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Idiosyncratic Volatility and Liquidity Risk: How they have Explanatory Power in Stock Returns

Jun-Biao Lina[1] and Ping-Yeh Su[2]

Abstract

Literatures have shown that idiosyncratic volatility and liquidity risk calculated from stock markets have explanatory power in stock returns. However, only few studies focus on the stock option markets. As we know that stock options with high leverage and low costs may attract investors who contain more information. In this study, we use option trading volume as a liquidity factor to reexamine the relationship among liquidity risk, idiosyncratic volatility and stock returns. In addition, we use call and put options trading volume separately to have further discussion.

The results show that high idiosyncratic volatility firms produce higher returns and firm size is negatively correlated with stock returns because of the size effect. However, call options and put options imply different signals. Stock returns are increasing with the level of call options and decreasing in put options. This is a result of the differing trading signals that call options and trading options convey. Furthermore, we changed the firm size data from that at the end of the previous year to that at the end of the previous month and eliminated outliers (the first and last 1 % of the data), to perform a robustness test. The empirical results were unaffected.

JEL classification numbers: G11; G12; G14; C61

Keywords: Idiosyncratic Volatility; Liquidity measures; Individual Stock Options;

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[1]Jun-Biao Lin (the corresponding author) is an Associate Professor at the Department of Money and Banking, National Kaohsiung First University of Science and Technology: Tel:886-7-6011000 (ext. 3121).

[2]Ping-Yeh Su is a graduate student at the National Kaohsiung First University of Science and Technology

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1 Introduction

The capital asset pricing model (CAPM) developed by Sharpe (1964) and Lintner (1965) in the 1960s states that portfolio risk comprises systematic as well as unsystematic risk. However, only the former exerts an influence on returns; the latter can be spread using asset allocation. However, many empirical studies in recent years have demonstrated that equity risk is subject to factors other than systematic risk, for which many other factors were included in the research.

Banz (1981) first proposed size effect in an investigation of corporations listed on the New York Stock Exchange (NYSE) between 1936 and 1975. His empirical results indicate that smaller companies possess more risk-adjusted premiums than their larger counterparts, thereby presenting a negative correlation between firm size and stock returns. Barry and Brown (1984) similarly pointed out that smaller companies tend to have higher returns than do larger companies, due to the fact that information is more transparent in larger companies. In contrast, the lack of information in smaller companies is one reason that investors request higher returns. Fama and French (1992, 1995) also discovered the size effect and proposed a number of explanations.

Many researchers have found that unsystematic risk also influences stock returns. Despite the fact that investors can mitigate unsystematic risk through diversified investments, it is in fact difficult for investors to hold completely diversified portfolios. Thus, when facing an increase in unsystematic risk, investors tend to increase the securities held to spread that risk, which subsequently raises transaction costs. Thus, returns are influenced by unsystematic as well as systematic risk. Hypothesizing an investor with a diversified portfolio and stock returns under the influence of both systematic risk and unsystematic risk, Levy (1978), Malkiel and Xu (2002) established that in addition to the ability to explain expected stock returns, idiosyncratic volatility has also greater explanatory power than systematic risk with regard to stock returns. This is because investors that are unable to spread their risk completely will request more premiums to compensate for the risk.

Fama and French (1993) incorporated the market-to-book ratio into a market risk model to develop a three-factor model, and used residuals to estimate idiosyncratic volatility. Carhart (1997) further included the momentum strategies presented by Jegadeesh and Titman (1993), in the creation of a four-factor model. Xu and Malkiel (2003) used the three-factor model developed by Fama and French (1993) to estimate idiosyncratic volatility in stock traded between 1955 and 1998 on the NYSE, AMEX, and NASDAQ. They revealed a positive correlation between idiosyncratic volatility and company earnings. Goyal and Santa-Clara (2003) studied stocks traded on the NYSE, AMEX, and NASDAQ between 1963 and 1999, discovering a significant, positive correlation between the risk specific to equal-weighted stocks and the excess returns of value-weighted portfolios. However, they were unable to use return volatility to forecast market returns. Using the US market as an example, Fu (2009) established that current stock returns had a significant, positive correlation with current idiosyncratic volatility but a negative correlation with firm size. Furthermore, current stock returns presented a significant, negative correlation with expected idiosyncratic volatility. However, researchers observed no significant relationships between unsystematic risk and stock returns. For instance, Bali et al. (2005) used value weighting and equal weighting to gauge unsystematic risk and adopted the approach presented by Goyal and Santa-Clara (2003). Their empirical results indicated a significant, positive correlation between equal-weighted unsystematic risk and returns. In contrast, value-weighted idiosyncratic volatility could not explain market returns.

However, once Bali et al. (2005) extended the study period, the positive correlation between equal-weighted unsystematic risk and returns disappeared. Moreover, controlling liquidity risk premiums also negated the correlation between idiosyncratic volatility and excess returns.

Other than the idiosyncratic volatility, many researchers have discovered that liquidity could also be used to explain asset prices. However, without a fixed index for liquidity, other measures such as turnover volume, bid-ask spread, or turnover rates have been used as proxy variables for liquidity. Amihud and Mendelson (1986) and Amihud (2002) confirmed the existence of liquidity premiums, and due to the compensation between liquidity and returns, lower liquidity translates to higher stock returns. Amihud and Mendelson (1986) used bid-ask spread to serve as a proxy for liquidity, based on the fact that bid-ask spread can represent the transactions costs of investors. A greater bid-ask spread indicates higher transaction costs, thereby revealing less stock liquidity. Their results showed that in the event of severe information asymmetry in the market, the bid-ask spread is greater. As a result, investors will demand greater compensation, thereby creating a positive relationship between the bid-ask spread and the expected excess returns and indicating the existence of liquidity premiums. In comparison, Pator and Stambaugh (2003) studied the NYSE and AMEX markets, proposing that the liquidity of the entire market plays a crucial role in stock pricing. Their empirical research revealed small cap stocks have poorer liquidity and have higher sensitivity to market liquidity risk. Furthermore Pator and Stambaugh (2003) found that even after controlling for firm size and momentum factors, excess returns still exist in stocks with greater sensitivity to market liquidity risk, implying that market returns possess liquidity premiums.

