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Determinants of Liquidity Costs in Futures Markets

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Recently considerable interest has focused on measuring liquidity and its determinants in continuous auction markets like those for securities and futures contracts. Because the bid-ask spread is rarely observed, several researchers (Smidt, Roll, Glosten and Milgrom, and Thompson and Waller) have proposed methods for indirect estimation. Additionally, Thompson (1985) and Brorsen and Nielsen have investigated the influence of several factors on the cost of liquidity in commodity futures markets. In this paper we compare a selection of the proposed measures and provide information about factors that influence the ~~size of~~ liquidity costs in commodity futures markets. We also show how the effects of these factors differ across commodities.

Intra-day data from corn and oats futures contracts traded on the Chicago Board of Trade are analyzed. Various measures of liquidity costs are used in a regression analysis of factors that influence the size of liquidity costs. The performance of the alternative proxies in the regression analysis is considered to determine the most appropriate liquidity measure. Economic factors such as the difference in the variance of prices, the volume of trading, and the ratio of market-maker participation to total trading activity are considered as determinants of liquidity costs. Besides the economic variables, the possibility of day-of-the-week effects, months-to-maturity effects, and an expiration month effect on liquidity costs is investigated via the use of dummy variables. Data from corn and oats contracts are analyzed separately as well as together in the regression analysis to determine if the determinants of liquidity have similar effects across commodities.

II. Background

Whether publicly quoted as in securities markets, or implicit in observed price behavior as in futures markets, the bid-ask spread is the cost of immediate liquidity incurred when entering or exiting a market. It is also the accepted measure of liquidity in a market. Market-makers (scalpers in futures markets, specialists in securities markets) trade at prices separated by the bid-ask spread and are considered to be the providers of liquidity services. While not granted a monopoly by the exchange as are specialists in securities markets, scalpers may not always act in a competitive manner that minimizes the cost of liquidity. In thinner markets with fewer scalpers, the scalpers who are present may price their services in a monopolistic fashion. Therefore, the effect that scalpers have on a market depends to some extent on existing market liquidity, and the markets' ability to attract an adequate number of scalpers to insure competitive scalping (Jacobs).

Demsetz was the first to model the bid-ask spread formally. Subsequent research on securities markets [Logue; Tinic; Tinic and West (1971, 1974); Branch and Freed; and Stoll (1978a, 1978b)] indicates that certain common factors influence the bid-ask spread including the pace of trading activity, or trading volume, and the price of a security. Other factors including price volatility, competition between markets and market-makers, and the market-maker's financial condition have been shown to have importance in one or another of the studies.

Following research securities markets, Thompson (1985) suggested that liquidity in futures markets is a function of the time rate of transactions, the ratio of scalper to total trading activity, price variability, and the size of a market order. At the same time she recognized that there may be some simultaneity between liquidity and its determinants. Thompson and Waller found evidence that liquidity costs in futures markets are inversely related to trading activity and that liquidity costs are lower in nearby contracts than in distant contracts. Brorsen and Nielsen used total trading volume and a set of dummy variables representing seasonality and months-to-maturity in a model of liquidity costs.

III. Measures of Liquidity

Various methods have been proposed for estimating liquidity costs or for measuring relative differences in liquidity. Methods proposed by Smidt and by Thompson (1984) are similar in that they are both based on the absolute value of price changes. Smidt proposed grouping transactions prices into three catagories--no change from previous price, change in same direction as the previous price change, and change in opposite direction of previous price change--and estimating the spread from the third group as the minimum price change greater than seventy-five percent of the observations. Thompson suggested using the average of the absolute value of price changes as a direct measure of the average execution cost of trading in a contract. The average of the absolute value of price changes is determined by the average bid-ask spread, by the frequency of constant real price across transactions, and by the size of the average real price change. Thompson (1984) also proposed the degree of negative dependence in price changes as reflected in the autocorrelation coefficient as a measure of liquidity that does not depend on price levels. Therefore, it can be used in comparisons across contracts and time periods.

