DETERMINANTS OF DAILY FLUCTUATIONS IN LIQUIDITY AND TRADING ACTIVITY

TARUN CHORDIA, RICHARD ROLL AND AVANIDHAR SUBRAHMANYAM*

1. INTRODUCTION

Transaction expenses can accumulate to a relatively large decrement in total return when portfolios are turned over frequently. Since money managers often trade several securities simultaneously, it is important to know whether trading costs are correlated across securities. Yet research on trading costs has focused almost exclusively on individual securities. Typically, we do not think of illiquidity in a market-wide context, and the classic models of market microstructure involve a dealer in a single stock who provides immediacy at a cost that arises due to inventory holding risk (Stoll 1978) or because of the specter of trading with an investor with superior information (Glosten and Milgrom 1985). Empirical work also deals solely with the trading patterns of individual assets, most often equities sampled at high frequencies (see, for example, Wood, McInish, and Ord 1985).

There are a variety of reasons why illiquidity-induced trading costs should be correlated across securities. For example, if trading volume exhibits correlated changes in response to broad market movements, this should induce a correlation in liquidity costs. Similarly, the cost of holding inventory could be correlated across securities because it depends, in part, on market interest rates. Within the asymmetric information view of the spread, there might be types of information pertinent for most firms in an industry sector whose imminent revelation could influence the liquidity of several securities simultaneously.

Sudden changes in system-wide liquidity appear to have been important in some well-known financial episodes. The international stock market crash of October, 1987 was associated with no identifiable major news event (see Roll 1988), but was characterized by a temporary reduction in liquidity. During the

* Emory University, Goizueta School of Management, Atlanta.
Email: Tarun_chordia@Bus.emory.edu. UCLA, Anderson School, Los Angeles.
Email: Rroll@Anderson.ucla.edu. UCLA, Anderson School, Los Angeles.
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summer of 1998, a liquidity crisis appears to have simultaneously affected several mid- to low-grade bonds which, in turn, seems to have precipitated financial distress in certain highly-levered trading firms.[1]

In our ongoing research program, we are trying to shift focus from the notion of liquidity as a fixed attribute of an individual security, to the notion that time-series movements in liquidity have common underlying determinants. The present paper is focused on identifying drivers of market-wide liquidity. Our work has important implications for issues such as the effect of liquidity fluctuations on asset prices, the effect of monetary policy on stock market liquidity, and co-movement between stock and bond market liquidity.

2. Investigating Common Determinants of Liquidity

We now seek to explore the common influences that underlie movements in liquidity as well as trading activity. Such an exercise is valuable for obvious reasons: exchange organization, regulation, and investment management could all be improved by knowledge of factors that influence liquidity and trading activity. A better understanding of these determinants would increase investor confidence in financial markets and thereby enhance the efficacy of corporate resource allocation.

To investigate common determinants of liquidity, we construct time series of market-wide liquidity measures and market-wide trading activity over the eleven-year period 1988 through 1998 inclusive, almost 2,800 trading days. The data are averaged[2] over a comprehensive sample of NYSE stocks on each trading day. Measures of liquidity, as in the previous sections, are quoted and effective spreads plus market depth while the trading activity measures are volume and the number of daily transactions.

In choosing explanatory variables for liquidity and trading activity, we are guided by prior paradigms of price formation and by intuitive *a priori* reasoning. The inventory paradigm of Demsetz (1968), Stoll (1978), and Ho and Stoll (1981) suggests that liquidity depends on the costs of financing dealer inventories, on factors that influence the risk of holding inventory, and on extreme events that provoke order imbalances and thereby cause inventory overload. Thus, our first set of candidates for explanatory factors consists of short- and long-term interest rates, default spreads, market volatility, and contemporaneous market moves. The

1 See the *Wall Street Journal* (1998), "Illiquidity means it has become more difficult to buy or sell a given amount of any bond but the most popular Treasury issue. The spread between prices at which investors will buy and sell has widened, and the amounts in which Wall Street firms deal have shrunk across the board for investment grade, high-yield (or junk), emerging market and asset-backed bonds. The sharp reduction in liquidity has preoccupied the Fed because it is the lifeblood of markets."

2 For the most part, we study equal-weighted cross-sectional averages. However, for completeness and as a check on robustness, we also provide results obtained with value-weighted averages.

informed speculation paradigm (Kyle (1985) and Admati and Pfleiderer (1988)) suggests that market-wide changes in liquidity could closely precede informational events such as scheduled Federal announcements about the state of the economy. Further, trading activity could vary in a weekly cycle, for example, because of systematic variations in the opportunity cost of trading over the week; it could vary also around holidays. We thus include indicator variables to represent days around major macroeconomic announcements, days-of-the-week, and major holidays.

Many authors, starting with Banz (1981), Reinganum (1983), Gibbons and Hess (1981), have documented regularities in asset returns on a monthly or daily basis, but have not considered the time-series behavior of liquidity. In work that is more directly related to ours, Draper and Paudyal (1997) carry out an analysis of seasonalities in liquidity on the London Stock Exchange, but are able to obtain only monthly data for 345 firms. Ding (1999) analyzes time-series variations of the spread in the foreign exchange futures market, but his data span less than a year. Jones, Kaul, and Lipson (1994) study stock returns, volume, and transactions over a six-year period but do not attempt to explain why trading activity varies over time. Pettengill and Jordan (1988) analyze seasonalities in volume, and Lo and Wang (1999) analyze commonality in share turnover, both with data spanning more than twenty years, but they do not analyze the behavior of market liquidity. Finally, Hiemstra and Jones (1994) and Karpoff (1987) analyze the relation between stock returns and volume over several years, but again do not consider market liquidity.

Foster and Viswanathan (1993) examine patterns in stock market trading volume, trading costs, and return volatility using intraday data from a single year, 1988. For actively traded firms, they find that trading volume is low and adverse selection costs are high on Mondays. Lakonishok and Maberly (1990) use more than thirty years of data on odd-lot sales/purchases to show that the propensity of individuals to sell is particularly high on Mondays. Harris (1986, 1989) documents various patterns in intraday and daily returns using transactions data over a period of three years. However, he does not have data on spreads, depths or trading activity and consequently is unable to directly analyze the behavior of liquidity. Thus, to our knowledge, an analysis of the time-series behavior of liquidity over a long time span and its relations, if any, with macroeconomic variables, has not yet been explored.

3. The Comprehensive Sample

Data sources are the Institute for the Study of Securities Markets (ISSM) and the New York Stock Exchange TAQ (trades and automated quotations). The ISSM data cover 1988 to 1992 inclusive while the TAQ data are for 1993 through 1998. We use only NYSE stocks to avoid any possibility of the results being influenced by differences in trading protocols.

Stocks are included or excluded during a calendar year depending on the following criteria:

To be included, a stock had to be present at the beginning and at the end of the year in both the CRSP and the intraday databases.

If the firm changed exchanges from Nasdaq to NYSE during the year (no firms switched from the NYSE to the Nasdaq during our sample period), it was dropped from the sample for that year.

Because their trading characteristics might differ from ordinary equities, assets in the following categories were also expunged: certificates, ADRs, shares of beneficial interest, units, companies incorporated outside the U.S., Americus Trust components, closed-end funds, preferred stocks and REITs.

To avoid the influence of unduly high-priced stocks, if the price at any month-end during the year was greater than $999, the stock was deleted from the sample for the year.

