The Effect of Market Volatility on Liquidity and Stock Returns in the Korean Stock Market

Jieun Lee*
The Bank of Korea

Kee H. Chung†
University at Buffalo, The State University of New York

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* Economist, Financial & Monetary Economics Team, Economic Research Institute, the Bank of Korea. 39 Namdaemun-Ro, Jung-Gu, Seoul, 100-794, South Korea. e-mail: jelee@bok.or.kr.
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†**Address for Correspondence**: Kee H. Chung, Louis M. Jacobs Professor, Department of Finance, School of Management, University at Buffalo, The State University of New York, Buffalo, NY 14260, USA. e-mail: keechung@buffalo.edu.

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Abstract

This study analyzes the effect of market volatility on stock returns using data from the Korean stock market from January 1, 2004 to December 31, 2014. We show that unexpected increases in market volatility accompany decreases in both stock returns and liquidity and the effect of volatility shock on stock returns is greater for stocks with more domestic or foreign institutional trading. Individual investors mitigate the negative effect of volatility shock on stock returns, suggesting that they are noise traders who do not fully comprehend the pricing implication of volatility shock. The interaction effect of market volatility and liquidity on stock returns is stronger for stocks with more foreign institutional trading. We also document some evidence of asymmetric effects of market volatility on stock returns that are related to whether trades are buyer or seller initiated.

Keywords: Market volatility, VIX, Price impact, Bid-ask spread, Liquidity, Stock returns, Investor type, Financial crisis

JEL Classification: G10, G32, G34

1. Introduction

This paper analyzes the effects of market volatility on stock liquidity and returns using data from the Korean stock market. In particular, we analyze whether changes in stock returns and liquidity that result from unexpected changes in market volatility are related to trading volume accounted for by individual, domestic institutional, and foreign institutional investors. Our main thesis is that the effects of market volatility on liquidity and stock returns are likely to vary with the proportion of trades that are initiated by each type of investors because the information content of a trade is likely to differ across these investors.

Prior research shows that unexpected increases in market volatility decrease stock returns in the aggregate (i.e., market returns). For instance, French, Schwert, and Stambaugh (1987) find a negative relation between market returns and unexpected increases in market volatility. Similarly, Haugen, Talmor, and Torous (1991) show that increases in market volatility give rise to a subsequent decline in stock prices and higher future returns. Although the relation between market volatility and stock market returns in the aggregate is well documented, there is little evidence regarding how individual stock returns are related to market volatility. We provide such evidence in this study. To the extent that individual stock return sensitivity to market volatility is a priced factor in the cross-section of expected returns, the results of our study should help better understand the role of market volatility in asset pricing.

Prior research suggests that market uncertainty reduces liquidity for at least two reasons. Gorton and Metrick (2010) argue that liquidity suppliers provide less liquidity in times of high uncertainty because they face greater adverse selection problems during such times. Nagel (2012) shows that liquidity suppliers provide less liquidity during times of market turmoil because they require higher returns during such periods. Chung and Chuwonganant (2014) show that market volatility exerts a market-wide impact on liquidity, which generates co-movements in individual asset liquidity. Built on these findings, we analyze the effect of market uncertainty on individual stock liquidity and shed further light on how market uncertainty exerts an impact on stock returns through its effect on stock liquidity.

Bali, Peng, Shen, and Tang (2014) show that both contemporaneous and future stock returns increase with unexpected increases in liquidity. The authors interpret this finding as that the stock market underreacts to stock-level liquidity shocks. Our study differs from their study in that we consider liquidity to be an important channel through which market uncertainty affects stock returns, while theirs focuses primarily on the effect of liquidity shocks on stock returns without considering the role of market uncertainty. The focal point of our empirical analysis is to explore whether volatility shocks prompt liquidity shocks and also whether this effect helps better understand changes in stock returns that are associated with market volatility shocks.

Chung and Chuwonganant (2016) analyze the effects of market volatility on stock liquidity and returns using the US data. Prior research shows that the information content of trading differs across the type of traders. For instance, Park and Chung (2007) find evidence that foreign institutional (local institutional) investors have faster access to or processing power of new information than local institutional (local individual) investors. The present study extends Chung and Chuwonganant (2016) using data from the Korean stock market, which provides information regarding whether each trade is initiated by individual, domestic institutional, or foreign institutional traders. Because both the information content of a trade and the adverse selection risk of a trade to liquidity providers are likely to differ significantly across these different types of traders, the effects of market volatility on liquidity and stock returns are also likely to vary with the proportion of trades that are initiated by each type of traders. Our study contributes to the literature by providing evidence consistent with this conjecture.

Using the KOSPI 200 volatility index as a measure of market volatility and the price impact of a trade as well as the quoted bid-ask spread as measures of individual stock liquidity, we show that unexpected increases in market volatility accompany decreases in both liquidity and contemporaneous monthly stock returns. We also show that decreases in individual stock returns that are associated with increases in market volatility are larger for stocks with greater concurrent decreases in liquidity. These results suggest that liquidity providers play an important role in determining the effect of market uncertainty on individual stock returns in the Korean stock market.

We show that the negative effect of an increase in volatility shock on stock returns is greater for stocks with more domestic or foreign institutional trading, whereas individual traders mitigate the negative effect of an increase in volatility shock on stock returns. We interpret the latter result as evidence that individual traders are noise traders who do not fully comprehend the pricing implication of volatility shock. We also show that although the interaction effect of market volatility and liquidity on stock returns is stronger for stocks with more foreign institutional trading, the interaction effect does not vary with the extent of domestic investor trading.

We conjecture that the effect of market volatility on liquidity and stock returns may be particularly strong during times of financial crisis because investors are believed to be more risk averse during such times. To examine whether the effects of market volatility on liquidity and stock returns vary with market environments, we conduct regression analysis using data during the pre-crisis period (2004-2006), the crisis period (2007-2009), and the post-crisis period (2010-

2014), separately. The results show that an increase in market volatility generally results in a decrease in stock returns in all three sub-periods.

Consistent with our expectation, however, we find that the negative effect of an increase in volatility shock on stock returns is greater for stocks with more foreign institutional trading during only the crisis period. In a similar vein, we find that the interaction effect of market volatility and liquidity on stock returns is stronger for stocks with larger foreign or domestic institutional trading only during the crisis period. The effects of liquidity shock on stock returns are positive and significant during both the crisis period and the non-crisis period, while the negative effect of an increase in volatility shock on stock returns is greater for stocks with more institutional trading during only the crisis period.

Finally, we show that the relation between stock returns and volatility shock is qualitatively similar, regardless of whether we use volatility shock in Korea, the US, or Europe. We interpret this result as evidence of an integrated global market in which volatility shocks are highly correlated across markets because they are likely to arise largely from a common set of state variables and economic fundamentals.

This study contributes to the literature in several dimensions. First, it adds to a growing literature that uses market volatility index as a measure of market uncertainty. Pan and Singleton (2008) and Longstaff, Pan, Pedersen, and Singleton (2010) examine whether the Chicago Board Options Exchange (CBOE) market volatility index (VIX) can explain sovereign credit spreads. Graham and Harvey (2010) examine the relation between VIX and equity risk premium. Bao, Pan, and Wang (2011) analyze the relation between VIX and bond market liquidity, while Nagel (2012) explores whether the expected return from liquidity provision varies with VIX. Our study extends this literature by analyzing the effect of market volatility on the cross-section of liquidity and returns in the Korean stock market.

Prior research examines the effect of market uncertainty on stock returns without considering the role of liquidity. The present study helps better understand the effect of market uncertainty on stock returns by investigating how the effect of market volatility on liquidity could magnify the impact of market uncertainty on stock returns. Another important contribution is to show that the extent to which market uncertainty affects liquidity and stock returns depends on the proportion of trades that are executed by different types of trades.

The rest of the paper is organized as follows. Section 2 explains data sources and variable measurement methods and provides summary statistics. Section 3 analyzes the impact of unexpected changes in market volatility on the liquidity and return of individual securities. Section 4 analyzes whether the effects of volatility and liquidity shocks on stock returns vary with the intensity of trading by different types of traders. Section 5 explores whether the effects of market volatility on stock returns vary with market environments. Section 6 investigates the effects of volatility shock in the US and European stock markets on Korean stock returns. Section 7 provides a brief summary of the paper and concluding remarks.

2. Data sources and variable description

Our initial study sample includes stocks listed on the Korea Exchange (KRX), an electronic order-driven market, from January 1, 2004 to December 31, 2014. We exclude financial firms from the study sample. We collect daily returns, number of shares outstanding, return volatility, book value of equity, and trading volume from FnGuide. We exclude stock-month observations with missing trading volume or stock return, stocks with a price lower than

1000 Korean won (KRW), which is equivalent to about one US dollar, stocks with fewer than 12 trading days within a month, and stocks with fewer than 24 trading months.

We obtain the Korean TAQ data from the Korean Exchange (KRX). In order to minimize data errors, we exclude the following quotes and trades from the study sample: (1) quotes if either the ask or the bid is less than or equal to zero; (2) quotes if either the bid-ask spread is greater than 20% of share price or less than zero; (3) trades if price or volume is less than or equal to zero; (4) trade price, P_t, if $\left|\frac{(P_t - P_{t-1})}{P_{t-1}}\right| > 0.5$; (5) ask quote, ASK, if $\left|\frac{(ASK_t - ASK_{t-1})}{ASK_{t-1}}\right| > 0.5$; (6) bid quote, BID, if $\left|\frac{(BID_t - BID_{t-1})}{BID_{t-1}}\right| > 0.5$; (7) before-the-open and after-the-close trades and quotes.[1]

We calculate the quoted spread (SPREAD) using the following formula: $SPREAD_{i,t} = (ASK_{i,t} - BID_{i,t})/M_{i,t}$, where $ASK_{i,t}$ is the best ask price of stock i at time t, $BID_{i,t}$ is the best bid price of stock i at time t, and $M_{i,t}$ is the quote midpoint $(ASK_{i,t} + BID_{i,t})/2$ of stock i at time t. We then calculate the daily time-weighted mean quoted spread and the monthly equal-weighted mean value of the daily quoted spread. We calculate the daily Amihud (2002) illiquidity measure using the following formula: $AMIHUD_{i,t} = [|RET_{i,t}| / TRV_{i,t}]*10^9$, where $RET_{i,t}$ is stock i's return on day t and $TRV_{i,t}$ is stock i's trading volume (in KRW) on day t. To reduce outliers, we winsorize the data at 99.8% and require that the number of trading days within a month is at least 12 days. For each stock, we then calculate the monthly mean value of the Amihud measure.