Chan and Faff (2003) estimated liquidity using stock turnover rates and found that even when book-to-market ratios, firm size, systematic risk, and momentum are controlled, liquidity remains an important explanatory factor of stock returns. Their results showed a negative correlation between turnover rates and expected returns. Trading volume has also been used as a proxy variable for liquidity. Brennan et al. (1998) used stock trading volume as a liquidity index and established that turnover value was negatively related to stock returns and firm size. The excess returns of the stock compensated for insufficient liquidity for reasons other than risk factors. They also discovered a positive relationship between firm size and liquidity, implying that liquidity had potential explanatory power for firm size.

Spiegel and Wang (2005) divided firm size, liquidity risk, and idiosyncratic volatility into groups, deriving a negative correlation between idiosyncratic volatility and liquidity as well as a high correlation between firm size and liquidity risk. A positive correlation also existed between idiosyncratic volatility and current stock returns, such that when idiosyncratic volatility was controlled, stock returns increased with liquidity. Furthermore, Spiegel and Wang (2005) discovered that idiosyncratic volatility possessed greater explanatory power than liquidity risk, such that controlling idiosyncratic volatility reduced the explanatory power of liquidity with regard to expected returns.

This study examined the relationship among idiosyncratic volatility, liquidity risk and stock returns. Different from previous studies which focus on spot markets, we used trading volume on the options market as a variable with which to gauge liquidity risk. The options market features high leverage and low costs; therefore, it attracts investors with information content to derive greater returns. Manaster and Rendleman (1982) adopted the Black-Scholes options pricing model to deduce implied stock prices from given option prices. Discrepancies occurred between the calculated stock prices and the actual stock prices, revealing that the implicit information was not wholly reflected in actual stock prices. Thus, the options market can be said to lead the stock market. Easley O'Hara and Srinivas (1998) proposed the notion that investors prefer options transactions due to higher leverage effects. Their empirical results demonstrated that positive options trading volumes could reflect stock price information, making the options market more efficient. Thus, it can be said that options trading volumes lead variations in stock prices. Chakravarty, Gulen, and Mayhew (2004) investigated 60 listed companies on the NYSE between 1988 and 1992. Their empirical results demonstrated the capacity of the options market in providing information related to underlying prices. In addition, they identified the primary reasons for which the options market can reflect spot price information: high leverage and good liquidity. Cao and Wei (2008) found that the phenomenon of information asymmetry is more severe in the options market than in the stock market, implying that informed traders view the options market as more efficient. Roll, Schwartz, and Subrahmanyam (2009) proposed that the market value of underlying assets may rise because derivative transactions enable prices to reflect more information, which reduces the risk of investments in underlying assets and enhances information efficiency. Roll, Schwartz, and Subrahmanyam (2009) employed Tobin's Q to measure corporate value and observed the correlation between the trading volume of individual options and corporate value. Their empirical results indicated a positive correlation between the two, due to the information conveyed by stock prices, which could enable corporations to allocate resources more effectively and increase corporate value. This result also revealed that options trading can increase the reflective efficiency of stock prices.

Although Roll, Schwartz, and Subrahmanyam (2009) investigated the correlation between the trading volume of individual stock options and corporate value, their research focused on liquidity risk and did not include other factors of idiosyncratic volatility. Moreover, call options and put options implicitly contain different signals. Anthony (1988) studied listed stocks and the trading volume of call options on the NYSE and AMEX between January 1, 1982, and June 30, 1983, and found that the trading volumes of call options led stock trading volumes by one day. Anthony (1988) claimed that when investors obtain valuable information, they are likely to trade call options; when investors possess bearish information, they are likely to trade put options. In an examination of EUREX and DAX, Schlag and Stoll (2005) discovered that the signals of positive options trading volumes exert positive contemporaneous price effects, whereas negative trading volume signals produce negative price effects.

In the manner of Roll, Schwartz, and Subrahmanyam (2009), this study used the trading volume of individual stock options to serve as a proxy variable for liquidity risk. Based on the high correlation between idiosyncratic volatility and liquidity risk, this study first investigated the relationships among liquidity risk, idiosyncratic volatility following Spiegel and Wang (2005). As shown in previous research, call options and put options contain different signals. Therefore, we further divided the trading volume of individual stock options with regard to call options and put options. Second, since how liquidity affects stock returns has been getting more attention in recent years, in this paper, we investigated the relationships between stock returns and liquidity risk, idiosyncratic volatility, and firm size in the options market.

The remainder of this paper is organized as follows. A brief introduction to the data and methodology is provided in Section 2, followed, in Section 3, we show the main empirical results. Section 4 demonstrates some robustness check. Finally, the conclusions drawn from this study are presented in Section 5.

2 Data and Methodology

2.1 Data Description

The data used in this study was obtained from Ivy DB's Option Metrics and the Center for Research in Security Price (CRSP). The research subjects include all listed companies on the NYSE, AMEX, and NASDAQ, employing monthly data between December 1996, and December 2006. We eliminated data from companies that did not exist throughout the study period and data that were incomplete.

We used the data screening method adopted by Cao and Wei (2010) for the following reasons. For one, missing data is inevitable. We also wished to avoid the phenomenon in which investors settle positions held or transferred to other positions when contracts reach maturity. Furthermore, the trading volumes of deep-in-the-money and deep-out-the-money options are relatively low, giving rise to the issue of large fluctuations in trading volume.

