Dynamic Volume-Return Relation, Information Asymmetry, and Trade Size: An Analysis of Australian Market

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Abstract

This study investigates the influence of information asymmetry on the cross-sectional variation of volume-return relation in the context of Australian stock market. In particular, this paper extends current research by incorporating informed traders' trade-size preference as well as its impact on the relation between information asymmetry and volume-return dynamics into analysis. After classifying trading volume according to the size of trade, we find that the dynamic volume-return relation within medium-size trades has the most significant response to the degree of information asymmetry. Our findings are consistent with the notion that informed traders concentrate in the trades of medium-size.

JEL classifications: G10, G20, G24

Keywords: Trade-size, Information Asymmetry, Volume, Return

1 Introduction

Volume contains information about future price behaviour and a considerable amount of literature investigates the impact of trading volume on return autocorrelation (see, among others, Morse, 1980; Conrad, Hameed and Niden, 1992; Gallant, Rossi and Tauchen, 1992; Campbell, Grossman and Wang, 1993; Stickel and Verrecchia, 1994; Lee and Swaminathan, 2000). However, the existing empirical analysis on volume-return relation does not reach any unanimous conclusion and the results vary cross-sectionally. The relation between trading volume and autocorrelation of returns at the level of aggregate market index does not reconcile with the evidence at the individual stocks level (Llorente, Michaely, Saar and Wang, 2002). Consistent with the theoretical framework developed by Blume, Easley and O'Hara (1994) and Wang (1994), Llorente et al. (2002) propose a model which reconciles inconsistent empirical findings on the relation between volume and return.[1] They suggest that the degree of information asymmetry is essential in explaining the cross-sectional variation of the volume-return relation.

In this paper, we examine the relation between the degree of information asymmetry and the impact of volume on return autocorrelation with reference to the common stocks listed on the Australian Securities Exchange (ASX).[2] We analyse Llorente et al.'s (2002) model of dynamic volume-return relation based on Australian data and test whether cross-sectional variation of volume-return relation is still significantly linked to the extent of informed trading despite the institutional difference in Australia. More importantly, this study extends the current research by investigating the

[1] Llorente et al.'s (2002) study is also closely related to Brown and Jennings (1989), Grundy and McNichols (1989) and Hasbrouck (1988, 1991).
[2] "ASX" is previous named as Australian Stock Exchange.

informational role of trade-size and its impact on the relation between information asymmetry and volume-return dynamics. Specifically, we separate trading volume according to the size of trade and examine under which trade-size group the dynamic volume-return relation has the most significant response to the degree of information asymmetry.

We are motivated by studies on informed traders' trade-size decision such as Barclay and Warner (1993) and Chakravarty (2001) who suggest that informed trading is the main source of cumulative stock price change and informed traders demonstrate strong preference for medium-size trades. Informed traders' trade-size decision may have potential impact on the degree of information content in different trade-size groups. This in turn will influence the relation between information asymmetry and volume-return dynamics for different size of trades. Since trading volume can be decomposed into different trade-size groups, it is possible that the cross-sectional variation of volume-return relation may be mostly driven by the trades within certain trade-size class. Therefore, it is worthwhile to consider under which trade-size group that the volume-return dynamics have the greatest reaction to the extent of information asymmetry. In addition, we are also motivated by some studies such as Bugeja, Rosa and Lee (2009) who argue that institutional difference in Australia may affect the robustness of the results which based on U.S. data.

We contribute to the current literature on the connection between trading volume and return autocorrelation. To the best of the authors' knowledge, this is the first study of dynamic volume-return relation that incorporates informed traders' trade-size preference suggested by Barclay and Warner (1993) and Chakravarty (2001). In particular, we focus on the informational role of trade-size and its impact on the relation between information asymmetry and volume-return dynamics. We argue that the volume-return dynamics under medium trade-size group should have the most significant response to the degree of information asymmetry, provided that the cross-sectional variation of volume-return relation is linked to the relative significance of informed trading and informed traders focus on the medium-size trades.

We investigate the influence of informed traders' trade-size choice on the linkage between asymmetric information and volume-return dynamics for all common stocks listed on the ASX over the period from the beginning of 2006 to mid-2010. We find that, without considering the size of trade, the results on dynamic volume-return relation are mixed. Furthermore, after separating the trading volume into three subcategories according to the size of trade, the dynamic volume-return relation claimed by Llorente et al. (2002) is most robust and strong under medium trade-size group. This result supports Barclay and Warner (1993) Chakravarty's (2001) arguments that informed trading is the main source of cumulative stock price change and informed traders prefer the medium-size trades. The findings of this study also indicate that the degree of information asymmetry (i.e. the relative significance of informed trading) mainly contributes to the dynamic volume-return relation within medium trade-size and informed traders concentrate their trades on medium-size.

The rest of the paper is organized as follows. Section 2 provides a concise review of existing literature. Section 3 describes the data for this study. Section 4 explains the research methodology, discusses the results, and tests the robustness of the results. Section 5 concludes this paper.

2 Literature Review

Extensive literature examines the informational role of volume. For instance, Blume et al. (1994) argue that volume provides higher quality of information than price alone. Traders learn from trading volume and enjoy better performance as a result of the information extracted from it. Similarly, Wang (1994) concludes that asset market is incomplete and investors' heterogeneity such as the volume of trading is one of the vital determinants of price behaviour. Therefore, trading dynamics such as volume has a significant role in capturing the heterogeneous nature of investors and consequently can help identify the information asymmetry among them.

Various studies draw particular attention to the relation between trading volume and autocorrelation of returns under both individual stocks level and at aggregate market index level. At the aggregate level, Gallant et al. (1992) find that additional information can be extracted from trading volume and large price movement is typically accompanied by the high trading volume. Campbell et al. (1993) suggest that stock returns under high-volume days tend to have stronger reversal or weaker continuation in comparison to low-volume period. At the individual stocks level, Morse (1980) provides supporting evidence for existence of asymmetric information among individual stocks. He shows that returns under high-volume days tend to continue themselves. Conrad et al. (1992) find that the heavily traded securities are likely to experience negative returns autocorrelation, on the other hand, returns under low-volume days are more inclined to exhibit momentum. They claim that the future price movement depends on the extent of trading volume. Stickel and Verrecchia (1994) examine the phenomenon of greater price reversal of individual stocks under low-volume days on Wall Street based on earning announcements in U.S. market. Their evidence suggests that price changes are inclined to sustain or less likely to reverse with the support of large trading volume. Overall, the empirical results on volume-return relation are mixed and vary cross-sectionally. Meanwhile, some other literature claim return autocorrelation is also influenced by the asymmetric information, such as Brown and Jennings (1989) and Grundy and McNichols (1989). Nevertheless, as criticized by Blume et al. (1994), these studies do not take into account volume variable and provide no help to understand the underlying informational role of volume.

