Comparisons of Liquidity Measures in the Stock Markets*

Hyuk Choe ** **and Cheol-Won Yang** ***

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Abstract

The notion of liquidity is widely used in the finance area, such as in the studies of market microstructure and asset pricing. However, there are so many liquidity measures that it is difficult for researchers to decide which measure they should adopt. There is no consensus on which measure is the most appropriate as well. This paper compares various liquidity measures to find which of these measures is the most appropriate in the stock market. Analyses are performed on the nonfinancial firms listed in the Korea Exchange and the NYSE/AMEX for the period 1993~2004. Two methodologies are employed. One is a correlation check that will reveal the internal consistency between measures. The other method is to investigate the relation between risk-adjusted returns and liquidity measures by using the asset pricing framework of Brennan, Chordia, and Subrahmanyam (1998) (BCS). This paper provides us several kinds of new knowledge about liquidity measures. First, most liquidity measures are highly correlated with each other, except for the Pastor and Stambaugh (2003) measure. Therefore, we do not need to be severely concerned about the conflicts of the liquidity measures. Second, the Amihud (2002) measure and its modified measure perform distinguishably well. Third, researchers are interested in a liquidity measure which can replace the high-frequency measure, such as the bid-ask spread. This paper concludes that the most reliable solution is the Amihud (2002) measure.

Keywords: Liquidity measure, Correlation, Brennan, Chordia, and Subrahmanyam (1998) (BCS) method

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* This paper is from a part of Yang (2008)'s doctoral dissertation.
** Professor, College of Business Administration, Seoul National University, E-mail:hchoe@snu.ac.kr
*** Institute of Banking and Finance, College of Business Administration, Seoul National University, E-mail: cwyang94@snu.ac.kr

1. Introduction

The notion of liquidity is widely used in the finance area, such as in the studies of market microstructure and asset pricing. However, there are so many liquidity measures that it is difficult for researchers to decide which measure they should adopt. There is no consensus on which measure is the most appropriate as well. This paper compares various liquidity measures to find which of these measures is the most appropriate in the stock market.

Two criteria are considered to categorize the liquidity measures. The first criterion is the type of data from which the liquidity measure is derived.[1] In other words, the differences in the data frequencies are used to classify the measures. For example, high-frequency or intraday data are used to obtain bid-ask spread and depth, etc. On the other hand, low-frequency or daily data are used to obtain turnover and volume, etc. High-frequency data are usually used in microstructure studies. Their merit is the accuracy of measurement, while their drawback is the limit of their availability. They have a relatively small time span because large data are needed to estimate them. The merit of low-frequency data is the long time span. Therefore, these measures are usually used in the asset pricing tests which generally require a large cross-section and longer time period.

The second criterion is the concept of liquidity. What phenomenon or aspect does a liquidity measure really capture? In order to classify liquidity measures according to the concept of liquidity, it is first important to have a clear definition of liquidity. O'Hara (2001) documents that *"Liquidity is perhaps best described by how easily and inexpensively investors can trade assets. There are many aspects to liquidity, including simple transaction costs, the time it takes to execute trades(or immediacy) and the price impact of trades." (p.207).* Liu (2006) states that *"Liquidity is generally described as the ability to trade* ***large quantities quickly at low cost with little price impact.*** *". This description highlights four dimensions to liquidity, namely, trading quantity, trading speed, trading cost, and price impact."(p. 631)*

This paper adopts the second criterion and classifies the liquidity measures into four

[1] See, for example, Hasbrouck (2004)

categories. The first category captures the notion of *trading quantity*, in which liquidity measures, such as volume, trading amount, number of trades, and turnover, are included. The second category of liquidity measure catches the notion of *price impact*, into which Amivest liquidity ratio, Amihud (2002)'s illiquidity measure, Kyle (1985)'s lambda (λ), and Pastor and Stambaugh (2003)'s reversal measure are included. The third category captures the notion of *trading cost*, in which liquidity measures, such as proportional bid-ask spread, Roll (1984)'s spread, and amortized spread, are included. The fourth category catches the notion of *trading speed (time)*, into which proportion of zero daily return, Lesmond, Ogden, and Trzcinka (LOT) (1999)'s transaction cost, and Liu (2006)'s measure are included.

Comparisons of liquidity measures are performed on the Korean and the U.S. market. The Korean sample is all non-financial firms listed in the Korea Exchange for the period 1993~2004. The U.S. sample includes all non-financial firms listed in the NYSE /AMEX for the period 1993~2004.

To compare liquidity measures, two methodologies are employed. One is a correlation check between liquidity measures. It will reveal the internal consistency between measures. The other method is to investigate the relationship between risk-adjusted return and liquidity measure. This usage is based on the recent studies on liquidity asset pricing in which many researchers argue that liquidity should be priced in the asset prices (Amihud and Mendelson, 1986; Data et al., 1998; Brennan and Subrahmanyam, 1996; Pastor and Stambaugh, 2003; Acharya and Pedersen, 2005; Liu, 2006). The method of Brennan, Chordia, and Subrahmanyam (1998) (BCS) is adopted as an empirical asset pricing framework. Instead of examining the excess returns on a portfolio, the BCS method can examine the risk-adjusted returns of individual stocks. However, this methodology has a limitation because it tests the joint hypothesis that liquidity should be priced and a certain liquidity measure reflects the true liquidity of firms precisely. Hasbrouck (2004) also employs the BCS regression method to compare the liquidity measures in the U.S. stock market.

In the correlation analysis, most liquidity measures are highly correlated with each other. In the correlation analysis, Amihud (2002) measure, modified Amihud (MA) measure and proportional bid-ask spread prove to be the best measures in both Korea and the

U.S. However, Pastor/Stambaugh's reversal measure performs poorly. This measure is correlated with other liquidity measures in the opposite direction unlike theoretical explanations. In the BCS regression, volume, trading amount, turnover, number of trades, Amivest measure, Amihud (2002) illiquidity measure, MA measure, bid-ask spread, proportion of zero daily return, and LOT measure have positive and significant relations with adjusted returns in the Korean sample. In the case of the U.S., turnover, Amihud (2002) illiquidity measure, MA measure, and Liu (2006) measure are significantly correlated with risk-adjusted returns. Eventually, Amihud (2002) illiquidity measure and MA measure perform consistently well in the correlation check and the asset pricing test.

This paper is organized as follows. Section 2 summarizes various liquidity measures based on the concept of liquidity. Section 3 describes the data and the estimation of liquidity measures. Section 4 presents the empirical results of correlation and BCS asset pricing test. Section 5 concludes this paper.

2. Liquidity Measures

The liquidity measures are classified into four categories by the concept of liquidity. The first category captures the notion of *trading quantity*: liquidity as the ability to trade large quantities. The second category of liquidity measure catches the notion of *price impact*: liquidity as the ability to trade with little price impact. The third category captures the notion of *trading cost*: liquidity as the ability to trade at low cost. The fourth category of liquidity measure catches the notion of *trading speed (time)*: liquidity as the ability to trade quickly. However, these concepts are not entirely exclusive from each other. Finally, we propose a modified Amihud (2002) illiquidity measure which contains various dimensions of liquidity.

2.1. Liquidity as Concept of Trading Quantity

2.1.1. Volume (Share / Won)

Trading volume generally indicates how much quantity investors trade. Brennan and Subrahmanyam (1995) find that trading volume is an important determinant of the measure of liquidity. Brennan et al. (1998) and Chordia, Subrahmanyam, and Anshuman (2001) use dollar trading volume as a liquidity measure in asset pricing tests and find that volume has a significant and negative relation with risk-adjusted stock returns. Chordia et al. (2000) show a strong cross-sectional relation between trading volume and liquidity measures such as bid-ask spread and market depth.

2.1.2. Turnover

Turnover is the ratio of share volume to the number of stocks outstanding. Turnover measures how much quantity investors trade and how fast investors change their positions averagely relative to the total shares outstanding. Turnover is also used as the reciprocal of representative investors' holding period. Datar et al. (1998) use turnover as a liquidity measure to investigate the cross-sectional relation between stock returns and liquidity. Rouwenhorst (1999) implements the similar study for the 20 emerging markets and find a significant role of turnover. Chordia, Subrahmanyam, and Anshuman (2001) use turnover as well as dollar trading volume as liquidity measures in asset pricing tests. They find that turnover has a significant negative relation with risk-adjusted stock returns.

2.2. Liquidity as Concept of Price Impact

2.2.1. Amivest Measure

Amivest liquidity ratio is the average ratio of share volume to absolute return over all days with nonzero returns.

$$Amivest_i = \sum_{t=1}^{T} Volume_{it} \Big/ \sum_{t=1}^{T} | return_{it} | \tag{1}$$

It is based on the intuition that in a liquid stock, a large trading volume may be realized with small change in price. Cooper, Groth, and Avera (1985), Amihud, Mendelson, and Lauterbach (1997), and Berkman and Eleswarapu (1998) use this measure as liquidity measure in their own studies.

2.2.2. Amihud (2002)'s Illiquidity Measure

Amihud (2002) suggests a measure representing *illiquidity* as

$$Amihud_t^i = \frac{1}{Days_t^i} \sum_{d=1}^{Days_t^i} \frac{|R_{td}^i|}{V_{td}^i} \tag{2}$$

where R_{td}^i and V_{td}^i are, respectively, the return and won/dollar volume (in 10 million won / 10 thousand dollar) on day *d* in year *t*, and $Days_t^i$ is the number of valid observation days in year *t* for stock *i*. If a stock's price moves a lot in response to little volume, this stock has a high value of Amihud (2002) measure (This means that the stock is illiquid). Amihud (2002) shows that over time, expected market illiquidity positively affects ex ante stock excess return, suggesting that expected stock return partly represents an illiquidity premium. Acharya and Pedersen (2005) employ this Amihud (2002) measure as liquidity measure to estimate their asset pricing model with liquidity risk.

2.2.3. Kyle (1985)'s Lambda (λ)

Many economic studies such as Glosten and Harris (1988), Huang and Stoll (1997), Madhavan et al. (1997), and Foster and Viswanathan (1991) suggest models that incorporate dynamics for orders and price changes. These models involve both permanent and temporary effects. Permanent effect reflects the information content of order flows in line with Kyle (1985) and Glosten and Milgrom (1985). Temporary component arises from transient liquidity effects, inventory control behavior, and price discreteness, etc. To estimate the Kyle's lambda (λ), the Glosten and Harris (1988) model is adopted following the suggestion of Brennan and Subrahmanyam (1996). The regression specification is

$$\Delta P_t = \lambda V_t + \psi(Q_t - Q_{t-1}) + e_t \tag{3}$$

where λ is the adverse selection cost based on the permanent effect of trades, and ψ is the temporary spread component reflecting the order processing cost, etc. P_t is the trade price, V_t is the signed volume, and Q_t is the indicate variables representing trade direction (+1 for a buyer-initiated trade and -1 for a seller-initiated trade). Kyle's lambda (λ) measures the average price impact per one share. The larger is the Kyle's lambda (λ), the less liquid is the stock.

2.2.4. Reversal Measure of Pastor and Stambaugh (2003)

Pastor and Stambaugh (2003) suggest a reversal measure of liquidity. It is based on the finding of Campbell et al. (1993) that in a regression of a stock's daily return on its signed lagged dollar volume, the coefficient is more negative for less liquid stock. This implies that order flow induces a price adjustment that initially overshoots true value and the reversion occurs with a lag. This is caused by the risk aversion of market maker. For example, the decreasing of investors' desired holdings causes sales to the market makers (negative order flow) and the subsequent expected return must increase to compensate the market makers for bearing more risk. Pastor and Stambaugh (2003) estimate the following specification for each stock j :

$$r^e_{j,d+1} = \theta_j + \varphi_j r_d + \gamma_j sign(r^e_{j,d}) \cdot v_{j,d} + e_{j,d+1} \tag{4}$$

where d indexes days, $r^e_{j,d+1}$ is the return on stock j in excess of the market return and $v_{j,d}$ is the daily won/dollar volume. The more negative value of γ_j is interpreted as the less liquid stock.

2.3. Liquidity as Concept of Trading Cost

2.3.1. Bid-ask Spread

Bid-ask spread is the difference between ask price at which an investor is willing to sell a security and bid price at which the investor is willing to purchase a security. The bid-ask spread is an immediacy cost because it is paid when investors want to trade immediately. Many studies rely on the bid-ask spreads (Stoll and Whalley, 1983; Amihud and Mendelson, 1986, 1989; Eleswarapu and Reinganum, 1993; Kadlec and McConnell, 1994; Eleswarapu, 1997).

There are several kinds of bid-ask spread. First, *quoted spread* is the simple difference between ask price and bid price. Second, *proportional (or percentage) spread* is the quoted spread normalized by the midpoint of bid and ask price. The proportional spread is defined as

$$Proportional\ Spread_i = \sum_{t=1}^{T} \frac{Ask_{i,t} - Bid_{i,t}}{(Ask_{i,t} + Bid_{i,t})/2} \tag{5}$$

Third, *effective spread* is the difference between transaction price and the midpoint of bid and ask price prevailing at the time the order was received. In the U.S. market, market orders often transact at prices better than the posted bid-ask quotes for a variety of reasons. This motivates the use of effective spread. Thus, the effective spread is the most meaningful measure of liquidity and SEC obligate market centers to report summary statistics of effective spread periodically. Blume and Goldstein (1992), Lee (1993), and Petersen and Fialkowski (1994) find that the effective spread is approximately 50~70% of the specialist's quoted spread. Petersen and Fialkowski (1994) report that the cross-sectional correlation between effective spread and quoted spread is less than 0.31.