Following Cao and Wei (2010), this study selected options data as follows:

1. Data associated with a zero trading volume were deleted.
2. Options with a maturity shorter than 9 days or longer than 365 days were deleted.
3. For the moneyness (defined as the exercise price divided by the stock price), we were concerned only with the range of [0.9,1.1].
4. Similar to Cao and Wei (2010), we kept only the stocks with an option listing at both the beginning and the end of the year. In addition, we deleted stocks with fewer than 500 option observations within a calendar year.

2.2 Methodology

We referred to Ang et al. (2006), Chan, Chollete, and Ray (2009), and Xu and Malkiel (2003) in the use of within-month daily data for calculation. In addition, we adopted the three-factor model developed by Fama and French (1993, 1996) to estimate idiosyncratic volatility:

$$R_{i,dt} - R_{f,dt} = a_i + \beta_{i,t}^{MKT}\left(R_{m,dt} - R_{f,dt}\right) + \beta_{i,t}^{SMB} SMB_{dt} + \beta_{i,t}^{HML} HML_{dt} + \varepsilon_{i,dt} \qquad (1)$$

where $R_{i,dt}$ denotes the returns of individual stock i; t signifies the month of sample estimation, and d is the number of days in the month in question; $R_{f,dt}$ represents the return on risk-free assets, and $R_{m,dt}$ is the market return rate; SMB_{dt} and HML_{dt} are the cap factor and book-to-market ratio factor, respectively, as developed by Fama and French (1993, 1996), and $\varepsilon_{i,dt}$ is the residual term.

The three-factor variables of Fama and French were obtained from the Kenneth R. French database[3]

Finally, idiosyncratic volatility was taken from the standard deviation of the residual term in the following model.

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[3]Please refer to the website below for more details.
http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

$$IV_{i,t} = \sqrt{Var(\varepsilon_{i,t})} \quad (2)$$

As to other variables, we define the firm size variable as Corporate value = End-of-month stock price × Number of shares outstanding. Following Roll, Schwartz and Subrahmanyam (2009), this study averaged the daily bid and ask prices of the individual stock options multiplied by trading volume to obtain the call option, put option, and total trading volumes.

2.3 Descriptive Statistics

Based on the screening criteria above, we eliminated data that did not meet standards. After combining options trading volumes with bid and ask prices, closing prices, and the number of shares outstanding, we extracted 205 firms with a total of 24,583 pieces of data over 121 months. We used mean, median, standard deviation, maximum values, and minimum values to describe the data variables listed in Table 1. The total trading volume, call option trading volume, put option trading volume, and firm size were $142,520, $92,832, $49,688, and $46,993 million, respectively. Due to these high values, we used the natural logarithm to reduce differences among the variables. With regard to individual stock options, the total trading volume was 10.515, call option trading volume was 10.043, and put option trading volume was 9.311. The mean values of the three differed little with a standard deviation of only 1.665. However, the maximum values were somewhat greater than the minimum values, particularly with respect to put option trading volume. Despite eliminating 0 trading volumes from the samples during screening, the trading volumes in some months were still relatively low.

3 Empirical Results

3.1 Correlation among liquidity risk, idiosyncratic volatility, and firm size

A number of studies have indicated a correlation between liquidity and firm size. The greater the size of the firm, the better the liquidity is. Amihud (2002) discovered a positive correlation between firm size and stock liquidity and determined that liquidity possessed potential explanatory power with regard to size effect. In an investigation into the use of bid-ask spread and idiosyncratic volatility in the stock market, Spiegel and Wang (2005) observed a high correlation among liquidity, idiosyncratic volatility, and firm size.

Table 2 displays the stocks according to idiosyncratic volatility and in Table 3 data are arranged based on firm size, whereas in Table 4 stocks are divided into 10 groups and arranged according to liquidity risk with regard to total trading volume, call option trading volume, and put option trading volume.

As seen in Table 2, in which the stocks are groups by idiosyncratic volatility, the empirical results for the call option trading volume, put option trading volume, and total trading volume are the same; greater idiosyncratic volatility led to higher liquidity. However, at a 1 % level of significance, the results of the Spearman's rank correlation test did not reach significance. Table 2 also presents firm size arranged according to idiosyncratic volatility. The empirical results show that smaller companies possess greater idiosyncratic volatility than larger companies. These results presented significant, negative correlations in the

Spearman's rank correlation test. In Table 3, the trading volumes of individual stock options and idiosyncratic volatility were divided into 10 groups according to firm size. Table 3 indicates that the liquidity of smaller companies was poorer than that of larger companies, and it shows that smaller companies have greater idiosyncratic volatility than do larger companies. At a 1 % level of significance, the results of the Spearman's rank correlation test presented significant, negative correlations. Table 4 ranks the individual stock options according to total trading volume, call option trading volume, and put option trading volume. As mentioned previously, these data presented the same trend observed in idiosyncratic volatility and firm size: the higher the liquidity risk is, the greater the idiosyncratic volatility is. However, the trend was not as apparent, and the Spearman's rank correlation test did not produce significant results. In contrast, ranking and grouping firm size by liquidity presented a positive correlation.

The above results show high correlation among idiosyncratic volatility, liquidity risk, and firm size. Nevertheless, we can only see the rough trend in tables 2 through 4. For this reason, this study conducted regression analysis on liquidity with regard to idiosyncratic volatility and firm size, the results of which are displayed in Table 5.

Table 5 presents the ordinary least squares (OLS) of the individual stock options with regard to idiosyncratic volatility and firm size, the model of which is

$$\ln(DVOL_{i,t}) = \alpha_{i,t} + \beta_1 IV_{i,t} + \beta_2 \ln(SIZE_{i,t-1}) + \varepsilon_{i,t} \quad (3)$$

where $\ln(DVOL_{i,t})$ is the proxy variable of liquidity risk of individual stock i in month t of sample estimation; $IV_{i,t}$ denotes the idiosyncratic volatility; $\ln(SIZE_{i,t-1})$ signifies the size of the firm at the end of the previous year, and $\varepsilon_{i,t}$ is the residual term.