Next, intraday data were purged for one of the following reasons: trades out of sequence, trades recorded before the open or after the closing time,[3] and trades with special settlement conditions (because they might be subject to distinct liquidity considerations).[4]

Our preliminary investigation revealed that autoquotes (passive quotes by secondary market dealers) were eliminated in the ISSM database but not in TAQ. This caused the quoted spread to be artificially inflated in TAQ. Since there is no reliable way to filter out autoquotes in TAQ, only BBO (best bid or offer)-eligible primary market (NYSE) quotes are used. Quotes established before the opening of the market or after the close were discarded. Negative bid-ask spread quotations, transaction prices, and quoted depths were discarded. Following Lee and Ready (1991), any quote less than five seconds prior to the trade is ignored and the first one at least five seconds prior to the trade is retained.

For each stock we define the following variables:

QuotedSpread:	the quoted bid-ask spread associated with the transaction.
%QuotedSpread:	the quoted bid-ask spread divided by the mid-point of the quote (in percent).
EffectiveSpread:	the effective spread; i.e., the difference between the execution price and the mid-point of the prevailing bid-ask quote.
%EffectiveSpread:	the effective spread divided by the mid-point of the prevailing bid-ask quote (in percent).
Depth:	the average of the quoted bid and ask depths.
$Depth:	the average of the ask depth times ask price and bid depth times bid price.

[3] The last daily trade was assumed to occur no later than 4:05 p.m. Transactions are commonly reported up to five minutes after the official close, 4:00 p.m.

[4] These settlement conditions typically exclude dividend capture trades. While this caveat should be noted, this exclusion should not have any material impact on our results.

CompositeLiq = %QuotedSpread/$Depth: spread and depth combined in a single measure. *CompositeLiq* is intended to measure the average slope of the liquidity function in percent per dollar traded.

In addition to the above averages, we calculate the following measures of trading activity on a daily basis:

Volume: the total share volume during the day

$Volume: the total dollar volume (number of shares multiplied by the transaction price) during the day

NumTrades: the total number of transactions during the day

Our initial scanning of the intraday data revealed a number of anomalous records that appeared to be keypunching errors. We thus applied filters to the transaction data by deleting records that satisfied the following conditions:

1. *QuotedSpread* > $5
2. *EffectiveSpread/QuotedSpread* > 4.0
3. *%EffectiveSpread/%QuotedSpread* > 4.0
4. *QuotedSpread*/Transaction Price > 0.4

These filters removed less than 0.02 percent of all transaction records.[5] From this point on, our investigation focuses on daily cross-sectional averages of the liquidity and trading activity variables after employing the above screening procedure (for convenience, the same variable names are retained). Trading activity averages are calculated using all stocks present in the sample throughout the year as a divisor; e.g., stocks that did not trade are assigned a value of zero for trading volume, which is in fact their actual volume on a day they did not trade.

The same method cannot be employed for spread or depth averages because a non-trading stock does not really have a spread or depth of zero. One possibility is to calculate averages using only stocks trading on each day. However, infrequently-trading stocks probably have higher than average spreads (and lower depths), so daily changes in liquidity measures could be unduly influenced by such stocks moving in and out of the sample. An alternative is to use the last-recorded value for a non-trading stock, but of course the averages would then contain some stale data. We have done all the calculations both ways but report the results only with the latter method, filling in missing data from the past ten trading days *only* in order to limit the extent of staleness. Both methods yield virtually identical results.

Table 1 provides summary statistics of the basic market liquidity and trading activity measures. All variables display substantial intertemporal variation, but trading activity shows more variability than spreads as indicated by higher coefficients of variation. This might be attributable to the discrete nature of bid-ask spreads, which could serve to attenuate volatility through clustering. As can

5 There were over 3 billion records in the sample.

be seen, the effective spread is considerably smaller than the quoted spread, evidently reflecting within-quote trading. None of the variables exhibit any significant skewness; means are quite close to the medians.

4. Empirical Attributes of Market-Wide Liquidity and Aggregate Trading Activity

Table 2 reports pair-wise correlations among changes in the liquidity and trading activity variables. *A priori*, from reasoning at the individual stock level, one might have anticipated a positive relation between volume and liquidity and thus a negative (positive) relation between volume and spreads (depth). But while correlations between changes in the market-wide quoted and proportional quoted spread and share or dollar volume are negative, they are quite low, and the effective spread measures are actually positively correlated with either measure of volume. Further, the correlations between various spread changes and the number of transactions are also positive. In contrast, depth and dollar depth display a strong correlation with volume, positive as anticipated.[6]

Not surprisingly, spread changes are negatively correlated with depth changes. Correlations between transactions and either share or dollar volume are greater than 0.80.

4.1. Time Series Properties of Market Liquidity and Trading Activity

Table 3 records autocorrelations for percentage changes in each series out to a lag of five trading days (one week not accounting for holidays). Every series except price exhibits statistically significant negative first-order autocorrelation. There is even evidence of negative second-order autocorrelation, albeit weaker. Negative autocorrelation might be expected since most of these series are likely to be stationary; for example, bid-ask spreads probably will not wander off to plus or minus infinity.[7] Notice too that the fifth-order coefficients are uniformly positive and about half of them are significant. This reveals the presence of a weekly seasonal.

Negative first-order serial dependence in spreads could arise also from discreteness. Imagine, for instance, that most stocks have quoted spreads of either one eighth or one quarter, that some stocks oscillate between these discrete

6 The correlation between (changes in) the quoted spread and the relative quoted spread is only about 0.75, which might appear surprisingly low. But the relative quoted spread is calculated by averaging the stock-by-stock ratios of quoted spread to price and there is substantial cross-sectional variation in prices. The correlation between the average quoted spread and the ratio of average quoted spread to average price is much higher; about 0.95.

7 Formal unit root tests (not reported) strongly imply that daily changes of all variables are stationary.

TABLE 1
MARKET LIQUIDITY AND TRADING ACTIVITY VARIABLES, 1988 TO 1998 (INCLUSIVE)

These are descriptive statistics for time series of market-wide liquidity and trading activity. The series are constructed by first averaging all transactions for each individual stock on a given trading day and then cross-sectionally averaging all individual stock daily means that satisfy the data filters described in the text. The sample period spans the first trading day of 1988 through the last trading day of 1998, 2,779 trading days.

	Number of firms	Quoted spread ($)	% Quoted spread	Effective spread ($)	% Effective spread	Depth (shares)	Price ($)	Share volume (000's)	Dollar volume ($ million)	Number of daily trades	$ Depth ($0000)	Dollars/ trade ($00)
Mean	1326	0.208	1.497	0.137	1.033	6216	28.31	183.48	7.12	109.63	13.85	634.0
Sigma*	126	0.026	0.412	0.017	0.278	1195	2.84	75.76	3.74	47.94	2.95	104.7
C of V**	0.0954	0.125	0.276	0.126	0.269	0.192	0.100	0.413	0.525	0.437	0.213	0.165
Median	1344	0.217	1.490	0.138	0.993	6478	27.97	162.21	5.72	95.84	13.77	627.1
Minimum	252	0.142	0.691	0.099	0.480	3224	20.88	30.93	0.83	16.77	6.21	244.6
Maximum	1504	0.282	2.819	0.203	2.052	8584	36.52	613.95	27.76	379.22	21.77	1814.2

*Standard Deviation.