However, there is no difference between quoted and effective spread in the order-driven market such as the Korean market because trades always take place at quoted bid or ask prices. Therefore, we adopt proportional spread as a liquidity measure in this analysis.

2.3.2. Roll (1984)'s Spread

Roll (1984) suggests a simple model on the spread in an efficient market. The Roll's spread uses the bid-ask bounce-induced negative auto-covariance in daily returns to estimate the effective spread. The Roll's spread is defined as

$$Roll\ Spread_i = 2\sqrt{-COV_i} \tag{6}$$

where cov_i is the auto-covariance of returns for stock *i*. In calculating the Roll's spread, we adopt the approach of Roll (1984), Lesmond et al. (1999), and Lesmond (2005); converting all positive auto-covariances to negative.

2.3.3. Amortized Spread

Chalmers and Kadlec(1998) suggest the notion of amortized spread, the product of the effective relative spread and the turnover, where 1/turnover is a proxy for the average holding period. If the turnover is higher (the holding period is shorter), the higher impact of trades to bid-ask spread make the amortized spread larger.

To calculate this measure, total won/dollar volume expended on bid–ask spreads for each stock on each trading day are needed. A stock's daily won/dollar spread is the sum of the product of the absolute value of the effective spread, $|P_t\text{-}M_t|$, and the number of shares traded, V_t over all trades for day T, where P_t is the transaction price and M_t is the midpoint of the prevailing bid–ask quote. Daily amortized spread for day T is this daily won/dollar spread divided by the firm's market value at day T (P_T * $SharesOut_T$),

$$Amortized\ Spread_T = \frac{\sum_{t=1}^{T} |P_t - M_t| \cdot V_t}{P_t \cdot SharesOut_T}. \tag{7}$$

Approximately amortized spread is equal to the effective spread times share turnover.

$$Amortized\ Spread \approx \frac{|P_t - M_t|}{P} \cdot \frac{V}{SharesOut} \tag{8}$$

In case of Korea, amortized spread is calculated as the product of the proportional spread and the turnover of day T.

2.4. Liquidity as Concept of Trading Speed (Time)

2.4.1. Proportion of Zero Daily Return

Proportion of zero daily return is used as liquidity measure. Zero daily return is related to trading speed because the days with zero return mean the delay or difficulty in executing an order. It causes the interruption in the continuity of trading. Bekaert et al.

(2003) use this measure to examine the impact of liquidity on expected returns in emerging equity markets. They find the proportion of zero daily return can predict future returns significantly.

2.4.2. Lesmond, Ogden, and Trzcinka (LOT) (1999) Measure

LOT measure is the liquidity measure based on a limited dependent variable (LDV) model and uses only daily stock returns to estimate firm-level transaction cost. The intuition for the approach is that if transaction costs prevent more informed traders from trading, then more zero return will be observed in a firm with larger transaction cost. Because informed investors trade only when their gains from trading on mispricing exceed the costs of trading, a transaction cost operates as a threshold.

Actually LOT found that the frequency of zero daily return is greater for firms with larger trading cost. Firms with larger trading cost require a larger accumulation of news to overcome the trading cost threshold and their returns of nonzero-return days are expected to be larger than others.

The LDV model is characterized by the following equation:

$$\begin{aligned} R(i,t) &= R^*(i,t) - \alpha 1(i) && \textit{if } R^*(i,t) < \alpha 1(i) \\ R(i,t) &= 0 && \textit{if } \alpha 1(i) \le R^*(i,t) \le \alpha 2(i) \\ R(i,t) &= R^*(i,t) - \alpha 2(i) && \textit{if } R^*(i,t) > \alpha 2(i) \end{aligned} \qquad (9)$$

where $\alpha 1(i) < 0$ is the sell-side trading cost for asset i, $\alpha 2(i) > 0$ is the buy-side cost, $R(i,t)$ is the return of stock i, and $R^*(i,t)$ is the unobserved return in a frictionless market. LOT use the market model regression as the return-generating process for the informed trader. The specification is $R^*(i,t) = b(i)R_M(t) + e(i,t)$, where $R_M(t)$ is the market return (KOSPI return / CRSP value-weighted market return) and $e(i,t)$ captures all other information.

An econometric model can be formed by using the market model and equation (9). The assumption that return's distribution is normal makes the estimation of $\alpha 1$ and $\alpha 2$ possible by maximizing the following log-likelihood function:

$$\ln L = \sum_{R_1} \ln \frac{1}{(2\pi\sigma(i)^2)^{1/2}} - \sum_{1} \frac{1}{2\sigma(i)^2}(R(i,t) + \alpha 1(i) - b(i) R_M(t))^2$$

$$+\sum_{R_2} \ln \frac{1}{(2\pi\sigma(i)^2)^{1/2}} - \sum_{2} \frac{1}{2\sigma(i)^2}(R(i,t) + \alpha 2(i) - b(i) R_M(t))^2 + \sum_{R_0} \ln(\Phi_2(i) - \Phi_1(i)) \qquad (10)$$

where R_1, R_2 and R_0 represent the region where the measured return *R(i,t)* is in the nonzero negative, the nonzero positive, and the zero regions respectively. *b(i)* and $\sigma(i)^2$ are the market risk beta estimate and the variance of the nonzero observed returns. $\Phi_j(i)$ represents the cumulative distribution function for each stock *i* evaluated at region *j*. The terms of equation (10) corresponds to the negative returns, the positive returns, the zero-returns of equation (9) respectively.

The LOT transaction cost is the difference between $\alpha 2(i)$ and $\alpha 1(i)$: $\alpha 2(i) - \alpha 1(i)$, which means the implied round trip transaction costs. LOT show that their measure is actually at least 30% lower than quoted spread plus commission regardless of firm size. It means that the LOT transaction cost is relatively conservative measure compared to the most immediacy transaction costs.

2.4.3. Liu (2006) Measure

Liu (2006) suggests a liquidity measure defined as the standardized turnover-adjusted number of zero daily trading volumes over the prior *x* months. This measure particularly emphasizes on trading speed. Liu (2006)'s measure of liquidity is defined as

$$Liu_x = [Number\ of\ zero\ daily\ volumes\ in\ prior\ x\ months + \frac{1/(x-month\ turnover)}{Deflator}] \times \frac{21x}{NoTD} \qquad (11)$$

where *x*-month turnover is turnover over the prior *x* months, calculated as the sum of daily turnover over the prior *x* months, and *NoTD* is the total number of trading days in the market over the prior *x* months. *Deflator* is chosen such that

$$0 < \frac{1/(x - month\ turnover)}{Deflator} < 1 \tag{12}$$

The number of zero daily trading volumes plays a major role in determining the liquidity measure. Adjusted turnover plays a secondary role because its value is between 0 and 1. If there are two stocks with the same integer number of zero daily trading volumes, we can decide that the stock with the larger turnover is more liquid. The multiplication by the factor *21x / NoTD* normalizes the number of trading days in a month to 21. It makes the liquidity measure comparable over time because the number of trading days in a month can vary over time.

2.5. Modified Amihud (2002) Measure

In this section, we propose a modified Amihud (2002) illiquidity measure which contains various dimensions of liquidity. The modified Amihud (2002) illiquidity measure is defined as

$$MA_t^i = \frac{1}{Days_t^i} \sum_{d=1}^{Days_t^i} \frac{|R_{td}^i|}{V_{td}^i} \times (1 - a\log(1 - zero)) \tag{13}$$

where R_{td}^i and V_{td}^i are, respectively, the return and won/dollar volume (in 10 million won / 10 thousand dollar) on day *d* in year *t*, and $Days_t^i$ is the number of valid observation days in year *t* for stock *i*. $zero$ is the proportion of no trading volume day (0<= zero <1), and *a* is the arbitrary constant determining the slope of log curve.

The original Amihud (2002) measure is defined as

$$Amihud_t^i = \frac{1}{Days_t^i} \sum_{d=1}^{Days_t^i} \frac{|R_{td}^i|}{V_{td}^i} \tag{14}$$

This Amihud (2002) measure represents the *illiquidity* of individual stock. If a stock's price moves considerably in response to little volume, this stock has a high value of Amihud measure; It means that the stock is illiquid. However, Amihud (2002) state that "…the illiquidity measure presented in this study can be regarded as empirical proxies that measure different aspects of illiquidity. It is doubtful that there is one single measure that captures all its aspects." (p.35). Motivated by his statement, I develop a modified Amihud (2002) illiquidity measure reflecting various dimensions of liquidity.

Amihud (2002) measure has the following merits. First, the Amihud (2002) measure is easy to obtain because it is estimated from data readily available over long periods for most markets: daily return and volume (amount) data. Second, it follows Kyle (1985)'s concept of illiquidity, the response of price to the order flow; absolute (percentage) price change per won/dollar of daily trading volume, which can measure the daily price impact of the order flow. Third, the Amihud (2002) measure is strongly related to the liquidity measures such as the Amivest measure and the proportional spread. Fourth, it has the same economic concept as the reversal measure of Pastor and Stambaugh (2003); return scaled by trading volume. Fifth, it includes the concepts of liquidity such as trading quantity, trading cost, and price impact.

However, the Amihud (2002) measure also has its own drawbacks. First, the Amihud (2002) measure misses the concept of trading speed, which the liquidity measure should have, because it does not take account of the number of non-trading days. Second, the Amihud (2002) measure has the effect of extreme value. To solve the second problem, the wonsorization or the deletion is applied to Amihud (2002) measure at 1% level.

To solve the first problem, I develop a modified Amihud (2002) illiquidity measure complementing the dimension of trading speed. To understand the first problem easily, an example is given in Figure 1. The first problem stems from the measure's shortcoming that only valid observation days are counted in calculating the Amihud (2002) measure. The first case in Figure 1 has all six trading days and the Amihud (2002) measure is 0.1. The second case in Figure 1 has four trading days among six days and the Amihud (2002) measure is 0.1. The third case in Figure 1 has only one trading day among six days and the Amihud (2002) measure is 0.1. All three cases have the same value of Amihud (2002) measure, 0.1. However, we can intuitively know that the stock of the third case is extremely illiquid because the investor who wants to trade the stock will suffer a great deal of difficulty in fulfilling the transactions.

Therefore, we introduce a modifying factor, $1 - a\log(1 - zero)$ and multiply the original Amihud (2002) measure by this modifying factor to adjust the time concept of illiquidity. The value of modifying factor depends on zero and arbitrary constant, *a.* The curve of the modifying factor is presented in Figure 2. When zero is 0, the modifying factor is 1 and the modified Amihud (2002) measure is the same as the original Amihud (2002) measure. As *zero* rises gradually from 0 to 1, the modifying factor becomes greater than 1 and at the same time the modified Amihud (2002) measure becomes greater than the original Amihud (2002) measure. The range of zero is [0 , 1). The value of zero is not defined at 1 because it means no trading occurs through all trading days. As *zero* becomes closer to 1, the illiquidity goes to the infinite. It means that a stock is extremely illiquid because the trading itself is impossible. Therefore, using the modifying factor can reflect the solvency constraints of firm (Lustig, 2001; Holmstrom and Tirole, 2001) and the 'lock-in-risk' of investor that they can not sell out securities when they want to liquidate them (Liu, 2006).

3. Data

3.1. Data

Comparisons of liquidity measures are performed on the Korean and the U.S. market. The Korean sample includes all non-financial firms listed in the Korean stock market for the period 1993~2004. IFB/KSE (high frequency), KSRI and KIS-VALUE (daily) data are used to obtain liquidity measures.

Daily bid-ask quotes are obtained from the best bid/offer (BBO) quotations of the IFB/KSE database. The IFB/KSE database is composed of three parts: order data, trade data, and BBO data. The BBO data include quotation time, best bid price with depth, and best offer price with depth. For each stock, daily proportional spread is calculated by averaging all BBO quotes at the transaction during the continuous auction period. Then the yearly averages of daily proportional spreads are obtained. In this method, the yearly proportional spreads of sample firms are calculated for the period 1993~2004. Daily bid-ask quotes data are also used to calculate the amortized spread. Kyle's lambda (λ) is estimated from equation (3) using the price, volume, and trading direction data from the IFB/KSE. Number of trades is obtained from the IFB/KSE as well.

Daily volume, daily trading amount, and number of stock outstanding are obtained from the KIS-VALUE database for the period 1993~2004. The data are used to calculate annual volume, trading amount, and turnover. Volume data are also used to obtain Amivest liquidity ratio, amortized spread, and Liu's measure. Trading amount data are also used to obtain Amihud illiquidity measure and Pastor/Stambaugh's reversal measure.

Daily stock return data are derived from the KSRI database. The data are used to calculate Amivest liquidity ratio, Amihud (2002) measure, Pastor/Stambaugh's reversal measure, Roll's spread, proportion of zero daily return, and LOT measure.