The empirical results demonstrate that when idiosyncratic volatility and firm size were included in the regression equation, both were found to be significantly positively correlated to liquidity risk at a 1 % level of significance. However, investigations on liquidity risk and idiosyncratic volatility separately presented differing results; the results of total trading volume and call option trading volume indicated positive correlation, whereas those of put option trading volume showed a non-significant negative correlation. These results are inconsistent with those obtained by Spiegel and Wang (2005). Nevertheless, Spiegel and Wang (2005) used the bid-ask spread as the proxy variable of liquidity, while we used the trading volume of the individual stock options market in this study. Therefore, these results show that in the options market, greater idiosyncratic volatility indicates better liquidity and larger trading volume in individual stock options. Furthermore, larger firm size leads to better liquidity as well, which supports the findings of Spiegel and Wang (2005).

3.2 Stock returns, Idiosyncratic volatility and liquidity risk

How liquidity risk affect stock returns has been getting more attention in recent years. Table 6 through 8 illustrate trends in idiosyncratic volatility, liquidity risk, and firm size with regard to stock returns. This study employed contemporaneous data for idiosyncratic volatility, liquidity risk, and returns as well as data from the end of the previous year for firm size. We administered Spearman's rank correlation test and a normal population mean test, observing whether significant differences existed between the highest and lowest groups at a test level of 1 %.

In Table 6 and 7, we grouped our data according to firm size and then further grouped it according to idiosyncratic volatility and liquidity risk. Table 6 shows that when idiosyncratic volatility is controlled, the trends in portfolios with low idiosyncratic volatility are less apparent. However, in portfolios with high idiosyncratic volatility, smaller companies receive better returns than larger companies. The results of the Spearman’s rank correlation test did not reach significance, and among the portfolios with the highest idiosyncratic volatility, the difference between return rates of the largest company group and the smallest company group was significant. After controlling for firm size, smaller companies with higher idiosyncratic volatility earned greater returns. This trend was less apparent among portfolios that included larger companies. Furthermore, significant differences in return rates were only observed between the groups with the highest and lowest idiosyncratic volatility in groups with smaller companies.

In Table 7, the stock companies were first grouped according to firm size and then further grouped according to total trading volume, call option trading volume and put option trading volume. The empirical results indicate that after controlling for total trading volume, the return rates of smaller companies are greater than those of larger companies. The difference in return rate between the highest and lowest groups reached the level of significance; however, this trend was less pronounced in the group with the highest liquidity risk. After controlling for firm size, higher liquidity led to greater returns. When we control for call option trading volume, the results differed little from those in controlling for total trading volume. Similarly, when liquidity risk was controlled, only the return rates in the smaller companies in the low liquidity risk group were higher. The return rate difference between the highest and lowest groups was significant. However, when firm size was controlled, higher liquidity indicated greater returns, the trend of which was more apparent than that in total trading volume. The difference between the return rates of the highest and lowest groups reached significance at a 1 % level of significance. We also consider put option trading volume. When liquidity risk was controlled, the results were similar to those for total trading volume. However, after controlling for firm size, the results were the opposite of those related to call option trading volume: poorer liquidity led to greater returns. Nevertheless, the trend was not noticeable.

In Table 8, the stock companies were first ranked and grouped according to idiosyncratic volatility and then further grouped according to liquidity risk. The purpose was to investigate the relationship between liquidity risk and idiosyncratic volatility with regard to stock returns. When we grouped our data based on total trading volume, the empirical results show that, regardless of whether liquidity risk or idiosyncratic volatility was controlled, the trends were not apparent. When stock companies were first ranked and grouped according to idiosyncratic volatility and then further grouped and ranked according to call option trading volume. We found that higher idiosyncratic volatility indicated greater returns. However, this trend was less obvious in the groups with higher liquidity risk. After controlling for idiosyncratic volatility, high liquidity was accompanied by high returns, the difference of which between the highest and lowest groups reached significance. We also take the trading volume of put options served as a proxy variable for liquidity risk. When liquidity risk was controlled, high idiosyncratic volatility was accompanied by high return rates. When idiosyncratic volatility was controlled, we could see that the return rates of low liquidity were higher. Despite a less pronounced trend, this result was opposite to that of call options.

In Table 6 through 8, we can see various trends in the variables with regard to stock returns. In Table 9, we conducted OLS analysis to determine whether idiosyncratic volatility, liquidity risk, or firm size exerted influence on stock returns. The model is as follows:

$$R_{i,t} = \alpha_{i,t} + \beta_1 \ln(DVOL_{i,t}) + \beta_2 IV_{i,t} + \beta_3 \ln(SIZE_{i,t-1}) + \varepsilon_{i,t} \quad (4)$$

where $R_{i,t}$ is the stock returns of individual stock i in month t of sample estimation; $\ln(DVOL_{i,t})$ is the proxy variable of liquidity risk; $IV_{i,t}$ denotes idiosyncratic volatility; $\ln(SIZE_{i,t-1})$ represents the size of the company at the end of the previous year, and $\varepsilon_{i,t}$ is the residual term.

Our empirical results show that when the total trading volume serves as the proxy variable of liquidity (Model 1), a significant and positive correlation exists between liquidity risk and stock returns. This supports the findings of Spiegel and Wang (2005). Furthermore, due to the fact that call options and put options might contain different signals in the options market and respectively indicate whether investors hold bullish or bearish views towards the market, we divided the options trading volume into the trading volume of call options and put options. Model 2 presents a significant, positive correlation between call option trading volume and stock returns. This indicates that when the trading volume of call options rises, stock returns increase because the investors are optimistic about the market. In contrast, when the volume of put options increases, stock returns decrease because the investors are pessimistic about the market. Therefore, a significant, negative correlation exists between put option trading volume and stock returns. Idiosyncratic volatility is positively correlated to stock returns; therefore higher idiosyncratic volatility leads to higher returns. This is consistent with the findings of Spiegel and Wang (2005), in which high-risk stocks earned high returns. Firm size, however, was significantly and negatively correlated to stock returns. In other words, the return rates of smaller companies are greater than those of larger companies. This fits the results of the size effect proposed by Banz (1981).