In light of prior studies by Blume et al. (1994) and Wang (1994), Llorente et al. (2002) investigate the cross-sectional variation of volume-return relation and propose a theoretical model which reconciles the conflicting literature and provides a solution to justify why volume-return relation is dynamic and cross-sectionally different. They take account of the interaction among information asymmetry, trading volume and stock return as well as the joint behaviour of all the three variables. In particular, they find that the cross-sectional variation of volume-return relation is driven by the degree of information asymmetry and the relative significance of informed trading. Under their theoretical framework, informational and non-informational trades are the two main purposes of trading. Investors trade either to hedge and share risk (i.e. to rebalance portfolios), or alternatively, to speculate on private information (i.e. the informed trading). Llorente et al. (2002) further suggest that non-informational trades are more likely to produce negatively auto-correlated returns since no private information is incorporated into price. In contrast, informed trading driven by informational shocks is more inclined to generate positively auto-correlated returns due to the slow diffusion of private information across the market. Meanwhile, intensive trading volume is able to help identify the relative significance of particular trading motives because volume contains critical information regarding future price movements. Thus, if high trading volume is driven or dominated by informational (non-informational) trades, returns are more likely to have momentum (reversal) or less inclined to have reversal (momentum). The patterns of return autocorrelation will be ambiguous if neither types of trading dominate. Llorente et al.'s (2002) empirical analysis is based on bid-ask spread and market capitalization as the proxies for the information asymmetry.[3] They test their model based on the data of daily volume and return from both New York Stock Exchange (NYSE) and American Stock Exchange (AMEX). The evidence in their analysis supports the relation between volume-return dynamics and information asymmetry and is consistent with their argument that the relative significance of informed trading determines the return autocorrelation under high-volume period.

A few studies also look at the dynamic relation between trading volume and autocorrelation of returns. For instance, Gagnon and Karolyi (2007) extend Llorente et al.'s (2002) scope to international stock market and cross-listed shares. They claim that stocks associated with higher degree of informed trading under high-volume days tend to have similar patterns of returns for both overseas and U.S. market. Puri and Philippatos (2008) investigate the intraday volume-return relation based the data from London International Financial Futures and Options Exchange (LIFFE). They find the price-decrease is associated with higher trading volume than the price-increase and hence the volume-return relation is asymmetric.

Although the scope of volume-return relation is extended by various studies and the concept of information asymmetry is introduced into analysis since Llorente et al. (2002), to the best of our knowledge, none of volume-return literature has considered

[3] Llorente et al. (2002) also use analyst-following as the proxy for information asymmetry to check the robustness of the results.

the trade-size decision of informed traders. We are inspired by the studies on the informed investors' trading behaviour and especially their choice of trade-size. For instance, Easley and O'Hara (1987) investigate the behaviour of informed traders through the choice of trade size and its impact on security prices. Specifically, their study examines the influence of large-size trades (block trades) on stock price and they conclude that informed traders focus on large-size trades. Barclay and Warner (1993) examine informed traders' trading behaviour based on the trade size. Typically, small-size trades do not appear attractive to informed traders because of the limited profit and high trading cost. Instead, medium or large trade-size is the preference of informed traders and the choice depends on their investment constraints as well. Barclay and Warner (1993) also argue that informed traders tend to break up large-size trades because they wish to disguise themselves.[4] The significant price discount associated with large-size trades is likely to reveal the informed traders' identity and as a result the uninformed traders are inclined to adjust the trading strategy accordingly. Therefore, informed traders will either place a single medium-size trade, or alternatively, separate the large-size trade into several trades of medium-size. They classify the trade-size into three categories according to the number of shares per trade. They argue that trading activities under medium-size trades are the main reason of cumulative price change, provided that informed traders prefer medium trade-size and stock price movement is primarily driven by informed trading on private information. Following the study by Barclay and Warner (1993), Chakravarty (2001) categorizes trades into different trade-size groups based on the number of shares per trade. It is found that the largest cumulative price change occurs under medium trade-size and it is mainly due to the informed trading by institutions. This finding supports

[4] Similarly, Kyle (1985) suggests that informed traders are inclined to conceal their information so that private information will gradually incorporate into price.

the argument that informed trading is the main source of cumulative stock price change and informed traders prefer the trades of medium-size. Their study also confirms that institutional traders are informed traders.

3 Data

We investigate the volume-return relation for all ordinary shares listed on the ASX for the period between 3 January 2006 and 30 June 2010. We collect intraday bid-ask quotes, intraday transactions and shares outstanding data from the Securities Industry Research Centre of Asia-Pacific (SIRCA). The intraday bid-ask quotes data consist of stock code, date, time, and the best bid and ask quotes in the limit order book. The intraday transactions data contain stock code, date, time, transaction price, and volume of the transactions (i.e. the number of shares traded). For intraday bid-ask quotes data, we remove those observations with negative bid quote or ask quote and any observation with higher bid quote than ask quote. For intraday transactions data, the observations with negative price or negative volume are deleted.

Our sample starts from 3 January 2006. This is mainly because the ASX removed broker identification information from 28 November 2005 (Comerton-Forde and Tang, 2009; Duong, Kalev and Krishnamurti, 2009). Prior to 28 November 2005, brokers are able to identify other brokers who submitted orders. However, this practice was no longer endorsed by ASX since then.[5] Given that the informed traders tend to hide themselves, the investors' anonymity has profound impact on this study (Kyle, 1985; Barclay and Warner, 1993). Whether informed traders can be easily identified is

[5] The justification of the change to anonymous trading is discussed by Australian Stock Exchange (2003, 2005).

crucial to informed investors' decision on the size of trade and has significant influence on how soon the private information will fully impound into price. As a result, this study is confined to the period after the change by ASX, so as to maintain consistency during the analysis. In addition, as mentioned by Llorente et al. (2002, p. 1018), the nature of this study require "stock-specific parameters remain constant over time, which may not be the case over a long period". Therefore, the time horizon of four and half years is considered as appropriate for this study.