The U.S. sample includes all non-financial firms listed in the NYSE /AMEX for the period 1993-2004. The firms whose data are available in the CRSP database are included in the sample. The share code is used to exclude the following categories: certificates, American depository receipts, shares of beneficial interest, units, Americus Trust components, closed-end funds, and real estate investment trusts. Because their trading characteristics and accounting rules might differ from ordinary equities, stocks of financial firms, funds, and preferred stocks are removed from the sample. The firms whose prices are below 5 dollar are excluded from the sample.

Daily bid-ask spread, daily volume, daily trading amount are obtained from the CRSP database. Turnover, Amivest measure, Pastor/Stambaugh's reversal measure, Amihud (2002) measure, Roll (1984) spread, proportion of zero daily return, LOT measure, and Liu (2006) measure are calculated from the daily data of the CRSP.

3.2. Estimation of Liquidity Measures

For a particular firm and year, each liquidity measure is estimated as follows:

- Volume / Trading amount

Annual volume and trading amount is the sum of daily volume and trading volume for one year.

- Turnover

Monthly turnover is used to calculate the annual turnover according to Datar et al. (1998). Annual turnover is the average of monthly trading volume divided by the number of shares outstanding.

- Number of trades (Only in Korea)

Number of trades is obtained from the IFB/KSE.

- Amivest liquidity ratio

If a daily return is zero, it is treated as a missing value. In case of Korea, Amivest liquidity ratio is divided by 10^9 (in case of U.S., divided by 10^5) to adjust the scale because the volume is much larger than the return.

- Amihud illiquidity measure

If a daily trading amount is zero, Amihud illiquidity measure cannot be calculated. In this case, it is treated as a missing value. In case of Korea, Amihud (2002) measure is multiplied by 10^7 (in case of U.S., mutiplied by 10^4) for adjusting the scale.

- Kyle's lambda (λ) (Only in Korea)

Kyle's lambda (λ) is estimated from equation (3) using OLS regression. If Kyle's lambda is negative, it is treated as a missing value. Negative value has no meaning because Kyle's lambda (λ) is a sort of transaction cost.

- Pastor/Stambaugh's reversal measure

Pastor/Stambaugh's reversal coefficient for signed volume is estimated from equation (4) using OLS regression. Firms with at least 50 trading days are included in the sample.

- Proportional spread

In case of Korea, daily spread is calculated by averaging all the transaction during the continuous auction period. Then the yearly averages of daily proportional spreads are obtained. In case of the U.S., daily closing bid-ask prices are used to calculate daily spread, and then the yearly averages of daily proportional spreads are calculated.

- Roll' spread

If number of daily returns is less than 50 in one year, it is excluded from the sample to obtain a reliable parameter.

- Amortized spread (Only in Korea)

Daily amortized spread is the product of daily proportional spread and turnover. Then the yearly averages of daily amortized spreads are obtained.

- Zero

The proportion of zero daily return is the number of zero daily returns divided by the number of total trading days in that year.

- LOT

LOT measure is estimated by the maximum likelihood estimation. If the observation of trading days is less than 50 or the estimation cannot be converged, it is excluded from the sample.

- Liu

Liu (2006)'s measure is calculated by equation (11).

Table 1 reports the summary statistics of liquidity measures in Korea. The mean of volume is about 113 billion shares, but the median is lower (19 billion shares). This shows that its distribution is skewed to the right. The pattern that median is lower than mean is also founded in other measures except the Pastor/Stambaugh's measure. The distributions of most measures exhibit extreme values. For example, maximum of turnover is about 107 while their median and third quartile are 0.23 and 0.42 respectively.

Table 2 represents the annual summary statistics of liquidity measures in Korea. The median is used to explain the measures because the mean is vulnerable to the effect of extreme values. Liquidity is expected to be in the lowest level around 1997, when the Korea faced the financial crisis. As expected, the medians of volume, trading amount, turnover, Amivest measure, and Pastor/Stambaugh's measure are at the lowest during the period 1996-1998. The medians of Amihud measure, Kyle's lambda, proportional spread, Roll's spread, amortized spread, proportion of zero daily return, LOT measure, and Liu measure are at the highest illiquidity during the period 1996~1998. In case of Pastor/Stambaugh measure, the median in 1998 is positive value (0.048) contrary to the theoretical expectation.

Table 3 represents the summary statistics of sample firms in the U.S. The mean of volume is about 96 million shares, but the median is lower (18 million shares). This means that its distribution is skewed to the right. Other measures show the same pattern that median is lower than mean as well. The distributions of most measures exhibit extreme values. For example, maximum of turnover is about 41, while their median and third quartile are 0.68 and 1.19 respectively. The mean of the modified Amihud (MA) measure is 4.25, and its standard deviation is 24.74. The MA measure is larger than the original Amihud (2002) measure because the modifying factor is greater than 1. Table 4 reports the annual summary statistics of liquidity measures in the U.S.

4. Empirical Results

4.1. Correlation of Liquidity Measures

Correlations between liquidity measures are investigated in this section. This analysis can check the internal consistency of measures. Table 5 and Table 6 present the correlations between liquidity measures in Korea and the U.S. respectively. Panel A represents Pearson correlation and Panel B represents Spearman correlation. Spearman correlation is employed to pick up the non-linear and monotonic associations between measures.

Correlation comparisons are performed in two ways. The first is the relative comparison between liquidity measures. The second is the absolute comparison, which employs an absolute standard to compare liquidity measures.

The relative comparisons are employed for the following reasons. If measures are devised to be similar economically, high correlations are expected. However, most measures are devised to capture different aspect of liquidity, and thereby they are in the lack of economic similarity. It is difficult to compare measures using the absolute value of correlation since we cannot know which liquidity measure is really correct. Therefore, the sign of Spearman correlation is used for the cross-check. Though each pair does not have its own benchmark value of correlation, it has a sign that should appear in the normal relation. For example, in the case of the more liquid stock, the volume is higher while the Amihud (2002) illiquidity measure is lower. Thus, the correlation between volume and the Amihud (2002) measure should be negative. Every pair of liquidity measures has its own desirable sign.

We should be cautious about the difference between liquidity measure and illiquidity measure. Liquidity measure is higher when the stock's liquidity is higher. On the contrary, illiquidity measure represents stock's illiquidity and is higher when the stock's liquidity is lower. Illiquidity measures includes the Amihud (2002) measure, the MA measure, the Kyle's lambda, the proportional bid-ask spread, the Roll (1984)'s spread, the amortized spread, the proportion of zero daily return, the LOT measure, and the Liu (2006) measure. Because the illiquidity measures make it confusing to check the signs of Spearman correlations, they are converted into the liquidity measures by multiplying the minus sign. Therefore, all signs of correlation between measures should be positive if each measure has a normal relation. These signs of Spearman correlations are checked in the Panel C of Table 5 and Table 6. Panel C contains a shadow effect in a block if its sign violates normal relation (has a minus sign).

In the case of Korea (Table 5), each measure has 14 relations with others. We count the number of violations for each measure. The volume has 3 violations, the trading amount has 2 violations, the turnover has 3 violations, the number of trades has 3 violations, the Amivest liquidity ratio has 3 violations, the Pastor/Stambaugh's measure has 8 violations, the Amihud measure has no violation, the modified Amihud measure has no violation, the Kyle's lambda has no violation, the proportional bid-ask spread has 1 violation, the Roll's spread has 7 violations, the amortized spread has 7 violations, the proportion of zero daily return has 3 violation, the LOT measure has 1 violation, and the Liu's measure has 3 violations. In conclusion, the Amihud measure, the modified Amihud measure, and the Kyle's lambda perform the best. The Pastor/Stambaugh measure, the Roll's spread, and the amortized spread seem to be problematic. The Pastor/Stambaugh measure and the Roll's spread assume the negative autocorrelation of daily return; nevertheless, autocorrelation of daily return is not always negative and it does not only reflect the liquidity effect. Hasbrouck (2004) also argues that the Pastor/Stambaugh's reversal measure of individual stock shows large estimation errors in the U.S. (NYSE, AMEX, and NASDAQ) pointing out that Pastor and Stambaugh (2003) do not use these measures for individual firms, but only employ them to form portfolios.

Because Pastor and Stambaugh (2003) measure can distort the results, We count the number of violations for each measure excluding Pastor and Stambaugh (2003) measure. The volume has 2 violations, the trading amount has 2 violations, the turnover has 2 violations, the number of trades has 2 violations, the Amivest liquidity ratio has 2 violations, the Amihud measure has no violation, the modified Amihud measure has no violation, the

Kyle's lambda has no violation, the proportional bid-ask spread has no violation, the Roll's spread has 7 violations, the amortized spread has 7 violations, the proportion of zero daily return has 2 violations, the LOT measure has no violation, and the Liu's measure has 2 violations. In conclusion, the proportional bid-ask spread and the LOT measure are included into the best measures additionally.

In the case of the U.S. (Table 6), each measure has 11 relations with others. We count the number of violations for each measure. The volume has 1 violation, the trading amount has 1 violation, the turnover has 2 violations, the Amivest liquidity ratio has 1 violation, the Pastor/Stambaugh's measure has 11 violations, the Amihud measure has 1 violation, the modified Amihud measure has 1 violation, the proportional bid-ask spread has 1 violation, the Roll's spread has 3 violations, the proportion of zero daily return has 2 violations, the LOT measure has 1 violation, and the Liu's measure has 1 violation. When the Pastor and Stambaugh (2003) measure is excluded, the volume, the trading amount, the Amivest liquidity ratio, the Amihud measure, the modified Amihud measure, the proportional bid-ask spread, the LOT measure, and the Liu's measure have no violation.

The absolute comparisons, which employ an absolute standard to compare the liquidity measures, are performed as follows. The key of absolute comparison is to select the absolute standard to compare the liquidity measures. First, the widely used proxies for liquidity are introduced to examine their relations with the liquidity measures. Size and B/M are used as comparison standards of liquidity measures. Size is positively related with liquidity since a larger stock has a smaller price impact for a given order flow and a smaller bid-ask spread (Amihud, 2002). B/M is negatively related with liquidity since a distressed firm has a poor liquidity if B/M represents the distress risk (Liu, 2006). In case of Korea, the trading amount, the Amihud measure, the MA measure, the proportional bid-ask spread, and the amortized spread are highly correlated with firm size; that is, they are above 0.5 in the absolute value of Spearman correlation. The trading amount, the Amihud (2002) measure, the MA measure, and the proportion of zero daily return are highly correlated with B/M; that is, they are above 0.2 in the absolute value of Spearman correlation.

Second, the bid-ask spread is used as an absolute standard. The most precise measure of liquidity is the bid-ask spread because it is computed from high-frequency data. Many researchers are interested in an alternative liquidity measure to high-frequency measure since in many case they cannot obtain high-frequency measure, such as the bid-ask spread and depth. They want to know what measure can replace high-frequency measures. When proportional bid-ask spread is chosen as absolute comparison standard, the trading amount, the number of trades, the Amihud (2002) measure, and the MA measure are highly correlated with the bid-ask spread; that is, they are above 0.7 in the absolute value of Spearman correlation.

The same procedure is implemented to the liquidity measures of the U.S. Table 6 shows the correlations between firm characteristic variables and liquidity measures in the U.S. The volume, the trading amount, the Amivest measure, the Amihud (2002) measure, the MA measure, and the LOT measure are highly correlated with the firm size; that is, they are above 0.7 in the absolute value of Spearman correlation. The proportion of zero daily return and the LOT measure are highly correlated with the bid-ask spread; that is, they are above 0.2 in the absolute value of Spearman correlation.

4.2. Liquidity Measures and Stock Returns

The relation between stock returns and liquidity measures is examined in this section. The method of Brennan, Chordia, and Subrahmanyam (1998) (BCS) is adopted as empirical asset pricing framework. Instead of examining the excess returns on portfolio, BCS method examines the risk-adjusted returns of individual stocks.

The BCS procedure can be summarized as follows. BCS assume that returns are generated by an L-factor model. In this paper, we use the Fama and French (1993) three factor model as an L-factor model. An approximate factor model in which the return on the jth security is given by:

$$R_{jt} = E(R_{jt}) + \sum_{k=1}^{L} \beta_{jk} f_{kt} + e_{jt} \tag{15}$$

where f_t is a vector of factor realizations at time t, and β_j contains the factor loadings for security j. The APT implies that expected returns can be written as

$$E(R_{jt}) - R_{Ft} = \sum_{k=1}^{L} \lambda_{kt} \beta_{jk} \quad (16)$$

where R_{Ft} is the risk-free return, and λ_k is the risk premia for factor k. Substituting from equation (16) in equation (15), the realized returns are

$$R_{jt} - R_{Ft} = \sum_{k=1}^{L} \beta_{jk} F_{kt} + e_{jt} \quad (17)$$

where F_{kt}=λ_{kt} +f_{kt}. The key question is the extent to which the firm characteristics have incremental explanatory power for returns relative to the Fama and French (1993) three factor benchmark. The Fama and MacBeth (1973) method is introduced to estimate the following equation:

$$R_{jt} - R_{Ft} = c_o + \sum_{k=1}^{L} \beta_{jk} f_{kt} + \sum_{m=1}^{M} c_m Z_{mjt} + e_{jt} \quad (18)$$

where Z_{mjt} is the value of characteristics m for stock j in month t. The estimated risk-adjusted returns of stock j for each month t, are then calculated as

$$R_{jt}^{*} \equiv R_{jt} - (R_{Ft} + \sum_{k=1}^{L} \hat{\beta}_{jk} F_{kt}) \quad (19)$$

To calculate the risk-adjusted returns of stock j, I use the Fama and French (1993) three factor model. Factor loadings β_{jt} are estimated for all stocks that have at least 26 return observations over the prior 60 months. For each month t, the risk-adjusted returns are regressed against the set of firm characteristics (liquidity measures in this analysis):

$$R^*_{jt} = c_o + \sum_{m=1}^{M} c_m Z_{mjt} + e'_{jt} \qquad (20)$$

In this paper, Z_{mjt} consists of liquidity measures. Under the null hypothesis that the characteristics (here liquidity measures) do not affect returns, the coefficients of c_m will be equal to zero. BCS suggest two approaches to summarize the time series of these estimates: the time-series average of the coefficients associated with the characteristics (the standard Fama and MacBeth (1973) estimator) and the purged estimator developed by Black and Scholes (1974).