Measures proposed by Roll and by Glosten and Milgrom are based on the estimated covariance of prices. If markets are informationally efficient, the covariance between price changes is negative and directly related to the bid-ask spread. Roll proposed measuring the bid-ask spread with the following transformation of the first-order serial covariance of price changes.

$$RM = 2\sqrt{-\ covj}$$

where:

RM = Roll's measure of the dollar spread for asset (j).

covj = serial covariance of price changes for asset (j).

Glosten modified this measure by accounting for informational assymmetry between investors and the market-maker. Glosten and Milgrom claim that Roll's measure underestimates the spread by a factor proportional to an adverse selection component. Bhattacharya compared a generalized version of Roll's method with that of Glosten and Milgrom and found that both methods have problems because the covariance in price changes is frequently positive, although less so under Roll's method, and negative numbers occur beneath the square root signs in estimation equations. The negative estimates produced by both methods are a problem since the spread should be positive. Moreover, when compared to benchmark spreads, both methods frequently underestimate the spread, with the Glosten method underestimating the spread more. Roll's measure is investigated further below.

The measures of liquidity costs used in the regression analysis are:

TWM - The average of the absolute value of price changes as proposed by Thompson and Waller.

RM = Roll's measure.

AUTOCOF - The first order autocorrelation coefficient.

STD = The standard deviation of prices.

Under very restrictive assumptions these measures are closely related. For example, if price changes are not due to new information entering the market but only due to movements between bid and ask prices, the Roll measure equals the average of the absolute value of price changes. The Roll measure is also clearly related to the autocorrelation coefficient. If the distribution is symmetric and the mean is zero, the average of the absolute value of price changes is equal to the mean deviation, which is under these assumptions approximately equal to eighty percent of the standard deviation (Yule and Kendall). The standard deviation is used as a measure in part to test whether these assumptions hold in futures prices, and also because Brorsen and Nielsen use the standard deviation as a measure of liquidity costs.

There are no recorded bid-ask spreads at which trades occured from futures contracts to compare with the measures to determine the most accurate or appropriate measure. Therefore, the measures can only be compared to expected patterns of behavior based on theory and past research. Thompson and Waller and Brorsen and Nielsen suggest that the cost of liquidity increases as the time to maturity increases and as trading volume decreases. Corn futures contracts are generally considered to be to be more heavily traded and more liquid than the relatively thinly traded oats contracts. Therefore, it is expected that liquidity costs are higher in the more thinly traded oats contracts than in corn contracts. The cost of liquidity has been suggested to be around one quarter of a cent, or the minimum tick, or less in corn futures contracts (Working). The measures will also be evaluated as dependent variables in the regression analysis by their relationship to the independent variables proposed below. The significance and the direction of these relationships as well as the overall goodness-of-fit of the models will be used in the evaluation.

IV. Models of Liquidity Costs

The size of the bid-ask spread reflects the costs, risks, and competition faced by scalpers in the market. In reviewing past studies of different markets, certain common factors emerge that affect the bid-ask spread in all markets. Each market also has certain factors that affect liquidity and the bid-ask spread that are unique or more important to that specific type of market. We propose that in futures markets the primary economic factors that determine liquidity costs include: A, the amount of trading activity, or the time rate of transactions in the trading period; S/A, the ratio of trading activity by scalpers to overall trading activity; σ^2_p, equilibrium or real price variability; and Z, the size of a market order. The determinants of liquidity at a given point in time are assumed to be exogenous to the scalper.

$$LC = f(A, S/A, \sigma^2_p, Z) \tag{1}$$

Following Demsetz, A is expected to be negatively related to liquidity costs. Increased trading activity allows faster rates of inventory turnover for the scalper thus reducing the time and information risk faced by scalpers associated with a change in real price. Since a decrease in risk can be considered a decrease in perceived costs faced by the scalper, liquidity costs should decrease as trading activity increases. This relationship implies that active scalping does not create liquidity, but instead thrives on liquidity.