In the Korean TAQ data, each trade is flagged to identify whether it is initiated by a domestic individual investor, a domestic institutional investor, or a foreign institutional investor.

[1] The regular trading hour of the Korea Exchange is from 9:00 AM to 3:00 PM.

Using this information, we calculate, for each stock in each month, the proportion of trades that are initiated by domestic institutional investors (PINST), foreign institutional investors (PFORE), and domestic individual investors (PINDI). The Korean TAQ data also enable us to identify whether each trade is buyer- or seller-initiated using order sequence number and trade direction, which does not require the Lee and Ready (1991) algorithm. Specifically, we consider a trade to be buyer (seller)-initiated if a buy (sell) order is matched with existing sell (buy) orders using order sequence number and trade direction. We then calculate, for each stock in each month, the proportion of trades that are initiated by domestic institutional investors' sell orders (PSINST), foreign institutional investors' sell orders (PSFORE), domestic individual investors' sell orders (PSINDI), domestic institutional investors' buy orders (PBINST), foreign institutional investors' buy orders (PBFORE), and domestic individual investors' buy orders (PBINDI).

We collect the KOSPI 200 volatility index (VIXKO hereafter) from Bloomberg. Following Chung and Chuwonganant (2016), we measure unexpected changes in market volatility ($\Delta VIXKO_t$) and unexpected changes in individual stock liquidity ($\Delta AMIHUD_{i,t}$ and $\Delta SPREAD_{i,t}$) as follows:

$$\Delta VIXKO_t = (VIXKO_t - AVGVIXKO_{t-12,t-1}) / AVGVIXKO_{t-12,t-1}, \quad (1)$$

$$\Delta AMIHUD_{i,t} = -(AMIHUD_{i.t} - AVGAMIHUD_{i|t-12,t-1}) / AVGAMIHUD_{i|t-12,t-1}, \quad (2)$$

$$\Delta SPREAD_{i,t} = -(SPREAD_{i.t} - AVGSPREAD_{i|t-12,t-1}) / AVGSPREAD_{i|t-12,t-1}; \quad (3)$$

where subscript i denotes stock i and subscript t denotes month t. $VIXKO_t$ is the mean value of daily VIXKO in month t and $AVGVIXKO_{t-12,t-1}$ is the mean value of VIXKO in the past 12 months. A negative ΔVIXKO means a decline in VIXKO relative to the past 12-month average.

$AMIHUD_{i,t}$ is the mean value of the daily Amihud measure (AMIHUD) for stock i in month t. $AVGAMIHUD_{i|t-12,t-1}$ is the mean value of AMIHUD in the past 12 months. A negative ΔAMIHUD means a decline in liquidity relative to the past 12-month average. $SPREAD_{i,t}$ is the mean value of the daily quoted percentage spread for stock i in month t. $AVGSPREAD_{i|t-12,t-1}$ is the mean value of SPREAD in the past 12 months. A negative ΔSPREAD means an increase in spread (a decrease in liquidity) relative to the past 12-month average.

Table 1 shows the descriptive statistics of the key variables for our study sample of 1,598 KRX stocks. The mean value of ΔVIXKO, ΔAMIHUD, and ΔSPREAD is -0.027, -0.145, and 0.014, respectively. The mean monthly stock return is 0.015 and the mean trading volume is around 4.1 billion KRW. The majority of trades are initiated by domestic individual investors: on average, 81% of trades are initiated by individual investors, 12.6% are initiated by domestic institutional investors, and 6.4% are initiated by foreign institutional investors. Not surprisingly, the fraction of trades that are buyer-initiated is approximately equal to the fraction of trades that are seller-initiated for all three types of investors.

Table 2 shows the pairwise correlation matrix of the key variables. The results indicate that unexpected changes in market volatility (ΔVIXKO) are negatively correlated with unexpected changes in the Amihud measure (ΔAMIHUD) and the bid-ask spread (ΔSPREAD), with a correlation coefficient of -0.099 and -0.375, respectively. As expected, unexpected changes in the Amihud measure are positively related to unexpected changes in the bid-ask spread. The changes in market volatility are positively related to idiosyncratic risk (ΔIVO), the coefficient of variation of the Amihud illiquidity measure (CVAMIHUD), the maximum daily return (MAXRET), and negatively related to firm size (LOG(MVE)), log LOG(BM), and Beta.

3. Regression results

To investigate the effects of market volatility and liquidity shocks on stock returns after controlling for the variables that are associated with stock returns, we estimate the following regression model using the pooled time series and cross-sectional data for the sample of the KRX stocks from January 2004 to December 2014:

$$
\begin{aligned}
\begin{matrix} RET_{i,t} \\ RET_{i,t+1} \end{matrix} = \; & \beta_0 + \beta_1 \Delta VIXKO_t + \beta_2 (\Delta AMIHUD_{i,t} \text{ or } \Delta SPREAD_{i,t}) \\
& + \beta_3 \Delta VIXKO_t {*} (\Delta AMIHUD_{i,t} \text{ or } \Delta SPREAD_{i,t}) \\
& + \beta_4 \Delta IVO_{i,t} + \beta_5 \Delta TRV_{i,t} + \beta_6 BETA_{i,t} \\
& + \beta_7 LOG(MVE_{i,t-1}) + \beta_8 CVAMIHUD_{i,t} + \beta_9 MAXRET_{i,t} \\
& + \beta_{10} RET(-12,-2)_{i,t} + \beta_{11} STDTO_{i,t} + \beta_{12} LOG(BM_{i,t}) \\
& + \beta_{13} COSKEWNESS_{i,t} + \varepsilon_{i,t}; \qquad (4)
\end{aligned}
$$

where subscript i, t, and t +1 stands for stock i, month t, and month t+1, respectively, and $\varepsilon_{i,t}$ is the error term. Bali, Peng, Shen, and Tang (2014) find that liquidity shocks are related to both contemporaneous returns and future returns in the same direction and interpret the results as evidence that the stock market underreacts to stock-level liquidity shocks. To examine whether the stock market underreacts to uncertainty shocks as well, we use both the contemporaneous monthly return ($RET_{i,t}$) and the one-month ahead return ($RET_{i,t+1}$) as the dependent variable. As defined above, $\Delta VIXKO_t$, $\Delta AMIHUD_{i,t}$, and $\Delta SPREAD_{i,t}$ stand for unexpected changes in market volatility, the Amihud illiquidity measure, and the percentage quoted bid-ask spread.

To assess whether unexpected changes in market volatility exert an impact on stock returns that is beyond the effect on stock returns of unexpected changes in the idiosyncratic volatility and trading volume of individual securities, we include unexpected changes in idiosyncratic volatility and trading volume ($\Delta IVO_{i,t}$ and $\Delta TRV_{i,t}$) in the regression. We include a number of additional control variables in the regression. $BETA_{i,t}$ is the systematic risk, $LOG(MVE_{i,t-1})$ is the logarithm of market value of equity for stock i, month t – 1, $CVAMIHUD_{i,t}$ is the coefficient of variation of the Amihud illiquidity measure, $MAXRET_{i,t}$ is the maximum daily return, $RET(-12,-2)_{i,t}$ is the momentum, calculated by cumulative return during month t – 12 and month t – 2, $STDTO_{i,t}$ is the standard deviation of monthly volume turnover during the last 12 months, $LOG(BM_{i,t})$ is the logarithm of book-to-market value of equity ratio, $COSKEWNESS_{i,t}$ is the co-skewness measure. Appendix A provides the detailed description of these variables. We estimate regression model (7) with clustered standard errors by stock and time and show the results in Panel A of Table 3.[2]

The first two column results show that contemporaneous stock returns are significantly and negatively related to volatility shock, indicating that an increase in market volatility results in a decrease in contemporaneous stock returns. The negative relation between volatility shocks and contemporaneous stock returns is consistent with the positive relation between expected risk premiums and volatility (French, Schwert, and Stambaugh, 1987). That is, as investors require a higher return due to an unexpected increase in market volatility, share price (which is the present value of future cash flows discounted at the required rate of return) declines, resulting in a decrease in stock returns. The results also show that contemporaneous stock returns are significantly and positively related to liquidity shock, regardless of whether we measure liquidity shock by ΔAMIHUD or ΔSPREAD, indicating that an increase in individual stock liquidity

[2] For robustness check, we also estimate regression model (7) with firm fixed effects and standard errors clustered by firm. We find that although the results for contemporaneous returns are qualitatively similar, t-values for the coefficients on ΔVIXKO, ΔAMIHUD, ΔVIXKO*ΔAMIHUD, ΔSPREAD, ΔVIXKO*ΔSPREAD are much larger than those provided in Table 3.

results in an increase in contemporaneous stock returns. The positive relation between liquidity shocks and contemporaneous stock returns is consistent with the positive relation between expected returns and illiquidity (i.e., investors demand a premium for less liquid stocks) (Amihud and Mendelson, 1986).