The usage of BCS regression is based on the recent studies on the liquidity asset pricing, in which many researchers argue that liquidity should be priced in the asset prices (Amihud and Mendelson, 1986; Data et al., 1998; Brennan and Subrahmanyam, 1996; Pastor and Stambaugh, 2003; Acharya and Pedersen, 2005; Liu, 2006). However, this methodology has a limitation because it tests the joint hypothesis that liquidity should be priced and a certain liquidity measure reflects the true liquidity of firms precisely. Hasbrouck (2004) also employ the BCS regression method to compare the liquidity measures in the U.S. stock market.

Table 7 reports the BCS regression results in Korea. Values in the table are time-series averages of monthly coefficients of cross-sectional regression. The first specification incorporates one liquidity proxy at one time. In this univariate regression, coefficients of the volume, the trading amount, the turnover, the number of trades, the Amivest measure, the Amihud illiquidity measure, the MA measure, the bid-ask spread, the proportion of zero daily return, and the LOT measure have negative and significant relations with adjusted returns (at 10% level). When the liquidity measures in the same category are included in the regression at a time, the trading amount, the Amihud illiquidity measure, the proportional bid-ask spread, and the proportion of zero daily return are the best measures in each category.

Table 8 represents the BCS regression results in the U.S. In the univariate regression, coefficients of the turnover, the Amihud illiquidity measure, the MA measure, and the Liu measure have negative and significant relations with adjusted returns (at 10% level). When the liquidity measures in the same category are included in the regression at one time, the turnover, the Amihud illiquidity measure, the bid-ask spread, and the Liu measure are the best measures in each category.

5. Conclusion

This paper compares various liquidity measures to find which of these measures is the most appropriate. Based on the definitions of O'Hara (2001) and Liu (2006), liquidity measures are classified into four categories. The first category captures the notion of *trading quantity*, in which volume, trading amount, number of trades, and turnover are included. The second category of liquidity measure catches the notion of *price impact*, in which Amivest liquidity ratio, Amihud (2002) illiquidity measure, modified Amihud (2002) (MA) measure, Kyle's lambda (λ), and Pastor and Stambaugh (2003)'s reversal measure are included. The third category captures the notion of *trading cost*, in which proportional spread, Roll's spread, and amortized spread are included. The fourth category catches the notion of *trading speed (time)*, in which proportion of zero daily return, Lesmond, Ogden, and Trzcinka (1999) (LOT)'s transaction cost, and Liu (2006) measure are included.

Analyses are performed on sample firms listed in the Korean and the U.S. stock market for the period 1993~2004. Liquidity measures are compared by using two methodologies. One is a correlation check between liquidity measures that will reveal the internal consistency of measures. The other method is to investigate the relationship between risk-adjusted returns and liquidity measures. The empirical asset pricing framework of Brennan, Chordia, and Subrahmanyam (1998) (BCS) is adopted.

In the correlation analysis, the Amihud (2002) measure, the MA measure, and the proportional bid-ask spread prove to be the best measures in both Korea and the U.S. However, Pastor/Stambaugh's reversal measure performs poorly. This measure is correlated with other liquidity measures in the opposite direction unlike theoretical explanations. In the BCS regression, the volume, the trading amount, the turnover, the number of trades, the Amivest measure, the Amihud (2002) illiquidity measure, the MA measure, the bid-ask spread, the proportion of zero daily return, and the LOT measure have negative and significant relations with adjusted returns in the Korean sample. In the case of the U.S., the turnover, the Amihud (2002) illiquidity measure, the MA measure, and the Liu (2006) measure are significantly correlated with risk-adjusted returns.

The most precise measure of liquidity is the bid-ask spread. Many researchers are interested in another liquidity measure because they cannot obtain high-frequency measures, such as the bid-ask spread and depth. They want to know which measure can replace high-frequency measures. When the proportional bid-ask spread is chosen as an absolute comparison standard, the Amihud measure and the MA measure are highly correlated with the bid-ask spread. Eventually, the Amihud (2002) measure and the MA measure perform consistently well in the correlation check and the asset pricing test.

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Table 1. Summary statistics of liquidity measures in the Korean sample

This table reports the summary statistics of various liquidity measures. Each liquidity measure is calculated for one year during 1993-2004. Volume is the number of shares traded at the continuous auction for one year in billion shares. Trading amount is the total amount traded at the continuous auction for one year in billion won. Turnover is the annual average of monthly turnovers, which are the numbers of shares traded for one month scaled by the number of stocks outstanding. The Amivest measure is $\sum_{i=1}^{T} Volume_i \Big/ \sum_{i=1}^{T} | return_i |$ for one year (multiplied by 10^9). The Pastor and Stambaugh (2003)'s reversal measure is estimated from the regression equation $r^e_{j,d+1} = \theta_j + \varphi_j r_d + \gamma_j sign(r^e_{j,d}) \cdot v_{j,d} + e_{j,d+1}$,where d indexes days, $r^e_{j,d+1}$ is the return on stock j in excess of the market return and $v_{j,d}$ is the daily won volume (in billion won). The Amihud (2002) measure is $\frac{1}{Days^i_t} \sum_{d=1}^{Days^i_t} \frac{|R^i_{td}|}{V^i_{td}}$,where R^i_{td} and V^i_{td} are, respectively, the percentage return and won volume (in 10 million won) on day d in year t, and $Days^i_t$ is the number of valid observation days in year t for stock i. MA (Modified Amihud (2002)) measure is defined as $MA^i_t = \frac{1}{Days^i_t} \sum_{d=1}^{Days^i_t} \frac{|R^i_{td}|}{V^i_{td}} \times (1 - a\log(1 - zero))$, where *zero* is the proportion of no trading volume day, and a is the arbitrary constant determining the slope of log curve (a = 1 in this paper). Kyle's λ is estimated from the regression equation $\Delta P_t = \lambda V_t + \psi(Q_t - Q_{t-1}) + e_t$, where P_t is the trade price, V_t is the signed volume, and Q_t is the indicate variables representing trade direction (+1 for a buyer-initiated trade and −1 for a seller-initiated trade). Proportional spread is defined as $\sum_{t=1}^{T} \frac{Ask_t - Bid_t}{(Ask_t + Bid_t)/2}$,where Ask_t denotes a ask price at time t, Bid_t denotes a bid price at time t. The Roll (1984)'s spread is defined as $2\sqrt{-COV_i}$, where cov_i is the auto-covariance of returns for stock i. Amortized spread is defined as $\frac{\sum_{t=1}^{T} |P_t - M_t| \cdot V_t}{P_t \cdot SharesOut_T} \approx \frac{|P_t - M_t|}{P} \cdot \frac{V}{SharesOut}$, where P_t is the transaction price, M_t is the midpoint of the prevailing bid–ask quote, V_t is the number of shares traded over all trades, and *SharesOut* is the number of shares outstanding. Zero is the number of days with zero returns divided by total number of trading days. LOT (1999) measure is the difference between $\alpha 2(i)$ and $\alpha 1(i)$ estimated from estimation (2-10). Liu (2006) is defined as

$$[Number\ of\ zero\ daily\ volumes\ in\ prior\ x\ months + \frac{1/(x - month\ turnover)}{Deflator}] \times \frac{21x}{NoTD}$$

, where x-month turnover is turnover over the prior x months, calculated as the sum of daily turnover over the prior x months and *NoTD* is the total number of trading days in the market over the prior x months. Deflator is chosen such that $0 < \frac{1/(x - month\ turnover)}{Deflator} < 1$ (in this table, deflator=40,001).

Variables	Source	N	Mean	Std	Min	Q1	Median	Q3	Max
Volume	KIS-VALUE	6,605	113	1,327	0.000	7	19	63	99,128
Trading amount	KIS-VALUE	6,605	5,455	26,102	0.041	578	1,334	3,151	722,220
Turnover	KIS-VALUE	6,605	0.422	1.641	0.000	0.112	0.228	0.420	106.558
Number of trade	IFB/KSE	6,605	63,368	158,684	6.000	10,344	21,473	58,888	6,031,014
Amivest	KSRI / KIS-VALUE	6,604	0.140	0.980	0.000	0.012	0.032	0.096	66.829
Pastor Stambaugh	KSRI KIS-VALUE	6,480	-0.023	2.046	-33.411	-0.254	-0.018	0.144	45.614
Amihud	KSRI KIS-VALUE	6,605	0.661	3.208	0.000	0.045	0.124	0.346	115.546
MA	KSRI KIS-VALUE	6,605	0.882	7.105	0.000	0.045	0.124	0.348	250.246
Kyle lambda	IFB/KSE	6,420	0.024	0.190	0.000	0.001	0.004	0.015	9.536
Prop. spread	IFB/KSE	6,605	0.012	0.009	0.001	0.007	0.011	0.015	0.099
Roll	KSRI	6,562	0.023	0.015	0.000	0.013	0.020	0.030	0.119
Amortized spread	KSRI KIS-VALUE	6,605	0.048	0.173	0.000	0.011	0.024	0.046	8.538
Zero	KSRI	6,605	0.096	0.062	0.000	0.057	0.085	0.122	0.875
LOT	KSRI	6,565	0.010	0.010	0.000	0.006	0.008	0.011	0.210
Liu	KSRI KIS-VALUE	6,605	3.476	16.136	0.000	0.000	0.000	0.863	246.270

Table 2. Annual distributions of liquidity measures in the Korean sample

These tables report the annual summary statistics of various liquidity measures in Korea for the period 1993-2004. The explanations for liquidity measures are in the Table III-1.

A. Volume

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	459	21.141	27.056	0.267	4.997	10.491	26.789	254.916
1994	472	29.632	37.530	0.007	7.132	15.986	35.425	274.856
1995	491	18.868	25.533	0.000	3.709	9.248	22.160	187.069
1996	562	23.590	34.774	0.000	4.758	10.566	26.258	294.589
1997	619	33.858	55.228	0.000	6.194	14.231	33.945	490.508
1998	569	50.516	76.564	0.008	8.668	24.304	56.396	604.977
1999	530	118.710	228.545	0.053	13.015	38.805	115.768	1,898.433
2000	525	120.368	259.069	0.096	12.190	42.014	118.357	3,122.032
2001	533	172.591	1,353.342	0.029	10.879	36.632	106.116	30,690.783
2002	617	347.518	4,016.598	0.059	8.674	37.343	154.113	99,127.753
2003	616	217.019	861.617	0.049	4.210	20.095	107.363	14,082.128
2004	612	135.449	459.726	0.046	4.540	20.021	104.655	7,865.994

B. Trading amount

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	459	1,865	2,552	122	678	1,099	1,880	23,334
1994	472	3,401	6,434	1	978	1,723	3,245	70,365
1995	491	1,975	4,292	0	536	1,003	2,063	75,345
1996	562	1,875	2,688	0	693	1,188	2,113	36,373
1997	619	2,146	3,083	0	832	1,473	2,486	38,880
1998	569	2,527	7,097	4	460	915	2,084	105,230
1999	530	11,297	32,755	5	1,233	2,616	7,420	430,766
2000	525	9,005	39,865	44	733	1,858	5,472	690,752
2001	533	6,183	31,469	18	574	1,435	3,711	605,454
2002	617	9,455	44,210	18	572	1,566	5,685	722,220
2003	616	7,034	29,362	13	205	748	3,518	550,245
2004	612	7,520	33,758	6	223	819	3,860	679,800

C. Turnover

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	459	0.310	0.189	0.022	0.154	0.276	0.430	1.201
1994	472	0.277	0.150	0.001	0.159	0.250	0.367	0.841
1995	491	0.157	0.105	0.000	0.077	0.135	0.214	0.633
1996	562	0.206	0.147	0.000	0.090	0.177	0.286	0.894
1997	619	0.239	0.183	0.000	0.100	0.196	0.331	1.223
1998	569	0.372	0.502	0.001	0.174	0.292	0.458	7.710
1999	530	0.463	0.343	0.007	0.223	0.388	0.613	2.802
2000	525	0.492	0.528	0.007	0.175	0.327	0.667	6.098
2001	533	0.513	0.683	0.003	0.142	0.277	0.635	7.790
2002	617	0.645	1.388	0.004	0.123	0.266	0.662	26.197
2003	616	0.813	4.905	0.002	0.055	0.145	0.350	106.558
2004	612	0.467	1.214	0.004	0.049	0.130	0.375	16.332