4 Robustness Test

This study changed the firm size data to that obtained from the end of the previous month to conduct a robustness test. Considering the influence from outliers on the empirical results, firm size data from the end of the previous year was replaced with that from the end of the previous month, as shown in Table 10 and 11. The empirical results without outliers are displayed in Table 12 and 13, showing that total trading volume was significantly positively correlated to stock returns, and a positive correlation still existed between idiosyncratic volatility and stock returns. In addition, a significant, negative correlation existed between firm size and stock returns. Furthermore, when we divided the total trading volume by call option and stock option, a significant, positive correlation still existed between stock returns and call option trading volume, and a significant, negative correlation existed between stock returns and put option trading volume. Only the correlation with idiosyncratic volatility was negative; however, this was not significant. Finally, eliminating the first and last 1 % of each variable returned a total of 22,603 pieces of data. The empirical results show that stocks with high idiosyncratic volatility earned high returns and that firm size was significantly, negatively correlated to stock returns. A higher trading volume for call options led to greater returns. In contrast, a higher trading volume for put options indicated that the investors held a bearish view towards the market, thereby leading to lower stock returns. The results were not considerably different, indicating that the empirical results were not affected by outliers.

5 Conclusion

This study targeted listed companies on the NYSE, AMEX, and NASDAQ to investigate the relationships among idiosyncratic volatility, liquidity risk, and returns. Due to the influence of firm size on liquidity, the factor of size was also included to identify its relationship with stock returns. To estimate idiosyncratic volatility, we employed the three-factor model developed by Fama and French (1993, 1996). Liquidity risk was gauged using the trading volume of the options market. We obtained monthly data during the study period from December 1996 to December 2006 for the investigation, and derived the results using grouping, ranking, and OLS. The study results show that when the total trading volume serves as the proxy variable of liquidity, a positive correlation exists between liquidity and stock returns. A positive correlation was also found between liquidity and idiosyncratic volatility, indicating higher returns with higher idiosyncratic volatility. In contrast, a negative correlation was shown to exist between stock returns and firm size, a result of the size effect proposed by researchers and consistent with the results obtained by Spiegel and Wang (2005).

This study divided options into call options and put options to examine their respective relationships with stock returns. From the empirical results, we discovered that in terms of idiosyncratic volatility and company returns, the results for call option trading volume and put option trading volume with regard to stock returns were similar to those of the total trading volume. However, the results for liquidity were different. This is a result of the differing trading signals that call options and trading options convey. When the trading volume of call options rises, it implies that investors are optimistic about the market, which increases stock prices as well as stock returns. In contrast, when the trading volume of put options increases, then investors hold a bearish view towards the market, thereby creating a negative correlation between put option trading volume and stock returns. Furthermore, we changed the firm size data from that at the end of the previous year to that at the end of the previous month and eliminated outliers (the first and last 1 % of the data), to perform a robustness test. The empirical results were unaffected.

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Appendix

Table A1: Summary Statistics

Similar to Roll, Schwartz and Subrahmanyam (2009), we take the logarithm of all variables except for Skturn. Vol represents the total trading volume includes call and put options. CVol is the trading volume of call option; PVol. is the put options trading volume. IV represents the Idiosyncratic Volatility. Size is market capitalization (in millions of dollars). Skturn is returns in the underlying stock. The time period is from 1996/12 to 2006/12.

	Samples	Mean	Median	Standard deviation.	Max.	Min.
Vol	24583	10.52	10.50	1.67	16.14	5.26
CVol.	24583	10.04	10.02	1.68	15.99	3.95
PVol.	24583	9.31	9.38	1.86	14.82	1.01
IV	24583	0.08	0.07	0.05	0.86	0.01
Firm Size	24583	23.70	23.66	1.30	28.05	19.56
Skturn (%)	24583	1.55	1.10	0.12	2.07	-0.73

Table A2: The relationship between idiosyncratic volatility, liquidity and size

In each month equal-weighted portfolios are sorted by idiosyncratic risk. The time series are cross sectional average and standard deviation of total trading volume (Vol), call option trading volume (CVol), put option trading volume (PVol) and firm size. Mean columns with ++(--) and +(-) shows positive (negative) Spearman rank correlations significant at the 1% and 5% levels respectively.

	Vol		CVol		PVol		Size	
Rank	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean--	Standard Deviation
1(LOW)	10.3047	1.8221	9.8410	1.8385	9.0553	2.0253	24.4813	1.1473
2	10.3046	1.7252	9.8376	1.7445	9.0654	1.9414	24.2654	1.1224
3	10.3519	1.6724	9.8859	1.6871	9.1300	1.8746	24.1220	1.1308
4	10.4898	1.6539	10.0175	1.6670	9.2871	1.8579	24.0307	1.1712
5	10.4979	1.6530	10.0129	1.6733	9.3134	1.8387	23.8501	1.1992
6	10.5407	1.5959	10.0593	1.6251	9.3447	1.7909	23.6733	1.2124
7	10.5401	1.6313	10.0563	1.6541	9.3536	1.8297	23.4897	1.2071
8	10.5952	1.5586	10.1349	1.5686	9.3946	1.7473	23.2390	1.2150
9	10.7633	1.5956	10.2984	1.5942	9.5806	1.7945	23.0864	1.2134
10(HIGH)	10.7607	1.6430	10.2923	1.6495	9.5876	1.8267	22.7610	1.2292

Table A3: The relationship between Size, Liquidity and Idiosyncratic Volatility

In each month equal-weighted portfolios are sorted by size. The time series are cross sectional average and standard deviation of total trading volume (Vol), call option trading volume (CVol), put option trading volume (PVol) and idiosyncratic volatility. Mean columns with ++(--) and +(-) shows positive (negative) Spearman rank correlations significant at the 1% and 5% levels respectively.

