Trading Volume and Information Asymmetry Surrounding Scheduled and Unscheduled Announcements

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Contents

Abstract

This thesis investigates abnormal trading volume around scheduled and unscheduled announcements. The research is an extension of Chae (2005), Journal of Finance, Vol 60, which tests corporate announcements in the US stock market. In this thesis, Australian stocks are used to establish whether market characteristics affect trading behaviour around announcements. In addition, I extend the traditional methodology to overcome possible shortcomings in the previous studies. This thesis also discusses how information asymmetry affects the abnormal trading volume on the announcement day.

In contrast to earlier studies, I find abnormal trading volume does not change before either scheduled or unscheduled announcements, but, as expected, increases on and after the scheduled and unscheduled announcements. Information asymmetry increases trading volumes when unscheduled announcements are made, but has no effect for scheduled announcements.

I show that the failure to adjust for the correlation between corporate events, results in abnormal trading volumes being detected prior to announcements. Differences between the Australian and US results can not all be explained by methodological differences. It appears that the underlying dynamics of the Australian market are different; casting doubts on the ability to generalize market characteristics from US based studies on abnormal trading volumes.

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Chapter 1

Introduction

Investors' beliefs are not directly observable. But the change of trading volume reflects the differential belief revision. By analyzing trading volume, policymakers and researchers can find useful information for predicting volatility and market order placement strategies of traders. Bamber, Barron and Stober (1997) claim that belief disagreement, which causes trading, has real economic consequences. Kim and Verrecchia (1997) also give similar arguments. Atiase and Bamber (1994) argue that analyzing trading volume helps understand the market's assimilation of information. Investigating trading volume is likely to yield insight into the predisclosure information asymmetry and price reactions. Announcements generate differential belief revisions among investor, and then lead to fluctuations in trading volume. The effect of announcements on trading volume could be very strong as beliefs are revised due to released new information from announcements. In the thesis, therefore, the reactions of trading volume to announcements are examined.

The change in trading volume in response to public announcements has been documented over the last two decades. Until recently, however, there were few empirical studies comparing the change of trading volume between scheduled and unscheduled announcements. This thesis provides some evidence to examine four questions. The first question is: Does abnormal trading volume change differently around scheduled and unscheduled announcements? In contrast to the traditional event study where announcements are assumed independent, the second question is: If the cross-correlation of trading volume across announcements is considered, does the abnormal trading volume change differently around scheduled and unscheduled announcements? The third question is: Are the reactions of trading volume to announcements related to the financial market specific characteristics? The fourth question is: Does information asymmetry affect abnormal trading volume on the announcement date?

Two types of announcement are considered in the thesis, scheduled and unscheduled announcements. In addition, two types of trader are considered, informed and uninformed traders. The scheduled announcements refer to those announcements where the public knows when the announcement will take place in advance. Thus, traders could arrange times of trading in anticipation of the announcement. Unscheduled announcements refer to announcements for which the release time is not publicly known. Hence, traders cannot change the timing of their trades in anticipation of unscheduled announcements. In the thesis, I choose earnings announcements as the scheduled announcement as its release time is known in advance. Asset acquisition, asset disposal, capital and takeover announcements are identified as unscheduled announcements.

A number of papers find that trading volume decreases before scheduled announcements and increases before unscheduled announcements (Chae 2005, and Fabiano 2008). Prior to scheduled announcements trading volumes decrease because uninformed traders delay trading in order to avoid adverse selection costs due to the information asymmetry, as they believe that informed traders have private information. Hence, before scheduled announcements, high trading demand from informed traders would not be met with supply from uninformed investors. Consequently, trading activity slows down during the period before the announcement. This is the hypothesized reason why total trading volume usually decreases before scheduled announcements. After the announcement, uninformed traders increase their trading as the adverse selection problem disappears.

The change in trading volume before unscheduled announcements would mainly depend on the information asymmetry. A high degree of information asymmetry means that informed traders could have much private information relative to uninformed traders. Hence, informed traders trade more with uninformed traders before the unscheduled announcement. After the unscheduled announcement, uninformed traders trade in response to the new information. Thus, trading volume increases before and after unscheduled announcements.

The traditional event study methodology, used to study volumes and returns around announcement dates, treats announcements as independent. This ignores the possibility of clustering of announcements for related firms in the same industry. However, Chordia, Roll and Subrahmanyam (2000) and Hasbrouck and Seppi (2001) find a positive correlation in movements in liquidity for corporate events within industries because of multiple corporate announcements published in the same industry during the event period. From the financial markets, it can be seen that trading volume of one stock could change just due to the change of trading volume of another stock, or new macroeconomic information could lead to contemporaneous change of trading volume of stocks. This implies that the estimation of the response of trading volume to announcements could be different if the cross-correlation is considered. These correlations could have a significant effect on t-values especially when the sample size is large. The adjustment of the t-value to account for the correlation between corporate events could be an important contribution to the literature.

In the thesis, t-values and the conclusion could change significantly as the correlations are considered. I find the abnormal trading volume does not change before scheduled announcements, whether the correlation is considered or not. This may be due to the absence of market makers on the Australian stock market. In contrast to U.S. financial markets where market makers provide a platform for the traders to trade, the Australian Securities Exchange (ASX) is an order-driven market. The difference of financial markets between Australia and U.S. is considered in the thesis. For the change in abnormal trading volume before unscheduled announcements, with no adjustments of t-values for correlation between corporate events, the increase of abnormal trading volume is significant before the announcement. When the adjustments are made, the change of abnormal trading volume is no longer significant. Similarly, the abnormal trading volume shows a significant increase after both the scheduled and unscheduled announcement if no adjustments of t-values are made to correct for the correlation between corporate events. When t-values are adjusted for the correlation, the statistics show that the increase of the abnormal trading volume becomes significant just on the announcement day and the following day.

Information asymmetry plays an important role in determining the volume of trading around announcements. There are a number of proxies used in the literature to measure the degree of information asymmetry. These include company size, the number of analysts, bid–ask spread, industry dummies or the probability of information-based trading (PIN). The bid-ask spread and PIN are two important factors researchers pay attention to. Bid-ask spread reflects the concern of traders on the stock. A larger bid-ask spread reflects a more cautious attitude towards the stock. PIN is derived from a microstructure model. Market makers can notice the existence of information asymmetry by looking at the change of buy and sell orders. This method is used widely in the literature due to its high computing efficiency especially for a large sample of data, and with fewer truncation errors.