Consistent with the approach of Llorente et al. (2002), only stocks which have transaction over two-thirds of all the available trading days are included in the sample. As a result, the final sample consists of 1,067 stocks after this filtering process. Moreover, we use the average end-of-day mid-quote as the proxy for the closing price to reduce the bias from the bid-ask bounce effect addressed by Roll (1984). According to Llorente et al. (2002), the bid-ask bounce effect results in negative autocorrelation and consequently it tend to prejudice the return autocorrelation estimated by the model. Second, Lo and MacKinlay (1990) illustrate that less frequently traded stocks are likely to experience negative autocorrelation due to the variation of timing of last daily trade. Therefore, end-of-day mid-quote can help to alleviate the econometric problem resulted from closing price of less frequently traded stocks.

Following the analysis of Madhavan, Richardson and Roomans (1997) and the approach by Llorente et al. (2002), the opening spread is used to measure the information asymmetry components of the bid-ask spread. The actual spread used is relative spread rather than absolute spread. Relative spread is defined as the bid-ask spread at the opening relative to the mid-quote at the opening.

Both return and volume are measured in daily frequency. The return is defined as the "open-to-close return" which equals to end-of-day mid-quote divided by daily opening mid-quote and is taken logs afterwards.[6] In accordance with Llorente et al. (2002), trading volume is measured as daily share turnover which equals to the number of shares traded daily divided by daily shares outstanding. Similarly, Lo and Wang (2000) justify the share turnover as an appropriate proxy for volume and they also provide supporting evidence that daily share turnover tend to be non-stationary so that it is necessary to take logs and de-trend the time series of daily turnover. Consequently, in the study, the turnover is firstly taken logs and then de-trended by deducting the moving average log-turnover of the previous 200 trading days.

As illustrated following, the turnover is taken logs at first and the constant 0.00000255 is added to keep away from taking logs on zero trading volume:

$$\text{logturnover}_t = \log\left(\text{turnover}_t + 0.00000255\right), \tag{1}$$

and then the de-trending process is illustrated as follows:

$$V_t = \text{logturnover}_t - \frac{1}{200}\sum_{s=-200}^{-1} \text{logturnover}_{t+s}. \tag{2}$$

We use the bid-ask spread and market capitalization as our proxies for information asymmetry. Some studies suggest those two proxies offer better measure of asymmetric information (See, among others, Lee, Mucklow and Ready, 1993; Lo and MacKinlay, 1990). Specifically, higher bid-ask spreads are associated with higher

[6] The first 10 minutes is disregarded because "ASX's staggered opening procedure takes up to 10 minutes to complete" (Duong, Kalev and Krishnamurti, 2009, p. 537).

degree of information asymmetry. On the other hand, larger market capitalization stocks tend to have lower level of asymmetric information.

This study applies the approach of ordinal transformation of asymmetric information proxies. This method can enable two proxies (bid-ask spreads and market capitalization) to be examined under unified framework (Llorente et al., 2002). More specifically, the stocks within the sample are ranked in ascending order in terms of bid-ask spreads and market capitalization, respectively. The stocks with smallest market capitalization or smallest bid-ask spread is allocated with 1 and the largest market capitalization or bid-ask spread is ranked with 1,067. This ranking is then divided by the total number of stocks in the sample (i.e. 1,067) and this effectively makes the transformed proxies locate between 0 and 1. Both Johnston (1985) and Llorente et al. (2002) consider this approach as most appropriate since it reduces the potential large variation in magnitude of parameters.

4 Empirical Results

4.1 Descriptive Statistics

Table 1 provides the summary statistics for the entire sample as well as three equally-divided subgroups based on size of each stock. That is, stocks are first ranked based on market capitalization. Then the stocks which locate under bottom (top) third are included in the small (large) size group. The stocks which fall within middle third are included in medium size group. The daily average statistics is first calculated for each stock. Then the average statistics across stocks is calculated for each size group. Market capitalization ("AvgCap") is calculated as daily shares outstanding multiplied by end-of-day mid-quote. The mean value of average daily market capitalization under entire sample is around 1.1 billion. "BAsprd" in Table 1 represents the average daily percentage spread at the opening. The small size group (classified according to market capitalization) is associated with the largest bid-ask spread (8.87%) and the large size group has the smallest bid-ask spread (1.27%). That is, the bid-ask spread is inversely related to market capitalization. After reviewing of descriptive statistics in Table 1, it can be found that the daily average market capitalization under large-size group is almost 166 times larger than the daily average market capitalization within small-size group. In comparison, the daily average bid-ask spread of small-size group is only about 7 times more than the bid-ask spread in large-size group.

[Insert Table 1 here]

4.2 The Impact of Information Asymmetry on Cross-sectional Variation of Volume-Return Relation in Australian Stock Market

Similar to Llorente et al. (2002), we use the following model to exam the relation between information asymmetry and volume-return dynamics of individual stocks,

$$\text{Return}_{i,t+1} = \text{C0}_i + \text{C1}_i * \text{Return}_{i,t} + \text{C2}_i * \text{Volume}_{i,t} * \text{Return}_{i,t} + \text{error}_{i,t+1}\ , \quad (3)$$

where "$\text{Return}_{i,t}$" represents the daily log return of stock *i* on day *t* and "$\text{Volume}_{i,t}$" is the daily turnover of stock *i* on day *t* which has been taken log and de-trended. "$\text{Volume}_{i,t}$ * $\text{Return}_{i,t}$" represents the volume-return interaction term (shows how trading volume interact with return autocorrelation) and is the main focus of this study. Both non-informed trading and informed trading constitute investors' trading activities based on Llorente et al.'s (2002) model. The relative significance of particular type of trade determines the dynamic volume-return relation. When a stock is dominated by informed trading, C2 coefficient should be significant and positive. It indicates that for stocks with higher degree of information asymmetry, large trading volume are likely to have more positive or less negative return autocorrelation as a result of incomplete price adjustment to private information (i.e. gradual diffusion of private information across the market). In contrast, C2 coefficient will be significant and negative when non-informed trading dominates. It means that for stocks associated with lower level of information asymmetry, high volume days tend to experience more negative or less positive return autocorrelation because of the return reversal caused by non-informational reasons such as allocational and liquidity shocks. The C2 coefficient does not significantly differ from zero when neither types of trade dominate. In brief, the C2 coefficient (volume-return interaction parameter) is a function of the degree of information asymmetry and depends on the relative significance of informed trading relative to non-informed trading.

Specifically, larger bid-ask spreads are associated with higher degree of information asymmetry. Therefore, $C2_i$ should be more positive (or less negative) for stocks with larger bid-ask spreads. Likewise, relative larger market capitalization stocks tend to have lower level of asymmetric information. Consequently, $C2_i$ should be more negative (or less positive) for smaller market capitalization stocks. We examine the cross-sectional variation of volume-return relation under following model:

$$C2_i = a + b * A_i + \text{error}_i \,. \tag{4}$$

Accordingly, a statistical significant and positive b should be observed when bid-ask spread is used to proxy for information asymmetry and a statistical significant and negative b should be observed when market capitalization is adopted to proxy for asymmetric information.