**Coefficient of Variation: Standard Deviation ÷ Mean; (dimensionless).

points daily, and that they tend to oscillate as a correlated group. This would produce negative first-order autocorrelation in the percentage change of the *average* spread. Table 3 does show that the four spread measures have absolutely larger negative first-order autocorrelation coefficients than other variables.

Data recording errors are another possible source of negative serial correlation. However, we do not believe this is the main cause for two reasons. First, errors would just as likely appear in the average recorded price series, but its first-order coefficient is positive and insignificant. Second, we found that the negative serial correlation is just as strong for the quintile of largest firms and it seems unlikely that actively traded large firms would be as influenced by data recording errors. Overall, the evidence suggests that negative serial correlation is a basic feature of the true time-series process of liquidity.

5. Determinants of Liquidity and Trading Activity

This section reports time-series regressions of liquidity and trading activity measures on various potential determinants. First, some justification is provided for the explanatory variables.

5.1. Explanatory Variables

The inventory paradigm introduced by Demsetz (1968) and developed further by Stoll (1978) and Ho and Stoll (1981) suggests that liquidity depends on dealer financing costs, inventory turnover rates, and inventory risks. By reducing the cost of margin trading and decreasing the cost of financing inventory, a decrease in short rates could stimulate trading activity and increase market liquidity. An increase in longer-term Treasury bond yields could cause investors to reallocate wealth between equity and debt instruments and thus stimulate trading activity and affect liquidity. An increase in default spreads could increase the perceived risk of holding inventory and thereby decrease liquidity. Consequently, as plausible candidates for determinants of liquidity, we nominate the daily overnight Federal Funds rate,[8] a term structure variable, and a measure of default spread.

Equity market performance is another plausible causative candidate. Recent stock price moves could trigger changes in investor expectations while also prompting changes in optimal portfolio compositions. In addition, the direction of stock market movements could trigger asymmetric effects on liquidity. For example, sharp price declines could induce relatively more pronounced changes in liquidity to the extent that market makers find it more difficult to adjust inventory in falling markets than in rising markets. We thus consider the signed concurrent daily return on the Center for Research in Security Prices (CRSP) index.

[8] We repeated all calculations using the one-year Treasury Bill rate as a proxy for dealer financing costs but found that the Federal Funds rate is a better determinant of daily liquidity variations. The results are otherwise essentially identical.

TABLE 2
CORRELATIONS OF SIMULTANEOUS DAILY PERCENTAGE CHANGES IN MARKET-WIDE LIQUIDITY AND TRADING ACTIVITY

These are correlations among daily percentage changes in the variables described in Table I omitting the changes at the turn of each year. The acronyms *QuotedSpread, %QuotedSpread, EffectiveSpread, %EffectiveSpread, Depth, $Depth, CompositeLiq, Price, Volume, $Volume, and NumTrades* denote market-wide equal-weighted averages of, respectively, the quoted spread, the percentage quoted spread, the effective spread, the percentage effective spread, share depth, dollar depth, *%QuotedSpread/$Depth*, the average price of stocks that traded, share volume, dollar volume, and the average number of transactions per stock. A preceding Δ denotes the daily percentage change in the variable.

	ΔQuoted spread	Δ%Quoted spread	ΔEffective spread	Δ%Effective spread	ΔDepth	Δ$Depth	Δcomposite Liq.	ΔPrice	ΔVolume	Δ$Volume
	Liquidity variables							Trading activity variables		
Δ%Quoted spread	0.749									
ΔEffective spread	0.782	0.581								
Δ%Effective pread	0.492	0.568	0.686							
ΔDepth	-0.464	-0.355	-0.323	-0.181						
Δ$Depth	-0.460	-0.375	-0.316	-0.213	0.923					
ΔComposite Liq.	0.623	0.628	0.458	0.362	-0.882	-0.948				
ΔPrice	-0.150	-0.293	-0.192	-0.273	0.183	0.247	-0.303			
ΔVolume	-0.051	-0.138	0.091	-0.018	0.310	0.347	-0.308	-0.052		
Δ$Volume	-0.039	-0.142	0.095	-0.028	0.273	0.322	-0.290	-0.024	0.975	
ΔNum trades	-0.034	-0.059	0.151	0.112	0.241	0.256	-0.204	-0.066	0.838	0.834

TABLE 3
AUTOCORRELATIONS OF LIQUIDITY AND TRADING ACTIVITY VARIABLES

These are autocorrelation coefficients for the variables described in Table I, after omitting the changes at the turn of each year. The acronyms *QuotedSpread, %QuotedSpread, EffectiveSpread, %EffectiveSpread, Depth, $Depth, CompositeLiq, Price, Volume, $Volume, and NumTrades* denote market-wide equal-weighted averages of, respectively, the quoted spread, the percentage quoted spread, the effective spread, the percentage effective spread, share depth, dollar depth, *%QuotedSpread/$Depth*, the average price of stocks that traded, share volume, dollar volume, and the average number of transactions per stock. A preceding Δ denotes the daily percentage change in the variable. Numbers in boldface type indicate a p-value less than 0.0001 for an asymptotic test that the autocorrelation coefficient is zero.

	Order (Lag in daily observations)				
	1	2	3	4	5
	Liquidity Variables				
ΔQuotedSpread	-0.295	-0.131	-0.048	-0.032	0.081
Δ%QuotedSpread	-0.221	-0.127	-0.002	-0.018	0.047
ΔEffectiveSpread	-0.306	-0.093	-0.072	-0.017	0.035
Δ%EffectiveSpread	-0.291	-0.075	-0.031	-0.021	0.046
ΔDepth	-0.188	-0.212	-0.117	-0.015	0.229
Δ$Depth	-0.218	-0.179	-0.106	0.001	0.140
ΔCompositeLiq	-0.198	-0.178	-0.096	-0.005	0.130
	Trading Activity Variables				
ΔPrice	0.006	0.019	0.013	0.025	-0.030
ΔVolume	-0.266	-0.107	-0.042	-0.017	0.095
Δ$Volume	-0.268	-0.099	-0.038	-0.020	0.097
ΔNumTrades	-0.259	-0.097	-0.036	-0.007	0.033

Additionally, we include a measure of recent market history. The rationale is based on the notion that momentum or contrarian strategies[9] and various techniques for "technical analysis" involve past market moves thereby creating a link between trading activity and recent price trends. To proxy for such activity, we include a signed five-day moving average of past returns (ending the day prior to the observation date).

[9] See Lakonishok, Shleifer, and Vishny (1994) and Chan, Jegadeesh, and Lakonishok (1996) for evidence on the performance of momentum and contrarian strategies.

Because volatility should influence liquidity and trading activity through its effect on inventory risk as well as the risk of engaging in short-term speculative activity, we include a measure of recent market volatility. Our proxy is a five-day trailing average of daily absolute returns for the CRSP market index.

Trading activity might also be influenced by the opportunity cost of devoting time to trading decisions. Simple behavioral arguments (such as fluctuations in investor mood or sentiment over the week) suggest that trading activity could show systematic seasonal patterns. Work by Admati and Pfleiderer (1989) or Foster and Viswanathan (1990) implies that liquidity could exhibit predictable patterns through time.[10] To investigate such regularities, we include indicator variables for days of the week as well as for days preceding and following holiday closures.