In this thesis, using PIN and bid-ask spread to measure the degree of information asymmetry separately, I find that the increase of the abnormal trading volume on the scheduled announcement day is not due to the information asymmetry, but that the information asymmetry could increase the abnormal trading volume on the day of an unscheduled announcement.

Following the introduction, I review the related literature in Chapter 2. Chapter 3 discusses the reactions of trading volume to scheduled and unscheduled announcements. Chapter 4 discusses the effect of information asymmetry, measured by PIN, on trading volumes. Chapter 5 concludes. The appendix containing Tables 13–24 and SAS and

MATLAB code follows and precedes the complete list of references.

Chapter 2

Literature Review

This section contains two main parts. In the first part, the trading volume around scheduled and unscheduled announcements is discussed. Trading volume plays an important role in financial markets. In particular, trading volume around announcements is an important signal for investors to estimate financial risk. In the second part, I discuss the effect of information asymmetry on trading volume. During last two decades, information asymmetry has become an area of increasing importance in the finance literature. The literature shows that information asymmetry has an important effect on trading volume. Information asymmetry is generally shown through two channels: a few people with private information or people with high skills able to understand public information better. Information asymmetry becomes more severe around announcements than at other times.

2.1 Trading Volume and Announcement

Trading volume plays an important role in the financial markets. Investors can discover some valuable information about future price movement by observing volume of trade. Atiase and Bamber (1994) discuss the relationship between volume and price reactions, and find that trading volume (as opposed to returns) is more important to help reveal the market's reaction to accounting disclosures. Later, Bamber and Cheon (1995) find that the relationship between the magnitudes of price and volume reactions is positive but weaker than expected. Consequently, they suggest that trading volume based research has the potential to yield insights beyond those attainable through price-based research (p418). Karpoff (1987) and Gallant, Rossi and Tauchen (1992) arrive at similar conclusions. Blume, Easley, and O'Hara (1994) find that traders perform better in the market when they use trading volume as a measure in their technical analysis. Investors can also lower their risk by watching volume of trade. Lamoureux and Lastrapes (1990) find that traders can catch relevant information to predict future volatility by observing trading volume. Karpoff (1987) and Foster and Viswanathan (1995) find that there is a positive correlation between trading volume and contemporaneous stock return volatility. Traders observe the information contained in trading volume and then change their behavior accordingly. Hence, trading volume reflects investors' behavior or activity, and so it is important to discuss how and why trading volume changes.

The change in trading volume around announcements has been the subject of numerous studies[1] since the 1960s. Generally, they conclude that trading volume increases before unscheduled announcements and decreases before scheduled announcements.

Unscheduled announcements refer to announcements for which the release time is not publicly known. Thus, buyers and sellers would trade normally before an announcement. A number of papers find that trading volume increases dramatically before unscheduled announcements (Hakansson 1977, Bamber 1987, Kim and Verecchia 1991 and 1994, He and Wang 1995, and Chae 2005). This is because unscheduled announcements are not predictable and uninformed investors trade as usual, and may accept trading offers from informed traders who have private information and know the direction of price change. Hence, the total trading volume increases before unscheduled announcements. But uninformed traders may make loss. Spiess and Affleck-Graves (1999) argue that unscheduled announcement does not only have a short-term impact on returns but also long-term

[1] Such as Beaver (1968), Hakansson (1977), Morse (1980), Atiase (1980, 1985), Bamber (1987), Admati and Pfleiderer (1988), Jain (1988), Foster and Viswanathan (1990), Kim and Verecchia (1991, 1994), Wang (1994), He and Wang (1995), Ederington and Lee (1996), Krinsky and Lee (1996), Chordia, Roll, and Subrahmanyam (2001), Dontoh, Ronen and Sarath (2003), Chae (2005), and Saffi (2006).

impacts on performance over an extended period. In this thesis, I choose asset acquisition, asset disposal, capital and takeover announcements as unscheduled announcements. Kim and Verrecchia (1991) and Foster and Viswanathan (1993) discuss the change of the volatility and trading volume following takeover announcements and find that the change differs due to different information the takeover announcements release to traders.

Scheduled announcements are those for which the public knows when the announcement will be made in advance. Hence, traders could arrange to trade in advance of the announcement. There is a large literature[2] concerned with the change of trading volume around scheduled announcements. They find that trading volume decreases before scheduled announcements. Foster and Viswanathan (1990), Krinsky and Lee (1996), Chae (2005), Saffi (2006) find that before scheduled announcements, such as earnings announcements, trading volume decreases due to the presence of an adverse selection problem. Foster and Viswanathan (1990) discuss the adverse selection problem in a securities market with one informed trader and several liquidity traders and finds that trading volume decreases before announcements because uninformed traders tend to delay trading in order to avoid risk. Chae (2005) finds that trading volume decreases prior to scheduled announcements, and then increases after the announcement. The reason is that informed traders could take advantage of uninformed traders because they have private information. Uninformed traders cannot differentiate between informed and uninformed traders and so decrease their trading before scheduled announcements in order to minimize risk. Therefore, before scheduled announcements, trading demand from informed investors would be very high. What uninformed investors can do is to wait until the information is released. Hence, the trading activity slows down during the period before the announcement. Following the announcement, uninformed traders increase their trading as the adverse selection problem disappears.

The rate of decrease in trading volume is greater the closer you get to a scheduled announcement day. Foster and Viswanathan (1994) construct a dynamic model of strate-

[2]See Foster and Viswanathan (1990), Wang (1994), Foster and Viswanathan (1994), He and Wang (1995), Krinsky and Lee (1996), Bamber, Barron and Stober (1997), Chae (2005), and Saffi (2006).

gic trading with two asymmetrically informed traders. They find that before the announcement, the two asymmetrically informed traders trade intensively based on their own information. But as the time to the announcement decreases, the information known to both traders will largely be revealed. Then, the better informed trader will increase trade demand while the less informed trader would delay trading. By analyzing how strategic traders learn about each other's information, Foster and Viswanathan (1994) provide a channel to explain the increase in trading volume far before an announcement, and the decrease of trading volume just prior to an announcement. Similarly, He and Wang (1995) use a dynamic model of stock trading to analyze trading reactions and find trading volume decreases before the scheduled announcement. This is because as the announcement date approaches, most private information becomes publicly known and then trading opportunities for speculators decrease. Therefore, trading volume decreases.