Table 2 presents the results for the impact of information asymmetry on the cross-sectional variation of volume-return relation. In Panel A, the coefficient b is positive (0.005451) which is consistent with the hypothesis that larger extent of information asymmetry (i.e. larger bid-ask spread) are related to more positive C2 coefficient (i.e. volume-return dynamics). However, the coefficient b is not significant enough to support the relation between information asymmetry proxy and volume-return interaction term C2. Panel B provides the similar analysis as Panel A based on market capitalization as the information asymmetry proxy. In comparison, Panel B shows the result where the volume-return interaction term is regressed against the market capitalization proxy and parameter b is negative but insignificant. The results are consistent with the assumption that stocks with less degree of information asymmetry (i.e. larger market capitalization) under high volume have more possibility to reverse (i.e. C2 becomes more negative). However, this pattern is statistically insignificant.

[Insert Table 2 here]

Overall, without considering the informed traders' trade-size preference, this study does not find significant evidence regarding the impact of information asymmetry on dynamic volume-return relation based on both bid-ask spread and market capitalization proxies. The results in Table 2 are mixed and the relation between information asymmetry and volume-return dynamics is not statistically significant.

4.3 Informed Traders' Trade-size Choice and its Influence on the Relation between Information Asymmetry and Volume-Return Dynamics

In order to test whether the cross-sectional variation of volume-return relation within medium-size trades has the most significant response to the degree of information asymmetry, we break up the volume-return interaction term of Equation (3) into three subgroups according to the size of trade. We define trade sizes in accordance with Chakravarty (2001). Any trades with less than 500 shares per trade are considered as small-size trades; medium-size trades are those trades which have equal to or greater than 500 but no more than 9,999 shares per trade; the rest of trades (i.e. no less than 10,000 shares per trade) are classified as large-size trades. The Equation (3) then becomes as follows:

$$\text{Return}_{i,t+1} = \text{C0}_i + \text{C1}_i * \text{Return}_{i,t} + \text{C2}_i * \text{SVolume}_{i,t} * \text{Return}_{i,t} + \text{C3}_i * \text{MVolume}_{i,t} * \text{Return}_{i,t} + \text{C4}_i * \text{LVolume}_{i,t} * \text{Return}_{i,t} + \text{error}_{i,t+1}, \quad (5)$$

where "$\text{SVolume}_{i,t}$" represents the daily de-trended log turnover under all small-size trades of an individual stock; and "$\text{MVolume}_{i,t}$" accounts for the daily de-trended log turnover within medium trade-size of an individual stock; similarly, "$\text{LVolume}_{i,t}$" is the daily de-trended log turnover of all large-size trades of an individual stock. Thus, C2, C3 and C4 in Equation (5) represent the volume-return interaction parameters (and show how trading volume interact with return autocorrelation) for those trades within small-size, medium-size and large-size group, respectively.

The relation between volume-return interaction coefficient and the degree of information asymmetry for small, medium and large trade-size is estimated under Equations (6), (7), and (8) respectively:

$$C2_i = a_2 + b_2 * A_i + error_i \; ; \tag{6}$$

$$C3_i = a_3 + b_3 * A_i + error_i \; ; \tag{7}$$

$$C4_i = a_4 + b_4 * A_i + error_i \; . \tag{8}$$

A statistically significant and positive b is expected when bid-ask spread is used to proxy for information asymmetry and a statistically significant and negative b is expected when market capitalization is used to proxy for asymmetric information. For the proxy of bid-ask spread, the significant and positive b_3 (and/or b_2, b_4) indicates that the degree of information asymmetry accounts for the cross-sectional variation of volume-return relation under medium-size (and/or small-size, large-size) trades group. Similarly, for the proxy of market capitalization, a statistical significant and negative b_3 (and/or b_2, b_4) indicates that degree of information asymmetry explains the dynamic volume-return relation within the medium-size (and/or small-size, large-size) trades group. Most importantly, the relative significance of b_3 (or b_2, b_4) coefficient suggests that informed trading is relatively more intensive within medium-size (or small-size, large-size) trades category. If b_3 (or b_2, b_4) coefficient are most significant with correct sign (either positive or negative according to the proxy selected: i.e. b_3 coefficient is most robust and positive when bid-ask spread is used as proxy, b_3 coefficient is most robust and negative when market capitalization is used as the proxy), then it indicates that informed investors concentrate their trading in medium-size (or small-size, large-size) trades and the dynamic volume-return relation will be most significant under medium-size trades. Moreover, if b_2 (or b_3, b_4) coefficient is least significant or even insignificant, then it suggests that particular trade size do not attract informed traders and consequently the degree of information asymmetry no longer matters and cannot explain volume-return relation appropriately.

Table 3 presents the results from Equation (5) on individual stocks and illustrates how the variation of volume-return interaction parameters is related to bid-ask spread proxy and market capitalization proxy respectively for each trade-size group (small, medium, large). Panel A indicates that only medium trade-size group illustrates the positive and significant relation between bid-ask spread proxy and volume-return dynamics (i.e. b_3 is 0.021461 and significant). Small trade-size parameter b_2 is positive but insignificant. Large trade-size coefficient b_4 is significant but is negative (-0.009026) which indicates that the impact of asymmetric information on return autocorrelation under high volume days is opposite to what Llorente et al.'s (2002) prediction. Similarly, in Panel B, only medium trade-size group illustrates the negative and significant relation between market capitalization proxy and volume-return dynamics. Coefficient b_2 is insignificant and Coefficient b_4 is significant but positive.

In summary, under medium trade-size group, both panels support that the extent of information asymmetry has significant impact on the relation between trading volume and autocorrelation of returns. The relatively higher significance of informed trading is associated with greater possibility of return momentum under high volume days. This relation in small trade-size group is, however, mixed and insignificant. The evidence in large trade-size group is opposite to our hypothesis and returns are more likely to experience reversal when high trading volume is driven by informational trades.