D. Number of trades

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	459	10,882	10,509	1,181	5,335	8,036	12,363	125,039
1994	472	16,598	16,423	17	7,525	12,688	19,241	157,454
1995	491	14,530	14,735	279	5,966	10,344	18,035	142,755
1996	562	16,167	12,450	222	8,372	12,814	20,186	123,161
1997	619	20,289	16,684	6	10,447	16,389	25,699	159,498
1998	569	28,293	38,159	28	10,798	17,627	31,729	332,573
1999	530	98,070	161,511	116	22,500	43,560	99,524	2,010,968
2000	525	114,015	189,053	935	31,348	61,014	131,168	2,754,377
2001	533	99,396	248,808	573	25,037	58,561	107,829	5,268,121
2002	617	127,468	292,916	932	22,856	58,845	139,781	6,031,014
2003	616	92,623	172,639	209	10,638	31,813	103,424	2,254,381
2004	612	98,562	157,788	225	12,098	36,333	109,612	1,821,166

E. Amivest liquidity ratio

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	459	0.058	0.073	0.001	0.014	0.030	0.076	0.590
1994	472	0.051	0.064	0.000	0.012	0.028	0.063	0.400
1995	491	0.036	0.047	0.000	0.007	0.019	0.044	0.352
1996	562	0.039	0.053	0.000	0.009	0.019	0.046	0.481
1997	618	0.043	0.066	0.000	0.008	0.020	0.044	0.559
1998	569	0.049	0.075	0.000	0.009	0.023	0.056	0.662
1999	530	0.130	0.232	0.000	0.017	0.046	0.135	1.684
2000	525	0.130	0.260	0.000	0.015	0.047	0.135	3.214
2001	533	0.243	1.221	0.000	0.023	0.070	0.184	26.768
2002	617	0.367	2.749	0.000	0.018	0.065	0.244	66.829
2003	616	0.275	0.944	0.000	0.010	0.044	0.179	15.372
2004	612	0.195	0.561	0.000	0.012	0.046	0.171	8.384

F. Pastor/Stambaugh reversal measure

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	458	0.090	0.339	-1.306	-0.078	0.051	0.202	1.635
1994	465	-0.078	0.981	-15.966	-0.119	0.002	0.120	4.058
1995	479	-0.067	0.608	-5.761	-0.198	-0.010	0.141	2.287
1996	545	-0.179	0.889	-9.969	-0.270	-0.058	0.101	4.357
1997	593	-0.140	0.971	-13.887	-0.307	-0.061	0.100	11.752
1998	551	0.412	3.944	-23.477	-0.281	0.048	0.477	45.614
1999	517	-0.111	1.187	-9.234	-0.233	-0.038	0.051	17.195
2000	520	-0.140	1.830	-17.062	-0.380	-0.060	0.079	20.734
2001	523	-0.100	1.060	-6.682	-0.258	-0.034	0.121	11.465
2002	610	-0.013	1.652	-16.589	-0.277	-0.029	0.084	16.836
2003	612	0.011	2.920	-33.411	-0.452	-0.014	0.189	41.629
2004	607	0.022	3.358	-24.089	-0.369	-0.010	0.210	37.472

G. Amihud illiquidity measure

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	459	0.209	0.276	0.002	0.055	0.113	0.255	2.268
1994	472	0.282	0.976	0.001	0.051	0.114	0.256	18.211
1995	491	1.051	6.150	0.001	0.059	0.148	0.398	76.196
1996	562	0.745	5.767	0.003	0.071	0.155	0.326	115.546
1997	619	0.396	1.874	0.000	0.070	0.141	0.262	34.606
1998	569	1.406	4.302	0.001	0.115	0.341	0.897	67.418
1999	530	0.247	1.134	0.000	0.021	0.055	0.136	18.942
2000	525	0.349	0.782	0.000	0.032	0.101	0.301	6.722
2001	533	0.193	0.454	0.000	0.025	0.075	0.179	5.495
2002	617	0.413	1.551	0.000	0.023	0.088	0.294	31.778
2003	616	1.000	2.433	0.000	0.034	0.153	0.901	23.441
2004	612	1.418	4.057	0.000	0.031	0.164	0.886	39.714

H. Modified Amihud illiquidity measure

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	459	0.214	0.289	0.002	0.055	0.114	0.257	2.378
1994	472	0.356	2.162	0.001	0.051	0.117	0.257	45.061
1995	491	2.453	18.742	0.001	0.059	0.152	0.401	250.246
1996	562	1.420	13.868	0.003	0.071	0.155	0.327	244.486
1997	619	0.595	4.225	0.000	0.070	0.141	0.263	69.614
1998	569	1.592	5.319	0.001	0.117	0.343	0.909	75.503
1999	530	0.265	1.271	0.000	0.021	0.055	0.136	21.288
2000	525	0.355	0.812	0.000	0.032	0.101	0.301	6.722
2001	533	0.200	0.506	0.000	0.025	0.075	0.179	5.865
2002	617	0.424	1.581	0.000	0.023	0.088	0.294	31.778
2003	616	1.038	2.577	0.000	0.034	0.154	0.901	23.728
2004	612	1.553	4.780	0.000	0.031	0.165	0.906	54.177

I. Kyle lambda (λ)

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	454	0.001	0.001	0.000	0.000	0.001	0.001	0.007
1994	466	0.001	0.001	0.000	0.000	0.001	0.001	0.009
1995	483	0.017	0.027	0.000	0.005	0.010	0.021	0.370
1996	556	0.023	0.041	0.000	0.005	0.012	0.025	0.435
1997	607	0.030	0.084	0.000	0.004	0.014	0.032	1.667
1998	546	0.024	0.070	0.000	0.002	0.008	0.025	0.948
1999	516	0.031	0.130	0.000	0.002	0.009	0.025	2.043
2000	508	0.034	0.222	0.000	0.001	0.005	0.016	4.356
2001	525	0.029	0.217	0.000	0.001	0.003	0.012	4.273
2002	603	0.036	0.288	0.000	0.001	0.003	0.011	6.004
2003	586	0.028	0.397	0.000	0.000	0.002	0.007	9.536
2004	570	0.020	0.197	0.000	0.000	0.002	0.007	4.475

J. Proportional spread

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	459	0.010	0.003	0.003	0.008	0.009	0.011	0.019
1994	472	0.010	0.004	0.002	0.008	0.010	0.013	0.025
1995	491	0.012	0.005	0.002	0.008	0.011	0.014	0.030
1996	562	0.012	0.005	0.003	0.009	0.011	0.014	0.072
1997	619	0.016	0.008	0.003	0.011	0.014	0.018	0.058
1998	569	0.021	0.014	0.003	0.012	0.018	0.025	0.091
1999	530	0.013	0.010	0.002	0.007	0.011	0.014	0.099
2000	525	0.013	0.009	0.002	0.007	0.011	0.017	0.055
2001	533	0.008	0.004	0.002	0.005	0.007	0.010	0.039
2002	617	0.010	0.007	0.002	0.005	0.008	0.013	0.043
2003	616	0.012	0.008	0.001	0.005	0.010	0.016	0.064
2004	612	0.012	0.010	0.001	0.005	0.010	0.016	0.084

K. Roll's spread

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	459	0.014	0.006	0.001	0.009	0.013	0.018	0.033
1994	471	0.019	0.008	0.000	0.014	0.019	0.024	0.046
1995	487	0.014	0.007	0.000	0.009	0.014	0.018	0.053
1996	557	0.019	0.010	0.000	0.011	0.017	0.025	0.066
1997	614	0.037	0.012	0.006	0.029	0.036	0.044	0.072
1998	568	0.035	0.020	0.001	0.021	0.031	0.047	0.113
1999	523	0.028	0.014	0.001	0.018	0.026	0.036	0.078
2000	522	0.027	0.015	0.002	0.016	0.024	0.034	0.105
2001	530	0.022	0.012	0.001	0.014	0.020	0.028	0.088
2002	611	0.022	0.015	0.001	0.012	0.019	0.028	0.116
2003	612	0.020	0.013	0.000	0.011	0.017	0.025	0.110
2004	608	0.019	0.015	0.001	0.010	0.017	0.024	0.119

L. Amortized spread

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	459	0.026	0.016	0.001	0.014	0.023	0.036	0.116
1994	472	0.028	0.018	0.001	0.014	0.024	0.038	0.154
1995	491	0.016	0.017	0.000	0.008	0.014	0.021	0.327
1996	562	0.021	0.017	0.000	0.009	0.017	0.028	0.190
1997	619	0.035	0.025	0.000	0.016	0.029	0.049	0.175
1998	569	0.067	0.102	0.001	0.026	0.049	0.075	1.117
1999	530	0.054	0.042	0.002	0.025	0.042	0.071	0.311
2000	525	0.056	0.059	0.002	0.020	0.040	0.072	0.622
2001	533	0.048	0.086	0.001	0.012	0.026	0.056	1.337
2002	617	0.055	0.172	0.002	0.011	0.022	0.052	3.907
2003	616	0.096	0.478	0.001	0.006	0.013	0.029	8.538
2004	612	0.053	0.194	0.000	0.005	0.011	0.030	3.096

M. Proportion of zero daily return

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	459	0.141	0.037	0.041	0.118	0.139	0.162	0.280
1994	472	0.111	0.049	0.027	0.088	0.108	0.128	0.690
1995	491	0.146	0.080	0.051	0.106	0.133	0.160	0.875
1996	562	0.126	0.064	0.000	0.092	0.116	0.150	0.793
1997	619	0.107	0.069	0.024	0.075	0.096	0.120	0.743
1998	569	0.084	0.058	0.017	0.055	0.072	0.092	0.596
1999	530	0.067	0.041	0.000	0.044	0.060	0.080	0.444
2000	525	0.056	0.029	0.000	0.037	0.050	0.066	0.228
2001	533	0.068	0.034	0.000	0.045	0.061	0.085	0.272
2002	617	0.067	0.037	0.004	0.041	0.061	0.082	0.332
2003	616	0.089	0.055	0.000	0.053	0.073	0.111	0.534
2004	612	0.103	0.073	0.000	0.052	0.080	0.131	0.518

N. LOT measure

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	459	0.009	0.003	0.002	0.007	0.009	0.010	0.024
1994	471	0.008	0.006	0.001	0.006	0.008	0.009	0.094
1995	487	0.010	0.015	0.003	0.007	0.008	0.010	0.208
1996	557	0.011	0.011	0.002	0.007	0.009	0.012	0.160
1997	616	0.012	0.013	0.002	0.008	0.010	0.012	0.175
1998	568	0.012	0.014	0.002	0.008	0.010	0.013	0.210
1999	523	0.010	0.007	0.000	0.006	0.009	0.011	0.085
2000	523	0.009	0.005	0.000	0.006	0.008	0.011	0.062
2001	530	0.008	0.004	0.002	0.005	0.007	0.009	0.030
2002	611	0.008	0.004	0.000	0.005	0.007	0.009	0.035
2003	612	0.008	0.007	0.000	0.005	0.007	0.010	0.073
2004	608	0.010	0.011	0.000	0.005	0.007	0.011	0.186

O. Liu measure

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	459	2.693	5.881	0.000	0.000	0.851	1.703	59.595
1994	472	3.397	19.480	0.000	0.000	0.000	0.851	223.059
1995	491	6.563	28.919	0.000	0.000	0.000	0.860	244.282
1996	562	4.643	23.445	0.000	0.000	0.000	0.860	246.270
1997	619	4.619	19.227	0.000	0.000	0.000	2.589	212.376
1998	569	3.890	16.492	0.000	0.000	0.000	0.863	169.151
1999	530	1.755	6.124	0.000	0.000	0.000	0.000	64.771
2000	525	1.006	4.540	0.000	0.000	0.000	0.000	60.647
2001	533	1.761	6.410	0.000	0.000	0.000	0.000	68.635
2002	617	2.903	10.587	0.000	0.000	0.000	0.000	149.754
2003	616	3.731	16.140	0.000	0.000	0.000	1.020	244.858
2004	612	4.453	14.488	0.000	0.000	0.000	1.012	201.398