The expected negative relationship between S/A and liquidity costs follows from an assumption that there is some equilibrium ratio of scalpers to market activity at which the bid-ask spread reaches a competitive minimum. Increases in trading activity with no increase in the number of scalpers may result in spreads increasing beyond a competitive minimum as either scalping costs increase or scalpers earn rents for market-making. Under competitive conditions, this should attract more scalpers to the trading pit and eventually reduce spreads to competitive minimum levels.

σ^2_p is expected to be positively related to liquidity costs since price variability reflects the risk of a real price change faced by scalpers when inventorying futures contracts. As this risk increases, the size of the bid-ask spread increases to cover or offset the increase in potential scalping costs.

Finally, the relation between Z and liquidity costs is expected to be positive--larger orders create greater risk for market-makers. The likelihood of a real price change also increases with Z as large values of Z may imply a change in market conditions. Unfortunately, data on the size of each order are not available and this factor is dropped from further consideration.

Other researchers have suggested additional variables such as price or contract value and variables representing seasonality to explain the bid-ask spread in commodity futures markets. Demsetz suggests that the price of a security may be positively related to the size of the bid-ask spread, arguing that the spread per share may increase in proportion to increases in the price of the asset, thereby equalizing the costs of transacting per dollar exchanged. However, in futures, the value of a contract is not closely related to the initial margin, the amount of money required to hold a futures position. The margin is determined by a combination of the contract value, trading risks as perceived by the exchange, and the current allowable limits on daily price movement. Changes in margin requirements usually are infrequent and made only when a substantial change is needed. For this reason, the percentage return can not be accurately calculated from the price level or the contract value.

Brorsen and Nielsen suggest that seasonality may act as a proxy for the quantity of new information entering or expected to enter a market. If the amount of new information entering the market increases or is expected to increase, scalpers would perceive this as an increase in risk, and increase the size of bid-ask spread. However, this same information should be captured by changes in the variance of prices, σ^2.

Brorsen and Nielsen also consider the months to maturity of a contract to be important in determining liquidity costs. Following Samuelson and Anderson, they argue that the variance of prices may increase as a contract matures, adding that the composition of traders also may change as the contract matures. If market orders are more frequent as maturity approaches, there will be more opportunities for scalping.

Although day of the week effects previously have not been considered for liquidity costs, somewhat mixed evidence suggests that there may be a day of the week effect for futures prices (Chaing and Tapley, Gay and Kim).

Finally, it is possible that there may be an expiration month effect because traders face an additonal risk when trading in the delivery month, the risk of becoming involved in delivery of the physical commodity. This added risk may lead to an increase in the bid-ask spread.

The following basic model of liquidity costs includes only primary economic factors as proposed in (1):

$$LC_{ij} = b_{1j} + b_{2j}(DVAR) + b_{3j}(LSCTTV) + b_{4j}(SCT1A) + e_{ij} \qquad (2)$$

where: LC_{ij} = The measure of liquidity costs for the ith observation in the jth equation,

DVAR = the first difference of the variance of prices,

LSCTTV = the amount of trading activity as measured by the log of trading volume,

SCT1A = the ratio of scalper trading volume to total trading volume in contracts, and,

e_{ij} = the ith error term for the jth equation.

j = 1, 2, 3, 4--four regressions for the four possible dependent variables.

The first difference of the variance of prices, DVAR, is used instead of the variance as an independent variable since the variance is calculated in much the same manner as some of the measures of liquidity. The change in the variance, reflecting changes in price variability, may also be a superior representation of price risk as perceived by scalpers.

An expanded, or unrestricted, model is also considered that includes a number of dummy variables that may account for variability in market liquidity that is not captured by the variables in the basic model.

$$LC_{ij} = b_{1j} + b_{2j}(DVAR) + b_{3j}(LSCTTV) + b_{4j}(SCT1A) + b_{mj}(day) + b_{9j}(EXP) + b_{10j}(MTD) + e_{ij} \quad (3)$$

where: b_m ($m = 5, 6, 7, 8$) represents the coefficients on the days of the week (Tuesday through Friday) dummy variables,

EXP = 1 if trading in the expiration month, else = 0,

MTD = Months from contract delivery,

other variables are as defined earlier.