	Vol		CVol		PVol		Idiosyncratic Volatility	
Rank	Mean++	Standard Deviation	Mean++	Standard Deviation	Mean++	Standard Deviation	Mean--	Standard Deviation
1(LOW)	9.3428	1.2910	8.9043	1.3178	8.0191	1.5151	0.1127	0.0600
2	9.8129	1.3843	9.3194	1.4220	8.6118	1.5890	0.1043	0.0569
3	9.8416	1.4734	9.3845	1.4736	8.5895	1.7100	0.0917	0.0540
4	9.9413	1.3440	9.4601	1.3586	8.7405	1.5565	0.0827	0.0517
5	9.9984	1.4118	9.5193	1.4295	8.7815	1.6444	0.0765	0.0443
6	10.3113	1.4565	9.8177	1.4666	9.1380	1.6950	0.0772	0.0480
7	10.5504	1.2711	10.0951	1.2798	9.3075	1.5168	0.0722	0.0409
8	10.8953	1.3796	10.4144	1.4086	9.7294	1.5864	0.0707	0.0399
9	11.6078	1.2802	11.1308	1.2907	10.4689	1.4792	0.0677	0.0358
10(HIGH)	12.8003	1.0925	12.3433	1.1207	11.6783	1.1734	0.0630	0.0383

Table A4: The relationship between Total Trading Volume, Size and Idiosyncratic Volatility

In each month equal-weighted portfolios are sorted by total trading volume (Vol), call option trading volume (CVol), put option trading volume (PVol). The time series are cross sectional average and standard deviation of idiosyncratic volatility and size. Mean columns with ++(--) and +(-) shows positive (negative) Spearman rank correlations significant at the 1% and 5% levels respectively.

	Vol			
	Idiosyncratic Volatility		Size	
Rank	Mean	Standard Deviation	Mean++	Standard Deviation
1(LOW)	0.0840	0.0508	25.3520	1.1986
2	0.0838	0.0522	24.5939	1.1422
3	0.0880	0.0547	24.0999	1.0415
4	0.0858	0.0536	23.8466	0.9856
5	0.0836	0.0500	23.6166	1.0280
6	0.0827	0.0467	23.3602	1.0171
7	0.0837	0.0489	23.2242	1.0032
8	0.0803	0.0496	23.1003	0.9786
9	0.0760	0.0454	23.0150	0.9928
10(HIGH)	0.0728	0.0477	22.7799	1.0684

Table A4: (Continued)
The relationship between Total Trading Volume, Size and Idiosyncratic Volatility

	CVol				PVol			
	Idiosyncratic Volatility		Size		Idiosyncratic Volatility		Size	
Rank	Mean	Standard Deviation	Mean++	Standard Deviation	Mean	Standard Deviation	Mean++	Standard Deviation
1(LOW)	0.0833	0.0500	25.3647	1.1940	0.0850	0.0511	25.3013	1.2199
2	0.0853	0.0544	24.5546	1.1505	0.0827	0.0493	24.5702	1.1338
3	0.0864	0.0528	24.1097	1.0662	0.0882	0.0556	24.0997	1.0832
4	0.0856	0.0519	23.8148	0.9875	0.0860	0.0527	23.8302	1.0133
5	0.0840	0.0515	23.6080	1.0486	0.0839	0.0509	23.6464	1.0341
6	0.0840	0.0480	23.3669	1.0154	0.0826	0.0486	23.3897	1.0030
7	0.0830	0.0512	23.2368	1.0076	0.0830	0.0482	23.2232	0.9779
8	0.0802	0.0472	23.0986	1.0135	0.0791	0.0493	23.1193	1.0018
9	0.0764	0.0455	23.0426	0.9742	0.0765	0.0462	22.9959	1.0294
10(HIGH)	0.0726	0.0469	22.7915	1.0483	0.0737	0.0477	22.8157	1.0980

Table A5: Cross-sectional Regression

Estimation results for the estimates of the regression equation

$$\ln(DVOL_{i,t}) = \alpha_{i,t} + \beta_1 IV_{i,t} + \beta_2 \ln(SIZE_{i,t-1}) + \varepsilon_{i,t}$$

$\ln(DVOL_{i,t})$ is the proxy of liquidity risk at time *t* which is the dollar trading volume. Total trading volume, call option trading volume and put option trading volume are used as the liquidity risk proxies. Vol represents the total trading volume includes call and put options. CVol is the trading volume of call option; PVol. is the put options trading volume. $IV_{i,t}$ represents the idiosyncratic risk at time *t*, $\ln(SIZE_{i,t-1})$ is the firm size at the end of *t-1*. The t-statistics are reported in parentheses.

*significant at the 5% level. ** significant at the 1% level.

Liquidity Measure	Idiosycratic Volatility	Size
Vol	5.513**	0.777**
	(22.961)	(54.028)
	0.048	
	(0.203)	
		0.718**
		(51.021)
CVol	5.724**	0.777**
	(23.827)	(56.501)
	0.254	
	(1.078)	
		0.717**
		(52.729)
PVol	5.3205**	0.8103**
	(20.186)	(48.431)
	-0.383	
	(-1.492)	
		0.7543**
		(46.808)

Table A6: Returns on 25 portfolios formed by Firm Size and Idiosyncratic Volatility
In this table, we first sort returns(%) into 5 groups based on firm size. Then for each group we sort the data based on idiosyncratic volatility. IV1 is the equal-weighted portfolio of 20 percent stock returns with the lowest idiosyncratic risk. S1 is the equal-weighted portfolio of 20 percent stock returns with the smallest firm size. we use ++(--) and +(-) shows positive (negative) Spearman rank correlations significant at the 1% and 5% levels respectively on the first column and the first row. The t-statistics are reported to show the significance of the difference between group 1 and group 5.
*significant at the 5% level ** significant at the 1% level.

