levels of trading volume and in the relationship between mean values of *VOL* and *TWM*. Volume of trading is consistently greater in Chicago contracts than in the comparable Kansas City contracts. As hypothesized, higher mean values of *VOL* are associated with lower mean values of *TWM* in both Chicago and Kansas City. There is no obvious difference between mean values of *DVAR* in Chicago and Kansas City. However, as hypothesized, mean values of *DVAR* are positively associated with mean values of *TWM* in both Chicago and Kansas City. These relationships are explored further below.

Regression Analysis

Data from the seven contracts at each of the exchanges are pooled in a regression to test the relationship between liquidity costs, price variability, and volume. Slope and intercept shifters indicating the exchange on which the contract is traded and whether the contract was observed in the month of expiration are also included in the regression model.

The form of the relationship between liquidity costs (either *TWM* or *RM*) and its determinants is assumed to be as follows:

$$(1)\quad LOGLM^k_{ij} = \beta_0 + \beta_1 LOGVOL^k_{ij} + \beta_2 DVAR^k_{ij} + \beta_3 KC^k_{ij} + \beta_4 EXP^k_{ij} + \beta_5 KCLV^k_{ij} + \beta_6 KCDVAR^k_{ij} + \beta_7 EXPLV^k_{ij} + \beta_8 EXPDVAR^k_{ij} + e^k_{ij}.$$

For the *i*th market (Kansas City or Chicago) in the *j*th time period (January through June of 1985) for the *k*th contract (March, May, July, and September), *LOGLM* is the natural logarithm of either *TWM* or *RM*; *LOGVOL*, the natural logarithm of daily trading volume; *DVAR*, the first difference of the daily price variance; *KC*, a dummy variable representing the exchange, with Kansas City = 1 and Chicago = 0; *EXP*, a dummy variable indicating whether the contract is observed in its expiration month (*EXP* = 1) or not (*EXP* = 0); *KCLV*, the interaction of *KC* and *LOGVOL*; *KCDVAR*, the interaction of *KC* and *DVAR*; *EXPLV*, the interaction of *EXP* and *LOGVOL*; *EXPDVAR*, the interaction of *EXP* and

DVAR; and *e*, an error term. Thus, β_0, β_1, and β_2 represent the intercept, trading volume effect, and variance effect, respectively, for the CBT in months other than the expiration month. The other coefficients are adjustments that must be made to these effects for the Kansas City exchange (β_3, β_5, and β_6) or for expiration months (β_4, β_7, and β_8).

The choice of liquidity measure (*TWM* or *RM*) made some qualitative difference in the regression coefficients, but not in the regression diagnostics. Therefore, the same econometric procedures were followed for both regressions. In discussing the results, focus first will be on the results using *TWM*. Results using *RM* as the dependent variable will be discussed if they differ from the *TWM* regression results.

Initial estimates of equation (1) by OLS had expected signs. That is, increased volume was associated with lower liquidity costs. The negative impact of volume on liquidity costs was larger for the Kansas City exchange and in delivery months (the coefficients of *KCLV* and *EXPLV* are both negative and significant). Increased risk (as measured by *DVAR*) was associated with higher liquidity costs and, again, the impact was larger for Kansas City and in delivery months. Intercept dummies suggest that liquidity costs are higher in Kansas City and in delivery months. However, these interpretations must be tempered because residuals diagnostics suggest that the residuals are both autocorrelated and heteroskedastic.[8] Thus, while the OLS coefficient estimates are unbiased, they are inefficient and their standard errors are biased and inconsistent, invalidating any hypothesis tests performed using the OLS estimates of equation (1).

Since autocorrelation is a problem with the first moment of the distribution of the errors, we chose to correct it first by employing the estimated coefficients of the lagged residuals (which were used to test for autocorrelation as described in endnote 8) to transform observations (including the first observation from each month) from each exchange. After addressing the autocorrelation problem, the changing variance was confronted. The Breusch–Pagan (BP) test is a general test for heteroskedasticity. Because some restrictions on the form of the changing variance must be postulated, it was hypothesized that the variance is constant within an observation month at each exchange, but varies from month to month and between exchanges. These estimates of the variance were then used to transform the data once again to correct for heteroskedasticity.