Past research modeling the bid-ask spread has used ordinary least squares and has assumed the independent variables to be exogenous. As mentioned, the right hand side variables may be simultaneously related to each other and to the left hand side variables. Hence, the direction of causation between the independent and the dependent variables may not be completely one directional.

The exact functional form of the equation is not well defined by economic theory or past research. Demsetz suggested that both a linear and a semi-log form may fit well and be theoretically explainable. In this analysis, the final model and the forms of the variables to be used were determined by the goodness-of-fit of the model and the significance and the appropriateness of the signs of the regression coefficients. The most reasonable are reported.

V. ~~III~~. The Data

The data are taken from the Chicago Board of Trade Market Profile data series. The Profile data include three series: time and sales data, the liquidity data bank summary data, and the open, high, low, and closing prices along with volume and open interest each day.

Time and sales data are a consecutive record of intra-day prices on a tick basis. Every time a trade occurs at a price different from the last price, a price observation is recorded. The data set also includes the time of day of each such trade.[1,2]

The liquidity data bank includes information about volume of trading at various times and prices throughout the day aggregated over half-hour intervals. Volume data are grouped into four catagories representing the types of traders making transactions as follows: (1) the person executing the trade was trading for his/her own account or an account which he/she controlled; (2) the person executing the trade was trading for his/her clearing member's house account; (3) the person executing the trade was trading for another member present on the exchange floor, or for an account controlled by another such member; and (4) the person executing this trade was trading for any other type of customer. Category one is the group that we assume includes market-makers.

The Profile data allow for a more complete modeling of liquidity than has been possible in past studies. However, there are some limitations. Due to time and computer constraints associated with the large amount of data available, this study analyzes a selected sample of the Market Profile Data. The analysis is performed on four contract months for two commodities during two years. Month long data samples are selected for certain periods during the life of each contract, for each commodity, as explained below.

As mentioned earlier, the commodities studied are corn and oats. Corn is a major crop in the United States, while oats has been decreasing in relative importance in the agricultural sector. In 1984, CBOT corn traded 9,108,526 contracts, while oats traded 155,110 contracts (<u>CRB Yearbook</u>, 1985). The difference in trading volumes between the two commodities allows for comparisons of liquidity between commodities with different levels of trading activity.

The analysis is performed using eight sample periods of data. Four one-month periods of data are from the corn market, and four one-month periods are from the oats market. Although data are available between June of 1983 and December of 1986, samples are selected from 1984 and 1986 since those years are characterized by trading that was more active and variable and may provide more information regarding the determinants of liquidity. Each of the four months of price data for a commodity is taken at different times to maturity to consider the possibility of a maturity effect and an expiring contract effect. Table 1 shows the data used in this study. The table includes the commodities used (comm.), the contract months used (contract), the months in which observations are taken (obs. period), the contract year, the number of months before the contract expires (time to maturity), whether or not the contract is in its expiring month (expir.), and whether or not the observations are taken during the "critical information period".

The contracts selected for analysis are March, May, July, and December for corn, and March, May, September, and December for oats. The first contract of the crop year is selected for each commodity, as well as three other contracts that expire later in the crop year. Observations are taken from the expiring month of the May contract for both corn and oats, one month before expiration for the March contract for both corn and oats, eight months before expiration, and during a period of critical growing conditions for each commodity. The months of critical growing conditions are assumed to be July for corn (pollination), and June for oats (head filling and disease susceptibility).

Table 1 Description of the Data Used in the Study

Comm	Contract	Obs. Period	Contract Year	Time to Maturity	Expir.	Critical Period
Corn	May	May	1986	0 months	yes	no
	Mar.	Feb.	1984	1 month	no	no
	Dec.	July	1986	5 months	no	yes
	July	Nov.	1984	8 months	no	no
Oats	May	May	1986	0 months	yes	no
	Mar.	Feb.	1984	1 month	no	no
	Sept.	June	1986	3 months	no	yes
	Dec.	April	1984	8 months	no	no

The measures of liquidity as well as the other variables that are used in the analysis are calculated over both half-hour and daily intervals. Daily measures are calculated for each measure using the tick data for each day. For TWM the daily mean estimate is used. Variables such as the ratio of scalper trading volume to total trading volume are summed over the half-hour intervals in each day to obtain a value for each day. Half-hour estimates are calculated in the same fashion except that half-hour intervals are used instead of day long intervals. The daily results are the most important and these are discussed first.