The regression coefficient on the interaction term between volatility shock and liquidity shock is positive and significant when we measure liquidity by AMIHUD. This result indicates that the negative effect of an increase in market volatility on stock returns is greater for stocks with a larger concurrent increase in illiquidity as measured by the price impact of a trade (i.e., the adverse selection component of the spread). However, the regression coefficient on the interaction term between volatility shock and liquidity shock is insignificant when we measure liquidity by SPREAD. These results suggest that the negative effect of market volatility on stock returns increases with only a concurrent increase in the adverse selection cost.

The results show that the coefficients on idiosyncratic volatility shock (ΔIVO) (i.e., unexpected change in the idiosyncratic volatility of individual securities) are positive and significant, indicating that contemporaneous stock returns increase with unexpected increases in the idiosyncratic volatility of individual securities. Contemporaneous stock returns are positively and significantly related to CVAMIHUD and LOG(BM), but negatively and significantly related to LOG(MVE) and MAXRET, which is consistent with the finding of Bali, Peng, Shen, and Tang (2014).

Columns (3) and (4) in Table 3 show that one-month ahead stock returns ($RET_{i,t+1}$) are not significantly related to volatility shock, indicating that the market does not underreact to volatility shock.[3] The results also show that one-month ahead stock returns are not significantly related to liquidity shock measured by unexpected changes in the price impact of a trade (the Amihud measure). We find, however, that one-month ahead stock returns are significantly and positively related to liquidity shock measured by unexpected changes in the quoted bid-ask spread. These results suggest that the market tends to underreact to unexpected changes in the total trading cost (i.e., the spread), but not to unexpected changes in the adverse selection component of the spread (i.e., the price impact of a trade).[4] The regression coefficients on the interaction term between volatility shock and liquidity shock are not significantly different from zero, regardless of whether we use the Amihud measure or the quoted spread. This result indicates that the negative effect of an increase in market volatility on one-month ahead stock returns does not vary with liquidity shock in the current month.

Our empirical model (regression model (4)) implicitly assumes that increases in market volatility result in concurrent decreases in stock liquidity. To shed some light on the empirical validity of this assumption, we analyze the relation between stock liquidity and market volatility by regressing our measures of liquidity shock (i.e., ΔAMIHUD and ΔSPREAD) on volatility shock (ΔVIXKO) and the control variables we used in regression model (4). The results (see Panel B in Table 3) show that the coefficients on ΔVIXKO are negative and significant,

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[3] We find that the coefficients on ΔVIXKO in the regressions for one-month ahead stock returns are positive and significant when we estimate regression model (4) with firm fixed effects and standard errors clustered by firm. Hence, we have mixed results regarding whether or not the market underreacts to volatility shocks, which depends on the estimation method.

[4] A decrease in liquidity should result in high future returns in an efficient market (Acharya and Pedersen, 2005). We find that one-month ahead stock returns are significantly and positively related to liquidity shock measured by unexpected changes in both the Amihud measure and the quoted bid-ask spread when we estimate regression model (4) with firm fixed effects and standard errors clustered by firm.

regardless of whether we use ΔAMIHUD or ΔSPREAD as a measure of liquidity shock, which confirms the validity of our assumption.

4. Results using the proportion of trades that are initiated by different types of investors

Prior research shows that the information content of trading differs across different types of traders. For instance, Park and Chung (2007) show that returns of stocks with high foreign institutional ownership in Korea lead returns of stocks with low foreign institutional ownership. Likewise, returns of stocks with high local institutional ownership lead returns of stocks with low local institutional ownership. Based on these results, the authors conclude that foreign institutional (local institutional) investors have faster access to or processing power of new information than local institutional (local individual) investors. This section examines whether the effect of market volatility on contemporaneous stock returns varies with the proportion of trades that are initiated by domestic institutional investors (PINST), foreign institutional investors (PFORE), and domestic individual investors (PINDI), respectively, across stocks and over time. For this, we estimate the following regression model:

$$
\begin{aligned}
RET_{i,t} = \; & \beta_0 + \beta_1 \Delta VIXKO_t + \beta_2 (\Delta AMIHUD_{i,t} \text{ or } \Delta SPREAD_{i,t}) \\
& + \beta_3 \Delta VIXKO_t * (\Delta AMIHUD_{i,t} \text{ or } \Delta SPREAD_{i,t}) \\
& + \beta_4 \Delta VIXKO_t * (PINST_{i,t} \text{ or } PFORE_{i,t} \text{ or } PINDI_{i,t}) \\
& + \beta_5 \Delta VIXKO_t * (\Delta AMIHUD_{i,t} \text{ or } \Delta SPREAD_{i,t}) * (PINST_{i,t} \text{ or } PFORE_{i,t} \text{ or } PINDI_{i,t}) \\
& + \text{control variables} + \varepsilon_{i,t}; \qquad (5)
\end{aligned}
$$

Panel A in Table 4 shows the results when we use ΔAMIHUD and Panel B shows the results when we use ΔSPREAD as a measure of liquidity shock. The results show that the regression coefficient on the interaction term between volatility shock and PINST is negative and significant when we use ΔSPREAD as a measure of liquidity shock. Similarly, the coefficient on the interaction term between volatility shock and PFORE is negative and significant when we use ΔSPREAD as a measure of liquidity shock. These results indicate that the negative effect of an increase in volatility shock on stock returns is greater for stocks with more domestic or foreign institutional trading, which suggests that domestic and foreign institutional investors are sensitive to volatility shock. Surprisingly, we find that the coefficient on the interaction term between volatility shock and PINDI is positive and significant when we use ΔSPREAD as a measure of liquidity shock, suggesting that individual traders mitigate the negative effect of an increase in volatility shock on stock returns. One possible interpretation of this result is that individual traders are noise traders who do not fully understand the pricing implication of volatility shock.

The coefficients on ΔVIXKO*ΔAMIHUD*PFORE and ΔVIXKO*ΔSPREAD*PFORE are positive and significant, indicating that the interaction effect of market volatility and liquidity on stock returns is stronger for stocks with larger foreign institutional trading. However, the coefficients on ΔVIXKO*ΔAMIHUD*PINST and ΔVIXKO*ΔSPREAD*PINST are not significantly different from zero, indicating that the interaction effect of market volatility and liquidity on stock returns does not depend on domestic institutional trading. The coefficient on ΔVIXKO*ΔAMIHUD*PINDI is negative and significant when we use ΔAMIHUD as a measure of liquidity shock, which suggests that the interaction effect of market volatility and liquidity on stock returns is weaker for stocks with larger individual trading.

Brennan et al. (2012) show that sell-order liquidity is priced more strongly than buy-order liquidity in the cross-section of equity returns. Chiyachantana et al. (2004) report asymmetries in price impacts between institutional buy and sell orders. The authors show that institutional buys exert a larger price impact than institutional sells in bull markets, whereas institutional buys exert a smaller price impact than institutional sells in bear markets. To examine whether the effect of volatility shock on stock returns is different between buyer- and seller-initiated trades, we estimate regression model (5) using the percentage of trades that are buyer- and seller-initiated separately.

Panel A in Table 5 shows the results using the percentage of trades that are buyer-initiated for each type of traders and Panel B shows the results using the percentage of trades that are seller-initiated for each type of traders. In both panels, the first three columns show the results when we measure liquidity shock by ΔAMIHUD and the next three columns show the results when we measure liquidity shock by ΔSPREAD. The results show that the coefficients on ΔVIXKO, ΔAMIHUD, ΔSPREAD, ΔVIXKO*ΔAMIHUD, and ΔVIXKO*ΔSPREAD in both panels of Table 5 are qualitatively similar to those in Table 4, which indicates that separating trades into buyer- or seller-initiated trades does not change our main results. We find that the coefficients on the interaction term between volatility shock and the percentage trades that are initiated by individual investors are positive and significant only for seller-initiated trades, suggesting that individual traders mitigate the negative effect of an increase in volatility shock on stock returns only for these trades.

The regression coefficients on the interaction term between volatility shock and the percentage of trades that are initiated by domestic or foreign institutional investors are negative and significant only for buyer-initiated trades and when we use ΔSPREAD as a measure of liquidity shock. This result indicates that the negative effect of an increase in volatility shock on stock returns is greater for stocks with more domestic or foreign institutional buy trading.

5. Does the effect of market volatility on stock returns vary with market environments?

The effect of market volatility on liquidity and stock returns may vary with market environments. In particular, we conjecture that the effect of market volatility on liquidity and stock returns could be particularly strong during times of financial crisis because investors are believed to be more risk averse during such times. To test this conjecture, we estimate regression model (5) using data during the pre-crisis period (2004-2006), the crisis period (2007-2009), and the post-crisis period (2010-2014), separately. Panel A in Table 6 shows the results using ΔAMIHUD and Panel B shows the results using ΔSPREAD as a measure of liquidity shock.

Panel A shows that the effect of liquidity shock on stock returns is positive and significant during both the crisis period and the post-crisis period, but not significant during the pre-crisis period. The results also show that the coefficients on the interaction term between volatility shock and liquidity shock are positive and significant during only the crisis period, which indicates that the negative effect of an increase in market volatility on stock returns is greater for stocks with a larger concurrent decrease in liquidity only during the crisis period. These results suggest that the volatility-shock-induced liquidity change plays a more important role in asset pricing during the crisis period than during the non-crisis period.

We find that the coefficients on the interaction term between volatility shock and PFORE are negative and significant during only the crisis period, suggesting that the negative effect of an increase in volatility shock on stock returns is greater for stocks with more foreign institutional trading during only the crisis period. Such effect does not present during the non-crisis period. The coefficients on the interaction term between volatility shock and PINDI are positive and significant during only the crisis period, which suggests that individual traders mitigate the negative effect of an increase in volatility shock on stock returns only during the crisis period.