Information-based trading (based on the asymmetric information paradigms of Kyle (1985) and Admati and Pfleiderer (1988)) suggests another group of proximate determinants. As firm-specific information is more likely to induce information-based trades, sensible proxies would be dummies for earnings announcement dates. These dates, however, are not well coordinated across companies. Further, conversations with accounting researchers revealed that information about earnings is often conveyed to the market sometime before the official earnings announcement date. Thus, estimates of earnings with significant information content are often pre-released by managers (see, for example, Ruland, Tung, and George, 1990, and Baginski, Hassell, and Waymire, 1994); such pre-release dates are completely discretionary.

Because of these concerns, we decided to focus on information associated with macroeconomic announcements. We include dummy variables for macroeconomic announcements about GDP, the unemployment rate, and the Consumer Price Index. Separate dummies are provided for the day of the announcement and for the two days preceding the announcement.

5.2. Explanatory Variable Definitions

The explanatory variables are:

ShortRate: the daily first difference in the Federal Funds Rate.

TermSpread: the daily change in the difference between the yield on a constant maturity 10-year Treasury bond and the Federal Funds rate.

QualitySpread: the daily change in the difference between the yield on Moody's Baa or better corporate bond yield index and the yield on a ten-year constant maturity Treasury bond.[11]

10 These papers do not explicitly specify which days of the week should involve high/low liquidity.

11 All interest rates are from the Federal Reserve website, http://www.bog.frb.fed.us/releases/H15/data.htm. We thank Yacine Aït-Sahalia for directing us to this site. The Federal Reserve uses the daily yield curve to calculate the yield on a constant maturity Treasury bond on a daily basis.

MKT+: the concurrent CRSP daily index return if it is positive, and zero otherwise.[12]

MKT-: the concurrent CRSP daily index return if it is negative, and zero otherwise.

MA5MKT+: the past five trading-day CRSP daily index return if it is positive and zero otherwise.

MA5MKT-: the past five trading-day CRSP daily index return if it is negative and zero otherwise.

MA5|MKT|: the past five trading-day average of CRSP daily absolute index returns.

HOLIDAY: 1.0 if a trading day satisfies the following conditions: (1) if Independence Day, Christmas, or New Year's Day falls on a Friday then the preceding Thursday, (2) if any holiday falls on a weekend or on a Monday then the following Tuesday, (3) if any holiday falls on another weekday then the preceding and following days[13], and zero otherwise

Monday-Thursday: 1.0 if the trading day is, respectively, a Monday, Tuesday, Wednesday, or Thursday, and zero otherwise.

GDP(0): 1.0 on the day of a GDP announcement, and zero otherwise.

GDP(1-2): 1.0 on the two trading days prior to a GDP announcement, and zero otherwise.

UNP (0), UNP(1-2), CPI(0), CPI(1-2): Defined as for GDP but for unemployment and CPI announcements, respectively.

5.3 Regression Results

Time series regression results are reported in Table 4 for the scaled spread measures Δ*%QuotedSpread* and Δ*%EffectiveSpread*, for Δ*CompositeLiq*, for the dollar values of depth, Δ*$Depth*, and volume, Δ*$Volume*, and for the number of transactions, Δ*NumTrades*. (The "Δ" prefix denotes the daily percentage change in the corresponding variables described earlier.) To conserve space, results for the non-scaled spreads, *QuotedSpread* and *EffectiveSpread*, and for share depth and volume, are not reported. They are qualitatively similar and will be provided upon request.

Since OLS runs indicated a high Durbin-Watson test statistic in all regressions, a consequence of the previously-noted negative dependence in all of the dependent variables, we applied the Cochrane/Orcutt iterative correction procedure (first-order only) in the time-series regressions.[14] The Durbin-Watson

12 The equal-weighted (value-weighted) CRSP index is used for regressions with equal-weighted (value-weighted) liquidity and trading activity dependent variables.

13 This is always the case for Thanksgiving.

14 The results obtained using OLS do not differ qualitatively from those obtained from the Cochrane/Orcutt method. The OLS results are available from the authors upon request.

statistics from the final iteration of the Cochrane/Orcutt regressions were within the significance bounds.

The sample size is 2694 in the Panel A and B regressions. We started with 2779 trading days, eliminated the first day of the calendar year for 1989 to 1998 (ten observations) and lost five days at the beginning to accommodate the lagging five-day market trend. In addition, bond market data were unavailable for 35 holidays when the stock market was open (King's birthday, Columbus Day, and Veteran's Day, though not every year). This brought a further reduction of 70 (35 X 2) observations because the interest rate variables are first-differenced. The total reduction is 85. Panel C has a different sample size and is explained below.

The adjusted R^2s in Panels A and B range from 18 to 33 percent; i.e., the explanatory variables capture an appreciable fraction of the daily time-series variation in market-wide liquidity and trading activity.

The day-of-the-week dummies for Tuesday, Wednesday, and Thursday are significantly negative in the spread regressions and significantly positive for depth and the trading activity regressions. This is compelling evidence that market liquidity declines and trading activity becomes sluggish on Friday relative to the other days of the week, particularly the three days in mid-week. Usually, Tuesday has the largest absolute coefficient, suggesting that liquidity and trading activity appreciably increase on Tuesday relative to other days.[15] The composite liquidity measure shows a pattern that is similar to the individual liquidity and depth variables.

The regression intercepts are all strongly significant, positive for spreads and negative for depth and trading activity. Although one cannot rule out the possibility that significant intercepts are caused by omitted explanatory variables or by a departure from linearity, the most likely explanation is decreased liquidity and trading activity on Fridays (when the four day-of-the-week dummies are zero). If Tuesday instead of Friday is the zero base case for day-of-the-week dummies, the sign of every intercept is reversed and its significance is actually increased (not reported, but available on request.)

Trading activity also slows down around holidays as evidenced by the negative and significant coefficient for the holiday dummy in the Δ*$Volume* and Δ*NumTrades*. The reduced trading activity appears to result in decreased market depth and increased quoted spreads as evidenced by the negative and positive coefficients on the holiday dummy in the quoted spread and depth regressions, respectively. The holiday dummy for the composite liquidity variable (*CompositeLiq=%QuotedSpread/$Depth*) is also highly significant.

There is a distinctly asymmetric response of spreads to up and down markets. They weakly decline in up markets and strongly increase in down markets. The opposite is true for depth. This suggests that inventory accumulation concerns are more important in down markets.

15 A joint test that Tuesday's coefficient is the same as Monday's, Wednesday's and Thursday's was rejected with a p-value less than 0.0001 in all regressions except Δ*CompositeLiq*'s.

TABLE 4
TIME SERIES REGRESSIONS

Dependent variables are daily percentage changes in market-wide liquidity and trading activity as described in Table 1. The acronyms Δ*%QuotedSpread*, Δ*%EffectiveSpread*, Δ*$Depth*, Δ*CompositeLiq*, Δ*$Volume*, and Δ*NumTrades* denote market-wide averages of the percentage quoted spread, the percentage effective spread, the measure of dollar depth, the percentage quoted spread divided by dollar depth (a composite measure of liquidity), dollar volume, and the average number of transactions per stock, respectively. A preceding Δ denotes the daily percentage change in the variable.