	Firm Size					
Idiosyncratic risk	S1(small)	S2	S3	S4+	S5+	S1-S5++
IV1(LOW)	0.62	1.01	0.84	0.91	1.22	-0.60
IV2	1.15	1.51	1.12	1.15	1.38	-0.23
IV3	2.62	1.84	1.79	1.61	1.47	1.15*
IV4	2.87	2.64	1.94	1.75	1.29	1.58**
IV5	4.85	1.07	0.48	1.21	0.30	4.54**
IV5- IV1(- -)	4.22%**	0.06%	-0.36%	0.30%	-0.92%*	

Table A7: Returns on 25 portfolios formed by Firm size and Liquidity

In this table, we first sort returns(%) into 5 groups based on firm size. Then for each group we sort the data based on Liquidity risk. Panel A shows that when total trading volume is used as the liquidity risk. Vol1 is the equal-weighted portfolio of 20 percent stock returns with the smallest trading volume. S1 is the equal-weighted portfolio of 20 percent stock returns with the smallest firm size. Similar methods are used in Panel B and C which use call option trading volume (CVol) and put option trading volume (PVol) as the liquidity risk. We use ++(--) and +(-) to show positive (negative) Spearman rank correlations significant at the 1% and 5% levels respectively on the first column and the first row. The t-statistics are reported to show the significance of the difference between group 1 and group 5.

*significant at the 5% level. ** significant at the 1% level.

	Firm Size					
Panel A: Vol						
	S1(LOW)	S2	S3	S4	S5	S1-S5
Vol1(LOW)-	4.30	2.32	1.71	2.24	2.01	2.28**
Vol2	2.81	1.94	1.79	1.11	1.24	1.57**
Vol3	2.30	1.84	1.08	1.48	1.04	1.27**
Vol4	2.09	1.25	1.11	0.99	0.73	1.36**
Vol5	0.66	0.72	0.59	0.83	0.71	-0.05
Vol5- Vol1(++)	-3.63**	-1.60**	-1.12*	-1.40**	-1.31**	
Panel B: CVol						
CVol1(LOW)	5.16	3.33	2.91	3.16	2.48	2.68**
CVol 2	3.44	2.51	1.45	1.42	1.69	1.75**
CVol 3	2.32	1.36	1.02	1.18	0.79	1.53**
CVol 4	1.46	0.84	0.87	0.53	0.54	0.92*
CVol 5	-0.23	0.10	0.02	0.40	0.25	-0.49
CVol 5- CVol 1 ++	-5.39**	-3.23**	-2.89**	-2.76**	-2.23**	
Panel C: PVol						
PVol1(LOW) --	2.44	0.54	0.07	0.79	0.58	1.86**
PVol 2	1.35	1.63	1.16	0.79	1.02	0.33
PVol 3	2.70	1.48	1.86	1.49	1.48	1.23*
PVol 4	2.92	2.27	0.96	1.60	1.29	1.63**
PVol 5	2.69	2.18	2.12	1.97	1.30	1.39**
PVol 5- PVol 1++	0.25	1.64**	2.05**	1.18*	0.72	

Table A8: Returns on 25 portfolios formed by Idiosyncratic Volatility and Liquidity
In this table, we first sort returns (%) into 5 groups based on idiosyncratic volatility. Then for each group we sort the data based on Liquidity risk. Panel A shows that when total trading volume is used as the liquidity risk. Vol1 is the equal-weighted portfolio of 20 percent stock returns with the smallest total trading volume. S1 is the equal-weighted portfolio of 20 percent stock returns with the smallest firm size. Similar methods are used in Panel B and C which use call option trading volume (CVol) and put option trading volume (PVol) as the liquidity risk. We use ++(--) and +(-) shows positive (negative) Spearman rank correlations significant at the 1% and 5% levels respectively on the first column and the first row. The t-statistics are reported to show the significance of the difference between group 1 and group 5.
*significant at the 5% level. ** significant at the 1% level.

	Idiosyncratic Volatility					
Panel A: Vol						
	IV1(LOW)-	IV2-	IV3-	IV4	IV5	IV1- IV5
Vol1(LOW)-	1.64	1.27	0.50	0.99	0.82	-0.82
Vol2--	1.40	1.53	1.14	1.12	0.87	-0.53**
Vol3--	2.74	1.97	1.12	1.01	1.10	-1.63
Vol4--	2.53	1.54	1.21	1.03	1.31	-1.22
Vol5--	3.86	2.23	1.57	1.97	2.08	-1.77**
Vol5- Vol1	2.22**	0.96**	1.07**	0.99	1.27	
Panel B: CVol	IV1(LOW)-	IV2-	IV3	IV4	IV5	
CVol1(LOW)-	1.95	2.38	2.70	2.65	2.96	
CVol 2--	1.04	1.79	1.60	2.26	3.38	
CVol 3--	1.27	1.33	1.93	1.79	2.27	
CVol 4--	0.64	1.01	1.44	1.64	0.18	
CVol 5--	-0.09	0.43	-0.03	1.05	1.16	
CVol 5- CVol 1 ++	-2.04**	-1.95**	-2.73**	-1.60**	-1.79*	
Panel C: PVol	IV1(LOW)-	IV2-	IV3-	IV4	IV5	
PVol1(LOW) --						
PVol 2--	1.35	1.35	1.17	0.60	0.08	
PVol 3--	0.83	1.19	1.36	1.47	1.80	
PVol 4--	0.73	1.17	1.27	1.45	1.45	
PVol 5	0.75	1.36	1.93	2.74	2.90	
PVol 5- PVol 1++	1.22	1.88	2.01	3.17	3.82	

Table A9: Cross-sectional Regression

Estimation results for the estimates of the regression equation

$$R_{i,t} = \alpha_{i,t} + \beta_1 \ln(DVOL_{i,t}) + \beta_2 IV_{i,t} + \beta_3 \ln(SIZE_{i,t-1}) + \varepsilon_{i,t}$$

$R_{i,t}$ is the stock returns at time t, $\ln(DVOL_{i,t})$ is the dollar trading volume at time *t* and represents as a liquidity risk. Vol represents the total trading volume includes call and put options. CVol is the trading volume of call option; PVol. is the put options trading volume. $IV_{i,t}$ represents the idiosyncratic risk at time *t*, $\ln(SIZE_{i,t-1})$ is the firm size at the end of *t-1*. The t-statistics are reported in parentheses.