Table 3. Summary statistics of liquidity measures in the U.S. sample

This table reports the cross-sectional distributions of time-series means of firm characteristics and liquidity measures in the U.S. Total samples are 2,984 stocks, which are listed in the NYSE /AMEX. The share code is used to exclude the following categories: certificates, American depository receipts, shares of beneficial interest, units, Americus Trust components, closed-end funds, and real estate investment trusts. Volume is the number of shares traded for one year in thousand shares. Trading amount is the total amount traded for one year in thousand dollars. Turnover is the annual average of monthly turnovers, which are the numbers of shares traded for one month scaled by the number of stocks outstanding. The Amivest measure is $\sum_{i=1}^{T} Volume_i \Big/ \sum_{i=1}^{T} |return_i|$ for one year (multiplied by 10^5). The Pastor and Stambaugh (2003)'s reversal measure is estimated from the regression equation $r^e_{j,d+1} = \theta_j + \varphi_j r_d + \gamma_j sign(r^e_{j,d}) \cdot v_{j,d} + e_{j,d+1}$,where d indexes days, $r^e_{j,d+1}$ is the return on stock j in excess of the market return and $v_{j,d}$ is the daily dollar volume (in 10^5 dollar). The Amihud (2002) measure is $\frac{1}{Days^i_t}\sum_{d=1}^{Days^i_t}\frac{|R^i_{td}|}{V^i_{td}}$,where R^i_{td} and V^i_{td} are, respectively, the percentage return and dollar volume (in 10,000 dollar) on day d in year t, and $Days^i_t$ is the number of valid observation days in year t for stock i. MA (Modified Amihud (2002)) measure is defined as $MA^i_t = \frac{1}{Days^i_t}\sum_{d=1}^{Days^i_t}\frac{|R^i_{td}|}{V^i_{td}} \times (1 - a\log(1 - zero))$, where zero is the proportion of no trading volume day, and a is the arbitrary constant determining the slope of log curve (a = 1 in this paper). When calculating the MA, I winsorize the Amihud (2002) measure at 1% because of the effect of extreme value. Proportional spread is defined as $\sum_{t=1}^{T}\frac{Ask_t - Bid_t}{(Ask_t + Bid_t)/2}$,where Ask_t denotes a closing ask price at day t, Bid_t denotes a closing bid price at day t. Roll (1984) spread is defined as $2\sqrt{-COV_i}$, where cov_i is the auto-covariance of returns for stock i. Zero is the number of days with zero returns divided by total number of trading days. LOT (1999) measure is the difference between $\alpha 2(i)$ and $\alpha 1(i)$ estimated from estimation (2-10). Liu (2006) is defined as $[Number\ of\ zero\ daily\ volumes\ in\ prior\ x\ months + \frac{1/(x-month\ turnover)}{Deflator}] \times \frac{21x}{NoTD}$, where x-month turnover is turnover over the prior x months, calculated as the sum of daily turnover over the prior x months and $NoTD$ is the total number of trading days in the market over the prior x months. Deflator is chosen such that $0 < \frac{1/(x-month\ turnover)}{Deflator} < 1$ (in this table, deflator=11,000).

Variables	Source	N	Mean	Std	Min	Q1	Median	Q3	Max
Volume	CRSP	21,736	96,374	319,697	0.300	4,232	18,722	71,559	13,720,270
Trading amount	CRSP	21,736	3,180,766	11,694,293	0.375	36,224	310,056	1,851,128	595,687,526
Turnover	CRSP	21,736	0.943	1.048	0.000	0.359	0.683	1.193	41.475
Amivest	CRSP	21,734	2.347	7.461	0.000	0.094	0.437	1.856	268.913
Pastor Stambaugh	CRSP	21,368	0.243	6.792	-319.313	-0.005	0.000	0.009	376.471
Amihud	CRSP	21,734	3.226	17.696	0.000	0.003	0.023	0.341	359.474
MA	CRSP	21,734	4.250	24.736	0.000	0.003	0.023	0.352	617.304
Prop. spread	CRSP	20,081	0.023	0.020	0.000	0.009	0.016	0.030	0.100
Roll	CRSP	21,452	0.019	0.021	0.000	0.008	0.013	0.021	0.195
Zero	CRSP	21,659	0.143	0.128	0.000	0.036	0.111	0.217	1.000
LOT	CRSP	21,106	0.016	0.026	0.000	0.003	0.007	0.018	0.200
Liu	CRSP	21,736	9.274	28.015	0.000	0.000	0.000	1.000	247.281

Table 4. Annual distributions of liquidity measures in the U.S. sample

These tables report the annual summary statistics of various liquidity measures in the U.S. for the period 1993-2004. The explanations for liquidity measures are in the Table III-3.

A. Volume

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	1,775	32,621	66,761	22.600	2,544	10,229	33,206	791,324
1994	1,822	33,923	69,059	17.000	2,594	9,564	33,817	780,719
1995	1,873	39,869	85,545	16.800	3,106	11,602	38,640	1,114,350
1996	1,916	48,278	107,991	0.400	3,810	14,297	46,975	1,828,934
1997	1,967	57,947	128,405	4.900	4,399	16,087	52,948	1,592,928
1998	1,986	70,747	172,849	0.900	4,774	17,813	65,391	4,062,694
1999	1,958	87,681	243,533	8.800	4,875	19,046	73,322	5,130,254
2000	1,868	116,470	330,242	2.800	5,117	24,077	90,244	5,344,487
2001	1,729	140,837	411,985	33.400	4,484	24,122	107,476	6,448,003
2002	1,675	178,958	519,382	15.800	5,225	32,680	134,148	9,628,054
2003	1,621	189,275	537,343	0.300	7,931	41,303	158,602	13,095,382
2004	1,546	203,161	550,669	19.700	11,536	56,921	190,500	13,720,270

B. Trading amount

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	1,775	1,063,174	2,859,580	19.806	22,629	152,704	809,720	37,086,675
1994	1,822	1,111,619	2,991,266	17.194	23,287	156,638	861,027	37,743,537
1995	1,873	1,393,326	4,317,446	31.388	30,025	183,769	941,830	72,769,362
1996	1,916	1,786,578	5,373,342	1.275	42,231	246,412	1,288,974	99,487,800
1997	1,967	2,363,121	7,421,429	4.000	51,301	320,570	1,493,747	124,176,620
1998	1,986	2,898,037	9,888,887	16.125	49,394	338,122	1,863,021	172,899,820
1999	1,958	3,788,656	18,514,014	45.194	40,300	295,171	1,856,161	595,687,526
2000	1,868	4,749,179	17,639,784	32.513	37,311	323,561	2,248,430	247,067,210
2001	1,729	4,646,283	14,870,379	27.633	23,378	353,674	2,775,670	233,874,518
2002	1,675	4,758,213	13,815,956	38.925	26,594	474,087	3,013,687	210,428,660
2003	1,621	4,647,133	12,321,346	0.375	49,454	678,586	3,545,012	157,231,884
2004	1,546	5,796,896	13,829,490	183.674	108,927	1,231,262	5,121,747	184,141,105

C. Turnover

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	1,775	0.686	0.604	0.010	0.295	0.527	0.873	6.678
1994	1,822	0.632	0.565	0.005	0.271	0.494	0.811	4.923
1995	1,873	0.711	0.650	0.012	0.292	0.533	0.915	6.555
1996	1,916	0.814	1.221	0.000	0.348	0.607	0.990	41.475
1997	1,967	0.818	0.748	0.003	0.374	0.653	1.040	13.555
1998	1,986	0.865	0.771	0.000	0.385	0.676	1.088	7.212
1999	1,958	0.894	0.947	0.002	0.394	0.695	1.151	26.741
2000	1,868	1.018	0.966	0.002	0.408	0.789	1.305	11.963
2001	1,729	1.003	1.022	0.003	0.339	0.732	1.331	15.066
2002	1,675	1.179	1.225	0.002	0.366	0.872	1.538	16.744
2003	1,621	1.366	1.567	0.000	0.493	1.053	1.753	37.545
2004	1,546	1.506	1.522	0.006	0.649	1.167	1.898	23.383

D.Amivest liquidity ratio

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	1,775	0.961	2.025	0.001	0.058	0.251	0.964	22.029
1994	1,822	1.074	2.493	0.001	0.060	0.262	1.019	35.120
1995	1,873	1.285	2.725	0.000	0.077	0.320	1.255	28.537
1996	1,915	1.412	2.899	0.000	0.096	0.381	1.463	34.249
1997	1,966	1.523	3.123	0.000	0.114	0.437	1.510	35.014
1998	1,986	1.554	3.582	0.000	0.106	0.381	1.556	66.967
1999	1,958	1.807	4.468	0.000	0.100	0.403	1.653	67.192
2000	1,868	2.026	5.201	0.000	0.092	0.410	1.808	68.020
2001	1,729	2.948	7.577	0.001	0.084	0.475	2.467	116.127
2002	1,675	3.302	8.456	0.001	0.086	0.608	2.853	131.282
2003	1,621	4.864	12.520	0.000	0.163	1.113	4.349	183.618
2004	1,775	0.961	2.025	0.001	0.058	0.251	0.964	22.029

E. Pastor/Stambaugh reversal measure

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	1,765	0.476	11.476	-181.439	-0.005	0.001	0.021	376.471
1994	1,811	0.293	5.505	-74.063	-0.006	0.000	0.015	137.650
1995	1,856	0.339	10.663	-319.313	-0.004	0.001	0.017	276.784
1996	1,899	0.050	2.368	-54.636	-0.004	0.000	0.011	35.847
1997	1,924	0.146	1.994	-28.668	-0.005	0.000	0.006	36.489
1998	1,944	0.093	2.516	-40.978	-0.010	0.000	0.004	85.987
1999	1,909	0.043	2.280	-66.611	-0.005	0.000	0.010	45.081
2000	1,837	0.115	1.535	-32.614	-0.006	0.000	0.012	16.841
2001	1,698	0.767	11.093	-105.871	-0.004	0.000	0.010	350.008
2002	1,636	0.153	9.243	-269.730	-0.003	0.000	0.007	64.667
2003	1,579	0.434	7.625	-126.165	-0.003	0.000	0.004	187.763
2004	1,510	0.063	1.004	-16.678	-0.002	0.000	0.002	19.500

F. Amihud illiquidity measure

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	1,775	4.138	17.870	0.000	0.006	0.052	0.617	147.575
1994	1,822	3.042	12.310	0.000	0.006	0.047	0.554	92.440
1995	1,873	2.598	11.119	0.000	0.005	0.036	0.385	86.512
1996	1,916	1.886	8.163	0.000	0.004	0.026	0.274	60.156
1997	1,967	1.536	6.735	0.000	0.003	0.020	0.186	52.712
1998	1,986	1.552	6.297	0.000	0.003	0.023	0.226	47.727
1999	1,957	1.537	5.446	0.000	0.003	0.026	0.327	37.252
2000	1,868	2.164	7.660	0.000	0.003	0.027	0.398	53.495
2001	1,729	6.650	26.296	0.000	0.002	0.021	0.592	192.098
2002	1,675	9.236	43.746	0.000	0.002	0.015	0.540	359.474
2003	1,621	4.516	21.281	0.000	0.001	0.008	0.271	170.121
2004	1,545	0.844	3.565	0.000	0.001	0.004	0.091	27.282

G. Modified Amihud illiquidity measure

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	1,775	5.867	27.971	0.000	0.006	0.052	0.630	345.499
1994	1,822	3.760	16.670	0.000	0.006	0.050	0.579	204.471
1995	1,873	3.600	16.675	0.000	0.005	0.036	0.400	205.082
1996	1,916	2.523	12.006	0.000	0.004	0.026	0.280	181.129
1997	1,967	2.082	10.496	0.000	0.003	0.020	0.187	190.552
1998	1,986	2.029	8.814	0.000	0.003	0.023	0.229	101.421
1999	1,957	1.611	5.719	0.000	0.003	0.026	0.343	47.872
2000	1,868	2.857	11.128	0.000	0.003	0.027	0.404	113.478
2001	1,729	9.062	37.784	0.000	0.002	0.021	0.611	474.556
2002	1,675	12.034	58.533	0.000	0.002	0.015	0.564	617.304
2003	1,621	5.943	30.412	0.000	0.001	0.008	0.271	460.135
2004	1,545	0.936	4.352	0.000	0.001	0.004	0.092	67.726

H. Proportional spread

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	1,687	0.024	0.018	0.003	0.012	0.017	0.030	0.100
1994	1,733	0.025	0.018	0.003	0.012	0.018	0.030	0.100
1995	1,754	0.026	0.018	0.002	0.013	0.020	0.032	0.100
1996	1,811	0.026	0.019	0.003	0.013	0.020	0.033	0.100
1997	1,818	0.024	0.018	0.003	0.011	0.018	0.032	0.100
1998	1,766	0.026	0.019	0.002	0.012	0.020	0.035	0.100
1999	1,660	0.030	0.020	0.003	0.014	0.024	0.040	0.099
2000	1,591	0.030	0.022	0.003	0.014	0.023	0.039	0.100
2001	1,583	0.021	0.020	0.001	0.009	0.013	0.025	0.099
2002	1,578	0.018	0.019	0.000	0.007	0.011	0.020	0.099
2003	1,583	0.012	0.016	0.000	0.003	0.005	0.013	0.100
2004	1,517	0.008	0.013	0.000	0.001	0.002	0.008	0.098

I. Roll's spread

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	1,760	0.018	0.022	0.000	0.007	0.011	0.020	0.177
1994	1,807	0.017	0.020	0.001	0.007	0.011	0.019	0.184
1995	1,850	0.016	0.019	0.000	0.006	0.011	0.018	0.175
1996	1,896	0.016	0.018	0.000	0.007	0.011	0.018	0.158
1997	1,943	0.016	0.018	0.000	0.007	0.012	0.018	0.195
1998	1,955	0.020	0.020	0.000	0.010	0.015	0.023	0.187
1999	1,928	0.020	0.019	0.000	0.010	0.015	0.024	0.187
2000	1,835	0.024	0.023	0.000	0.010	0.017	0.028	0.187
2001	1,696	0.024	0.026	0.000	0.010	0.016	0.026	0.195
2002	1,646	0.023	0.024	0.000	0.010	0.016	0.026	0.186
2003	1,601	0.017	0.020	0.000	0.008	0.012	0.018	0.195
2004	1,535	0.013	0.013	0.000	0.006	0.009	0.015	0.146