To test the hypothesis that the variance is constant within an observation month at each exchange, but varies from month to month and between exchanges, the original data set was divided into the seven different observation months at each exchange. A regression of daily values of *LOGLM* on *DVAR* and *LOGVOL* was performed for each observation period to isolate the months. If the variance is constant within months but changes from month to month, no heteroskedasticity should appear in the regressions which consider each month separately. None of the BP tests performed for the 14 separate regressions were significant. Thus, our hypothesis that the variance is constant within months but not between months was supported.

To correct for the nonconstant error variance in the final regression, OLS was first performed using the transformed data. The residuals from this regression were used to estimate the changing variance for each month for each exchange. These estimates of the variance, which ranged from .0003 to .19, were then used to calculate weights which were scaled to sum to the number of observations and used in a weighted least squares procedure. The scaling has the effect of leaving the overall estimate of the variance from the final regression unchanged. The results of the final regression equation using the logarithm of *TWM* as the dependent variable are presented in table 9. Results of regressions using the logarithm of *RM* as the dependent variable are given in table 10. No significant autocorrelation or heteroskedasticity was detected in either regression.

The results of the final regression using *TWM* as the dependent variable indicate that, in Chicago in nonexpiration months, liquidity costs are not significantly related to trading volume and to changes in price variability. While the coefficients on *LOGVOL* and *DVAR* have expected signs, they are not statistically significant at the .05 level. These findings are not surprising given the lack of variability found in values of *TWM* in Chicago in nonexpiration months.

Table 9. Final Regression Analysis Results—*TWM* Dependent Variable

Variable Name	Estimated Coefficient	Standard Error	t-Ratio
CONSTANT	3.259*	.044	74.675
LOGVOL	−.004	.005	−.699
DVAR	.001	.000	1.409
KC	.679*	.111	6.089
EXP	.933*	.184	5.064
KCLV	−.085*	.015	−5.711
KCDVAR	.007*	.002	3.045
EXPLV	−.107*	.030	−3.611
EXPDVAR	.001	.001	.825

Durbin–Watson Statistic = 2.150
R^2 = 0.999
Breusch–Pagan Statistic = 13.283 with 8 degrees of freedom

Note: The logarithm of the Thompson–Waller measure (*TWM*) of liquidity was used for regressions. Results are GLS with each exchange corrected for $ar(1)$ errors and variances which change for each contract.
* Indicates significance at the .05 level.

Tests were performed of the joint significance of *KC*, *KCLV*, and *KCDVAR*, and of *EXP*, *EXPLV*, and *EXPDVAR* to determine if the relationships between liquidity costs and their hypothesized determinants significantly differ between exchanges and between expiration and nonexpiration months, respectively. The null hypotheses of no differences between exchanges or between expiration and nonexpiration months are rejected at the 5% level according to Wald tests (Wald statistic = 56.87, which is χ^2 with three degrees of freedom for the first test, and Wald statistic = 60.58 with three degrees of freedom for the second test). The intercept shifter *KC* indicates that (everything else held constant) liquidity costs are higher in Kansas City than in Chicago. The significantly negative slope shifter involving *KC* and *LOGVOL* indicates that liquidity costs are more sensitive to volume in Kansas City than in Chicago. The significant positive slope shifter involving

Table 10. Final Regression Analysis Results—*RM* Dependent Variable

Variable Name	Estimated Coefficient	Standard Error	t-Ratio
CONSTANT	2.548*	.286	8.922
LOGVOL	.106*	.035	3.068
DVAR	−.006	.004	−1.585
KC	2.519*	.623	4.042
EXP	2.862*	.826	3.465
KCLV	−.278*	.082	−3.391
KCDVAR	.003	.011	.281
EXPLV	−.434*	.127	−3.404
XPDVAR	.018	.011	1.568

Durbin–Watson Statistic = 1.829
R^2 = 0.983
Breusch–Pagan Statistic = 4.971 with 8 degrees of freedom

Note: The logarithm of Roll's measure (*RM*) of liquidity was used for regressions. Results are GLS with each exchange corrected for $ar(1)$ errors and variances which change for each contract.
* Indicates significance at the .05 level.