Even though informed traders could take advantage of private information, uninformed traders should decrease trading or widen the bid-ask spread to avoid risk and reduce losses. As Kyle (1985) argues that it is still possible for trading volume to increase before an announcement if the liquidity trading is exogenous and inelastic to price. However, if the liquidity trader has the ability to choose the time of the trade, trading volume can decrease. Kyle (1985), in his dynamic model of efficient price formation, assumes that there is one insider who has access to private information and one uninformed trader who engages in random, noisy trading. If investors who have no special or private information are going to buy or sell a large amount of stock, following Black (1971), Kyle (1985), those investors would like to trade over a long period of time at a relatively constant price. This implies that before the announcement, if the investor could delay their trading, the trading volume will decrease.

To discuss the reactions of trading volume to announcement, in some cases, we also need to analyze traders' actions through psychology. Liang (2003) claims the existence a phenomenon according to which stock prices go up after a positive earnings announcement and go down after a negative earnings announcement. The reason he finds, using empirical study on U.S. stock market, is because of investors' confidence about their private information and the reliability of the earnings information. If investors are overconfident or under confident about their private information, their trading activities could be different.

A number of papers consider the response of market trading to announcements from the point of timing (Ederington and Lee 1996). They examine the impact of information releases on market uncertainty and find that the implied standard deviation from option market falls on Friday and increases on Monday. This is because scheduled news is usually released on weekdays. In contrast, Smith (2000) find that the trade-timing decisions depend on the nature of the budget constraint because the traders who have finite wealth and limited borrowing capacity may have to sell their stocks to reduce losses as bad news is announced.

The change of trading volume around earnings announcements could vary depending on other factors, such as prior beliefs, change in dispersion, belief jumbling, and even some macroeconomic variables. Wang (1994), and Bamber, Barron and Stober (1997) investigate the change of trading volume around earnings announcements through analyzing prior beliefs, change in dispersion and belief jumbling and find that trading volume rises as these three disagreements become greater. Chordia, Roll, and Subrahmanyam (2001) find that the magnitude of the change of trading activities increases before major macroeconomic announcements, and varies during the days of week or around major holidays. Furthermore, they find that trading activities could be affected by some factors, such as interest rates, spreads, market volatility or market movements. The aggregate trading activity could even increase prior to a scheduled announcement of GDP or the unemployment rate. For example, if investors predict high GDP growth or low unemployment, trading activity would go up. This implies that when investors analyze the response of trading volume to announcements, they should not only focus on the firm-level announcements. The macroeconomic variables could also have significant effects.

In addition, firm size is an important factor to affect the reaction of trading volume to announcements. Atiase (1980) argues that investors have less incentive to collect information about smaller firms. Therefore, the smaller the firm, the higher the unexpected trading volume around quarterly earnings announcements will be. This argument is also supported by empirical evidence (Atiase 1985). Similarly, Bamber (1987) finds that pre-announcement trading volume is inversely related to firm size. The reason is that the larger the firm, the more information public is likely to have. Hence, traders would have smaller and quicker reactions to that expected earnings announcement.

In addition, to analyze the reaction of trading volume to announcements, we also need to consider cross-correlation of trading volume across announcements because it may lead to significant bias on the estimation. In a number of prior papers, the authors have assumed that announcements are random events and are not common to the sample firms, or firms are not in the same industry. However, if firms are in the same industry or announcements were made in the same event period, the major events are not independent. Huberman and Halka (1999) find evidence of commonality in liquidity using time series models for quotes and depths for market capitalization weighted portfolios. Edelen and Warner (2001) find that mutual fund flows are highly correlated with returns at a daily level. Chordia, Roll and Subrahmanyam (2000) emphasize the existence of commonality in liquidity, trading volume, bid-ask spreads and inventory cost. Through statistical analysis, Mitchell and Stafford (2000) argue that corporate actions do not happen independently but take place with significant correlation because major corporate events may cluster through time by industry. If we assume independence, it may lead to overestimated test statistics. Hasbrouck and Seppi (2001) discuss the cross-sectional interactions between stocks by analyzing the common factors in the order flows and returns of the 30 stocks in the Dow Jones Industrial Average (DJIA). The concern of correlation is also discussed in Brav (2000) and Khotari and Warner (2005). Therefore, considering the existence of the cross-correlation is quite important in the estimation.

From the above literature survey, it can be seen that in general trading volume increases before unscheduled and decreases before scheduled announcements. Actually, the main difference between scheduled and unscheduled announcements is the disclosure of information. And the main difference between informed and uninformed traders is also about information. Therefore, it can be seen the information asymmetry has significant effects on trading volumes. In the following subsection I review the relevant literature on the effect of information asymmetry on trading volume.

2.2 The Effect of Information Asymmetry on Trading Volume

The effect of information asymmetry on trading volume has been discussed extensively[3]. The main finding is that trading volume may increase or decrease with information asymmetry depending on the conditions. There are numerous articles in which it is claimed that the trading volume increases with information asymmetry. Kim and Verrecchia's (1991) measure information asymmetry as the deviations of the precision of investors' private information from average precision. Atiase and Bamber (1994) find that the magnitude of trading volume reaction to earnings announcements is positively related to the degree of information asymmetry, which they measure using the dispersion and range of analysts' forecasts. They assume that all investors have equal access to public information, and that some investors get private information. Hence, investors are asymmetrically informed and thus form different expectations on the stocks. This induces trading as different investors need to revise their expectations as the annual earnings are announced. Similarly, Bamber and Cheon (1995) find the same result as Atiase and Bamber (1994) using quarterly earnings announcements. Barron, Harris, and Stanford (2005), using empirical evidence on the analysts' belief revisions, confirm Kim and Verrecchia's (1991)

[3]Such as Black (1971), Jaffe and Winkler (1976), Copeland and Galai (1983), Kyle (1985), Glosten and Milgrom (1985), Venkatesh and Chiang (1986), Holthausen and Verrecchia (1990), Kim and Verrecchia (1991), Atiase and Bamber (1994), Bamber and Cheon (1995), Easley, Kiefer and O'Hara (1996), Easley, Kiefer, O'Hara and Paperman (1996), Easley, O'Hara and Paperman (1998), Easley, Engle, O'Hara and Wu (2001) and Easley, Hvidkjaer and O'Hara (2002), Liang (2003), Chae (2005), Barron, Harris, and Stanford (2005), and Li and McNally (2007).

theoretical models that private information is positively correlated with greater trading volume at the time of an earnings announcement. More private information is acquired by analysts from the announcement so that the trading volume may increase as a result of the decrease of consensus about the informational content of the announcement.