Overall, based on the results from Table 3, this study finds statistically significant evidence regarding the influence of informed traders' trade-size choice on the relation between information asymmetry and volume-return dynamics. Using bid-ask spread and market capitalization as the proxies for information asymmetry, we find that the cross-sectional variation of volume-return relation has the most significant response to the degree of information asymmetry within medium-size trades. While results in Table 2 do not support a robust relation between information asymmetry and volume-return dynamics, analysis from Table 3 shows significant evidence when informed traders' trade-size preference is considered. After breaking up the volume into three subcategories according to the size of trade, we find that the relation between the degree of information asymmetry and volume-return dynamics is statistically significant within medium trade-size group. This is consistent with the notion that informed traders concentrate on medium-size trades and are the main cause of cumulative stock price change. Moreover, the mixed and weaker results within the small trade-size group may be explained by the fact that the trades of small-size may not particularly show attraction to informed traders because of the limited profit and high trading cost (Barclay and Warner, 1993; Chakravarty, 2001). Consequently, trading activities under small-size group do not have sufficient information content and hence information asymmetry does not act as the key factor in explaining the cross-sectional variation of volume-return relation. In addition, large trade-size group demonstrates contrasting evidence on the relation between asymmetric information and volume-return dynamics. One possible explanation suggested by Barclay and Warner (1993) is that the significant price discount associated with large-size trades make it very difficult for the informed traders to disguise themselves. Therefore, a large number of uninformed traders who observe the informational shocks are inclined to adjust trading strategy accordingly. This leads to fast diffusion of private information across the market and the degree of information asymmetry plunges quickly. As a result, the large number of "follow-on" uninformed trading after the informational shocks explains why stocks with relatively high degree of informed trading tend to experience negative return autocorrelation within large trade-size group in previous analysis.[7]

[Insert Table 3 here]

4.4 Robustness of Results

4.4.1 The Cross-correlation of Errors among Stocks

According to Llorente et al. (2002), the errors from time-series regressions of individual stocks (i.e. Equations (3) and (5)) might be correlated across stocks. This could possibly result in non-independent estimation of volume-return interaction parameters from the time-series regressions. Consequently, the cross-sectional analysis (Equations (4), (6), (7) and (8)) which based on the volume-return interaction coefficients could produce biased results. In light of the argument by Llorente et al. (2002), this study follows Jorion's (1990) approach to tackle this problem. Specifically, this paper uses the return of All Ordinaries Index as the market proxy to mimic the common factors and to control the sensitivity of returns to common factors.[8]

[7] See discussion by Barclay and Dunbar (1996), Chakravarty and McConnell (1997, 1999), and Chakravarty and Sarkar (1998).
[8] All Ordinaries Index consists of 500 listed largest market-capitalisation stocks and is one of the most important market indicators in Australia (Australian Securities Exchange, 2010).

Table 4 presents the results where the market return (i.e. return of All Ordinaries Index) is used as the proxy for common factors to reduce cross-correlation of errors from Equations (3) and (5). Panel A presents the results for three different trade-size groups respectively where the bid-ask spread is used as the information asymmetry proxy. Panel B shows the similar analysis where the market capitalization is adopted as the proxy for asymmetric information. Both Panel A and B demonstrate that small (medium, large) trade-size coefficient b_2 (b_3, b_4) shows consistent sign and significance with the main findings reported in Table 3.[9] The findings of this study are still robust after controlling return sensitivity to common factors where market return is used as the proxy. The relation between the degree of information asymmetry and volume-return dynamics again appears most significant within medium-size trades.

[Insert Table 4 here]

4.4.2 "Stale" Limit Orders

Another potential problem addressed by Llorente et al. (2002, p. 1033) is due to the "stale" limit orders. Typical market participants who submitted limit orders do not observe the market frequently. It then takes time for new information to incorporate into price and "quotes may not reflect the 'true' price of the security despite being commitments to trade". This often occurs in the last trade at the end of the day and as a consequence the end-of-day mid-quotes used in this study may produce potential biased results. Therefore, we adopt Llorente et al.'s (2002, p. 1034) approach and use the number of trades "as a proxy for the 'freshness' of the closing price" in time-

[9] It should be noticed that the only variation is large trade-size coefficient b_4 is insignificant in Panel B when market capitalization proxy is used.

series Equations (3) and (5) to control the variation of the last trade at the end of the day.

Table 5 shows the results where the number of trades is included in Equations (3) and (5) to mimic the freshness of closing price. Panel A presents the results for three different trade-size groups respectively where bid-ask spread proxy is used. Similarly, Panel B performs the similar analysis based on market capitalization. Once again, both Panels present robust evidence supporting the findings in this study. The relation between the extent of informed trading and return autocorrelation under high volume period is most strong within medium-size trades. The findings of this study are robust despite the potential problem associated with last trade at the end of the day.

[Insert Table 5 here]

4.4.3 Alternative Measure of Information Asymmetry Proxy

This study measures the degree of information asymmetry based on both ordinal transformed bid-ask spreads and market capitalization proxies. While ordinal transformation makes the analysis more comparable between the two proxies, it may potentially distort the results due to the change of proxies' magnitude. Therefore, we test the robustness of the results based on the raw bid-ask spread and raw market capitalization without ordinal transformation. We find that in Table 6 the results are statistically significant and the parameters demonstrate appropriate sign under medium trade-size group.

[Insert Table 6 here]

4.4.4 Alternative Definition of the Trade-size

In this study, we define the trade-size according to the number of shares per trade. Similar to Chakravarty (2001), any trades which have equal to or greater than 500 but less than 10,000 shares per trade are considered as medium-size trades. This classification, however, is somewhat arbitrary. The size of trade defined by traders may vary across markets and differ across stocks. Instead of classifying trade-size by the number of shares per trade, we categorize trade-size based on an alternative percentage measure. Any trades in the lower quartile (25th percentile) of an individual stock are considered as small-size trades; any trades in the upper quartile (75th percentile) of an individual stock are classified as large-size trades; medium-size trades are located within the interquartile range (the difference between upper and lower quartiles). Table 7 presents the analysis based on this alternative quartile measure. Our results again are robust and support our main findings.

[Insert Table 7 here]

4.4.5 The Implications of Robustness Tests

Overall, it can be concluded that the results under medium trade-size group are consistently demonstrating robust evidence for our findings. This also supports the assumption by Barclay and Warner (1993) and Chakravarty (2001) that informed traders concentrates on the trades of medium-size. It is worth mentioning that the analysis under other trade-size groups exhibits some variation and the results are mixed. Nevertheless, it does not prevent us from drawing our conclusion on medium trade-size.

5 Conclusion

We examine the influence of information asymmetry on the dynamic volume-return relation in Australia. Our findings indicate that, without considering informed traders' trade-size choice, the cross-sectional variation of volume-return dynamics does not have significant response to the degree of asymmetric information. The results which appear robust in U.S. do not hold in Australia.