The coefficients on the three-way interaction terms [i.e., ΔVIXKO*ΔAMIHUD* (PFORE or PINST)] are positive and significant during the crisis period, but are not significantly different from zero during the non-crisis period, indicating that the interaction effect of market volatility and liquidity on stock returns is stronger for stocks with larger foreign or domestic institutional trading only during the crisis period. In contrast, we find that the coefficients on ΔVIXKO*ΔAMIHUD*PINDI are negative and significant during the crisis period, but are not significantly different from zero during the non-crisis period, which indicates that the interaction effect of market volatility and liquidity on stock returns is weaker for stocks with larger individual trading during the crisis period.

Panel B shows that the effect of liquidity shocks (measured by unexpected changes in the Amihud price impact) on stock returns is positive and significant during both the crisis period and the non-crisis period. However, the coefficients on the interaction term between volatility shock and institutional trading (PINST and PFORE) are negative and significant during only the crisis period, which indicates that the negative effect of an increase in volatility shock on stock returns is greater for stocks with more institutional trading during only the crisis period. We find that the coefficients on the interaction term between volatility shock and PINDI are positive and significant during only the crisis period, suggesting that individual traders mitigate the negative effect of an increase in volatility shock on stock returns only during the crisis period. None of the coefficients on the three-way interaction terms are significantly different from zero even during the crisis period.

6. Results using measures of volatility shock in the US and Europe

In this section we analyze whether volatility shock in the global market places affects Korean stock returns. To conduct this analysis, we first measure volatility shock in the US market by $\Delta VIXUS_t = (VIX_t - AVGVIX_{t-12,t-1})/AVGVIX_{t-12,t-1}$, where VIX_t is the Chicago Board Options Exchange (CBOE) market volatility index in month t and $AVGVIX_{t-12,t-1}$ is the mean value of the CBOE market volatility index in the past 12 months. Similarly, we measure volatility shock in the European market by $\Delta VIXEU_t = (VIXEU_t - AVGVIXEU_{t-12,t-1})/AVGVIXEU_{t-12,t-1}$, where $VIXEU_t$ is the Euro STOXX50 volatility index in month t and $AVGVIXEU_{t-12,t-1}$ is the mean value of the Euro volatility index in the past 12 months. We then reproduce Table 3 using ΔVIXUS and ΔVIXEU in lieu of ΔVIXKO.

The first four columns in Table 7 show the results using volatility shock in the US market and the next four columns show the results using volatility shock in the European market. The results in columns (1), (2), (5), and (6) show that there is a significant and negative relation between contemporaneous stock returns in Korea and volatility shock, regardless of whether we use volatility shock in the US or European markets. In contrast, the results in columns (3), (4), (6), and (8) show that one-month ahead stock returns are not significantly related to volatility shock in the US or European markets. These results suggest that the Korean stock market does not underreact to volatility shock in the US or European markets.

The results in columns (1), (2), (5), and (6) show that there is a significant and positive relation between contemporaneous stock returns and both measures of liquidity shock (i.e., ΔAMIHUD and ΔSPREAD). Similarly, the results in columns (4), (6), and (8) show that one-month ahead stock returns are also significantly and positively related to liquidity shock. These results suggest that the Korean stock market underreacts to liquidity shock that is triggered by volatility shock in the US or European markets.

Columns (1), (2), (5), and (6) show that the coefficients on the interaction term between volatility shock and both measures of liquidity shock are all positive and significant, regardless of whether we use volatility shock in the US or European markets. These results indicate that the negative effect of an increase in US or European market volatility on contemporaneous Korean stock returns is greater for stocks with a larger concurrent decrease in liquidity. In contrast, columns (3), (4), (7), and (8) show that the coefficients on the interaction term between volatility shock and both measures of liquidity shock are not significantly different from zero, regardless of whether we use volatility shock in the US or European markets. These results should not come as a surprise given the fact that one-month ahead stock returns in Korea are not significantly related to volatility shock in the US or European markets in the first place.

The results for control variables are similar to those reported in Table 3. Contemporaneous stock returns increase with ΔIVO, CVAMIHUD, and LOG(BM), but decrease with LOG(MVE) and MAXRET. We reproduce both panels in Table 4 using volatility shock in the US market and provide the results in Panel A of Table 8. Likewise, we reproduce both panels in Table 4 using volatility shock in the European market and provide the results in Panel B of Table 8. Again, we find that the results in Table 8 are qualitatively identical to those in Table 4.

On the whole, our results show that the relation between stock returns in Korea and volatility shock is qualitatively similar, regardless of whether we use volatility shock in Korea, the US, or Europe.[5] We interpret these results as evidence of an integrated global market in which volatility shocks are highly correlated across markets because they are likely to arise largely from a common set of state variables and economic fundamentals.

7. Summary and concluding remarks

This paper investigates the effects of market volatility on stock liquidity and returns in the Korean stock market. We show that unexpected changes in market volatility exert a significant impact on both the liquidity and returns of individual stocks. In particular, we show that volatility shock exerts a greater impact on stock returns when stock liquidity decreases more in response to an increase in market volatility. Put differently, a stock's price is more sensitive to unexpected changes in market volatility when its liquidity providers react more strongly to unexpected changes in market uncertainty. We also show that stock return sensitivity to unexpected changes in market volatility depend on the extent of trading by certain types of investors. Specifically, we show that stock returns decline more in response to unexpected increases in market volatility when there is more trading by foreign or domestic institutional investors. We also document some evidence of asymmetric effects of market volatility on stock returns that are related to whether trades are buyer or seller initiated.

Consistent with our expectation, we find evidence that the effect of market volatility on stock liquidity and returns varies with market environments. In particular, we show that market

[5] We conduct the regression analyses using the residuals of VIXKO after accounting for the global market volatilities (VIXUS, VIXEU) instead of VIXKO in regression model (7). We find that the coefficients of residuals of VKOSPI become insignificant, implying that the global market volatilities play a significant role in explaining stock market returns.

volatility and liquidity play a more important role in asset pricing during the crisis period than the non-crisis period. Finally, we show that stock returns in Korea react similarly to market volatility in Korea, the US, and Europe, which suggests an integrated global market in which volatility shocks are highly correlated across markets. In short, our study sheds additional light on the effects of market volatility on stock returns by underscoring the roles of liquidity providers, different types of traders, and market environments. We show that market volatility exerts a stronger impact on stock returns when liquidity providers are more reactive to market uncertainty, when there is more institutional trading, and during the crisis period.

A fruitful area of future research would be the equilibrium asset pricing implication of the cross-sectional variation in the sensitively of stock returns to market volatility. For instance, it would be interesting to find out whether stocks with returns that are more sensitive to changes in market volatility provide investors with higher average returns in the long run. In a similar vein, the results of our study suggest that stocks with greater institutional trading will have higher expected returns.

Liquidity suppliers in the Korean stock market are fundamentally different from traditional market makers (e.g., NYSE specialists and NASDAQ dealers) because they do not have an affirmative obligation to maintain a fair and orderly market. As a result, liquidity providers in the Korean stock market, including high-frequency traders, are likely to provide liquidity opportunistically based on their perceived adverse selection risks. To the extent that uncertainty shock exerts a greater impact on stock returns when it has a greater effect on stock liquidity, providing liquidity suppliers with an incentive to supply liquidity during times of high market uncertainty could reduce stock return volatility. In this respect, an important policy implication of our finding is that regulatory authorities may consider initiatives that could promote the robust supply of liquidity by market participants even during times of high uncertainty. For example, large liquidity suppliers, including major high-frequency traders, may be required to store order placement and cancelation records and make them available to relevant authorities upon request, incentivizing them to provide the stable and robust supply of liquidity based on certain regulatory policy guidelines and thereby reducing excessive swings in stock return.

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Table 1. Descriptive statistics

This table shows the descriptive statistics of the key variables for our study sample of 1,598 KRX stocks. We measure unexpected changes in market volatility ($\Delta VIXKO_t$) and unexpected changes in individual stock liquidity ($\Delta AMIHUD_{i,t}$ and $\Delta SPREAD_{i,t}$) as follows:

$$\Delta VIXKO_t = (VIXKO_t - AVGVIXKO_{t-12,t-1}) / AVGVIXKO_{t-12,t-1},$$
$$\Delta AMIHUD_{i,t} = -(AMIHUD_{i.t} - AVGAMIHUD_{i|t-12,t-1}) / AVGAMIHUD_{i|t-12,t-1},$$
$$\Delta SPREAD_{i,t} = -(SPREAD_{i.t} - AVGSPREAD_{i|t-12,t-1}) / AVGSPREAD_{i|t-12,t-1};$$

where subscript i denotes stock i and subscript t denotes month t. $VIXKO_t$ is the mean value of daily VIXKO in month t and $AVGVIXKO_{t-12,t-1}$ is the mean value of VIXKO in the past 12 months. We collect the KOSPI 200 volatility index (VIXKO) from Bloomberg. $AMIHUD_{i,t}$ is the mean value of the daily Amihud measure (AMIHUD) for stock i in month t. $AVGAMIHUD_{i|t-12,t-1}$ is the mean value of AMIHUD in the past 12 months. $SPREAD_{i,t}$ is the mean value of the daily quoted percentage spread for stock i in month t. $AVGSPREAD_{i|t-12,t-1}$ is the mean value of SPREAD in the past 12 months. We calculate the quoted spread (SPREAD) using the following formula: $SPREAD_{i,t} = (ASK_{i,t} - BID_{i,t})/M_{i,t}$, where $ASK_{i,t}$ is the best ask price of stock i at time t, $BID_{i,t}$ is the best bid price of stock i at time t, and $M_{i,t}$ is the quote midpoint $(ASK_{i,t} + BID_{i,t})/2$ of stock i at time t. We then calculate the monthly time-weighted mean quote spread. We calculate the daily Amihud (2002) illiquidity measure using the following formula: $AMIHUD_{i,t} = [|RET_{i,t}| / TRV_{i,t}]*10^9$, where $RET_{i,t}$ is stock i's return on day t and $TRV_{i,t}$ is stock i's trading volume (in KRW) on day t. To reduce outliers, we winsorize the data at 99.8% and require that the number of trading days within a month is at least 12 days. For each stock, we then calculate the monthly mean value of the Amihud measure. In the Korean TAQ data, each trade is flagged to identify whether it is initiated by a domestic individual investor, a domestic institutional investor, or a foreign institutional investor. Using this information, we calculate, for each stock in each month, the proportion of trades that are initiated by domestic institutional investors (PINST), foreign institutional investors (PFORE), and domestic individual investors (PINDI). The Korean TAQ data also enable us to identify whether each trade is buyer- or seller-initiated using order sequence number and trade direction, which does not require the Lee and Ready (1991) algorithm. Specifically, we consider a trade to be buyer (seller)-initiated if a buy (sell) order is matched with existing sell (buy) orders using order sequence number and trade direction. We then calculate, for each stock in each month, the proportion of trades that are initiated by domestic institutional investors' sell orders (PSINST), foreign institutional investors' sell orders (PSFORE), domestic individual investors' sell orders (PSINDI), domestic institutional investors' buy orders (PBINST), foreign institutional investors' buy orders (PBFORE), and domestic individual investors' buy orders (PBINDI).