However, Levin (2001) revisits Akerlof's (1970) classic adverse-selection model and finds that whether the trading volume increases or decreases with the degree of information asymmetry depends on whether the better information is on buyer's side or seller's side. If the seller has better information, buyers will be worse off and then decrease demand. Then, seller's equilibrium supply would decline due to the decrease of demand. In contrast, if the buyer has better information then the trading volume will increase. This is because sellers wouldn't sell their stocks at a price they are not happy with and make loss, while buyers could also earn profit with better information. Therefore, for the whole market, whether trading volume increases or decreases with the degree of information asymmetry depends on the relative sizes of these two effects.

To analyze the response of the trading volume to information asymmetry, we need to consider factors such as the traders' preferences, risk aversion, and the ability of traders to detect or anticipate private information (Jaffe and Winkler 1976, Copeland and Galai 1983, Glosten and Milgrom 1985, and Venkatesh and Chiang 1986). Among these, the difference in the ability of investors to detect private information is important relative to the other factors. This is because no uninformed traders want to be taken advantage of by informed traders. Thus, if the uninformed trader can detect private information, they can widen the bid-ask spread to help them to reduce the risk. The ability to anticipate the information asymmetry varies among informed traders. Hence, there is still pre-announcement trading by uninformed traders who are unable to the detect information asymmetry.

In addition, by considering transaction costs, George, Kaul and Nimalendran (1994) model a market maker based market and find that trading volume is indirectly and ambiguously related to the degree of information asymmetry. Informed traders trade for profit while liquidity traders trade for rebalancing portfolios. If transactions cost are high, both will decrease their trading regardless of the degree of information asymmetry. However, if transaction costs decrease, adverse selection problems may affect the liquidity traders' trading behavior. In this case, the correlation between trading volume and information asymmetry depends on whether liquidity trading decreases with transaction costs at an increasing or decreasing rate. If liquidity traders decrease their trading at a decreasing rate, then the correlation is positive because they would not deter much of trading as the bid-ask spread increases due to adverse selection. Otherwise, the correlation is negative. George, Kaul and Nimalendran (1994) find that the correlation is negative because liquidity traders decrease their trading at an increasing rate with increasing transaction costs. This is because the more the liquidity traders trade, the greater the degree of information asymmetry and hence the ask-bid spread decreases. Consequently, the correlation is negative in a market with high transaction cost.

Most of the above literature is based on empirical tests of data from the American stock markets. For my thesis I test whether we obtain similar results using data from the Australian stock market. Australian stock market is order-driven, with no market maker. This may lead to different market behavior because market makers could notice information asymmetry sensitively and then increase the bid-ask spread to avoid risk. When market maker is absent, a certain level of information asymmetry may not be noticed by uninformed traders. From the literature, we find that trading volume decreases before scheduled announcements and increases before unscheduled announcements. However, based on Australian stock market, my hypotheses are as follows:

Hypothesis 1: abnormal trading volume does not change before scheduled announcements, but does increase after the announcement. The difference between my hypothesis and literature is mainly due to the absence of market markers who are very sensitive to the information asymmetry. Without market makers, traders with different ability, knowledge or perception, would keep trading so that trading volume does not change significantly. In addition, considering cross-correlation also helps to explain the insignificant change of trading volume before scheduled announcements.

Hypothesis 2: abnormal trading volume does not change before unscheduled announcements, but does increase after the announcements. This is not consistent with Chae (2005) who finds trading volume increases dramatically before unscheduled announcements. In contrast, it is consistent with Schaik and Steenbeekb (2004) who find that trading volume does not increase until the actual announcement day, and remains high until three days after the merger announcement in the Japanese financial market. They explain that this result could be that the result of realized trading profit on limited trading activities is delayed as little information is leaked before the announcements. The small change of PIN between the before and after announcement periods shows little information leakage. Most of investors do not have private information and trade as usual before the unscheduled announcement. A significant level of cross-correlation, which leads to decreasing t-values dramatically, shows the existence of correlations among corporate events.

Hypothesis 3: the size of the abnormal trading volume after scheduled announcements is less than after unscheduled announcements. This is consistent with Chae (2005) in which he finds the level of abnormal trading volume is much lower before scheduled announcements than before unscheduled announcements. This is because some investors have completed trading before scheduled announcements based on their analysis of the firm's historical performance or published information. They trade after the scheduled announcement as a result of surprise at the information contained in the announcement.

Hypothesis 4: the increase of the abnormal trading volume on the scheduled announcement days is not due to the information asymmetry. This is because when the scheduled announcement is published, trading volume increases as investors rebalance their portfolios for the surprise of their expectations and different opinions among different investors.

Hypothesis 5: a greater information asymmetry leads to abnormal trading volume on the date of unscheduled announcements. This is because information asymmetry could also be explained by the differences of understanding public information due to differences of ability or knowledge. The higher the information asymmetry, the higher demand from high skilled traders will be. Hence, trading volume increases abnormally.

Chapter 3

Trading Volume around Scheduled and Unscheduled Announcements

In this section, I use an event study methodology to test the reaction of trading volume to scheduled and unscheduled announcements. All data are from the SIRCA from 1994 to 2007. All stocks are ordinary common stocks listed on the Australian Securities Exchange (ASX). One reason to choose ASX as the sample market for the thesis is that ASX is the largest stock exchange in the Oceania with 2,225 listed companies and a total market value of approximately US$1.45 trillion. Another important reason is that ASX is an order-driven market which is significantly different from US financial markets, which are the focus of most studies. Studying the reaction of trading volume to announcements on the ASX could shed light on the literature and could lead to further research on market characteristics.

3.1 Data

There are five types of corporate announcement used in the thesis: earnings, asset acquisition, asset disposal, capital, and takeover announcements. These announcements have important effects on trading volumes and returns. I choose earnings announcements as a proxy for scheduled announcements because the release date is publicly known in advance. I choose asset acquisition, asset disposal, capital and takeover announcements as proxies for unscheduled announcements because announcements are not predefined and release time is not publicly known in advance.

Trading volume is the sum of all individual investors' trades (Kim and Verrecchia 1991). Trading volumes and outstanding shares are collected from SIRCA, which are in the document of ASX daily data. The sample data are from 1994 to 2007. The sample comprises all ordinary common stock listed on the ASX.

Quarterly earnings, asset acquisition, asset disposal, capital and takeover announcements are collected from SIRCA. From 1994 to 2007, there are 32,123 earnings announcements, 16,681 asset acquisition, 6,781 asset disposal announcements, 10,333 capital announcements and 1,707 takeover announcements. The data are filtered twice. First, the announcements are matched with the company which has trading volume data in SIRCA. The number of announcements satisfying this condition is 31,294 earnings announcements, 16,298 asset acquisition, 6,681 asset disposal announcements, 10,233 capital announcements and 1,661 takeover announcements. Second, to avoid the contemporary effects across different kinds of announcements which are announced by a firm on the same announcement day, I filter announcements where there is more than one announcement of a company on the same day, leaving just those announcements which are announced by each company without other kinds of announcements published in the same day. The final list of events used is shown in Table 1.