More importantly, we extend the scope of current research on volume-return relation and incorporate informed traders' trade-size preference. After dividing the volume into three subcategories based on the size of trade, it is found that the impact of information asymmetry on the dynamic volume-return relation is only robust under medium trade-size group. Cross-sectional variation of volume-return relation has the most significant response to the degree of information asymmetry within medium-size trades. This result supports the argument that informed traders prefer the trades of medium-size. Our findings are robust to the adoption of market return as the control of sensitivity to common factors, the inclusion of number of trades as the proxy for freshness of closing prices, the alternative measure of information asymmetry proxies, and the alternative definition of trade-size. Overall, our findings highlight the importance of incorporating informed traders' trade-size preference in the examination of the dynamic volume-return relation.

One possible future direction of research is to investigate the trades initiated by institutional traders. In light of Chakravarty's (2001) argument that informed trades are initiated by institutions and institutional investors are informed traders, it is intuitively to ask whether the relation between information asymmetry and volume-return dynamics is driven by institutional trades.

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Table 1
Summary statistics

Descriptive statistics of entire sample and three subsamples based on size (1Jan06-30Jun10)	AvgCap (in million $)	AvgTrd (in 100s)	AvgTurn (in %)	AvgPrc (in $)	BAsprd (in %)
Entire Sample					
Mean	1099.39	13463	2.301	2.58	4.69
Median	88.46	3627	0.271	0.63	3.50
Std. Dev.	5590.12	29866	13.045	6.45	4.26
Observations	1067	1067	1067	1067	1067
Size group: small					
Mean	19.14	11223	3.358	0.20	8.87
Median	18.55	3163	0.271	0.13	8.09
Std. Dev.	9.17	22738	16.704	0.28	4.39
Observations	356	356	356	356	356
Size group: medium					
Mean	99.15	5778	1.539	1.23	3.92
Median	88.46	2166	0.195	0.64	3.48
Std. Dev.	46.32	12888	8.019	3.09	1.96
Observations	355	355	355	355	355
Size group: large					
Mean	3177.08	23366	2.005	6.30	1.27
Median	729.31	7338	0.390	3.00	0.96
Std. Dev.	9345.29	42817	12.885	9.70	1.18
Observations	356	356	356	356	356

The final sample consists of 1,067 listed on ASX which are traded during the period from 1 January 2006 to 30 June 2010. The descriptive statistics of entire sample and three subsamples by size are presented. For each stock, "AvgCap" is defined as average daily market capitalization which is calculated as daily shares outstanding multiplied by end-of-day mid-quote. "AvgTrd" represents the daily average number of shares traded. "AvgTurn" is the average daily share turnover for each individual stock, which is defined as the number of shares traded daily relative to daily shares outstanding. "AvrPrc" is average end-of-day mid-quote which used as the proxy for the closing price. "BAsprd" represents the proxy for information asymmetry and is defined as the average daily opening percentage spread of an individual stock over the entire sample period, which is calculated as the bid-ask spread at the opening divided by the mid-quote at the opening. The daily average statistics is first calculated for each stock. Then the average statistics across stocks is calculated for each size group. Stocks are ranked based on market capitalization. The stocks which locate under bottom (top) third are included in the small (large) size group. The stocks which fall within middle third are included in medium size group.

Table 2

Information asymmetry and dynamic volume-return relation

Panel A: Bid-ask spread and impact of volume on return autocorrelation

Dependent variable	a	b	R^2 (%)	Observations
C2	-0.009736	0.005451	0.157	1067
	(-4.006)	(1.296)		

Panel B: Market capitalization and impact of volume on return autocorrelation

Dependent variable	a	b	R^2 (%)	Observations
C2	-0.005431	-0.003151	0.053	1067
	(-2.234)	(-0.749)		

Table 2 illustrates the relation between asymmetric information and the impact of volume on return autocorrelation. The proxies for information asymmetry are the average daily opening percentage spread of an individual stock over the entire sample period and the average daily market capitalization of an individual stock over the entire sample period. The impact of volume on return autocorrelation is measured by $C2_i$ coefficient from the regression below:

$$\text{Return}_{i,t+1} = C0_i + C1_i * \text{Return}_{i,t} + C2_i * \text{Volume}_{i,t} * \text{Return}_{i,t} + \text{error}_{i,t+1} ,$$

where "$\text{Return}_{i,t}$" represents the daily log return of an individual stock and "$\text{Volume}_{i,t}$" is the daily turnover of the individual stock which has been taken log and de-trended.

Panel A provides the analysis on the relation between volume-return dynamics and information asymmetry proxy via the cross-sectional regression below:

$$C2_i = a + b * \text{ORDBA}_i + \text{ERROR}_i ,$$

where ORDBA is the proxy of information asymmetry (ordinal transformed bid-ask spread) and the figures in parentheses are *t*-statistics.

Panel B provides the analysis on the relation between volume-return dynamics and information asymmetry proxy via the cross-sectional regression below:

$$C2_i = a + b * \text{ORDCAP}_i + \text{ERROR}_i ,$$

where ORDCAP is the proxy of information asymmetry (ordinal transformed market capitalization) and the figures in parentheses are *t*-statistics.

Table 3
Trade-size, information asymmetry and dynamic volume-return relation

Panel A: Bid-ask spread and impact of volume on return autocorrelation: by size

Small trade-size

Dependent variable	a_2	b_2	R^2 (%)	Observations
C2	-0.026087	0.061585	0.102	1067
	(-0.764)	(1.042)		

Medium trade-size

Dependent variable	a_3	b_3	R^2 (%)	Observations
C3	-0.020105	0.021461	0.722	1067
	(-4.514)	(2.784)		

Large trade-size

Dependent variable	a_4	b_4	R^2 (%)	Observations
C4	0.004682	-0.009026	0.402	1067
	(1.862)	(-2.074)		

Panel B: Market capitalization and impact of volume on return autocorrelation: by size

Small trade-size

Dependent variable	a_2	b_2	R^2 (%)	Observations
C2	0.010707	-0.011935	0.004	1067
	(0.313)	(-0.202)		

Medium trade-size

Dependent variable	a_3	b_3	R^2 (%)	Observations
C3	-0.000293	-0.018126	0.515	1067
	(-0.066)	(-2.349)		

Large trade-size

Dependent variable	a_4	b_4	R^2 (%)	Observations
C4	-0.003668	0.007658	0.290	1067
	(-1.458)	(1.758)		