Variables	Mean	Standard deviation	Percentile				
			5	25	50	75	95
ΔVIXKO	-0.027	0.296	-0.355	-0.212	-0.093	0.048	0.647
ΔAMIHUD	-0.145	3.320	-2.006	-0.402	0.168	0.548	0.877
ΔSPREAD	0.014	0.346	-0.596	-0.149	0.054	0.234	0.490
RET	0.015	0.152	-0.192	-0.070	-0.002	0.078	0.279
TRV (billion won)	4.133	19.077	0.010	0.087	0.375	1.735	16.690
PINDI	0.810	0.227	0.290	0.716	0.920	0.972	0.998
PINST	0.126	0.176	0.000	0.003	0.032	0.195	0.525
PFORE	0.064	0.079	0.000	0.011	0.036	0.083	0.233
PSINDI	0.417	0.124	0.151	0.358	0.450	0.505	0.568
PSINST	0.064	0.096	0.000	0.001	0.013	0.094	0.282
PSFORE	0.034	0.044	0.000	0.005	0.019	0.043	0.127
PBINDI	0.393	0.126	0.132	0.326	0.423	0.478	0.556
PBINST	0.062	0.093	0.000	0.000	0.011	0.093	0.271
PBFORE	0.030	0.043	0.000	0.003	0.014	0.037	0.122

Table 2. Correlation matrix

This table shows the pair-wise correlation coefficient between the variables. ΔVIXKO, $\Delta AMIHUD_i$, and ΔSPREAD stand for unexpected changes in market volatility, the Amihud illiquidity measure, and the percentage quoted bid-ask spread. ΔIVO and ΔTRV are unexpected changes in idiosyncratic volatility and trading volume. $LOG(MVE_{i,t-1})$ is the logarithm of market value of equity for stock i, month t – 1, $CVAMIHUD_{i,t}$ is the coefficient of variation of the Amihud illiquidity measure, STDTO is the standard deviation of monthly volume turnover during the last 12 months, LOG(BM) is the logarithm of book-to-market value of equity ratio, COSKEWNESS is the co-skewness measure, $BETA_{i,t}$ is the systematic risk, RET(-12,-2) is the momentum, calculated by cumulative return during month t – 12 and month t – 2, MAXRET is the maximum daily return.

	ΔVIXKO	ΔAMIHUD	ΔSPREAD	ΔIVO	ΔTRV	LOG(MVE)	CVAMIHUD	STDTO	LOG(BM)	COSKEWNESS	BETA	RET(-12,-2)	MAXRET
ΔVIXKO	1												
ΔAMIHUD	-0.099*	1											
ΔSPREAD	-0.375*	0.216*	1										
ΔIVO	0.171*	0.034*	0.022*	1									
ΔTRV	-0.001	0.002	0.011*	0.016*	1								
LOG(MVE)	-0.006*	0.035*	0.037*	-0.022*	-0.002	1							
CVAMIHUD	0.060*	-0.065*	-0.050*	0.080*	0.004	-0.238*	1						
STDTO	-0.003	-0.026*	0.027*	-0.025*	-0.003	-0.083*	-0.022*	1					
LOG(BM)	-0.007*	-0.010*	-0.050*	0.035*	-0.003	-0.302*	0.182*	-0.158*	1				
COSKEWNESS	-0.022*	-0.005	-0.003	-0.018*	-0.003	-0.025*	-0.013*	0.011*	-0.022*	1			
BETA	-0.009*	-0.004	-0.003	-0.016*	-0.007*	0.044*	-0.091*	-0.003	-0.003	0.181*	1		
RET(-12,-2)	-0.004	0.009*	0.043*	-0.014*	0.019*	0.030*	-0.012*	0.265*	-0.080*	-0.026*	0.001	1	
MAXRET	0.143*	0.038*	0.122*	0.107*	0.007*	-0.151*	-0.053*	0.141*	-0.172*	0.006*	0.036*	0.033*	1

Table 3. Regression results for the effects of market volatility on stock liquidity and returns

Panel A shows the results of the following regression model:

$$RET_{i,t} \text{ or } RET_{i,t+1} = \beta_0 + \beta_1\Delta VIXKO_t + \beta_2 (\Delta AMIHUD_{i,t} \text{ or } \Delta SPREAD_{i,t}) + \beta_3\Delta VIXKO_t*(\Delta AMIHUD_{i,t} \text{ or } \Delta SPREAD_{i,t}) + \beta_4 \Delta IVO_{i,t} + \beta_5 \Delta TRV_{i,t} + \beta_6 BETA_{i,t} + \beta_7 LOG(MVE_{i,t-1}) + \beta_8 CVAMIHUD_{i,t} + \beta_9 MAXRET_{i,t} + \beta_{10} RET(-12,-2)_{i,t} + \beta_{11} STDTO_{i,t} + \beta_{12} LOG(BM_{i,t}) + \beta_{13} COSKEWNESS_{i,t} + \varepsilon_{i,t};$$

where subscript i, t, and t +1 stands for stock i, month t, and month t+1, respectively, and $\varepsilon_{i,t}$ is the error term. To examine whether the stock market underreacts to uncertainty shocks as well, we use both the contemporaneous monthly return ($RET_{i,t}$) and the one-month ahead return ($RET_{i,t+1}$) as the dependent variable. $\Delta VIXKO_t$, $\Delta AMIHUD_{i,t}$, and $\Delta SPREAD_{i,t}$ stand for unexpected changes in market volatility, the Amihud illiquidity measure, and the percentage quoted bid-ask spread. To assess whether unexpected changes in market volatility exert an impact on stock returns that is beyond the effect on stock returns of unexpected changes in the idiosyncratic volatility and trading volume of individual securities, we include unexpected changes in idiosyncratic volatility and trading volume ($\Delta IVO_{i,t}$ and $\Delta TRV_{i,t}$) in the regression. We include a number of additional control variables in the regression. $BETA_{i,t}$ is the systematic risk, $LOG(MVE_{i,t-1})$ is the logarithm of market value of equity for stock i, month t – 1, $CVAMIHUD_{i,t}$ is the coefficient of variation of the Amihud illiquidity measure, $MAXRET_{i,t}$ is the maximum daily return, $RET(-12,-2)_{i,t}$ is the momentum, calculated by cumulative return during month t – 12 and month t – 2, $STDTO_{i,t}$ is the standard deviation of monthly volume turnover during the last 12 months, $LOG(BM_{i,t})$ is the logarithm of book-to-market value of equity ratio, $COSKEWNESS_{i,t}$ is the co-skewness measure. Panel B shows the results when we replace stock returns in the above regression model with two liquidity measures ($\Delta AMIHUD_{i,t}$ and $\Delta SPREAD_{i,t}$).

Panel A. Effects of market volatility shock on stock returns

Variables	(1) RET(t)	(2) RET(t)	(3) RET(t+1)	(4) RET(t+1)
ΔVIXKO	-0.0560**	-0.0407*	0.0154	0.0191
	(-2.41)	(-1.81)	(0.82)	(0.97)
ΔAMIHUD	0.0078***		0.0023	
	(3.56)		(1.54)	
ΔVIXKO*ΔAMIHUD	0.0177*		0.0009	
	(1.74)		(0.21)	
ΔSPREAD		0.0553***		0.0150*
		(8.71)		(1.88)
ΔVIXKO*ΔSPREAD		0.0536		0.0022
		(1.28)		(0.13)
ΔIVO	0.0670***	0.0762***	-0.0117***	-0.0117***
	(5.52)	(10.16)	(-3.72)	(-3.68)
ΔTRV	0.0011	0.0010	-0.0001	-0.0001
	(1.59)	(1.54)	(-1.06)	(-0.98)
$LOG(MVE)_{i,t-1}$	-0.0018**	-0.0021**	-0.0016*	-0.0017**
	(-2.05)	(-2.35)	(-1.81)	(-1.99)
CVAMIHUD	0.0181***	0.0151***	-0.0027	-0.0036
	(4.38)	(3.84)	(-0.74)	(-0.91)
STDTO	0.0067	0.0060*	-0.0046*	-0.0039
	(1.44)	(1.70)	(-1.73)	(-1.43)
LOG(BM)	0.0170***	0.0169***	0.0199***	0.0198***
	(6.82)	(6.86)	(7.79)	(7.52)
COSKEWNESS	-0.0288	-0.0208	0.0153	0.0123
	(-1.05)	(-0.76)	(0.79)	(0.63)
BETA	0.0011	0.0001	-0.0022	-0.0020
	(0.36)	(0.03)	(-1.22)	(-1.08)
RET(-12,-2)	0.0014	0.0009	-0.0004	-0.0002
	(0.88)	(0.55)	(-0.21)	(-0.10)
MAXRET	-0.0011**	-0.0017***	0.0007	0.0007*
	(-1.99)	(-3.10)	(1.57)	(1.66)
Constant	0.0457*	0.0590**	0.0541**	0.0584**
	(1.80)	(2.35)	(2.17)	(2.29)
Number of observations	131,668	127,120	130,488	126,041
R-squared	0.12	0.13	0.01	0.01
Clustered standard errors by stock and time	Yes	Yes	Yes	Yes