Asset acquisition and asset disposal are discussed separately because they have different effects on the stock price and trading volume. I choose capital announcements which are related to the capital placement and reconstruction because they are important for analyzing the stock price and trading volume in the market.

Table 1: Numbers of the Announcements

This table shows the total number of announcements and the number of announcements after filter. All the announcements are collected from SIRCA database from 1994 to 2007. No. of announcements after filter which is filted for only one announcement of each firm on the announcement day.

ASX	Earnings	Asset acquisition	Asset Disposal	Capital	Takeover
No. of announcements before filter	31,294	16,298	6,681	10,233	1,661
No. of announcements after filter	12,765	11,146	5,219	5,430	1,353

The second row shows the total number of announcements from 1994 to 2007 after matching with trading volume data in SIRCA. The third row shows the total number of announcements which are the only an announcement made by that company on that day.

3.2 Methodology

In the thesis, I use an event study to test the reaction of trading volume to announcements. The event study is an important research tool in economics and finance. Researchers use event studies to measure the effects of economic events on the value of firms by examining security prices surrounding the event. Llorente, Michaely, Saar and Wang (2002) and Chae (2005) use an event study to measure the trading volume change around announcements. Raw volume turnover of each stock is the ratio of the trading volume to the number of outstanding shares. It corrects for the number of outstanding shares because of the company size effect. Less trading volumes of small companies does not mean the relative trading activity is less. Using this ratio can provide a stronger interpretation of the results.

Table 2: Summary Statistics

This table shows the summary statistics of the sample period and sub-period. Raw daily volume turnover is daily trading volume divided by outstanding shares. Log volume turnover is logarithm of daily volume turnover. Log daily modified volume turnover is logarithm of daily volume turnover plus a constant number 0.00000255.

Daily Volume Turnover					
Period	Mean	Median	SD	Skewness	Kurtosis
1994 – 2007	0.001825	0.000388	0.016128	550.58	474314.90
1994 – 1998	0.001206	0.000196	0.015520	951.74	1019977.87
1999 – 2002	0.001936	0.000366	0.021638	387.76	214862.50
2003 – 2007	0.002206	0.000619	0.010826	120.73	34109.88

Log Daily Volume Turnover					
Period	Mean	Median	SD	Skewness	Kurtosis
1994 – 2007	-7.178204	-7.023115	1.666278	-0.676300	1.789380
1994 – 1998	-7.475135	-7.324332	1.671110	-0.702745	1.858378
1999 – 2002	-7.207459	-7.076900	1.680006	-0.614909	1.868314
2003 – 2007	-6.969966	-6.794787	1.623129	-0.718815	1.788143

Log Daily Modified Volume Turnover					
Period	Mean	Median	SD	Skewness	Kurtosis
1994 – 2007	-9.358041	-8.487349	3.057030	-0.027165	-1.565130
1994 – 1998	-10.363368	-12.879417	2.919292	0.504941	-1.383893
1999 – 2002	-9.142524	-8.197616	3.006511	-0.141619	-1.465206
2003 – 2007	-8.515243	-7.509173	2.941022	-0.470118	-1.200722

From Table 2 it can be seen that the mean of daily raw volume turnover is 0.1825% of shares outstanding for the whole sample period from 1994 to 2007. The sub-period daily raw volume turnover increases from one period to the next. For example, the mean of daily raw volume turnover for period from 1994 to 1998 is 0.1206% of the shares outstanding. This increases to 0.1936% of shares outstanding and 0.2206% of shares outstanding in period 1999–2002 and 2003–2007. The ASX stock market trade increased from 1994 as GDP per capita in Australia increased[4].

However, the raw volume turnover has a very fat tail (474314.90 kurtosis) and extreme positive skewness (550.58). The raw volume turnover follows a non-normal distribution. However, the assumption of this research is normality. As discussed by Ajinkya

[4]Australia GDP per capita can be found from Australian Bureau of Statistics website.

and Jain (1989), I apply the log function to transformal non-normal distribution to normal. Thus the daily log volume turnover $\tau_{i,t}$ is defined:

$$\tau_{i,t}(\textit{unmodified}) = Log\left(\frac{\textit{Trading Volume}_{i,t}}{\textit{Outstanding}_{i,t}}\right). \tag{1}$$

Trading Volume$_{i,t}$ is the number of shares traded each date for each company listed in ASX. Outstanding$_{i,t}$ is the number of outstanding shares each date for each company. After the transformation, the skewness and kurtosis are -0.676300 and 1.789380, respectively. The daily log volume turnover is close to normally distributed.

A shortcoming of this method is that if a company's trading volume is zero, log of zero in the above logarithm transformation is treated as a missing value in SAS. This will lead to some stocks being excluded. In order to avoid such bias, I use the technique employed by as Llorente, Michaely, Saar and Wang (2002), and add a small constant (0.00000255) to the volume turnover to the companies which have no trading when market is opening. From the Table 2, we can see the distribution of log daily volume turnover is closer to normal distribution after adding the constant[5]. The skewness and kurtosis are -0.027165 and -1.565130, respectively. This method leads to an increase of about 30% in the sample size for earnings announcement and about 20% for asset acquisition as some illiquid stocks are included. Equation (1) becomes

$$\tau_{i,t}(\textit{modified}) = Log\left(0.00000255 + \frac{\textit{Trading Volume}_{i,t}}{\textit{Outstanding}_{i,t}}\right). \tag{2}$$

For each announcement, the volume turnover is measured from 40 days before to 10 days after the announcement. To compare with Chae (2005), I choose the estimation period from $t = -40$ to $t = -11$, 30 days (one month) as a benchmark estimation period. The event period is from $t = -10$ to $t = +10$ days. The log abnormal trading volume turnover, $\xi_{i,t}$, is defined as the difference between the observed log volume turnover and

[5]See Richardson, Sefcik, and Thompson (1986), Ajinkya and Jain (1989), and Cread and Ramanan (1991) for how to choose the value of constant number.

the estimated average log volume turnover, $\tau_{i,t}$, as follows

(3) $$\xi_{i,t} \equiv \tau_{i,t} - \bar{\tau}_i,$$

where $\bar{\tau}_i = \frac{\sum_{t=-40}^{t=-11} \tau_{i,t}}{30}$.