Explanatory variables are: *MKT+* (*MKT-*): the CRSP equally-weighted return if it is positive (negative) and zero otherwise; *MA5MKT+* (*MA5MKT-*): the CRSP equally-weighted return over the past five trading days if it is positive (negative) and zero otherwise; *MA5|MKT|*: the average CRSP equally-weighted daily absolute return over the past five trading days (all of the preceding variables are in percentages); *Monday-Thursday*: four variables that take on a value of 1 if the trading day is, respectively, a Monday, Tuesday, Wednesday, or Thursday, and zero otherwise; *Holiday*: a variable that takes on a value of 1 if a trading day satisfies the following conditions: (1) if Independence Day, Veteran's Day, Christmas, or New Year's Day falls on a Friday then the preceding Thursday, (2) if any holiday falls on a weekend or on a Monday then the following Tuesday, (3) if any holiday falls on another weekday then the preceding and following days*, and zero otherwise; *ShortRate*: the daily first difference in the Federal Funds rate; *TermSpread*: the daily change in the difference between the yield on a constant maturity ten-year Treasury bond and *ShortRate*; *Quality Spread*: the daily change in the difference between the yield on Moody's Baa or better corporate bond yield index and the yield on a ten-year constant maturity Treasury bond; *GDP(0)*: one on the day of a GDP announcement, and zero otherwise; *GDP(1-2)*: one on the two trading days prior to a GDP announcement, and zero otherwise; *UNP (0), UNP(1-2), CPI(0), CPI(1-2)*: Defined as for GDP but for unemployment and CPI announcements, respectively.

The Cochrane/Orcutt method is employed to correct first-order serial dependence in the disturbances. Coefficients significantly different from zero at the one percent (five percent) level are indicated by ** (*).

Table continued on next page

* This is always the case for Thanksgiving.

TABLE 4, CONTINUED
PANEL A: EQUALLY-WEIGHTED (2694 OBSERVATIONS)

Explanatory variables	Δ%Quoted spread		Δ%Effective spread		Δ$Depth		ΔComposite liq		Δ$Volume		ΔNum trades	
	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
MKT+	-0.486 **	-3.74	-0.373 *	-2.27	3.285 **	9.07	-3.514 **	-8.27	10.43 **	7.19	8.871 **	7.97
MKT-	-2.375 **	-22.34	-2.855 **	-21.27	2.936 **	9.92	-5.821 **	-16.78	-11.95 **	-10.09	-12.32 **	-13.56
MA5MKT+	0.052	1.36	0.010	0.22	-0.434 **	-3.98	0.425 **	3.33	-0.65	-1.49	-0.346	-1.03
MA5MKT-	0.036	0.72	0.210 **	3.34	-0.151	-1.06	0.234	1.41	1.970 **	3.46	1.910 **	4.35
MA5|MKT|	-0.141 **	-3.97	-0.124 **	-2.80	-0.033	-0.33	-0.097	-0.83	-1.266 **	-3.15	-1.101 **	-3.56
Monday	-0.592 **	-3.88	-0.573 **	-2.90	0.335	0.82	-0.775	-1.61	1.484	0.90	6.656 **	5.33
Tuesday	-1.400 **	-10.78	-1.300 **	-7.81	5.982 **	16.85	-7.369 **	-17.65	19.39 **	13.63	11.144 **	10.26
Wednesday	-0.367 **	-2.75	-0.691 **	-4.05	2.830 **	7.74	-3.414 **	-7.94	8.01 **	5.47	4.555 **	4.07
Thursday	-0.553 **	-3.73	-0.681 **	-3.54	1.460 **	3.69	-2.214 **	-4.74	4.81 **	3.02	3.429 **	2.84
Holiday	0.807 **	3.40	0.161	0.54	-4.807 **	-7.21	7.150 **	9.16	-10.77 **	-4.04	-8.792 **	-4.29
Short rate	2.485 **	2.63	0.461	0.39	-5.795 *	-2.21	7.910 **	2.57	-32.43 **	-3.08	-28.724 **	-3.56
Term spread	2.092 *	2.23	-0.047	-0.04	-5.466 *	-2.10	7.141 *	2.34	-34.60 **	-3.32	-29.582 **	-3.70
Quality spread	0.959	0.61	-0.087	-0.04	3.549	0.81	-3.354	-0.65	-1.508	-0.09	-8.983	-0.67
GDP(1-2)	-0.549	-1.91	-0.216	-0.59	1.975 *	2.47	-2.384 **	-2.54	12.81 **	4.00	7.138 **	2.91
GDP(0)	-0.242	-0.84	0.022	0.06	-0.542	-0.68	0.096	0.10	-3.485	-1.08	-1.248	-0.51
UNP(1-2)	-0.293	-1.58	-0.088	-0.37	2.046 **	3.97	-2.159 **	-3.57	4.561 *	2.21	3.865 *	2.45
UNP(0)	0.135	0.72	0.118	0.49	-1.389 **	-2.66	1.522 *	2.48	2.549	1.22	3.457 *	2.15
CPI(1-2)	-0.166	-0.97	0.014	0.06	0.672	1.41	-0.908	-1.62	-1.539	-0.81	-0.827	-0.57
CPI(0)	-0.183	-1.06	0.078	0.36	0.302	0.63	-0.416	-0.74	1.961	1.03	0.579	0.40
Intercept	0.909 **	6.02	1.005 **	5.08	-2.519 **	-6.31	3.923 **	8.32	-7.183 **	-4.48	-6.283 **	-5.18
Adjusted R2	0.288		0.270		0.290		0.334		0.206		0.179	

TABLE 4, CONTINUED
PANEL B: VALUE-WEIGHTED (2694 OBSERVATIONS)

Explanatory variables	Δ%Quoted spread		Δ%Effective spread		ΔSDepth		ΔComposite liq		ΔSVolume		ΔNum trades	
	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
MKT+	-0.141	-1.34	0.385 **	3.22	5.307 **	12.89	-4.453 **	-9.51	14.83 **	13.98	11.27 **	14.44
MKT-	-2.867 **	-29.69	-3.496 **	-31.80	1.992 **	5.27	-5.405 **	-12.58	-12.72 **	-13.05	-11.94 **	-16.64
MA5MKT+	0.017	0.40	0.055	1.13	-0.389 *	-2.35	0.335	1.79	-0.502	-1.15	-0.115	-0.36
MA5MKT-	0.094	1.93	0.129 *	2.34	-0.291	-1.53	0.435 *	2.02	1.33 **	2.67	1.115 **	3.03
MA5|MKT|	-0.194 **	-6.14	-0.300 **	-8.30	-0.470 **	-3.79	0.339 *	2.41	-2.172 **	-6.67	-1.722 **	-7.16
Monday	-1.002 **	-5.41	-0.851 **	-4.08	-0.193	-0.27	-0.664	-0.80	-2.828	-1.58	7.315 **	5.60
Tuesday	-0.769 **	-4.90	-1.091 **	-6.14	3.942 **	6.42	-4.926 **	-7.04	15.75 **	10.17	10.19 **	8.98
Wednesday	-0.043	-0.27	-0.513 **	-2.79	0.849	1.34	-1.323	-1.83	5.82 **	3.62	4.243 **	3.60
Thursday	-0.178	-0.98	-0.623 **	-3.06	1.058	1.49	-1.521	-1.87	1.831	1.05	3.196 *	2.51
Holiday	0.432	1.51	0.377	1.16	-2.281 *	-2.04	4.393 **	3.46	-9.840 **	-3.38	-6.933 **	-3.23
Short rate	0.797	0.69	-0.925	-0.70	-2.522	-0.56	2.542	0.49	-17.50	-1.50	-21.00 *	-2.44
Term spread	0.801	0.70	-0.868	-0.66	-1.732	-0.39	1.749	0.34	-19.42	-1.68	-21.93 **	-2.57
Quality spread	3.069	1.60	2.601	1.19	6.339	0.84	-3.633	-0.43	4.96	0.26	-3.791	-0.27
GDP(1-2)	-0.664	-1.91	-0.739	-1.86	2.339	1.72	-3.16 *	-2.04	9.243 **	2.63	6.510 *	2.52
GDP(0)	0.398	1.14	0.100	0.25	-0.793	-0.58	0.879	0.56	-3.097	-0.88	-0.892	-0.34
UNP(1-2)	-0.557 *	-2.48	-0.446	-1.75	3.752 **	4.27	-4.250 **	-4.26	2.981	1.32	3.077	1.85
UNP(0)	0.482 *	2.12	0.259	1.00	-2.839 **	-3.19	3.109 **	3.07	1.577	0.69	3.821 *	2.27
CPI(1-2)	-0.359	-1.72	-0.189	-0.80	1.736 *	2.13	-2.208 *	-2.38	-2.174	-1.04	-0.361	-0.23
CPI(0)	-0.151	-0.72	-0.206	-0.87	1.811	2.22	-1.692	-1.82	2.498	1.19	1.218	0.79
Intercept	0.500**	2.64	0.787 **	3.71	-0.700	-0.95	2.350 **	2.77	-2.806	-1.56	-6.013 **	-4.59
Adjusted R2	0.326		0.324		0.229		0.245		0.226		0.211	