VI. Results

Summary statistics for the various measures of liquidity costs in corn and oats contracts based on daily data intervals are presented in Table 2. Regression results also based on daily intervals are presented for the expanded model in Table 3 for corn and in Table 4 for oats. Regression results for the basic model are presented in Appendix A1 for corn and in Appendix A2 for oats. The day of the week dummies were never jointly significant in any of the regressions and are not included in the estimates reported here.

The various measures differ substantially from each other and often from expectations. The estimates produced by AUTOCOF are consistently negative, as expected, for corn contracts, but not for oats. The average of the absolute value of price changes (TWM) provides estimates that are the most consistent with theoretical expectations. Mean values of TWM decrease as the months to contract maturity decrease, except in the expiring month where the values increase. Moreover, at comparable lengths from maturity, TWM values for corn are smaller than those for oats. Roll's measure

Table 2. Summary Statistics for the Various Measures of Liquidity Costs, in Hundreths of a Cent, Daily Estimates

	CORN						OATS				
Variable	N	Mean	Std. Dev.	Min.	Max.	Variable	N	Mean	Std. Dev.	Min.	Max
	1986 May Corn Sampled in May						1986 May Oats Sampled in May				
TWM	14	31.02	5.56	25.89	45.71	TWM	14	53.71	14.88	33.33	83.33
RM	8	24.75	14.23	5.20	45.24	RM	2	20.99	29.69	0.00	41.98
AUTOCOF	14	-0.03	0.16	-0.29	0.27	AUTOCOF	12	0.13	0.18	-0.28	0.50
STD	14	115.37	52.06	63.02	251.71	STD	14	88.76	42.18	37.50	175.07
	1984 March Corn Sampled in Feb.						1984 March Oats Sampled in Feb.				
TWM	20	24.98	0.06	24.79	25.11	TWM	20	34.49	5.65	28.07	47.96
RM	20	37.95	3.11	31.04	43.16	RM	19	30.95	10.55	7.43	52.05
AUTOCOF	20	-0.58	0.10	-0.75	-0.38	AUTOCOF	20	-0.18	0.11	-0.45	0.01
STD	20	70.54	48.57	35.22	246.22	STD	20	83.98	40.76	41.44	219.72
	1986 Dec. Corn Sampled in July						1986 Sept. Oats Sampled in June				
TWM	22	25.04	0.17	24.80	25.62	TWM	21	34.63	4.94	25.00	46.88
RM	22	36.35	3.29	30.23	43.84	RM	7	22.73	12.43	4.75	42.12
AUTOCOF	22	-0.53	0.09	-0.77	-0.36	AUTOCOF	21	0.09	0.19	-0.26	0.50
STD	22	59.61	18.01	26.26	96.36	STD	21	90.79	46.22	23.94	184.69
	1984 July Corn Sampled in Nov. 1983						1984 Dec. Oats Sampled in April				
TWM	21	25.38	0.56	25.00	26.92	TWM	20	37.92	9.67	22.50	57.14
RM	21	25.35	7.41	5.56	35.51	RM	15	35.98	19.88	0.00	84.73
AUTOCOF	21	-0.27	0.13	-0.50	-0.01	AUTOCOF	18	-0.21	0.27	-0.83	0.24
STD	21	101.30	51.99	39.54	227.46	STD	20	46.55	22.09	16.70	88.77

Table 3 Regression Results of the Expanded Model
Using Corn Data for Daily Intervals