In this thesis, first, following the previous literature, I estimate the reaction of trading volume to announcements assuming that corporate announcements are random events. But actually, there are correlations across announcements. There are two reasons to explain the existence of cross-correlation of abnormal trading volume across announcements.

The first reason is that trading volume of one stock could change just due to the change of trading volume of another stock. For example, traders buy stock A due to its positive announcement and sell stock B not because of its negative announcement but rebalancing portfolio. Many traders buy stock A while selling other stocks in order to keep portfolio balanced. Consequently, trading volume of stock A increases significantly and trading volume of other stocks increases a little bit. In the thesis, I consider the response of trading volume to announcements, defined as the change of trading volume of a stock due to its own announcement. Therefore, the increase of trading volume of other stocks due to the increase of trading volume of stock A should not be included in the estimation. That is why we need to consider the cross-correlation of abnormal trading volume across announcements in order to reduce the bias of estimation.

The second reason to consider cross-correlation is that macroeconomic information could lead to contemporary change of trading volume of stocks. As important macroeconomic information, such as the interest rate, the unemployment rate, the inflation rate and so on, is released; a number of stocks could be traded intensively and contemporaneously. This leads to cross-correlation across stocks. For example, if OPEC announces that they will reduce output of oil it is expected that oil price will increase. Then, stocks of energy consuming companies will be expected to decrease as their costs will increase. In contrast, stocks of hybrid energy or green energy producing companies will increase. Consequently, trading volume of energy relevant stocks will increase due to this macroeconomic information which is a common factor leading to significant co-movements of trading volume. That is why the correlation of cross-correlation of abnormal trading volume should be considered, because it biases the estimation of the response of trading volume to announcements.

Mitchell and Stafford (2000) find that t-statistics fall from over 6.0 to less than 1.5 after considering commonality among major events for long term stock price performance. Khotari and Warner (2005) review a number of papers in order to solve the contemporaneous correlation problem and find that even a very small amount of cross-correlation in data could lead to serious misspecification of the test.

They claim that major corporate actions are not independent, but instead are correlated with each other, and especially by industry. For example, when a firm releases an important announcement, other firms in that industry would evaluate that announcement and may take steps to keep their market share or reduce potential risks. Then, we can see a positive correlation among the major events. It then could lead commonality in abnormal trading turnover across events. Moreover, this dependence problem increases with sample size. The dependence concern is also addressed in Brav (2000). Although the correlation could be very small, it could have significant effects on significance tests, especially when the sample size is large. I transform the formula of standard deviation in Mitchell and Stafford (2000) to calculate the t-value of dependent sample by adjusted t-value of independent sample in which there are no correlations between events. This is done as follows

$$t_{(dependence)} = \frac{t_{(independence)}}{\sqrt{1 + (N-1)\overline{\rho}_{i,j}}}, \tag{4}$$

where $t_{(dependence)}$ is the t-value of the dependent sample with which the corporate announcement is correlated, $t_{(independence)}$ is the t-value of the independent sample which the corporate announcement is random, N is the number of events, $\overline{\rho}_{i,j}$ is the average correlation between individual log abnormal volume turnover.

From the above equation, it can be seen if the sample size N is large, a small average correlation $\overline{\rho}_{i,j}$ could affect the t-value significantly. If we do not consider the correlation cross the events, t-value could be overestimated.

3.3 Description and Discussion of Empirical Results

In this section I discuss the empirical results and test hypotheses 1 to 3. First, I show the change in cross-sectional average log abnormal volume turnover around scheduled announcements. Second, I describe the change of cross-sectional average log abnormal volume turnover around unscheduled announcements. Finally, I discuss the cross-sectional average log abnormal volume turnover and cumulative log abnormal volume turnover ($t = -10$ to $t = +10$) around scheduled and unscheduled announcements.

3.3.1 Volume around scheduled announcements

The cross-sectional average log abnormal volume turnover ($t = -10$ to $t = +10$) for earnings announcements is shown in Table 3. Using (1) and (3), the left of Table 3 shows the mean of abnormal volume turnover. The mean of the abnormal volume turnover on the right of the table is calculated using (2) and (3) for the modified data. The modified data is the actual turnover data plus 0.00000255. Hence, the sample size in for modified data is larger, as some companies which have less trading activity are included. I use 21 log abnormal volume turnovers during the event period ($t = -10$ to $t = +10$) to calculate the correlation coefficients across scheduled announcements. These are shown in second column of the Table 4. The correlation between the earnings announcements for the actual data is 0.001304. The correlation between the earnings announcements for the modified data is 0.000886. The adjusted t-value is the t-value adjusted for the correlation between these events for the dependent sample which are calculated using (4), between events within a same industry in the certain time. The small positive correlation coefficient across events has a significant effect on the t-values.

Table 3: Daily Abnormal Turnover around Earnings Announcement

This table shows the mean of abnormal volume turnover for earnings announcement from ordinary common stock listed in the ASX from 1994 to 2007. Volume turnover is trading volume divided by outstanding shares. Log abnormal volume turnover is the difference between observed log volume turnover and the average log volume turnover estimated from t = -40 to t = -11. The t-value is the t-value of independent corporate announcements and I assume these events occur randomly. The adjusted t-value is the t-value of dependent corporate announcements. The t-test and adjusted t-value are used to test whether the mean is significantly different from zero or not.

	Unmodified data				Modified data			
Event day	N	Mean	t-value	adjusted t-value	N	Mean	t-value	adjusted t-value
-10	8,345	0.0176	1.35	0.32	12,765	-0.0027	-0.14	-0.04
-9	8,381	0.0084	0.61	0.15	12,765	0.0156	0.79	0.23
-8	8,340	0.0096	0.69	0.16	12,765	-0.0109	-0.54	-0.15
-7	8,380	0.0256	1.85*	0.44	12,765	0.0082	0.41	0.12
-6	8,386	0.0175	1.25	0.30	12,765	0.0054	0.27	0.08
-5	8,302	0.0060	0.43	0.10	12,765	0.0045	0.22	0.06
-4	7,953	0.0140	0.96	0.23	12,765	-0.0098	-0.47	-0.13
-3	7,681	-0.0070	-0.46	-0.11	12,765	-0.0492	-2.27**	-0.65
-2	8,290	0.0199	1.38	0.33	12,765	0.0263	1.27	0.36
-1	8,426	0.0587	4.22***	1.00	12,765	0.0584	2.86***	0.82
0	8,794	0.1221	8.80***	2.10**	12,765	0.1577	7.93***	2.26**
1	8,404	0.1371	9.61***	2.29**	12,765	0.0416	1.92	0.55
2	8,430	0.0730	5.01***	1.19	12,765	0.0474	2.26**	0.64
3	8,539	0.0288	2.02**	0.48	12,765	0.0316	1.53	0.44
4	8,534	0.0493	3.50***	0.83	12,765	0.0376	1.83*	0.52
5	8,444	0.0627	4.38***	1.04	12,765	-0.0116	-0.55	-0.16
6	8,589	0.0457	3.20***	0.76	12,765	0.0370	1.77*	0.50
7	8,507	0.0152	1.06	0.25	12,765	-0.0311	-1.49	-0.42
8	8,560	-0.0002	-0.01	-0.002	12,765	-0.0134	-0.64	-0.18
9	8,613	0.0244	1.70*	0.40	12,765	0.0249	1.18	0.34
10	8,626	0.0267	1.85*	0.44	12,765	0.0312	1.51	0.43

Note: ***, **,* indicate p-value significant at 1%, 5% and 10% level.