TABLE 4, CONTINUED
PANEL C: EQUAL-WEIGHTED, 1993 THROUGH 1998, FOR STOCKS THAT TRADED EVERY DAY THROUGHOUT THE PERIOD (1472 OBSERVATIONS)

Explanatory Variables	Δ%Quoted spread		Δ%Effective spread		Δ$Depth		ΔComposite liq		Δ$Volume		ΔNum trades	
	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
MKT+	-0.823 **	-4.48	-0.574 **	-3.16	2.793 **	5.76	-3.459 **	-6.06	4.241 *	2.21	4.205 **	2.82
MKT-	-2.563 **	-17.90	-2.844 **	-20.07	1.919 **	5.08	-4.776 **	-10.74	-9.674 **	-6.48	-9.967 **	-8.60
MA5MKT+	0.091	1.73	0.095	1.85	-0.35 *	-2.47	0.374 *	2.26	-0.259	-0.45	0.070	0.16
MA5MKT-	0.068	1.03	0.128 *	1.97	-0.025	-0.14	0.125	0.60	1.680 *	2.33	1.481 **	2.67
MA5|MKT|	-0.121 **	-2.66	-0.167 **	-3.73	-0.010	-0.08	-0.081	-0.56	-0.499	-1.00	-0.616	-1.61
Monday	-0.604 **	-2.68	-0.894 **	-3.94	1.001	1.75	-1.437 *	-2.10	3.099	1.44	9.281 **	5.47
Tuesday	-1.300 **	-6.88	-1.204 **	-6.37	5.128 **	10.51	-6.429 **	-11.09	17.41 **	9.22	11.51 **	7.81
Wednesday	-0.276	-1.42	-0.629 **	-3.23	2.067	4.09	-2.557 **	-4.27	7.585 **	3.86	4.963 **	3.24
Thursday	-0.430 *	-1.97	-0.778 **	-3.53	1.482 **	2.69	-2.175 **	-3.29	4.150 *	2.01	3.801 *	2.33
Holiday	1.356 **	3.86	0.839 *	2.42	-4.195 **	-4.49	7.203 **	6.57	-9.711 **	-2.59	-8.836 **	-3.06
Short rate	3.026 *	2.44	2.568 *	2.09	-7.592 *	-2.33	11.72 **	3.05	-38.84 **	-3.02	-31.08 **	-3.11
Term spread	2.375	1.95	1.636	1.35	-6.735 *	-2.10	10.07 **	2.66	-43.76 **	-3.46	-34.12 **	-3.47
Quality spread	-0.563	-0.19	2.002	0.69	-1.459	-0.19	1.662	0.18	-77.80 **	-2.60	-57.63 *	-2.47
GDP(1-2)	-0.656	-1.55	-0.438	-1.05	1.678	1.51	-1.867	-1.43	11.51 **	2.62	8.504 *	2.50
GDP(0)	0.023	0.06	-0.658	-1.57	-1.607	-1.44	1.431	1.09	-2.801	-0.64	-1.810	-0.53
UNP(1-2)	-0.347	-1.28	-0.251	-0.93	2.287 **	3.20	-2.310 **	-2.74	5.609 *	1.99	4.782 *	2.18
UNP(0)	0.221	0.82	0.165	0.62	-1.715 *	-2.40	2.001 *	2.38	3.065	1.09	4.419 *	2.02
CPI(1-2)	0.110	0.44	0.162	0.65	0.719	1.10	-0.704	-0.91	-2.224	-0.86	-1.014	-0.51
CPI(0)	-0.241	-0.96	-0.199	-0.80	0.558	0.85	-0.698	-0.90	3.371	1.30	2.385	1.18
Intercept	0.773 **	3.47	1.098 **	4.85	-2.524 **	-4.55	3.844 **	5.74	-7.174 **	-3.50	-7.475 **	-4.60
Adjusted R2	0.325		0.342		0.232		0.298		0.164		0.175	

Depth increases significantly in up markets. One possible explanation is that market makers attempt to manage inventory by quoting higher depth on the bid side but the same or only slightly lower depth on the ask side such that average depth increases. Note that the trading activity variables show a symmetric response; they increase in both up and down markets.

A recently falling market (*MA5MKT-*) tends to be associated with increased trading activity and decreased effective spreads. On the other hand, a recently rising market (*MA5MKT+*) appears to cause a decrease in depth but has little effect on spreads and trading activity; this might imply that market makers quote lower depth on the buy side which leads to a smaller overall depth.

High levels of recent market-wide volatility *MA5|MKT|* decrease trading activity as might have been expected, but, perhaps surprising, they also decrease spreads though depth is virtually unaffected.[16] It appears that sluggish trading following recent volatility allows dealers to reduce inventory imbalances, which then prompts them to reduce spreads.

In Table 4, Panel A, the Federal Funds rate change is negative and significant in regressions for the trading activity and depth measures, but positive and significant for the quoted spread. An increase in Treasury bond yields relative to the short rate (*TermSpread*) is accompanied by significantly decreased trading activity, decreased depth, and increased quoted spreads. The composite (inverse) measure of liquidity, Δ*CompositeLiq*, has a positive reaction that is consistent with the coefficient sign on the depth variable. Overall, there is evidence that increases in either the long- or short-term interest rate have a significantly negative effect on both liquidity and trading activity. The default spread variable (*QualitySpread*) apparently has little influence on either trading activity or liquidity.

Turning to the macroeconomic variables, trading activity increases *prior* to GDP and unemployment announcements. Depth also rises but there is no significant impact on bid-ask spreads. On the day of the announcement, (which occurs typically in the morning), depth falls back toward its normal level. This pattern is consistent with differences in anticipations about the forthcoming figures and a concomitant flurry of prior uninformed trading. Increased speculative trading activity allows greater depth to be quoted. This result is also consistent with an increase in the number of informed traders as the announcement date approaches. Competition among informed traders could bring additional liquidity (Admati and Pfleiderer, 1988).