Panel B. Effects of market volatility shock on stock liquidity

Variables	(1) ΔAMIHUD	(2) ΔSPREAD
ΔVIXKO	-1.2359***	-0.4740***
	(-7.79)	(-9.49)
ΔIVO	0.3377***	0.0489***
	(2.87)	(5.85)
ΔTRV	0.0022	0.0010
	(1.45)	(1.53)
$LOG(MVE)_{i,t-1}$	0.0473***	0.0113***
	(3.05)	(3.23)
CVAMIHUD	-0.4831***	-0.0111
	(-5.02)	(-1.21)
STDTO	-0.4585	-0.0181***
	(-1.21)	(-2.65)
LOG(BM)	0.0142	0.0002
	(0.45)	(0.04)
COSKEWNESS	-0.0146	-0.0324
	(-0.08)	(-0.66)
BETA	-0.0491***	-0.0073**
	(-3.11)	(-2.17)
RET(-12,-2)	0.1267***	0.0225***
	(3.15)	(4.24)
MAXRET	0.0489***	0.0151***
	(7.94)	(15.44)
Constant	-1.1303**	-0.3660***
	(-2.41)	(-3.81)
Number of observations	131,668	127,120
R-squared	0.07	0.19
Clustered standard errors by stock and time	Yes	Yes

Table 4. Results using the proportion of trades that are initiated by different types of investors

This table shows whether the effect of market volatility on contemporaneous stock returns varies with the proportion of trades that are initiated by domestic institutional investors (PINST), foreign institutional investors (PFORE), and domestic individual investors (PINDI), respectively, using the following regression model:

$$RET_{i,t} = \beta_0 + \beta_1 \Delta VIXKO_t + \beta_2 (\Delta AMIHUD_{i,t} \text{ or } \Delta SPREAD_{i,t}) + \beta_3 \Delta VIXKO_t * (\Delta AMIHUD_{i,t} \text{ or } \Delta SPREAD_{i,t}) + \beta_4 \Delta VIXKO_t * (PINST_{i,t} \text{ or } PFORE_{i,t} \text{ or } PINDI_{i,t}) + \beta_5 \Delta VIXKO_t * (\Delta AMIHUD_{i,t} \text{ or } \Delta SPREAD_{i,t}) * (PINST_{i,t} \text{ or } PFORE_{i,t} \text{ or } PINDI_{i,t}) + \text{control variables} + \varepsilon_{i,t};$$

where $RET_{i,t}$ is stock i's return in month t, and $\Delta VIXKO_t$, $\Delta AMIHUD_{i,t}$, and $\Delta SPREAD_{i,t}$ stand for unexpected changes in market volatility, the Amihud illiquidity measure, and the percentage quoted bid-ask spread. Panel A shows the results when we use ΔAMIHUD and Panel B shows the results when we use ΔSPREAD as a measure of liquidity shock.

Panel A. Regression results using ΔAMIHUD

Variables	(1) RET(t)	(2) RET(t)	(3) RET(t)
ΔVIXKO	-0.0537**	-0.0511**	-0.0649***
	(-2.20)	(-2.11)	(-3.08)
ΔAMIHUD	0.0077***	0.0077***	0.0077***
	(3.51)	(3.53)	(3.50)
ΔVIXKO*ΔAMIHUD	0.0154*	0.0138	0.0563**
	(1.77)	(1.35)	(2.13)
ΔVIXKO*PINST	-0.0103		
	(-0.42)		
ΔVIXKO*PFORE		-0.0563	
		(-0.93)	
ΔVIXKO*PINDI			0.0128
			(0.69)
ΔVIXKO*ΔAMIHUD*PINST	0.0463		
	(1.33)		
ΔVIXKO*ΔAMIHUD*PFORE		0.0995**	
		(2.44)	
ΔVIXKO*ΔAMIHUD*PINDI			-0.0424**
			(-2.00)

Panel B. Regression results using ΔSPREAD

Variables	(1) RET(t)	(2) RET(t)	(3) RET(t)
ΔVIXKO	-0.0339	-0.0304	-0.0772***
	(-1.44)	(-1.34)	(-3.42)
ΔSPREAD	0.0558***	0.0562***	0.0561***
	(8.71)	(8.92)	(8.80)
ΔVIXKO*ΔSPREAD	0.0551	0.0473	0.0746
	(1.51)	(1.13)	(0.89)
ΔVIXKO*PINST	-0.0495**		
	(-2.08)		
ΔVIXKO*PFORE		-0.1435**	
		(-2.33)	
ΔVIXKO*PINDI			0.0462**
			(2.49)
ΔVIXKO*ΔSPREAD*PINST	-0.0038		
	(-0.05)		
ΔVIXKO*ΔSPREAD*PFORE		0.1496**	
		(2.34)	
ΔVIXKO*ΔSPREAD*PINDI			-0.0226
			(-0.43)

Table 5. Results using the proportion of buyer-initiated and seller initiated trades

Panel A shows the results using the percentage of trades that are buyer-initiated for each type of traders and Panel B shows the results using the percentage of trades that are seller-initiated for each type of traders. In both panels, the first three columns show the results when we measure liquidity shock by ΔAMIHUD and the next three columns show the results when we measure liquidity shock by ΔSPREAD.

Panel A. Regression results using the percentage of trades that are buyer-initiated for each trader type

	Results using ΔAMIHUD			Results using ΔSPREAD		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	RET(t)	RET(t)	RET(t)	RET(t)	RET(t)	RET(t)
ΔVIXKO	-0.0520**	-0.0515**	-0.0404*	-0.0327	-0.0321	-0.0457**
	(-2.12)	(-2.08)	(-1.82)	(-1.37)	(-1.38)	(-2.02)
ΔAMIHUD or ΔSPREAD	0.0078***	0.0078***	0.0077***	0.0555***	0.0559***	0.0562***
	(3.54)	(3.55)	(3.50)	(8.68)	(8.84)	(8.84)
ΔVIXKO*ΔAMIHUD	0.0171*	0.0177*	0.0573***			
	(1.90)	(1.75)	(3.66)			
ΔVIXKO*ΔSPREAD				0.0643*	0.0573	0.1380**
				(1.72)	(1.37)	(2.05)
ΔVIXKO*PBINST	-0.0532			-0.1251**		
	(-0.89)			(-2.27)		
ΔVIXKO*PBFORE		-0.1546			-0.2973***	
		(-1.27)			(-2.74)	
ΔVIXKO*PBINDI			-0.0367			0.0157
			(-0.92)			(0.36)
ΔVIXKO*ΔAMIHUD*PBINST	0.0309					
	(0.46)					
ΔVIXKO*ΔAMIHUD*PBFORE		0.0143				
		(0.17)				
ΔVIXKO*ΔAMIHUD*PBINDI			-0.0896***			
			(-4.80)			
ΔVIXKO*ΔSPREAD*PBINST				-0.2149*		
				(-1.71)		
ΔVIXKO*ΔSPREAD*PBFORE					-0.1427	
					(-1.23)	
ΔVIXKO*ΔSPREAD*PBINDI						-0.1915**
						(-2.44)

Panel B. Regression results using the percentage of trades that are seller-initiated for each trader type

	Results using ΔAMIHUD			Results using ΔSPREAD		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	RET(t)	RET(t)	RET(t)	RET(t)	RET(t)	RET(t)
ΔVIXKO	-0.0559**	-0.0527**	-0.0927***	-0.0364	-0.0328	-0.0998***
	(-2.32)	(-2.24)	(-3.35)	(-1.60)	(-1.49)	(-3.49)
ΔAMIHUD or ΔSPREAD	0.0076***	0.0077***	0.0078***	0.0563***	0.0560***	0.0558***
	(3.48)	(3.55)	(3.54)	(8.80)	(8.89)	(8.79)
ΔVIXKO*ΔAMIHUD	0.0142	0.0125	0.0210			
	(1.62)	(1.16)	(0.61)			
ΔVIXKO*ΔSPREAD				0.0459	0.0424	-0.0317
				(1.23)	(0.99)	(-0.42)
ΔVIXKO*PSINST	0.0156			-0.0561		
	(0.39)			(-1.30)		
ΔVIXKO*PSFORE		-0.0466			-0.1847	
		(-0.37)			(-1.43)	
ΔVIXKO*PSINDI			0.0896*			0.1430***
			(1.87)			(3.32)
ΔVIXKO*ΔAMIHUD*PSINST	0.1343**					
	(2.29)					
ΔVIXKO*ΔAMIHUD*PSFORE		0.2055***				
		(3.12)				
ΔVIXKO*ΔAMIHUD*PSINDI			-0.0062			
			(-0.10)			
ΔVIXKO*ΔSPREAD*PSINST				0.2257		
				(1.40)		
ΔVIXKO*ΔSPREAD*PSFORE					0.3927***	
					(2.69)	
ΔVIXKO*ΔSPREAD*PSINDI						0.1995**
						(2.28)

Table 6. The effects of market volatility on stock returns in different market environments

This table shows the regression results using data during the pre-crisis period (2004-2006), the crisis period (2007-2009), and the post-crisis period (2010-2014), separately. Panel A shows the results using ΔAMIHUD and Panel B shows the results using ΔSPREAD as a measure of liquidity shock.