From the above table, it can be seen that most of the t-values are not significant for either the unadjusted or adjusted data before the announcement. This means that trading volume does not change before earnings announcements. The exception is the day immediately prior to the earnings announcement, in which case the trading volume begins to increase if we do not consider the correlation across the events. This could be due to information leakage. Morse (1981) finds significant price changes and the excess trading volume one day before WSJ announcements. From day -1 to day 6, trading volume increases significantly if the t-values are not adjusted for the correlation. However, there is some bias in the unadjusted t-values. Commonality in liquidity could cause co-movement in trading volume of each stock. After the t-values are adjusted, it can be seen that the increase of trading volume is significant only in days 0 and 1. This means that trading volume does not change significantly before the announcement. In the other words, earnings announcements have an effect on the trading volume only on the announcement day and the following day. This is not consistent with the literature. For example, Krinsky and Lee (1996), Chae (2005), and Saffi (2006) find that before scheduled announcements, such as earnings announcements, trading volume decreases due to the presence of an adverse selection problem. A possible explanation for this contradiction could be due to less information leakage, or the absence of market maker activity in the Australian Market. The absence of market maker could lead to a certain level of information asymmetry that may not be detected by uninformed traders. The uninformed traders may not delay their trading if they cannot detect the information asymmetry. Another reason is that despite decreasing trading volume due to the presence of an adverse selection problem, trading volume could also increase due to traders revising beliefs differentially, leading investors to rebalance their portfolios before the announcement. We cannot determine which effect is more powerful. Thus we cannot predict whether the log abnormal volume turnover will increase or decrease. When the announcement is made, investors trade based on their surprise at the true announcement. In addition, different investors have different opinions about the announcement. These surprises of expectations and different opinions will lead to an increase in trading volume on the day of the announcement and the following days.

I add a small number to the volume turnover for the companies which have no trading on some days when the market is opening in order to reduce bias. The sample sizes in column 6 larger than those in column 2. I obtain similar results to those for the actual data; the earnings announcement only has an effect on trading volume on the announcement day. This confirms the conclusion that abnormal trading volume does not change before scheduled announcements, and increases on and after scheduled announcements.

Table 4:Correlation for Adjust t-statistics

This table shows the average correlation of each corporate event for five announcements. I use 21 days of event period for individual event to calculate the correlation. The number of unique correlations is n(n-1)/2. N is the number of sample events. There are five types of corporate announcement: earnings, asset acquisition, asset disposal, capital and takeover announcements. For the panel A, I use unmodified turnover, it means some turnovers are 0 for the stock does not trade while the market is opening. For the Panel B, I use modified data, it means I plus a constant number 0.00000255 to the actual turnover.

Announcements	Earnings	Asset acquisition	Asset Disposal	Capital	Takeover
		Panel A: Using Unmodified Turnover			
Correlation	0.001304	0.005155	0.004111	0.010239	0.079219
		Panel B: Using Modified Turnover			
Correlation	0.000886	0.003925	0.002891	0.006356	0.062348

3.3.2 Trading Volume around unscheduled announcements

After discussing the changing in trading volume before and after scheduled announcements, the following four Tables show the change in average abnormal trading volume in response to unscheduled announcements. I show the cross-sectional average log abnormal volume turnover ($t = -10$ to $t = +10$) for asset acquisition announcements in Table 5, asset disposal announcements in Table 6, capital announcements in Table 7, and takeover announcements in Table 8. Using (1) and (3), the mean of abnormal volume turnover is calculated from the actual data and shown on the left of each table. Using (2) and (3), the mean abnormal volume turnover, calculated from the modified data, is shown on the right of each table. I use 21 log abnormal volume turnovers during the event period ($t = -10$ to $t = +10$) to calculate the correlation coefficient across each unscheduled announcements, and these are shown in Table 4. These correlation coefficients across events are small and positive. However, it has significant effects on tests for significance. I show the adjusted t-values in columns 5 and 9 of each table.

Table 5: Daily Abnormal Turnover around Asset Acquisition Announcement

This table shows the mean of abnormal volume turnover for asset acquisition announcement from ordinary common stock listed in the ASX from 1994 to 2007. Volume turnover is trading volume divided by outstanding shares. Log abnormal volume turnover is the difference between observed log volume turnover and the average log volume turnover estimated from t = -40 to t = -11. The t-value is the t-value of independent corporate announcements and I assume these events occur randomly. The adjusted t-value is the t-value of dependent corporate announcements. The t-test and adjusted t-value are used to test whether the mean is significantly different from zero or not.

	Unmodified data				Modified data			
Event day	N	Mean	t-value	adjusted t-value	N	Mean	t-value	adjusted t-value
-10	9,059	0.0322	2.72***	0.36	11,146	0.0731	4.24***	0.63
-9	9,094	0.0230	1.93*	0.25	11,146	0.0800	4.58***	0.68
-8	8,995	0.0175	1.45	0.19	11,146	0.0461	2.66***	0.40
-7	9,062	0.0110	0.91	0.12	11,146	0.0513	2.92***	0.44
-6	8,993	0.0526	4.26***	0.56	11,146	0.0755	4.21***	0.63
-5	8,984	0.0421	3.43***	0.45	11,146	0.0562	3.10***	0.46
-4	8,984	0.0537	4.42***	0.58	11,146	0.0522	2.88***	0.43
-3	9,005	0.0672	5.45***	0.71	11,146	0.0753	4.11***	0.61
-2	8,998	0.0621	4.90***	0.64	11,146	0.0635	3.39***	0.51
-1	8,923	0.1264	10.05***	1.31	11,146	0.0760	3.91***	0.58
0	9,328	0.3105	23.53***	3.08***	11,146	0.3418	17.14***	2.56***
1	9,253	0.2987	23.04***	3.01***	11,146	0.3827	19.56***	2.92***
2	9,068	0.2004	15.66***	2.05**	11,146	0.2755	14.21***	2.12**
3	8,952	0.1322	10.18***	1.33	11,146	0.2004	10.43***	1.56
4	8,967	0.1164	9.09***	1.19	11,146	0.1612	8.31***	1.24
5	8,944	0.0882	6.83***	0.89	11,146	0.1392	7.26***	1.09
6	8,901	0.0723	5.65***	0.74	11,146	0.1235	6.54***	0.98
7	8,839	0.0381	2.91***	0.38	11,146	0.0735	3.81***	0.57
8	8,858	0.0282	2.15**	0.28	11,146	0.0584	3.06***	0.46
9	8,835	0.0349	2.65***	0.35	11,146	0.0699	3.62***	0.54
10	8,858	0.0272	2.08**	0.27	11,146	0.0811	4.29***	0.64