Overall, the evidence can be summarized as follows:

- Quoted spreads, depths, and trading activity respond to short-term interest rates, the term spread, equity market returns, and recent market volatility.

16 In contrast to this result for recent market-wide volatility, it is well known that individual stock volatility is cross-sectionally associated with higher spreads (Benston and Hagerman (1974)), reflecting the notion that individual stock volatility is more closely associated with asymmetric information.

- Depth and the composite measure of liquidity respond to recent market trends.
- Effective spreads respond strongly to equity market returns, recent market trends, and recent market volatility.
- Spreads respond asymmetrically to contemporaneous market movements, increasing much more in down markets than they decrease in up markets.
- There is strong evidence that liquidity and trading activity fall on Fridays.
- Tuesday tends to be accompanied by increased trading activity and increased liquidity.
- Depth and trading activity tend to decrease around major holidays.
- Both depth and trading activity increase prior to announcements of GDP and unemployment rates.
- Impending CPI announcements do not seem to influence either liquidity or trading activity. Evidently, inflation has been relatively easy to predict in the U.S. recently.

The explanatory power of these regressions ranges from 18 to 33 percent and the number of separate significant regressors is impressive. For example, in the Δ*NumTrades* regression, Panel A, twelve of the nineteen variables are significant at the one percent level and two others are significant at the five percent level. There are more significant determinants in the depth and trading activity regressions than in the spread regressions.

Panel B of Table 4 reports regressions with value-weighted liquidity and trading activity measures, where the weights are proportional to each company's total market capitalization at the end of the previous year. The stock market indexes are also value-weighted. The results are qualitatively similar to those of Panel A, except that interest rate variables are no longer significant for the liquidity variables and the weekly seasonals are weaker (though mostly still significant). This may imply that inventory considerations are more important for smaller stocks and that weekly variations in trading have a larger impact on the liquidity of smaller companies. On the other hand, explanatory power is actually slightly higher in the spread regressions and for dollar volume and the number of transactions. Notice too that the unemployment announcement is now statistically significant for quoted spreads.

5.4. Robustness Checks

Since the number of firms trading varies daily, there is some ambiguity about average liquidity measures because spreads and depth are not available for non-trading firms. (This does not affect the trading activity measures because volume is properly counted as zero when a stock does not trade.) We addressed this issue by using liquidity measures from the last day the stock did trade, going back a maximum of ten trading days. To ensure the results are not influenced by this procedure, we re-ran the regressions for a sample of stocks that traded every single trading day in each calendar year from 1993 to 1998, the period corresponding

to the TAQ data source. Because of aberrant variation in the reported number of stocks trading in the ISSM data, the same robustness check was not done for the 1988 to 1992 period. The resulting sample size is 1472 days. The results, presented in Panel C, are qualitatively similar to those in Panel A. There is a loss in significance for some of the coefficients, particularly those representing the weekly seasonals, but the overall pattern of significance is unchanged (except that the effective spread also is influenced significantly by the short rate).

6. Conclusions

We study liquidity and trading activity for a comprehensive sample of NYSE-listed stocks over an eleven-year period. Daily changes in these variables are negatively serially correlated. There has been a secular downtrend in spreads and an upward trend in depth and volume, though there have been major excursions around these trends and at least one important structural break, when the minimum tick size was reduced from 1/8 to 1/16 in mid-1997.

We find that liquidity and trading activity are influenced by several factors. Based on theoretical paradigms of price formation (inventory and asymmetric information) and on intuitive reasoning, we nominated candidates as possible determinants. The explanatory variables include short- and long-term interest rates, default spreads, market volatility, recent market movements, and indicator variables for the day of the week, for holiday effects, and for major macroeconomic announcements.

Equity market returns and recent market volatility influence liquidity and trading activity. Short-term interest rates and the term spread significantly affect liquidity as well as trading activity. There are strong day-of-the-week regularities in liquidity and in trading activity. A typical Friday has decreased liquidity and trading activity. This is also true for days adjacent to major holidays.

A particularly intriguing result is the asymmetric response of bid-ask spreads to market movements. Both quoted and effective spreads increase dramatically in down markets, but decrease only marginally in up markets. Indeed, the down-market variable is the most significant one in our analysis. In addition, contrary to intuition, recent market volatility tends to reduce spreads. While informal speculation about these results is possible, a formal theoretical investigation of this result would be desirable.

Trading activity and market depth increase prior to scheduled macroeconomic announcements of GDP and the unemployment rate while they fall back toward normal levels on the announcement day itself. This is consistent with increased trading induced by differences of opinion prior to the announcement which, being conducted by uninformed traders, is accommodated by dealers offering greater depth. The depth pattern would also be consistent with an increase in the number of informed traders as the announcement day approaches. Competition among this larger number of informed agents would drive down

asymmetric information costs to dealers and result in higher liquidity (Admati and Pfleiderer, 1988).

The determinants investigated here explain between 18 and 33 percent of daily changes in liquidity and trading activity. This is consistent with the evidence for commonality in liquidity documented by Chordia, Roll, and Subrahmanyam (2000).

It is worth reiterating the adage pointed out, for example, by Chowdhry and Nanda (1991) and Admati and Pfleiderer (1988), that "liquidity begets liquidity." While a return anomaly is subject to arbitrage forces, a "liquidity anomaly" is self-perpetuating; that is, as agents find out about such an anomaly, they will avoid trading in illiquid periods, which will further reduce liquidity in those periods. Thus, regularities in the time-series behavior of liquidity and trading activity should be dynamically stable.

To our knowledge, no other study has examined such a long history of spreads, depth, and trading activity nor has any study attempted to identify their determinants. However, the sample period here, 1988 to 1998 inclusive, is a relentless bull market. It seems possible that liquidity and trading activity might behave differently in a bear market. Rising markets attract more investors and there is indeed ample evidence of steadily increasing liquidity over the past decade. Prolonged bear markets, on the other hand, could be subject to falling liquidity.

While liquidity *levels* could vary with market trends, the determinants of day-to-day *changes* in liquidity are probably the same in most environments, though their explanatory power might very well fluctuate. For example, based on recent experience with crash events, down markets may be characterized by frenzied selling (in contrast to steady buying in rising markets) so inventory could accumulate and the impact of interest rates on liquidity could become stronger in bear markets.

Macroeconomic variables should have influences over horizons longer than those examined here. If macro- variables anticipate economic downturns, they might also anticipate lower liquidity and trading activity in equity markets. As a longer history of data becomes available, future studies will shed more light on this interesting issue.

Our results have clear and direct implications for practitioners, for example, they suggest the following:

- High negative serial correlation in trading costs suggests that days of spread increases are generally followed by days of spread decreases and hence there is a benefit to postponing trading to the day following a day of unusually high decrease in liquidity.
- Investors should avoid trading on Fridays and attempt to trade Tuesdays, if the cost of postponing trades is not too high.
- Sharp declines in the market are accompanied by significantly decreased liquidity and are to be avoided as a day for high levels of trading.
- Days of dramatic increases in short-term interest rates are to be avoided for trading purposes

- Both depth and trading activity increase prior to announcements of GDP and unemployment rates; these days therefore have lower trading costs.