	Dependent Variables							
	TWM		AUTOCOF		STD		RM	
Variables	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Intercept	40.69	4.41	-.51	.26	118.05	64.91	61.94	15.32
DVAR	3.70E-05	1.72E-05	7.88E-07	1.03E-06	2.19E-03	2.53E-04	-4.44E-05	6.75E-05
LSCTTV	-1.42	.67	--.07	.04	-9.70	9.83	-.40	2.26
SCT1A	-17.80	5.72	.41	.34	-33.08	84.19	-37.73	21.04
Exp.	0.59	1.76	0.59	0.11	38.64	25.95	-24.28	6.55
Mtd.	-0.04	0.13	0.03	0.01	3.77	1.84	-1.65	0.42
Adj. R^2	.57		.70		.56		.33	
D.W.	1.91		1.75		1.27		1.23	
#obs.	72		72		72		66	

Table 4 Regression Results of the Expanded Model Using Oats Data for Daily Intervals

	Dependent Variables							
	TWM		AUTOCOF		STD		RM	
Variables	Coef.	Std.Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Intercept	27.58	8.41	-.68	.22	39.33	29.68	81.12	16.18
DVAR	2.80E-04	8.54E-05	5.24E-06	2.08E-06	2.52E-03	3.01E-04	4.66E-04	1.92E-04
LSCTTV	-6.29	1.70	-.08	.04	.92	6.01	6.30	3.94
SCTIA	25.79	15.74	1.44	.41	110.08	55.53	-122.01	32.61
Exp.	7.19	4.48	-0.03	0.11	-8.94	15.83	1.86	10.23
Mtd.	-0.34	0.48	-0.01	0.01	-4.74	1.70	1.09	0.94
Adj. R^2	.54		.31		.57		.31	
D.W.	1.82		1.53		1.10		2.18	
#obs.	68		64		68		37	

produces estimates that often behave exactly the opposite of expectations and of the other measures. Furthermore, in many cases no RM estimates were possible because the covariances between price changes were positive.

Estimates of liquidity costs (TW measure) range from 24.98 to 31.02 hundredths of a cent for corn contracts, and from 34.49 to 53.71 for oats contracts. Hence, the estimated execution cost of trading for corn appears to be around one quarter of a cent as expected from past findings. The execution cost of trading for oats appears to be slightly greater than for corn. This is as expected since the oats futures market is thinner than the corn futures market and presents a more risky environment for scalpers. Estimates of liquidity costs are largest in the expiring contract for both corn and oats.

The regression results indicate that TWM performs as well or better than the other measures considered. The directional relationships between TWM and the independent variables are more consistent with theory than those of the other estimators. The overall fit is also generally better in the TWM regressions than for the other measures. TWM therefore appears to be the best measure of liquidity costs.

The results of the regression analysis using TWM suggest that the economic variables (DVAR, LSCTTV, SCT1A) are strongly associated with liquidity costs in both the corn and the oats markets. As expected, the change in price variance, DVAR, is positively related to liquidity costs, and trading volume, LSCTTV, is negatively related to liquidity costs. However, the magnitude of the effects of these variables on liquidity costs are not the same across commodities. The extent of scalper participation, SCT1A, has the greatest differential effect across commodities, entering negatively, as expected, with respect to corn liquidity costs, and positively with respect to oats liquidity costs. This probably occurs because scalpers and floor traders behave differently in the two markets. In larger, more liquid markets with more scalpers, scalpers may act in a very competitive manner and liquidity costs may be at a competitive minimum. In more thinly traded markets where the number of scalpers may be small, scalpers may act in a more monopolistic fashion since they have fewer competitors on the trading floor. An increase in the ratio of scalper trading to total trading volume in thin markets may not represent a competitive increase in the number of scalpers, but instead may reflect the domination of scalpers and other floor traders in sparse trading activity. The few scalpers may collect larger gross returns for services since they dominate trading.

Simple F-tests of the variance of the regressions using corn data compared to the variance of the regressions using oats data show that the variances are significantly different. Therefore, before combining the data sets, a correction is applied to the data to standardize the error variance of the regressions as suggested by Maddala. Each observation of the dependent and the independent variables is multiplied by the inverse of the standard deviation of the errors for that regression, either corn or oats. When the commodities are combined in the TWM regression for the basic model, all of the slope shifter variables as well as the intercept shifter are significant. Hence the effects of DVAR, LSCTTV, and SCT1A on liquidity costs differ across commodities.