J. Proportion of zero daily return

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	1,775	0.222	0.123	0.005	0.130	0.202	0.292	0.964
1994	1,821	0.216	0.115	0.000	0.131	0.194	0.286	0.948
1995	1,873	0.225	0.122	0.000	0.135	0.210	0.294	0.937
1996	1,916	0.206	0.128	0.000	0.114	0.181	0.276	0.996
1997	1,967	0.163	0.123	0.000	0.075	0.130	0.225	0.972
1998	1,986	0.124	0.115	0.000	0.044	0.079	0.173	0.893
1999	1,919	0.138	0.123	0.000	0.048	0.091	0.198	0.933
2000	1,868	0.135	0.120	0.000	0.040	0.091	0.206	0.853
2001	1,729	0.079	0.099	0.000	0.012	0.036	0.117	0.996
2002	1,675	0.068	0.098	0.000	0.012	0.024	0.091	0.893
2003	1,621	0.057	0.076	0.000	0.012	0.024	0.071	0.583
2004	1,509	0.046	0.069	0.000	0.012	0.020	0.056	1.000

K. LOT measure

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	1,683	0.024	0.032	0.001	0.006	0.012	0.029	0.198
1994	1,755	0.022	0.029	0.000	0.006	0.011	0.027	0.193
1995	1,801	0.022	0.028	0.001	0.007	0.012	0.026	0.197
1996	1,865	0.020	0.026	0.000	0.006	0.011	0.024	0.198
1997	1,930	0.019	0.027	0.000	0.005	0.009	0.019	0.194
1998	1,945	0.014	0.024	0.000	0.003	0.006	0.013	0.200
1999	1,914	0.017	0.026	0.000	0.003	0.007	0.019	0.187
2000	1,837	0.019	0.028	0.000	0.003	0.008	0.023	0.199
2001	1,706	0.013	0.024	0.000	0.001	0.003	0.012	0.194
2002	1,652	0.009	0.020	0.000	0.001	0.002	0.008	0.198
2003	1,480	0.007	0.020	0.000	0.001	0.001	0.005	0.195
2004	1,538	0.005	0.012	0.000	0.001	0.001	0.004	0.178

L. Liu measure

Year	N	Mean	Std	Min	Q1	Median	Q3	Max
1993	1,775	11.926	31.378	0.000	0.000	0.000	3.073	213.155
1994	1,822	12.033	31.490	0.000	0.000	0.000	3.000	216.001
1995	1,873	10.420	29.850	0.000	0.000	0.000	2.000	217.003
1996	1,916	8.630	26.588	0.000	0.000	0.000	0.992	230.177
1997	1,967	7.519	25.540	0.000	0.000	0.000	0.996	241.912
1998	1,986	8.165	26.060	0.000	0.000	0.000	1.000	247.281
1999	1,958	8.373	26.304	0.000	0.000	0.000	1.000	235.011
2000	1,868	8.634	27.207	0.000	0.000	0.000	0.013	223.019
2001	1,729	11.405	32.023	0.000	0.000	0.000	1.016	220.502
2002	1,675	10.388	29.785	0.000	0.000	0.000	0.001	221.026
2003	1,621	8.412	26.860	0.000	0.000	0.000	0.000	227.204
2004	1,546	5.269	19.957	0.000	0.000	0.000	0.000	197.003

Table 5. Correlations among liquidity measures in the Korean sample

These tables report the correlations of liquidity measures in the Korean sample for the period 1993-2004. Panel A represents the Pearson correlation and Panel B represents the Spearman correlation. The explanations for liquidity measures are in the Table III-1. Panel C shows the signs of Spearman correlations in the Panel B. There is the difference between liquidity measure and illiquidity measure. Liquidity measure is higher when the stock's liquidity is higher. On the contrary, illiquidity measure represents illiquidity and it is higher when the stock's liquidity is lower. Illiquidity measure includes Amihud (2002) measure, MA measure, Kyle's lambda, proportional bid-ask spread, Roll's spread, amortized spread, proportion of zero daily return, LOT measure, and Liu measure. Because the illiquidity measures make it confusing to check the signs of Spearman correlations, they are converted into the liquidity measures by multiplying the minus sign. Therefore, all signs of correlation between measures should be positive if each measure has a normal relation. Panel C contains a shadow effect in a block if its sign violates the normal relation (has a minus sign, except B/M).

A. Pearson correlation

	Size	B/M	Volume	Trading amount	Turnover	Number of trades	Amivest	PS	-Amihud	-MA	-Kyle	-Prop. spread	-Roll	-Amo. spread	-Zero	-LOT	-Liu
Size	1.000																
B/M	-0.308	1.000															
Volume	0.174	-0.074	1.000														
Trading amount	0.621	-0.201	0.713	1.000													
Turnover	-0.112	-0.009	0.223	0.114	1.000												
Number of trades	0.376	0.005	0.782	0.825	0.174	1.000											
Amivest	0.084	-0.016	0.264	0.194	0.113	0.218	1.000										
PS	0.013	0.018	-0.077	-0.062	-0.012	-0.070	-0.003	1.000									
-Amihud	0.147	-0.053	0.320	0.405	0.033	0.244	0.025	-0.313	1.000								
-MA	0.067	-0.007	0.268	0.313	0.023	0.159	0.016	-0.318	0.898	1.000							
-Kyle	-0.025	-0.039	0.181	0.084	0.019	0.111	0.015	-0.021	0.051	0.036	1.000						
-Prop. spread	0.431	-0.142	0.508	0.664	0.056	0.640	0.078	-0.161	0.440	0.246	0.180	1.000					
-Roll	0.286	-0.114	-0.158	-0.023	-0.160	-0.102	-0.060	-0.000	0.101	0.067	0.019	0.217	1.000				
-Amo. spread	0.172	-0.006	-0.189	-0.029	-0.895	-0.099	-0.113	0.012	-0.009	-0.004	-0.016	0.041	0.210	1.000			
-Zero	-0.012	0.135	0.473	0.416	0.097	0.566	0.061	-0.057	0.309	0.366	0.103	0.310	-0.199	-0.059	1.000		
-LOT	0.108	0.017	0.266	0.318	-0.005	0.298	0.002	-0.083	0.436	0.494	0.127	0.404	0.122	0.077	0.726	1.000	
-Liu	0.045	0.022	0.336	0.361	-0.026	0.292	-0.002	-0.076	0.552	0.614	0.139	0.318	0.134	0.072	0.536	0.696	1.000

B. Spearman correlation

	Size	B/M	Volume	Trading amount	Turnover	Number of trades	Amivest	PS	-Amihud	-MA	-Kyle	-Prop. spread	-Roll	-Amo. spread	-Zero	-LOT	-Liu
Size	1.000																
B/M	-0.344	1.000															
Volume	0.124	-0.079	1.000														
Trading amount	0.576	-0.258	0.644	1.000													
Turnover	-0.346	-0.079	0.566	0.392	1.000												
Number of trades	0.280	0.062	0.744	0.782	0.484	1.000											
Amivest	0.194	-0.124	0.954	0.602	0.477	0.678	1.000										
PS	0.145	-0.078	-0.064	0.014	-0.123	-0.084	-0.038	1.000									
-Amihud	0.599	-0.224	0.560	0.892	0.291	0.729	0.605	0.005	1.000								
-MA	0.598	-0.222	0.560	0.893	0.290	0.730	0.604	0.005	1.000	1.000							
-Kyle	0.161	-0.074	0.399	0.223	0.175	0.260	0.470	0.035	0.246	0.245	1.000						
-Prop. spread	0.564	-0.185	0.517	0.768	0.230	0.711	0.596	-0.003	0.888	0.889	0.356	1.000					
-Roll	0.296	-0.102	-0.162	-0.054	-0.345	-0.129	-0.042	0.084	0.088	0.090	0.091	0.215	1.000				
-Amo. spread	0.639	-0.044	-0.312	-0.016	-0.856	-0.159	-0.199	0.125	0.101	0.103	0.002	0.221	0.476	1.000			
-Zero	-0.069	0.202	0.435	0.331	0.431	0.619	0.334	-0.121	0.274	0.274	0.019	0.305	-0.276	-0.302	1.000		
-LOT	0.184	0.036	0.166	0.250	0.046	0.320	0.185	-0.037	0.310	0.313	0.080	0.456	0.184	0.189	0.622	1.000	
-Liu	-0.054	0.025	0.406	0.384	0.543	0.471	0.306	-0.105	0.318	0.325	0.033	0.317	-0.047	-0.355	0.365	0.240	1.000

C. Sign of Spearman correlation

	Size	B/M	Volume	Trading amount	Turnover	Number of trades	Amivest	PS	-Amihud	-MA	-Kyle	-Prop. spread	-Roll	-Amo. spread	-Zero	-LOT	-Liu
Size																	
B/M	–																
Volume	+	–															
Trading amount	+	–	+														
Turnover	–	–	+	+													
Number of trades	+	+	+	+	+												
Amivest	+	–	+	+	+	+											
PS	+	–	–	+	–	–	–										
-Amihud	+	–	+	+	+	+	+	+									
-MA	+	–	+	+	+	+	+	+	+								
-Kyle	+	–	+	+	+	+	+	+	+	+							
-Prop. spread	+	–	+	+	+	+	+	–	+	+	+						
-Roll	+	–	–	–	–	–	–	+	+	+	+	+					
-Amo. spread	+	–	–	–	–	–	–	+	+	+	+	+	+				
-Zero	–	+	+	+	+	+	+	–	+	+	+	+	–	–			
-LOT	+	+	+	+	+	+	+	–	+	+	+	+	+	+	+		
-Liu	–	+	+	+	+	+	+	–	+	+	+	+	–	–	+	+	

Table 6. Correlations among liquidity measures in the U.S. sample

These tables report correlations of liquidity measures in the U.S. sample for the period 1993-2004. Panel A represents the Pearson correlation and Panel B represents the Spearman correlation. The explanation to liquidity measures are in the Table III-3. Panel C shows the signs of Spearman correlations in the Panel B. There is the difference between liquidity measure and illiquidity measure. Liquidity measure is higher when the stock's liquidity is higher. On the contrary, illiquidity measure represents illiquidity and it is higher when the stock's liquidity is lower. Illiquidity measure includes Amihud (2002) measure, MA measure, proportional bid-ask spread, Roll's spread, proportion of zero daily return, LOT measure, and Liu measure. Because the illiquidity measures make it confusing to check the signs of Spearman correlations, they are converted into the liquidity measures by multiplying the minus sign. Therefore, all signs of correlation between measures should be positive if each measure has a normal relation. Panel C contains a shadow effect in a block if its sign violates the normal relation (has a minus sign).

A. Pearson correlation

	Size	Volume	Trading amount	Turnover	Amivest	PS	-Amihud	-MA	-Prop. spread	-Roll	-Zero	-LOT	-Liu
Size	1.000												
Volume	0.774	1.000											
Trading amount	0.893	0.923	1.000										
Turnover	0.223	0.517	0.456	1.000									
Amivest	0.457	0.456	0.423	0.150	1.000								
PS	-0.059	-0.040	-0.058	-0.018	-0.007	1.000							
-Amihud	0.333	0.215	0.336	0.103	0.052	-0.140	1.000						
-MA	0.324	0.232	0.339	0.104	0.050	-0.148	0.966	1.000					
-Prop. spread	0.059	0.075	0.074	0.069	0.067	0.006	-0.016	-0.015	1.000				
-Roll	0.485	0.181	0.412	-0.007	0.110	-0.124	0.530	0.482	0.039	1.000			
-Zero	0.069	0.117	0.090	0.112	0.096	0.002	-0.013	-0.009	0.136	0.000	1.000		
-LOT	0.613	0.366	0.560	0.154	0.155	-0.098	0.416	0.402	0.108	0.682	0.131	1.000	
-Liu	0.469	0.575	0.549	0.227	0.103	-0.059	0.330	0.400	0.020	0.192	0.020	0.349	1.000

B. Spearman correlation

	Size	Volume	Trading amount	Turnover	Amivest	PS	-Amihud	-MA	-Prop. spread	-Roll	-Zero	-LOT	-Liu
Size	1.000												
Volume	0.792	1.000											
Trading amount	0.900	0.933	1.000										
Turnover	0.417	0.757	0.684	1.000									
Amivest	0.900	0.919	0.922	0.639	1.000								
PS	-0.070	-0.045	-0.068	-0.044	-0.056	1.000							
-Amihud	0.832	0.724	0.812	0.487	0.829	-0.077	1.000						
-MA	0.834	0.729	0.817	0.492	0.833	-0.076	1.000	1.000					
-Prop. spread	0.074	0.112	0.101	0.097	0.120	-0.007	0.105	0.105	1.000				
-Roll	0.453	0.173	0.345	-0.011	0.340	-0.049	0.395	0.393	0.064	1.000			
-Zero	0.075	0.137	0.106	0.142	0.117	-0.039	0.094	0.094	0.236	-0.021	1.000		
-LOT	0.759	0.587	0.730	0.405	0.678	-0.075	0.687	0.688	0.241	0.425	0.296	1.000	
-Liu	0.577	0.789	0.748	0.886	0.748	-0.058	0.605	0.610	0.100	0.096	0.132	0.521	1.000