As a follow-up, it would be interesting to investigate cross-sectional differences in the market-wide effects found here. For example, do interest rates and equity returns differentially influence the liquidity of large and small firms? Are the day-of-the-week effects more prevalent in actively traded stocks or the relatively inactive ones? Do default spreads influence the liquidity of small, relatively new, companies?

More generally, however, the goal of our research has been to shift focus from liquidity as a "micro" concept, namely, a fixed property of a given stock, to a broad-based concept with a strong time-series flavor, namely time-series variation in aggregate market liquidity. Such a shift allows us to explore frontiers hitherto unvisited, such as the effect of monetary policy on stock market liquidity, and the co-movement between stock and bond market liquidity.

An important change to the microstructure regime in recent times has been the shift to decimal pricing. The issue of how our results would change in this regime is an important one. We believe that with the removal of the rigidity in the spread induced by the discrete grid, liquidity would be even more sensitive to macroeconomic conditions; so that if anything, our results should be strengthened in this regime. Unfortunately, there is not enough data at this time to reliably replicate our study for the post-decimal period. In addition, the practice of allowing limit orders to be placed within the spread, and the reduction in the monopoly power of the specialist should undoubtedly cause the spread to narrow in the post-decimal regime. Further, depth should reduce dramatically after decimalization. However, there is no reason to believe that day-to-day *changes* in either spreads or depths should influenced significantly by this regime. Hence we believe the broad conclusions of this paper should remain largely unaffected as a result of decimalization.

In the work described here, trading activity is measured by aggregate volume. An intuitive measure of trading activity that potentially could have a stronger relation to liquidity and returns is the imbalance between buying and selling activity. In ongoing research, we are investigating the tripartite relation between market-wide order imbalance, liquidity, and stock market returns. This research represents the first attempt to measure order imbalance on a large scale. Initial results suggest that imbalance has a strong association with both liquidity and returns.

The implications of our results for asset pricing remain unexplored. For example, do weekly regularities in liquidity correspond to previously documented patterns in returns? Do unanticipated liquidity variations represent a risk factor priced in the cross-section of asset returns? Such questions deserve definitive answers from future research.

REFERENCES

Admati, A. R., and P. Pfleiderer (1988), "A theory of intraday patterns: Volume and price variability", *Review of Financial Studies* 1, 3-40.

Admati, A. R., and P. Pfleiderer (1989), "Divide and conquer: A theory of intraday and day-of-the-week mean effects", *Review of Financial Studies* 2, 189-223.

Baginski, S., J. Hassell, and G. Waymire (1994), "Some evidence on the news content of preliminary earnings estimates", *Accounting Review* 69, 265-273.

Banz, R.W. (1981), "The relationship between return and market value of common stocks", *Journal of Financial Economics* 9, 3-18.

Benston, G. J., and R. L. Hagerman (1974), "Determinants of bid-asked spreads in the over-the-counter market", *Journal of Financial Economics* 1, 353-364.

Chan, L. K. C., N. Jegadeesh, and J. Lakonishok (1996), "Momentum strategies", *Journal of Finance* 51, 1681-1713.

Chordia, T., R. W. Roll, and A. Subrahmanyam (2000), "Commonality in liquidity", *Journal of Financial Economics* 56, 3-28.

Chordia, T., R. Roll, and A. Subrahmanyam (2001), "Market liquidity and trading activity", *Journal of Finance* 56, 501-530.

Chowdhry, B., and V. Nanda (1991), "Multimarket trading and market liquidity", *Review of Financial Studies* 24, 483-511.

Demsetz, H. (1968), "The cost of transacting", *Quarterly Journal of Economics* 82 (February), 33-53.

Ding, D. K. (1999), "The determinants of bid-ask spreads in the foreign exchange futures market: A microstructure analysis", *Journal of Futures Markets* 19, 307-324.

Draper, P. and K. Paudyal (1997), "Microstructure and seasonality in the UK equity market", *Journal of Business Finance and Accounting* 24, 1177-1204.

Foster, F. D. and S. Viswanathan (1990), "A theory of the interday variations in volume, variance, and trading costs in securities markets", *Review of Financial Studies* 3, 593-624.

Foster, F. D. and S. Viswanathan (1993), "Variations in trading volume, return volatility, and trading costs: Evidence on recent price formation models", *Journal of Finance* 48, 187-211.

Gibbons, M. R., and P. Hess (1981), "Day of the week effects and asset returns", *Journal of Business* 54, 579-596.

Glosten, L. and P. Milgrom (1985), "Bid, ask and transaction prices in a specialist market with heterogeneously informed traders", *Journal of Financial Economics* 14, 71-100.

Harris, L. (1986), "A transaction data study of weekly and intradaily patterns in stock returns", *Journal of Financial Economics* 16, 99-117.

Harris, L. (1989), "A day-end transaction price anomaly", *Journal of Financial and Quantitative Analysis* 24, 29-45.

Harris, L. (1994), "Minimum price variations, discrete bid-ask spreads, and quotation sizes", *Review of Financial Studies* 7, 149-178.

Hiemstra, C. and J. D. Jones (1994), "Testing for linear and nonlinear Granger causality in the stock price-volume relation", *Journal of Finance* 49, 1639-1664.

Ho, T. and H. R. Stoll (1981), "Optimal dealer pricing under transactions and return uncertainty", *Journal of Financial Economics* 9, 47-73.

Jones, C. M., G. Kaul, and M. L. Lipson (1994), "Transactions, volume, and volatility", *The Review of Financial Studies* 7, 631-651.

Karpoff, J. M. (1987), "The relation between price changes and trading volume: a survey", *Journal of Financial & Quantitative Analysis* 22, 109-126.

Kyle, A. S. (1985), "Continuous Auctions and Insider Trading", *Econometrica* 53, 1315-1336.

Lakonishok, J. and E. Maberly (1990), "The weekend effect: Trading patterns of individual and institutional investors", *Journal of Finance* 45, 231-243.

Lakonishok, J., A. Shleifer, and R. W. Vishny (1994), "Contrarian investment, extrapolation, and risk", *Journal of Finance* 49, 1541-1578.

Lee, C. M. C., and M. J. Ready (1991), "Inferring trade direction from intraday data", *Journal of Finance* 46, 733-747.

Lo, A. W., and J. Wang (1999), "Trading volume: Definitions, data analysis, and implications of portfolio theory", forthcoming, *Review of Financial Studies* 13. 257-300.

Pettengill, G. N. and B. D. Jordan (1988), "A comprehensive examination of volume effects and seasonality in daily security returns", *Journal of Financial Research* 11, 57-70.

Reinganum, M. R. (1983), "The anomalous stock market behavior of small firms in January: Empirical tests for tax-loss selling effects", *Journal of Financial Economics* 12, 89-104.

Roll, R. (1988), "The international crash of October 1987", *Financial Analysts Journal*, 44 (September-October), 19-35.

Ruland, W., S. Tung, and N. George (1990), "Factors associated with the disclosure of managers' forecasts", *Accounting Review* 65, 710-721.

Stoll, H. R. (1978), "The supply of dealer services in securities markets", *Journal of Finance* 33, 1133-1151.

Wall Street Journal (1998), "Illiquidity is Crippling Bond World," (October 19): C1.

Wood, R., T. McInish, and J. Ord (1985), "An investigation of transactions data for NYSE stocks", *Journal of Finance* 40, 723-739