Panel A. Regression results using ΔAMIHUD

	Pre-crisis period (2004-2007)			Crisis period (2007-2009)			Post-crisis period (2010-2014)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variables	RET(t)	RET(t)	RET(t)	RET(t)	RET(t)	RET(t)	RET(t)	RET(t)	RET(t)
ΔVIXKO	-0.1016*	-0.0966*	-0.1048**	-0.0457	-0.0404	-0.0917**	-0.0426	-0.0424	-0.0600**
	(-1.68)	(-1.66)	(-2.18)	(-1.36)	(-1.29)	(-2.52)	(-1.16)	(-1.15)	(-2.19)
ΔAMIHUD	0.0021	0.0022	0.0021	0.0104***	0.0106***	0.0104***	0.0147***	0.0145***	0.0147***
	(1.26)	(1.26)	(1.25)	(3.06)	(3.08)	(3.04)	(3.39)	(3.19)	(3.36)
ΔVIXKO*ΔAMIHUD	0.0046	0.0044	0.0299	0.0252**	0.0244**	0.0783***	0.0070	0.0030	-0.0090
	(0.46)	(0.46)	(0.57)	(2.42)	(2.02)	(3.52)	(1.13)	(0.28)	(-0.27)
ΔVIXKO*PINST	0.0108			-0.0450			-0.0232		
	(0.13)			(-1.26)			(-0.63)		
ΔVIXKO*PFORE		-0.0830			-0.1976**			-0.0348	
		(-0.59)			(-2.40)			(-0.40)	
ΔVIXKO*PINDI			0.0055			0.0496*			0.0183
			(0.08)			(1.92)			(0.64)
ΔVIXKO*ΔAMIHUD*PINST	0.0254			0.0654**			-0.0329		
	(0.43)			(2.19)			(-0.65)		
ΔVIXKO*ΔAMIHUD*PFORE		0.0954			0.1227***			0.0209	
		(0.75)			(3.36)			(0.28)	
ΔVIXKO*ΔAMIHUD*PINDI			-0.0256			-0.0543***			0.0160
			(-0.48)			(-3.55)			(0.45)

Panel B. Regression results using ΔSPREAD

	Pre-crisis period (2004-2007)			Crisis period (2007-2009)			Post-crisis period (2010-2014)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variables	RET(t)	RET(t)	RET(t)	RET(t)	RET(t)	RET(t)	RET(t)	RET(t)	RET(t)
ΔVIXKO	-0.0716	-0.0686	-0.1143***	-0.0290	-0.0229	-0.1009***	-0.0372	-0.0378	-0.0582**
	(-1.14)	(-1.13)	(-2.65)	(-0.87)	(-0.74)	(-2.75)	(-0.96)	(-0.99)	(-2.16)
ΔSPREAD	0.0382***	0.0387***	0.0384***	0.0533***	0.0544***	0.0540***	0.0543***	0.0534***	0.0542***
	(3.35)	(3.38)	(3.35)	(3.22)	(3.33)	(3.30)	(9.25)	(9.24)	(9.22)
ΔVIXKO*ΔSPREAD	0.0550	0.0421	0.0880	0.0737	0.0656	0.0718	0.0296	0.0223	0.0995***
	(0.86)	(0.64)	(0.64)	(1.63)	(1.33)	(0.68)	(1.15)	(0.86)	(2.62)
ΔVIXKO*PINST	-0.0424			-0.0803***			-0.0279		
	(-0.52)			(-2.69)			(-0.81)		
ΔVIXKO*PFORE		-0.1607			-0.2671***			-0.0374	
		(-1.07)			(-2.81)			(-0.44)	
ΔVIXKO*PINDI			0.0460			0.0765***			0.0221
			(0.68)			(3.09)			(0.80)
ΔVIXKO*ΔSPREAD*PINST	-0.0030			-0.0356			0.0798		
	(-0.02)			(-0.41)			(1.29)		
ΔVIXKO*ΔSPREAD*PFORE		0.3255			0.1266			0.1610	
		(1.18)			(1.54)			(1.20)	
ΔVIXKO*ΔSPREAD*PINDI			-0.0401			-0.0009			-0.0755
			(-0.29)			(-0.01)			(-1.48)

Table 7. Results using measures of volatility shock in the US and Europe

This table shows whether and how volatility shock in the global market places affects Korean stock returns. To conduct this analysis, we first measure volatility shock in the US market by $\Delta VIXUS_t = (VIX_t - AVGVIX_{t-12,t-1})/AVGVIX_{t-12,t-1}$, where VIX_t is the Chicago Board Options Exchange (CBOE) market volatility index in month t and $AVGVIX_{t-12,t-1}$ is the mean value of the CBOE market volatility index in the past 12 months. Similarly, we measure volatility shock in the European market by $\Delta VIXEU_t = (VIXEU_t - AVGVIXEU_{t-12,t-1})/AVGVIXEU_{t-12,t-1}$, where $VIXEU_t$ is the Euro STOXX50 volatility index in month t and $AVGVIXEU_{t-12,t-1}$ is the mean value of the Euro volatility index in the past 12 months. We then reproduce Table 3 using ΔVIXUS and ΔVIXEU in lieu of ΔVIXKO. The first four columns show the results using volatility shock in the US market and the next four columns show the results using volatility shock in the European market.

	ΔVIXUS				ΔVIXEU			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	RET(t)	RET(t)	RET(t+1)	RET(t+1)	RET(t)	RET(t)	RET(t+1)	RET(t+1)
ΔVIXUS or ΔVIXEU	-0.0556**	-0.0468**	0.0182	0.0215	-0.0619**	-0.0520**	0.0228	0.0261
	(-2.34)	(-2.05)	(1.04)	(1.17)	(-2.27)	(-2.00)	(1.19)	(1.29)
ΔAMIHUD	0.0073***		0.0022		0.0076***		0.0023*	
	(3.66)		(1.64)		(3.58)		(1.68)	
(ΔVIXUS or ΔVIXEU)*ΔAMIHUD	0.0203***		0.0027		0.0187**		0.0031	
	(2.77)		(0.72)		(2.31)		(0.88)	
ΔSPREAD		0.0493***		0.0148**		0.0488***		0.0158**
		(6.95)		(2.17)		(6.53)		(2.21)
(ΔVIXUS or ΔVIXEU)*ΔSPREAD		0.0526*		0.0081		0.0594**		0.0075
		(1.73)		(0.53)		(2.10)		(0.47)
ΔIVO	0.0687***	0.0776***	-0.0119***	-0.0119***	0.0679***	0.0776***	-0.0120***	-0.0120***
	(6.01)	(10.84)	(-3.96)	(-3.93)	(5.87)	(10.99)	(-3.91)	(-3.90)
ΔTRV	0.0011	0.0010	-0.0001	-0.0001	0.0011	0.0010	-0.0001	-0.0001
	(1.59)	(1.54)	(-1.06)	(-0.98)	(1.59)	(1.54)	(-1.05)	(-0.98)
$LOG(MVE)_{i,t-1}$	-0.0019**	-0.0021**	-0.0016*	-0.0018**	-0.0018**	-0.0021**	-0.0016*	-0.0017**
	(-2.23)	(-2.47)	(-1.86)	(-2.01)	(-2.16)	(-2.49)	(-1.89)	(-1.99)
CVAMIHUD	0.0177***	0.0155***	-0.0027	-0.0037	0.0172***	0.0154***	-0.0027	-0.0037
	(4.23)	(3.91)	(-0.77)	(-0.98)	(4.03)	(3.84)	(-0.75)	(-0.97)
STDTO	0.0058	0.0058	-0.0045*	-0.0038	0.0055	0.0060*	-0.0045*	-0.0039
	(1.37)	(1.64)	(-1.69)	(-1.40)	(1.35)	(1.70)	(-1.70)	(-1.42)

LOG(BM)	0.0165***	0.0165***	0.0200***	0.0199***	0.0164***	0.0167***	0.0200***	0.0199***
	(6.31)	(6.35)	(7.85)	(7.57)	(6.33)	(6.45)	(7.87)	(7.58)
COSKEWNESS	-0.0360	-0.0272	0.0171	0.0145	-0.0364	-0.0278	0.0176	0.0151
	(-1.31)	(-0.98)	(0.91)	(0.76)	(-1.32)	(-1.01)	(0.92)	(0.79)
BETA	0.0015	0.0002	-0.0021	-0.0020	0.0016	0.0003	-0.0022	-0.0020
	(0.48)	(0.07)	(-1.22)	(-1.09)	(0.51)	(0.10)	(-1.23)	(-1.11)
RET(-12,-2)	0.0011	0.0008	-0.0003	-0.0002	0.0011	0.0007	-0.0003	-0.0002
	(0.74)	(0.49)	(-0.19)	(-0.08)	(0.69)	(0.44)	(-0.20)	(-0.08)
MAXRET	-0.0012**	-0.0016***	0.0007	0.0007*	-0.0012**	-0.0016***	0.0006	0.0007
	(-2.06)	(-2.86)	(1.56)	(1.68)	(-2.11)	(-2.83)	(1.50)	(1.57)
Constant	0.0508**	0.0610**	0.0544**	0.0585**	0.0494**	0.0616**	0.0552**	0.0582**
	(2.06)	(2.48)	(2.22)	(2.33)	(1.99)	(2.49)	(2.25)	(2.32)
Number of observations	131,668	127,120	130,488	126,041	131,668	127,120	130,488	126,041
R-squared	0.13	0.14	0.01	0.01	0.13	0.14	0.01	0.01
Clustered standard errors by stock and time	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 8. Results using measures of volatility shock in the US and Europe and the proportion of trades that are initiated by different types of investors

We reproduce both panels in Table 4 using volatility shock in the US market and provide the results in Panel A. Likewise, we reproduce both panels in Table 4 using volatility shock in the European market and provide the results in Panel B.