Table 3 demonstrates the relation between asymmetric information and the impact of volume on return autocorrelation for each trade-size group (small, medium, large). The information asymmetry proxies are the average daily opening percentage spread and the average daily market capitalization of an individual stock over the entire sample period. The impact of volume on return autocorrelation for each trade-size group is measured by $C2_i$, $C3_i$ and $C4_i$ coefficients respectively from the regression below:

$$\text{Return}_{i,t+1} = C0_i + C1_i * \text{Return}_{i,t} + C2_i * \text{SVolume}_{i,t} * \text{Return}_{i,t} + C3_i * \text{MVolume}_{i,t} * \text{Return}_{i,t} + C4_i * \text{LVolume}_{i,t} * \text{Return}_{i,t} + \text{error}_{i,t+1},$$

where "$\text{Return}_{i,t}$" is the daily log return of an individual stock and "$\text{Volume}_{i,t}$" is daily turnover of the individual stock which has been taken log and de-trended. "$\text{SVolume}_{i,t}$" ("$\text{MVolume}_{i,t}$", "$\text{LVolume}_{i,t}$") refers to the de-trended daily log turnover for small (medium, large) trade-size group of an individual stock. Panel A and B report results from the following cross-sectional regressions respectively:

$$C2_i = a_2 + b_2 * A_i + \text{ERROR}_i\,;\; C3_i = a_3 + b_3 * A_i + \text{ERROR}_i\,;$$
$$C4_i = a_4 + b_4 * A_i + \text{ERROR}_i\,,$$

where "A_i" is the proxy of information asymmetry (ordinal transformed bid-ask spread and ordinal transformed market capitalization respectively) and the figures in parentheses are *t*-statistics.

Table 4
Using market return to control the sensitivity to common factors

Panel A: Bid-ask spread and impact of volume on return autocorrelation: by size

Small trade-size

Dependent variable	a_2	b_2	R^2 (%)	Observations
C2	-0.023351	0.056555	0.087	1067
	(-0.690)	(0.965)		

Medium trade-size

Dependent variable	a_3	b_3	R^2 (%)	Observations
C3	-0.017907	0.018472	0.554	1067
	(-4.086)	(2.435)		

Large trade-size

Dependent variable	a_4	b_4	R^2 (%)	Observations
C4	0.003640	-0.007184	0.255	1067
	(1.448)	(-1.651)		

Panel B: Market capitalization and impact of volume on return autocorrelation: by size

Small trade-size

Dependent variable	a_2	b_2	R^2 (%)	Observations
C2	0.008784	-0.007655	0.002	1067
	(0.259)	(-0.131)		

Medium trade-size

Dependent variable	a_3	b_3	R^2 (%)	Observations
C3	-0.001070	-0.015170	0.373	1067
	(-0.244)	(-1.998)		

Large trade-size

Dependent variable	a_4	b_4	R^2 (%)	Observations
C4	-0.002843	0.005769	0.165	1067
	(-1.131)	(1.326)		

Table 4 presents results which employs market return as the proxy for common factors to reduce errors correlation (from time-series Equations (5)) across stocks. The coefficients $C2_i$, $C3_i$ and $C4_i$ for both panels are estimated from the following time-series regression:

$$\text{Return}_{i,t+1} = C0_i + C1_i * \text{Return}_{i,t} + C2_i * \text{SVolume}_{i,t} * \text{Return}_{i,t}$$
$$+ C3_i * \text{MVolume}_{i,t} * \text{Return}_{i,t} + C4_i * \text{LVolume}_{i,t} * \text{Return}_{i,t} + C5_i * \text{MktReturn}_{m,t+1} + \text{error}_{i,t+1},$$

where "$\text{Return}_{i,t}$" is the daily log return of an individual stock and "$\text{MktReturn}_{m,t+1}$" is daily log return of All Ordinaries index for both equations. "$\text{SVolume}_{i,t}$" ("$\text{MVolume}_{i,t}$", "$\text{LVolume}_{i,t}$") refers to the de-trended daily log turnover for small (medium, large) trade-size group of an individual stock.

Panel A and B report results from the following cross-sectional regressions respectively:

$$C2_i = a_2 + b_2 * A_i + \text{ERROR}_i;\ C3_i = a_3 + b_3 * A_i + \text{ERROR}_i;$$
$$C4_i = a_4 + b_4 * A_i + \text{ERROR}_i,$$

where "A_i" is the proxy of information asymmetry (ordinal transformed bid-ask spread and ordinal transformed market capitalization respectively) and the figures in parentheses are *t*-statistics.

Table 5
Using number of trades as the proxy for freshness of closing price

Panel A: Bid-ask spread and impact of volume on return autocorrelation: by size

Small trade-size

Dependent variable	a_2	b_2	R^2 (%)	Observations
C2	-0.041768	0.122616	0.353	1067
	(-1.145)	(1.942)		

Medium trade-size

Dependent variable	a_3	b_3	R^2 (%)	Observations
C3	-0.019480	0.025305	0.948	1067
	(-4.254)	(3.193)		

Large trade-size

Dependent variable	a_4	b_4	R^2 (%)	Observations
C4	0.005721	-0.007881	0.296	1067
	(2.236)	(-1.780)		

Panel B: Market capitalization and impact of volume on return autocorrelation: by size

Small trade-size

Dependent variable	a_2	b_2	R^2 (%)	Observations
C2	0.052775	-0.066293	0.103	1067
	(1.445)	(-1.048)		

Medium trade-size

Dependent variable	a_3	b_3	R^2 (%)	Observations
C3	0.003904	-0.021420	0.679	1067
	(0.851)	(-2.699)		

Large trade-size

Dependent variable	a_4	b_4	R^2 (%)	Observations
C4	-0.001600	0.006749	0.217	1067
	(-0.625)	(1.523)		

Table 5 presents results which employs the number of trades (in time-series Equations (5)) as the proxy for freshness of closing price to alleviate the problem associated with end-of-day mid-quotes. The coefficients $C2_i$, $C3_i$ and $C4_i$ for both panels are estimated from the following time-series regression:

$$\begin{aligned}\text{Return}_{i,t+1} &= \text{C0}_i + \text{C1}_i * \text{Return}_{i,t} + \text{C2}_i * \text{SVolume}_{i,t} * \text{Return}_{i,t} \\ &+ \text{C3}_i * \text{MVolume}_{i,t} * \text{Return}_{i,t} + \text{C4}_i * \text{LVolume}_{i,t} * \text{Return}_{i,t} \\ &+ \text{C5}_i * \text{SNT}_{i,t} * \text{Return}_{i,t} + \text{C6}_i * \text{MNT}_{i,t} * \text{Return}_{i,t} + \text{C7}_i * \text{LNT}_{i,t} * \text{Return}_{i,t} + \text{error}_{i,t+1},\end{aligned}$$

where "$\text{SNT}_{i,t}$" ("$\text{MNT}_{i,t}$", "$\text{LNT}_{i,t}$") refers to the number of trades of an individual stock under small (medium, large) trade-size group. Panel A and B report results from the following cross-sectional regressions respectively:

$$\text{C2}_i = a_2 + b_2 * A_i + \text{ERROR}_i;\ \text{C3}_i = a_3 + b_3 * A_i + \text{ERROR}_i;$$
$$\text{C4}_i = a_4 + b_4 * A_i + \text{ERROR}_i,$$

where "A_i" is the proxy of information asymmetry (ordinal transformed bid-ask spread and ordinal transformed market capitalization respectively) and the figures in parentheses are *t*-statistics.