C. Sign of Spearman correlation

	Size	Volume	Trading amount	Turnover	Amivest	PS	-Amihud	-MA	-Prop. spread	-Roll	-Zero	-LOT	-Liu
Size													
Volume	+												
Trading amount	+	+											
Turnover	+	+	+										
Amivest	+	+	+	+									
PS	–	–	–	–	–								
-Amihud	+	+	+	+	+	–							
-MA	+	+	+	+	+	–	+						
-Prop. spread	+	+	+	+	+	–	+	+					
-Roll	+	+	+	–	+	–	+	+	+				
-Zero	+	+	+	+	+	–	+	+	+	–			
-LOT	+	+	+	+	+	–	+	+	+	+	+		
-Liu	+	+	+	+	+	–	+	+	+	+	+	+	

Table 7. Risk-adjusted return regression on liquidity measures in the Korean sample

Each month Fama and MacBeth (1973) regressions are implemented using the cross section of individual securities. The dependent variable is the excess return risk-adjusted by the Fama and French (1993) three factor model. Explanatory variables are various liquidity measures explained in the Table III-1. These tables contain the time-series averages of coefficients obtained from monthly cross-sectional regressions and t-statistics are in parentheses. There is the difference between liquidity measure and illiquidity measure. Liquidity measure is higher when the stock's liquidity is higher. On the contrary, illiquidity measure represents illiquidity and it is higher when the stock's liquidity is lower. Illiquidity measure includes Amihud (2002) measure, MA measure, Kyle's lambda, proportional bid-ask spread, Roll's spread, amortized spread, proportion of zero daily return, LOT measure, and Liu measure. Because the illiquidity measures make it confusing to check the signs of Spearman correlations, they are converted into the liquidity measures by multiplying the minus sign. Therefore, all signs of coefficients of measures should be negative if each measure has a significant relation with the adjusted returns.

Volume	Trading amount	Turnover	Number of trades	Amivest	PS	-Amihud	-MA	-Kyle	-Prop. spread	-Roll	-Amo. spread	-Zero	-LOT	-Liu
-0.002	.	.	.	.	.	.	.	.	.	.	.	.	.	.
(-1.742)	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	-0.006	.	.	.	.	.	.	.	.	.	.	.	.	.
.	(-3.014)	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	-0.030	.	.	.	.	.	.	.	.	.	.	.	.
.	.	(-2.180)	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	-0.005	.	.	.	.	.	.	.	.	.	.	.
.	.	.	(-1.932)	.	.	.	.	.	.	.	.	.	.	.
0.000	-0.011	-0.017	0.008	.	.	.	.	.	.	.	.	.	.	.
(-0.055)	(-1.781)	(-1.224)	(1.316)	.	.	.	.	.						
.	.	.	.	-0.040	.	.	.	.	.	.	.	.	.	.
.	.	.	.	(-2.301)	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	-0.002	.	.	.	.	.	.	.	.	.
.	.	.	.	.	(-1.957)	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	-0.006	.	.	.	.	.	.	.	.
.	.	.	.	.	.	(-2.811)	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	-0.005	.	.	.	.	.	.	.
.	.	.	.	.	.	.	(-2.715)	.	.	.	.	.	.	.

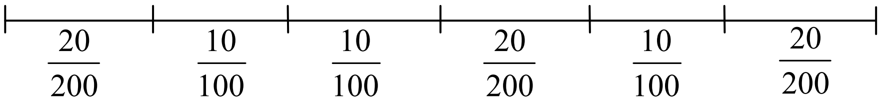
Volume	Trading amount	Turnover	Number of trades	Amivest	PS	-Amihud	-MA	-Kyle	-Prop. spread	-Roll	-Amo. spread	-Zero	-LOT	-Liu
.	.	.	.	.	.	.	.	-0.118	.	.	.	.	.	.
.	.	.	.	.	.	.	.	(-0.242)	.	.	.	.	.	.
.	.	.	.	-0.030	-0.002	-0.173	0.160	-0.112	.	.	.	.	.	.
.	.	.	.	(-1.771)	(-1.688)	(-2.043)	(1.975)	(-0.232)	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	-0.614	.	.	.	.	.
.	.	.	.	.	.	.	.	.	(-1.741)	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	0.423	.	.	.	.
.	.	.	.	.	.	.	.	.	.	(2.895)	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	0.184	.	.	.
.	.	.	.	.	.	.	.	.	.	.	(1.557)	.	.	.
.	.	.	.	.	.	.	.	.	-0.508	0.378	0.033	.	.	.
.	.	.	.	.	.	.	.	.	(-1.409)	(2.259)	(0.249)	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	-0.060	.	.
.	.	.	.	.	.	.	.	.	.	.	.	(-1.999)	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	-0.536	.
.	.	.	.	.	.	.	.	.	.	.	.	.	(-1.790)	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.000
.	.	.	.	.	.	.	.	.	.	.	.	.	.	(0.135)
.	.	.	.	.	.	.	.	.	.	.	.	-0.047	-0.288	0.000
.	.	.	.	.	.	.	.	.	.	.	.	(-0.738)	(-0.479)	(0.902)
0.001	-0.012	-0.043	0.008	-0.026	-0.002	-0.108	0.098	-0.092	1.012	0.393	-0.452	0.012	-0.378	-0.000
(0.588)	(-1.920)	(-1.793)	(0.981)	(-0.977)	(-1.379)	(-1.034)	(0.963)	(-0.262)	(1.249)	(2.400)	(-2.222)	(0.148)	(-0.495)	(-0.251)

Table 8. Risk-adjusted return regression on liquidity measures in the U.S. sample

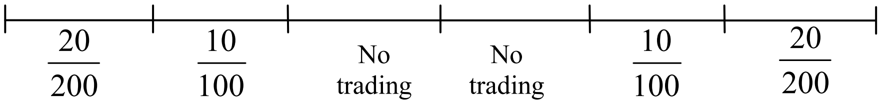
Each month Fama and MacBeth (1973) regressions are implemented using the cross section of individual securities. The dependent variable is the excess return risk-adjusted by the Fama and French (1993) three factor model. Explanatory variables are various liquidity measures explained in the Table III-3. These tables contain the time-series averages of coefficients obtained from monthly cross-sectional regressions and t-statistics are in parentheses. There is the difference between liquidity measure and illiquidity measure. Liquidity measure is higher when the stock's liquidity is higher. On the contrary, illiquidity measure represents illiquidity and it is higher when the stock's liquidity is lower. Illiquidity measure includes Amihud (2002) measure, MA measure, proportional bid-ask spread, Roll's spread, proportion of zero daily return, LOT measure, and Liu measure. Because the illiquidity measures make it confusing to check the signs of Spearman correlations, they are converted into the liquidity measures by multiplying the minus sign. Therefore, all signs of coefficients of measures should be negative if each measure has a significant relation with the adjusted returns.

Volume	Trading amount	Turnover	Amivest	PS	-Amihud	-MA	-Prop. spread	-Roll	-Zero	-LOT	-Liu
-0.055	.	.	.	.	.	.	.	.	.	.	.
(-1.278)	.	.	.	.	.	.	.	.	.	.	.
.	-0.060	.	.	.	.	.	.	.	.	.	.
.	(-1.542)	.	.	.	.	.	.	.	.	.	.
.	.	-0.214	.	.	.	.	.	.	.	.	.
.	.	(-1.983)	.	.	.	.	.	.	.	.	.
0.214	-0.189	-0.185	.	.	.	.	.	.	.	.	.
(1.116)	(-1.121)	(-1.488)	.	.	.	.	.	.	.	.	.
.	.	.	0.001	.	.	.	.	.	.	.	.
.	.	.	(0.057)	.	.	.	.	.	.	.	.
.	.	.	.	-0.016	.	.	.	.	.	.	.
.	.	.	.	(-0.336)	.	.	.	.	.	.	.
.	.	.	.	.	-0.031	.	.	.	.	.	.
.	.	.	.	.	(-1.876)	.	.	.	.	.	.
.	.	.	.	.	.	-0.021					
.	.	.	.	.	.	(-2.154)	.	.	.	.	.
.	.	.	0.007	-0.024	-0.048	0.020	.	.	.	.	.
.	.	.	(0.664)	(-0.471)	(-0.793)	(0.454)	.	.	.	.	.

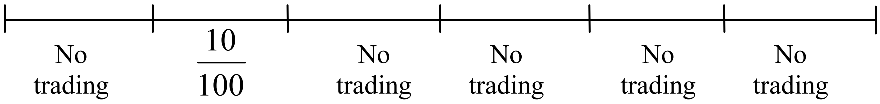
Volume	Trading amount	Turnover	Amivest	PS	-Amihud	-MA	-Prop. spread	-Roll	-Zero	-LOT	-Liu
.	.	.	.	.	.	.	-3.437	.	.	.	.
.	.	.	.	.	.	.	(-1.477)	.	.	.	.
.	.	.	.	.	.	.	.	-4.290	.	.	.
.	.	.	.	.	.	.	.	(-0.455)	.	.	.
.	.	.	.	.	.	.	-3.049	-1.559	.	.	.
.	.	.	.	.	.	.	(-1.327)	(-0.171)	.	.	.
.	.	.	.	.	.	.	.	.	0.063	.	.
.	.	.	.	.	.	.	.	.	(0.160)	.	.
.	.	.	.	.	.	.	.	.	.	-3.110	.
.	.	.	.	.	.	.	.	.	.	(-0.396)	.
.	.	.	.	.	.	.	.	.	.	.	-0.005
.	.	.	.	.	.	.	.	.	.	.	(-1.943)
.	.	.	.	.	.	.	.	.	0.161	-0.835	-0.006
.	.	.	.	.	.	.	.	.	(0.415)	(-0.101)	(-2.190)
0.231	-0.195	-0.092	0.014	0.031	-0.146	0.083	-2.708	8.150	0.245	13.925	-0.007
(1.499)	(-1.534)	(-0.671)	(0.952)	(0.737)	(-1.462)	(1.060)	(-1.284)	(0.943)	(0.628)	(1.571)	(-2.415)



$$Zero = 0, \quad Amihud = 0.1$$
$$Modified\ \ Amihud = 0.1 \times (1 - 3.33 \times \log(1-0)) = 0.1$$



$$Zero = 2/6, \quad Amihud = 0.1$$
$$Modified\ \ Amihud = 0.1 \times (1 - 3.33 \times \log(1-2/6)) = 0.159$$



$$Zero = 5/6, \quad Amihud = 0.1$$
$$Modified\ \ Amihud = 0.1 \times (1 - 3.33 \times \log(1-5/6)) = 0.359$$

Figure 1. Examples for the Amihud (2002) measure

Above three cases represents the results of Amihud (2002) measure. Each case has six days. But, second case has four trading days and third case has only one trading day. The numerator of fraction is the daily percentage return of a stock and the denominator is the won/dollar volume. Zero is the number of trading days divided by the total number of days. Amihud (2002) measure is defined as $\frac{1}{Days_t^i}\sum_{d=1}^{Days_t^i}\frac{|R_{td}^i|}{V_{td}^i}$, where R_{td}^i and V_{td}^i are, respectively, the return and won/dollar volume on day *d* in month *t*, $Days_t^i$ is the number of valid observation days in month t for stock *i*. Modifying factor is $(1 - a\log(1-zero)$. Modified Amihud (2002) measure is defined as $MA_t^i = \frac{1}{Days_t^i}\sum_{d=1}^{Days_t^i}\frac{|R_{td}^i|}{V_{td}^i} \times (1 - a\log(1-zero))$, where *zero* is the proportion of no trading volume day, and *a* is the arbitrary constant determining the slope of log curve (*a* = 3.33 in this example).

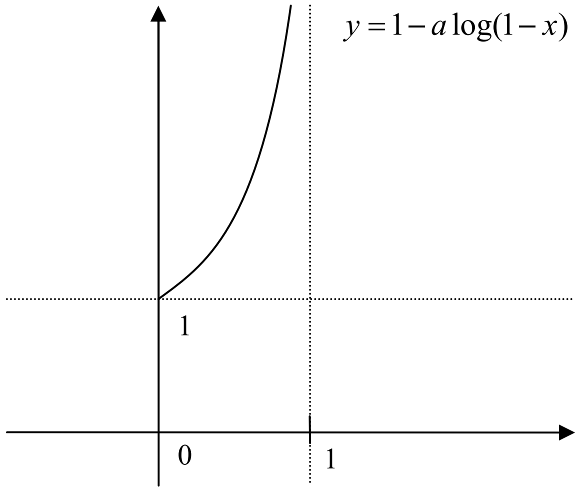


Figure 2. Modifying factor of the modified Amihud (2002) measure

Above line represents the curve of modifying factor of the modified Amihud (2002) measure. Modifying factor is $(1 - a\log(1 - zero)$, where *zero* is the proportion of no trading volume day, and *a* is the arbitrary constant determining the slope of log curve. The *x*-axis represents the value of zero.