Panel A. Results using ΔVIXUS

Variables	(1) RET(t)	(2) RET(t)	(3) RET(t)	(4) RET(t)	(5) RET(t)	(6) RET(t)
ΔVIXUS	-0.0524**	-0.0468*	-0.0736***	-0.0404*	-0.0339	-0.0843***
	(-2.10)	(-1.88)	(-3.45)	(-1.71)	(-1.47)	(-3.86)
ΔAMIHUD	0.0073***	0.0073***	0.0072***			
	(3.60)	(3.61)	(3.59)			
ΔVIXUS*ΔAMIHUD	0.0183***	0.0183**	0.0492***			
	(2.62)	(2.15)	(3.16)			
ΔSPREAD				0.0498***	0.0504***	0.0502***
				(7.14)	(7.23)	(7.23)
ΔVIXUS*ΔSPREAD				0.0536**	0.0499	0.0704
				(2.07)	(1.61)	(1.06)
ΔVIXUS*PINST	-0.0164			-0.0458**		
	(-0.67)			(-2.08)		
ΔVIXUS*PFORE		-0.1219**			-0.1819***	
		(-2.12)			(-3.26)	
ΔVIXUS*PINDI			0.0240			0.0477***
			(1.29)			(2.80)
ΔVIXUS*ΔAMIHUD*PINST	0.0395					
	(1.64)					
ΔVIXUS*ΔAMIHUD*PFORE		0.0581				
		(1.29)				
ΔVIXUS*ΔAMIHUD*PINDI			-0.0316*			
			(-1.93)			
ΔVIXUS*ΔSPREAD*PINST				0.0010		
				(0.01)		
ΔVIXUS*ΔSPREAD*PFORE					0.0898*	
					(1.66)	
ΔVIXUS*ΔSPREAD*PINDI						-0.0187
						(-0.41)

Panel B. Results using ΔVIXEU

Variables	(1) RET(t)	(2) RET(t)	(3) RET(t)	(4) RET(t)	(5) RET(t)	(6) RET(t)
ΔVIXEU	-0.0579**	-0.0510*	-0.0834***	-0.0440	-0.0360	-0.0974***
	(-1.99)	(-1.73)	(-3.71)	(-1.59)	(-1.33)	(-4.33)
ΔAMIHUD	0.0075***	0.0076***	0.0075***			
	(3.50)	(3.46)	(3.46)			
ΔVIXEU*ΔAMIHUD	0.0166**	0.0167*	0.0505***			
	(2.05)	(1.74)	(3.57)			
ΔSPREAD				0.0493***	0.0499***	0.0497***
				(6.67)	(6.76)	(6.74)
ΔVIXEU*ΔSPREAD				0.0605**	0.0588**	0.0755
				(2.49)	(2.00)	(1.20)
ΔVIXEU*PINST	-0.0194			-0.0553**		
	(-0.61)			(-1.97)		
ΔVIXEU*PFORE		-0.1449*			-0.2189***	
		(-1.90)			(-3.48)	
ΔVIXEU*PINDI			0.0290			0.0581***
			(1.15)			(2.65)
ΔVIXEU*ΔAMIHUD*PINST	0.0432*					
	(1.86)					
ΔVIXEU*ΔAMIHUD*PFORE		0.0629				
		(1.15)				
ΔVIXEU*ΔAMIHUD*PINDI			-0.0346**			
			(-1.97)			
ΔVIXEU*ΔSPREAD*PINST				0.0032		
				(0.04)		
ΔVIXEU*ΔSPREAD*PFORE					0.0529	
					(0.89)	
ΔVIXEU*ΔSPREAD*PINDI						-0.0163
						(-0.36)

Appendix. Variable descriptions

Variable	Definition and Measurement
Volatility shocks	
$\Delta VIXUS_t$	U.S market uncertainty shock calculated as $(VIX_t - AVGVIX_{t-12,t-1})/AVGVIX_{t-12,t-1}$ where VIX_t is the CBOE (Chicago Board Options Exchange) market volatility index in month t and $AVGVIX_{t-12,t-1}$ is the mean value of the CBOE market volatility index in the past 12 months.
$\Delta VIXKO_t$	Korean market uncertainty shock calculated as $(VIXKO - AVGVIXKO_{t-12,t-1})/AVGVIXKO_{t-12,t-1}$ where $VIXKO_t$ is the KOSPI 200 volatility index in month t and $AVGVIXKO_{t-12,t-1}$ is the mean value of the KOSPI 200 volatility index in the past 12 months.
$\Delta VIXEU_t$	Euro market uncertainty shock calculated as $(VIXEU - AVGVIXEU_{t-12,t-1})/AVGVIXEU_{t-12,t-1}$ where $VIXEU_t$ is the Euro STOXX50 volatility index in month t and $AVGVIXEU_{t-12,t-1}$ is the mean value of the Euro volatility index in the past 12 months.
Liquidity shocks	
$\Delta AMIHUD$	$\Delta AMIHUD = -(AMIHUD_{i,t} - AVGAMIHUD_{t-12,t-1})/AVGAMIHUD_{t-12,t-1}$ where AMIHUD is the Amihud illiquidity measure (Amihud (2002) and $AVGAMIHUD_{t-12,t-1}$ is the mean value of the Amihud measure in the past 12 months.
$\Delta SPREAD$	$\Delta SPREAD = -(SPREAD_{i,t} - AVGSPREAD_{t-12,t-1})$ where SPREAD is the percentage quoted spread and $AVGSPREAD_{t-12,t-1}$ is the mean value of the percentage quoted spread in the past 12 months.
Types of Traders	
$PINST_{i,t}$	Proportion of trades that are initiated by domestic institutional investors for stock i in month t
$PFORE_{i,t}$	Proportion of trades that are initiated by foreign institutional investors for stock i in month t.
$PINDI_{i,t}$	Proportion of trades that are initiated by individual investors for stock i in month t
$PSINST_{i,t}$	Proportion of trades that are initiated by domestic institutional investors' sell orders for stock i in month t
$PSFORE_{i,t}$	Proportion of trades that are initiated by foreign institutional investors' sell orders for stock i in month t.
$PSINDI_{i,t}$	Proportion of trades that are initiated by individual investors' sell orders for stock i in month t
$PBINST_{i,t}$	Proportion of trades that are initiated by domestic institutional investors' buy orders for stock i in month t
$PBFORE_{i,t}$	Proportion of trades that are initiated by foreign institutional investors' buy orders for stock i in month t
$PBINDI_{i,t}$	Proportion of trades that are initiated by individual investors' buy orders for stock i in month t
Control variables	
$\Delta IVO_{i,t}$	The idiosyncratic volatility shock of stock i in month t. Following Ang, Hodrick, Xing and Zhang (2006), we estimate the regression model: $R_{i,d} - R_{F,d} = \alpha_i + \beta_i(R_{M,d} - R_{F,d}) + \gamma_i SMB_d + \delta_i HML_d + e_{i,t}$ where subscript d denotes day d, R_i is the return on stock i, R_F is the yield on CD 91 days, R_M is the value-weighted market return.

$\Delta TRV_{i,t}$	Won trading volume shock for stock i in month t, calculated as $(TRV_{i,t} - AVGTRV_{i\|t-12,t-1})/AVGTRV_{i\|t-12,t-1}$ where $TRV_{i,t}$ is the won trading volume of the stock in month t and $AVGDVOL_{i\|t-12,t-1}$ is the mean value of stock i's dollar trading volume in the past 12 months.
$MVE_{i,t-1}$	The market value of equity of stock i in the prior month calculated as the share price * number of outstanding shares. MVE is expressed won.
$CVAMIHUD_{i,t}$	The coefficient of variation in the Amihud illiquidity of stock i in month t. Following Petkova, Akbas and Armstrong (2011), we calculate CVAMIHUD as the standard deviation of the daily Amihud illiquidity measure divided by the average Amihud illiquidity measure for the month.
$MAXRET_{i,t}$	The maximum daily return over the past one month for stock i (see Bali, Cakici, and Whitelaw (2011), Chung and Chuwonganant (2016))
$RET(-12,-2)_{i,t}$	The momentum of stock i in month t computed as the cumulative return of stock i over the previous 12 months ending on month prior to month t (Jegadeesh and Titman (1993)).
$STDTO_{i,t}$	The standard deviation of monthly turnover over the last 2 months for stock i in month t (Chordia, Subrahmanyam and Anshuman (2001)).
$BM_{i,t}$	The ratio of book value of equity to market value of stock i in month t. Book value of equity for the fiscal year ending in the previous year and market value of equity of stock i in month t-1
BETA	The market beta of stock i in month t. We follow Fama and French (1992) by estimating the beta from the following regression model: $R_{i,t} - R_{F,t} = \alpha_i + \beta_i^1(R_{M,t} - R_{F,t}) + \beta_i^2(R_{M,t-1} - R_{F,t-1}) + \varepsilon_{i,t}$, where subscripts t and t-1 denote month t and month t-1, respectively. R_i is the return on stock i, R_F is the yield on CD 91 days, and $R_{M,t}$ is the value-weighted market return. The market beta for stock i (BETAi) is the sum of the estimated regression coefficients $\beta i^1 + \beta i^2$. We use monthly returns over the prior 60 months in the regression (at least 24 observations required).
COSKEWNESS	The co-skewness of stock i in month t. Following Harvey and Siddique (2000) and Chung and Chuwonganant (2016), we estimate co-skewness by carrying out the following regression model for each stock using the monthly returns over the past 60 month (at least 20 months available): $R_{i,t} - R_{f,t} = \alpha_i + \beta_i(R_{M,t} - R_{F,t}) + \gamma_i(R_{M,t} - R_{Ft})^2 + e_{i,t}$ where $R_{i,t}$ is the monthly return for stock i, $R_{f,t}$ is yield on CD 91 days for the month, and $R_{M,t}$ is the value-weighted market return. The estimated regression coefficient γ_i is the co-skewness measure of the stock.