Table 6
Raw bid-ask spread and raw market capitalization as the proxies

Panel A: Bid-ask spread and impact of volume on return autocorrelation: by size
Small trade-size

Dependent variable	a_2	b_2	R^2 (%)	Observations
C2	-0.028732	0.713941	0.297	1067
	(-1.133)	(1.782)		

Medium trade-size

Dependent variable	a_3	b_3	R^2 (%)	Observations
C3	-0.015560	0.132159	0.595	1067
	(-4.695)	(2.524)		

Large trade-size

Dependent variable	a_4	b_4	R^2 (%)	Observations
C4	0.001772	-0.034293	0.126	1067
	(0.946)	(-1.159)		

Panel B: Market capitalization and impact of volume on return autocorrelation: by size
Small trade-size

Dependent variable	a_2	b_2	R^2 (%)	Observations
C2	0.003518	1.106×10^{-12}	0.012	1067
	(0.202)	(0.362)		

Medium trade-size

Dependent variable	a_3	b_3	R^2 (%)	Observations
C3	-0.007918	-1.316×10^{-12}	1.017	1067
	(-3.496)	(-3.309)		

Large trade-size

Dependent variable	a_4	b_4	R^2 (%)	Observations
C4	-0.000617	7.108×10^{-13}	0.934	1067
	(-0.483)	(3.169)		

Table 6 presents results based on the alternative measure of information asymmetry proxies which the raw average daily opening percentage spread and the raw average daily market capitalization of an individual stock is used without ordinal transformation. The coefficients $C2_i$, $C3_i$ and $C4_i$ for both panels are estimated from the following time-series regression:

$$\text{Return}_{i,t+1} = C0_i + C1_i * \text{Return}_{i,t} + C2_i * \text{SVolume}_{i,t} * \text{Return}_{i,t} + C3_i * \text{MVolume}_{i,t} * \text{Return}_{i,t} + C4_i * \text{LVolume}_{i,t} * \text{Return}_{i,t} + \text{error}_{i,t+1},$$

where "$\text{Return}_{i,t}$" is the daily log return of an individual stock. "$\text{Volume}_{i,t}$" is the de-trended daily log turnover of the individual stock and "$\text{SVolume}_{i,t}$" ("$\text{MVolume}_{i,t}$", "$\text{LVolume}_{i,t}$") refers to the de-trended daily log turnover for small (medium, large) trade-size group of an individual stock. Panel A and B report results from the following cross-sectional regressions respectively:

$$C2_i = a_2 + b_2 * RA_i + ERROR_i;\ C3_i = a_3 + b_3 * RA_i + ERROR_i;$$
$$C4_i = a_4 + b_4 * RA_i + ERROR_i,$$

where "RA" is the proxy of information asymmetry (raw bid-ask spread and raw market capitalization) and the figures in parentheses are *t*-statistics.

Table 7
Alternative definition of trade-size

Panel A: Bid-ask spread and impact of volume on return autocorrelation: by size

Small trade-size

Dependent variable	a_2	b_2	R^2 (%)	Observations
C2	-0.006850	0.005915	0.083	1067
	(-1.882)	(0.939)		

Medium trade-size

Dependent variable	a_3	b_3	R^2 (%)	Observations
C3	-0.018016	0.020214	0.813	1067
	(-4.559)	(2.955)		

Large trade-size

Dependent variable	a_4	b_4	R^2 (%)	Observations
C4	0.006327	-0.009100	0.462	1067
	(2.675)	(-2.223)		

Panel B: Market capitalization and impact of volume on return autocorrelation: by size

Small trade-size

Dependent variable	a_2	b_2	R^2 (%)	Observations
C2	-0.001704	-0.004369	0.045	1067
	(-0.468)	(-0.693)		

Medium trade-size

Dependent variable	a_3	b_3	R^2 (%)	Observations
C3	0.001310	-0.018402	0.674	1067
	(0.331)	(-2.688)		

Large trade-size

Dependent variable	a_4	b_4	R^2 (%)	Observations
C4	-0.002215	0.007968	0.354	1067
	(-0.936)	(1.945)		

Table 7 presents results based on the alternative definition of trade-size. Any trades in the lower quartile (25^{th} percentile) of an individual stock are considered as small-size trades; any trades in the upper quartile (75^{th} percentile) of an individual stock are classified as large-size trades; medium-size trades are located within the interquartile range (the difference between upper and lower quartiles). The coefficients $C2_i$, $C3_i$ and $C4_i$ for both panels are estimated from the following time-series regression:

$$\text{Return}_{i,t+1} = C0_i + C1_i * \text{Return}_{i,t} + C2_i * \text{SVolume}_{i,t} * \text{Return}_{i,t} + C3_i * \text{MVolume}_{i,t} * \text{Return}_{i,t} + C4_i * \text{LVolume}_{i,t} * \text{Return}_{i,t} + \text{error}_{i,t+1},$$

where "$\text{Return}_{i,t}$" is the daily log return of an individual stock and "$\text{Volume}_{i,t}$" is daily turnover of the individual stock which has been taken log and de-trended. "$\text{SVolume}_{i,t}$" ("$\text{MVolume}_{i,t}$", "$\text{LVolume}_{i,t}$") refers to the de-trended daily log turnover for small (medium, large) trade-size group of an individual stock. Panel A and B report results from the following cross-sectional regressions respectively:

$$C2_i = a_2 + b_2 * A_i + \text{ERROR}_i \,;\; C3_i = a_3 + b_3 * A_i + \text{ERROR}_i \,;$$
$$C4_i = a_4 + b_4 * A_i + \text{ERROR}_i \,,$$

where "A_i" is the proxy of information asymmetry (ordinal transformed bid-ask spread and ordinal transformed market capitalization respectively) and the figures in parentheses are *t*-statistics.