Results are not clear regarding the value of MTD, the variable representing months to maturity, and EXP, the dummy variable representing trading in the expiration month. In the TWM regressions for corn and oats data separately, neither MTD nor EXP have significant t-statistics, nor are

Table 5 Elasticities for Corn and Oats Using TWM as the Measure of Liquidity Costs.

Variable	CORN Elasticities	OATS Elasticities
DVAR	+.0018	+.0027
LSCTTV	-.0551	-.1998
SCT1A	-.3754	+.5556

they jointly significant under the F-test in corn regressions. However, the F-test of the null hypothesis that MTD and EXP are jointly insignificant is rejected at the .05 level for oats data. In the combined data set, the F-test of the joint insignificance of these variables (including shifters for different commodities) is not rejected for any of the models. These results suggest that the dummy variables do not significantly improve upon the power of the basic economic variables in explaining liquidity costs.

Based on the regression results from the basic model, estimates of elasticities of liquidity costs with respect to DVAR, LSCTTV, and SCT1A are presented in Table 5. These estimates provide further evidence that the independent variables do not have the same effect on liquidity costs in corn contracts as in oats contracts. Liquidity costs in oats contracts are more sensitive to every variable in the basic model than liquidity costs in corn contracts. Hence, thinner markets appear to be more sensitive to variations in determinants of liquidity than are more actively traded markets.

The results of regressions using the other dependent variables are less satisfying. The significance of and signs on independent variables vary with the different dependent variables and whether the basic or expanded models are used. The results of the F-tests of the joint significance of months to maturity (MTD) and the expiration month (EXP) variables in individual corn and oats regressions are not clear, but suggest that these variables probably do not improve upon the explanatory power of the basic model.

Results Using Half-Hour Data

Identical analyses were performed using half-hour interval data. Due to more severe autocorrelation in the regressions based on half-hour data and extremely low R^2's, the results of these regressions are not discussed at length here. Only three regressions have Durbin-Watson statistics that assure no autocorrelation problems. In all three of these models the adjusted R^2 is .07 or lower, indicating that very little variation in the dependent variable is explained. Lower R^2's are not unusual in regressions of more disaggregated data. As the level of aggregation is reduced, factors that are not easily or normally included in regressions often become more important. These factors may be somewhat random and often "wash out" as the data is aggregated, but may be non-random and important in explaining variations in liquidity over much shorter time intervals.

The results from the basic model using TWM as the dependent variable with half-hour data for both corn and oats data are presented in Appendix B. The signs are the same in the half hour regressions as in the daily regressions with the exception of SCT1A for the oats data. DVAR enters positively and is significant for both corn and oats at the .05 level. LSCTTV and SCT1A both enter negatively in both corn and oats regressions, but they are only significant in the corn regression.

VII. Conclusions and Implications

The evidence presented in this study suggests that the most appropriate measure (of those tested) of liquidity costs in commodity futures markets is the average of the absolute value of the price changes, TWM. The fact that the measures are not closely related suggests that the assumptions underlying some of the measures may not hold. The assumption of strict informational efficiency necessary for the Roll measure may be violated in the data analyzed. Roll suggested that as the estimation interval was shortened to less than a weekly interval such problems could occur.

The economic variables proposed in the basic model are significantly related to liquidity costs as proxied by TWM. However, because the effect of the variables differ in magnitude and, for one variable, in direction across corn and oats contracts, the regression results may not be easily or accurately generalized across commodities. A better understanding of the trading in individual markets may be needed before the magnitude of the impacts of these variables can be established for other markets.

The regression results also suggest that the dummy variables do not improve over the explanatory power of the economic variables. If the dummy variables used in previous analyses do capture essentially the same effects as the economic variables proposed here, it may be more appropriate and precise to use economic variables in an empirical model of liquidity costs. However, the direction of causality may be clearer between certain dummy variables and liquidity costs than for the economic variables and liquidity costs.