*significant at the 5% level. ** significant at the 1% level.

Model	Vol	CVol	PVol	IV	Size
1	0.005**			0.057	-0.007**
	(8.238)			(1.322)	(-7.481)
2		0.047**	-0.038**	0.022	-0.008**
		(44.343)	(-41.948)	(0.518)	(-9.369)

Table A10: Cross-sectional Regression- firm size are calculated based on previous month data

Estimation results for the estimates of the regression equation

$$\ln(DVOL_{i,t}) = \alpha_{i,t} + \beta_1 IV_{i,t} + \beta_2 \ln(SIZE_{i,t-1}) + \varepsilon_{i,t}$$

$\ln(DVOL_{i,t})$ is the proxy of liquidity risk at time *t* which is the dollar trading volume. Total trading volume, call option trading volume and put option trading volume are used as the liquidity risk proxies. Vol represents the total trading volume includes call and put options. CVol is the trading volume of call option; PVol. is the put options trading volume. $IV_{i,t}$ represents the idiosyncratic risk at time *t*, $\ln(SIZE_{i,t-1})$ is the firm size at the end of *t-1* which is the previous month. The t-statistics are reported in parentheses.

*significant at the 5% level. ** significant at the 1% level.

Liquidity Measure	Idiosyncratic Volatility	Size
Vol	6.429**	0.822**
	(27.446)	(56.805)
	0.048	
	(0.203)	
		0.746**
		(52.89)
CVol	6.694**	0.83**
	(28.831)	(60.552)
	0.254	
	(1.078)	
		0.751**
		(55.504)
PVol	6.158**	0.843**
	(23.358)	(49.26)
	-0.383	
	(-1.492)	
		0.77**
		(47.241)

Table A11: Cross-sectional Regression- firm size are calculated based on previous month data

Estimation results for the estimates of the regression equation

$$R_{i,t} = \alpha_{i,t} + \beta_1 \ln(DVOL_{i,t}) + \beta_2 IV_{i,t} + \beta_3 \ln(SIZE_{i,t-1}) + \varepsilon_{i,t}$$

$\ln(DVOL_{i,t})$ is the proxy of liquidity risk at time *t* which is the dollar trading volume. Total trading volume, call option trading volume and put option trading volume are used as the liquidity risk proxies. Vol represents the total trading volume includes call and put options. CVol is the trading volume of call option; PVol. is the put options trading volume. IV represents the Idiosyncratic Volatility. Size is market capitalization (in millions of dollars). $IV_{i,t}$ represents the idiosyncratic risk at time *t*, $\ln(SIZE_{i,t-1})$ is the firm size at the end of *t-1*. The t-statistics are reported in parentheses.
*significant at the 5% level. ** significant at the 1% level.

Model	Vol	CVol	PVol	IV	Size
1	0.0056**			0.044	-0.008**
	(9.037)			(1.019)	(-8.299)
2		0.048**	-0.039**	-0.005	-0.011**
		(45.082)	(-42.069)	(-0.112)	(-11.944)

Table A12: Cross-sectional Regression- extreme data are deleted

Estimation results for the estimates of the regression equation

$$\ln(DVOL_{i,t}) = \alpha_{i,t} + \beta_1 IV_{i,t} + \beta_2 \ln(SIZE_{i,t-1}) + \varepsilon_{i,t}$$

$\ln(DVOL_{i,t})$ is the proxy of liquidity risk at time *t* which is the dollar trading volume. Total trading volume, call option trading volume and put option trading volume are used as the liquidity risk proxies. Vol represents the total trading volume includes call and put options. CVol is the trading volume of call option; PVol. is the put options trading volume. $IV_{i,t}$ represents the idiosyncratic risk at time *t*, $\ln(SIZE_{i,t-1})$ is the firm size at the end of *t-1*. The t-statistics are reported in parentheses.
*significant at the 5% level. ** significant at the 1% level.

Liquidity Measure	Idiosyncratic Volatility	Size
Vol	5.421**	0.718**
	(12.833)	(37.34)
	-0.204	
	(-0.375)	
		0.665**
		(35.212)
CVol	5.661**	0.722**
	(13.27290)	(37.429)
	0.005	
	(0.008673)	
		0.6671**
		(35.011)
PVol	5.134**	0.741**
	(11.029)	(34.752)
	-0.669	
	(-1.135)	
		0.691**
		(33.228)

Table A13: Cross-sectional Regression- extreme data are deleted

Estimation results for the estimates of the regression equation

$$R_{i,t} = \alpha_{i,t} + \beta_1 \ln(DVOL_{i,t}) + \beta_2 IV_{i,t} + \beta_3 \ln(SIZE_{i,t-1}) + \varepsilon_{i,t}$$

$R_{i,t}$ is the stock returns at time t , $\ln(DVOL_{i,t})$ is the dollar trading volume at time *t* and represents as a liquidity risk. Vol represents the total trading volume includes call and put options. CVol is the trading volume of call option; PVol. is the put options trading volume. $IV_{i,t}$ represents the idiosyncratic risk at time *t*, $\ln(SIZE_{i,t-1})$ is the firm size at the end of *t-1*. The t-statistics are reported in parentheses.

*significant at the 5% level.

** significant at the 1% level.

Model	Vol	CVol	PVol	IV	Size
1	0.003**			0.044	-0.004**
	(6.428)			(1.953)	(-4.87)
2		0.04**	-0.034**	0.008	-0.005**
		(42.308)	(-42.286)	(0.385)	(-7.265)