KC and *DVAR* indicates that liquidity costs are also more sensitive to changes in price variability in Kansas City than in Chicago. The expiration month intercept shifter is positive and significant, indicating higher liquidity costs in expiration months. The slope shifter involving the *EXP* and *LOGVOL* is negative and significant and indicates that liquidity costs are sensitive to volume in expiration months at both exchanges. However, the positive slope shifter involving *EXP* and *DVAR* is insignificant, suggesting that liquidity costs are no more sensitive to changes in price variability in expiration months.

The results of the final regression using *RM* as the dependent variable differ from those using *TWM* as the dependent variable in that the signs of the coefficients on *LOGVOL* and *DVAR* are reversed, and the coefficient on *LOGVOL* is significantly positive.[9] Recall that values of *RM* are much more variable than values of *TWM,* even in nonexpiration months in Chicago. This higher degree of variability in *RM* may explain in part why *LOGVOL* is significantly related to liquidity costs during nonexpiration months in Chicago. However, the sign on *LOGVOL* is surprising and suggests that the supply of market-making services is not perfectly elastic in wheat futures in Chicago. The coefficients on the slope and intercept shifting variables involving exchange and expiration month effects are qualitatively similar across regressions. Taken together, they suggest that liquidity costs are higher, and decrease with increases in volume, in Kansas City and in expiration months.

Summary and Implications

The objectives of this study were to: (*a*) quantify differences in liquidity costs between Kansas City and Chicago wheat futures contracts, and (*b*) determine the factors which influence liquidity in these two markets. Two proxies for liquidity costs were used. Liquidity costs as measured by the mean absolute value of intra-day price changes (*TWM*) are higher on average in Kansas City. Monthly averages of *TWM* are from 4% to 100% higher in Kansas City, depending on contract expiration and observation period. Liquidity costs based on the covariance of intra-day price changes (*RM*) differ from those based on *TWM* by their relative estimation of the size and variability of liquidity costs. *RM*s for Kansas City are 25% to 400% higher than those in Chicago, suggesting that the magnitudes of liquidity cost differences are much larger than one would conclude from *TWM*. *RM*s are also more variable than *TWM*s by factors ranging from two to 40. Comparisons of these monthly averages to those of volume and price variability further indicate that liquidity and volume are positively related, while price variability is negatively associated with liquidity.

To analyze these relationships further, a regression model was specified relating liquidity costs to volume and price variability. Initial estimation revealed problems with autocorrelation and heteroskedasticity in the errors. We first made a correction for autocorrelation. The changing error variance was shown to be related to contract month and observation periods. That is, for a given contract and monthly trading period, the regression error variance is constant, but it changes from contract to contract and month to month. This finding led to the use of monthly variance estimates, calculated using residuals from an OLS regression on data transformed to account for first-order autocorrelation, in a weighted least squares procedure. Results of the final specification do not reject the hypothesis of white noise errors.

Regression results suggest that there are significant differences in liquidity costs between Chicago and Kansas City which are in part due to the lower trading volume at Kansas City. However, there appears to be a significantly higher cost of doing business at Kansas City which is independent of trading volume, as reflected in the significant increase in the intercept for Kansas City. The results of the *TWM* regression also suggest that liquidity costs in Kansas City are sensitive to changes in price variability. On average, liquidity costs at both exchanges are higher and more sensitive to trading volume in expiration months.

The implications of these findings to traders is that transacting is more expensive in

Kansas City than in Chicago. Using *TWM* as a measure, the difference in transactions costs ranges from a minimum of \$.54 per contract for the July wheat contract traded in June to \$14.01 per contract for the lightly traded September contract traded in February. While certainly smaller than commission costs for off-floor traders (which may be as high as \$80 per contract on either exchange), these differences may be important for speculators in deciding between wheat futures contracts. For hedgers, these differences imply that one component of hedging costs is higher in Kansas City. Whether these costs are offset by the benefits derived from perhaps having a "closer" hedge in Kansas City depends on the predictability of the relationships between the cash price of the wheat hedged and the prices of the wheat futures traded in Kansas City and Chicago. For short-term "operational" hedges, such as are common for millers, a hedge in Chicago may be preferred since the basis between Kansas City and Chicago may be expected to remain fairly constant over a period of a few days.