Another implication of this study is that there may be some general level of liquidity and trading activity required to maintain a competitive scalping environment on the trading floor. The exchanges may need to take this into consideration both when planning the introduction of new futures contracts, and when dealing with problems in thin or illiquid contracts.

Finally, since the average absolute value price change in most corn contracts is approximately the minimum price change, one quarter cent, it is possible that reducing the size of the minimum price change would reduce liquidity costs. The minimum price change in the past was one eighth cent for both corn and oats contracts. Scalpers now may be willing to provide liquidity for a gross return of less than one quarter cent. However, if bid-ask spreads are already at a competitive minimum, then lowering the size of the minimum ~~price change~~ tick would not reduce liquidity costs. As suggested by Thompson and Waller, certain price changes are too small to warrant scalping.

The data set used for this study was narrow in scope. Extending the size of the data set to include other commodities, other time periods, and other exchanges would increase confidence in the results. Other variables that explain differences in the determinants of liquidity across commodities should be explored. The size of contracts traded and the size of market orders may also influence liquidity costs.

Endnotes

1. These data differ from transaction-to-transaction price data that record a price for every trade that is made, including trades made at the same price as the previous trade (zero price-change trades). Hence, the tick data provide less information than the transaction-to-transaction data. Lacking the additional information provided by the zero price change trades means that fewer aspects of liquidity can be analyzed. The distribution of prices can not actually be determined, since a portion of the data set is missing. However, since transaction-to-transaction data are not available for commodities traded on the Chicago Board of Trade, tick data are the best available data series.

2. Because a few bid and ask quotes are included in the original data series, some zero price change trades occur in the data set. A zero price change occurs in the data set if, for instance, a price is recorded for a trade, a bid is recorded next at a lower price but no trade occurs, then a short time later a trade occurs at the same price as the last recorded trade. We have deleted the bids and asks from the raw data set because trades did not occur at these prices when quoted. Hence, a few consecutive ticks at equal prices occur in the data set.

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Appendix A1 Regression Results of the Basic Model Using Corn Data for Daily Intervals

	Dependent Variables							
	TWM		AUTOCOF		STD		RM	
Variables	Coef.	Std.Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Intercept	42.13	1.76	.83	.13	203.43	26.66	10.10	8.27
DVAR	3.68E-05	1.70E-05	9.44E-07	1.25E-06	2.2E-03	2.57E-04	4.92E-05	7.67E-05
LSCTTV	-1.44	.48	-.23	.035	-23.07	7.19	6.40	1.91
SCT1A	-20.85	3.49	-.49	.26	-47.24	52.89	-11.69	14.67
Adj.R^2	.58		.55		.55		.13	
D.W.	1.91		1.83		1.38		1.27	
#obs.	72		72		72		66	

Appendix A2 Regression Results of the Basic Model Using Oats Data for Daily Intervals

	Dependent Variables							
	TWM		AUTOCOF		STD		RM	
Variables	Coef.	Std.Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Intercept	19.38	7.60	-.81	.18	-11.21	27.30	8.51	14.98
DVAR	2.92E-04	8.97E-05	5.34E-06	2.05E-06	2.56E-03	3.22E-04	4.44E-04	1.90E-04
LSCTTV	-7.80	1.15	-.06	.03	6.08	4.14	3.17	2.57
SCT1A	43.75	15.17	1.60	.36	176.41	54.49	125.82	31.61
Adj. R^2	0.50		.32		.51		.32	
D.W.	1.80		1.56		1.05		2.17	
#obs.	68		64		68		37	

Appendix B Regression Results of the Basic Model Using Data for Half-Hour Intervals, TWM Dependent Variable

	Corn		Oats	
	Coefficient	Standard Error	Coefficient	Standard Error
Intercept	31.36	0.60	34.55	2.70
DVAR	1.01E-04	3.67E-05	8.49E-04	1.38E-04
LSCTTV	- 0.83	0.17	- 1.24	.84
SCT1A	- 7.98	1.17	- 2.16	4.29
Adj.R^2	0.14		0.10	
D.W.	1.23		1.36	
#obs.	601		335	