The results of this study must be interpreted with caution because data from only one short time period were available for analysis. It is possible that some of the effects observed are peculiar to this time period. However, the liquidity costs and regression results found here for Chicago and Kansas City are consistent with those found for corn and oats traded at the CBT during 1984 and 1986 (Thompson and Waller 1988).[10]

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Notes

[1] Copeland and Galai; Glosten and Milgrom; and George, Kaul, and Nimalendran have pointed out and estimated an "adverse-selection component" in bid–ask spreads. That is, market makers may inflate their bid–ask spreads to cover losses they incur when trading with better informed traders. George, Kaul, and Nimalendran report that the adverse selection component in securities markets accounts for 8 to 13% of the quoted spread. However, findings regarding the adverse selection component are inconsistent and it is ignored in the subsequent analysis. Note, also, that the impact of contract value on liquidity in futures is likely to be minimal, since futures contract values are not highly correlated with the initial margin required to establish a position.

[2] As was pointed out to us by a reviewer, Roll's development depends on certain assumptions, which may or may not be applicable in the case of wheat futures. That is, if wheat futures price changes are nonstationary, one may find cases where the serial covariance of these price changes are positive. This is inconsistent with Roll's model and makes his measure of liquidity impossible to calculate.

[3] Glosten and Milgrom claim that Roll's measure underestimates the spread by a factor proportional to an adverse-selection component, and propose a modification to Roll's measure. Both methods have problems because the covariance in price changes is frequently positive, making calculation of an estimate impossible. George, Kaul, and Nimalendran show that in security markets both methods are biased, since returns contain positively autocorrelated components because of time variation in expected returns. Moreover, since transaction returns also contain a large "unexpected" return component, these estimates are inefficient as well (pp. 650–51). They offer a method to estimate the spread and its components using both transaction prices and published bid–ask quotes. Since bid–ask spreads are not available for wheat futures, the correction suggested by George, Kaul, and Nimalendran is not possible in this analysis.

[4] Because of the similarity in calculation between *TWM* and the daily variance, riskiness is measured here as the first difference in the daily variance. That is, *DVAR* for the ith day, for the jth contract is calculated as follows:

$$DVAR_{jt} = \Delta VAR^{i}_{jt}$$
$$= \frac{\sum_{t=2}^{T_i} (\Delta F^{i}_{jt} - \overline{\Delta F^{i}_{j}})}{T_i - 3} - \frac{\sum_{t=2}^{T_{i-1}} (\Delta F^{i-1}_{jt} - \overline{\Delta F^{i-1}_{j}})}{T_{i-1} - 3},$$

where F^{i}_{jt} is the price of the jth wheat futures contract on day i at tick t, and $\Delta F^{i}_{jt} = F^{i}_{jt} - F^{i}_{jt-1}$.

[5] This is due to the operating system of the computer used at the KCBT. For the first six months of 1985, the KCBT used an IBM system. Other than this six-month period, the system used at the KCBT is compatible with no other known system.

[6] The Roll measure cannot be calculated for days when the covariance of intra-day price changes is positive.

[7] Listed below are correlations of *TWM* and *RM* in less liquid months:

September in February		March in March		May in May	
Chicago	.18	Chicago	.64	Chicago	.75
KC	.89	KC	.82	KC	.91

[8] Because the sample is comprised of daily observations of different contracts on different exchanges, testing for autocorrelation is problematic. We chose to regress the OLS residuals on the lagged residuals and the right-hand-side variables from the original regression, omitting the first observation of each month. This was done separately for each exchange. The coefficient of the lagged residual is asymptotically normal. The t-values for Chicago and Kansas City residuals were 5.01 and 2.49, respectively. The Breusch–Pagan test (BP) for heteroskedasticity was significant (44.747 with eight degrees of freedom; the .05 critical level is 15.51).

[9] A reviewer pointed out to us that we have a missing data problem. The observations for which the *RM* is imaginary (i.e., *RM* is missing) were dropped when calculating the regression estimates.

[10] In the corn contracts considered, liquidity costs were very close to the minimum tick, except in the expiration month. In the more thinly traded oats contracts, where trading volume is normally similar or less than the Kansas City wheat contract, liquidity costs were always greater than the minimum tick, and ranged to more than twice the value of the minimum tick in the expiration month.

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