Note: ***, **,* indicate p-value significant at 1%, 5% and 10% level.

From the above Table, it can be seen that the estimation results for the unmodified and modified data are not significantly different. In contrast, by comparing unadjusted t-values with adjusted t-values, we can see that most of the increase in trading volume before and after asset acquisition announcements is significant if announcements are assumed independent. However, if we consider the correlation across announcements, only the increase of trading volume on and after announcement up to two days is significant. From that, we can say that if we do not consider cross-correlation, it leads to overestimated test statistics. It implies that the assumption of the distribution of announcements may have significant effects on the estimation results.

Table 6: Daily Abnormal Turnover around Asset Disposal Announcement

This table shows the mean of abnormal volume turnover for asset disposal announcement from ordinary common stock listed in the ASX from 1994 to 2007. Volume turnover is trading volume divided by outstanding shares. Log abnormal volume turnover is the difference between observed log volume turnover and the average log volume turnover estimated from t = -40 to t = -11. The t-value is the t-value of independent corporate announcements and I assume these events occur randomly. The adjusted t-value is the t-value of dependent corporate announcements. The t-test and adjusted t-value are used to test whether the mean is significantly different from zero or not.

	Unmodified data				Modified data			
Event day	N	Mean	t-value	adjusted t-value	N	Mean	t-value	adjusted t-value
-10	4,054	0.0666	3.86***	0.81	5,219	0.0745	3.03***	0.76
-9	4,038	0.0650	3.70***	0.78	5,219	0.0488	1.93*	0.48
-8	4,049	0.0631	3.52***	0.74	5,219	0.0635	2.56***	0.64
-7	4,026	0.0617	3.38***	0.71	5,219	0.0537	2.18**	0.54
-6	4,004	0.0283	1.47	0.31	5,219	0.0167	0.66	0.16
-5	4,036	0.0567	3.14***	0.66	5,219	0.0514	2.01**	0.50
-4	4,022	0.0362	1.94*	0.41	5,219	0.0366	1.40	0.35
-3	4,023	0.0746	4.13***	0.87	5,219	0.0459	1.74*	0.43
-2	4,019	0.0902	4.95***	1.04	5,219	0.0661	2.48**	0.62
-1	4,026	0.1201	6.24***	1.32	5,219	0.0941	3.39***	0.85
0	4,232	0.2985	14.63***	3.09***	5,219	0.3466	12.34***	3.08***
1	4,118	0.2941	14.90***	3.14***	5,219	0.3537	12.63***	3.15***
2	4,035	0.1703	8.69***	1.83*	5,219	0.2112	7.76***	1.93**
3	4,005	0.1127	5.78***	1.22	5,219	0.1210	4.44***	1.11
4	4,001	0.1047	5.49***	1.16	5,219	0.1265	4.73***	1.18
5	4,029	0.0951	5.00***	1.06	5,219	0.1136	4.24***	1.06
6	4,004	0.1105	5.77***	1.22	5,219	0.1215	4.52***	1.13
7	3,973	0.0774	3.99***	0.84	5,219	0.0728	2.73***	0.68
8	3,985	0.0665	3.48***	0.73	5,219	0.0785	2.96***	0.74
9	3,951	0.0612	3.13***	0.66	5,219	0.0306	1.13	0.28
10	3,992	0.0583	3.09***	0.65	5,219	0.0760	2.91***	0.73

Note: ***, **,* indicate p-value significant at 1%, 5% and 10% level.

Similar with Table 5, the above Table shows that the estimation results between using unmodified and modified data do not change much but most of the increase of trading volume before and after asset disposal announcement is significant if announcements are assumed independent. In contrast, if we consider the correlation across announcements, only the increase in trading volume on and after announcement for up to two days is significant. These give a similar conclusion to the one arrived at in Table 5, that the test statistics could be overestimated if the cross-correlation is not considered and the assumption of the distribution of announcements may have significant effects on the estimation results.

Table 7: Daily Abnormal Turnover around Capital Announcement

This table shows the mean of abnormal volume turnover for capital announcement from ordinary common stock listed in the ASX from 1994 to 2007. Volume turnover is trading volume divided by outstanding shares. Log abnormal volume turnover is the difference between observed log volume turnover and the average log volume turnover estimated from t = -40 to t = -11. The t-value is the t-value of independent corporate announcements and I assume these events occur randomly. The adjusted t-value is the t-value of dependent corporate announcements. The t-test and adjusted t-value are used to test whether the mean is significantly different from zero or not.

	Unmodified data				Modified data			
Event day	N	Mean	t-value	adjusted t-value	N	Mean	t-value	adjusted t-value
-10	3,796	0.0822	4.14***	0.55	5,430	0.1320	4.13***	0.69
-9	3,794	0.0734	3.66***	0.49	5,430	0.1117	3.55***	0.60
-8	3,792	0.1244	6.02***	0.80	5,430	0.1374	4.21***	0.71
-7	3,841	0.0936	4.48***	0.60	5,430	0.1743	5.35***	0.90
-6	3,865	0.1499	7.26***	0.97	5,430	0.2461	7.51***	1.26
-5	3,844	0.1702	8.09***	1.08	5,430	0.2310	7.05***	1.18
-4	3,836	0.1504	6.83***	0.91	5,430	0.2032	5.92***	0.99
-3	3,855	0.2011	9.07***	1.21	5,430	0.2675	7.72***	1.30
-2	3,777	0.2497	11.50***	1.53	5,430	0.2075	5.67***	0.95
-1	3,728	0.2955	13.07***	1.74*	5,430	0.1507	3.93***	0.66
0	4,000	0.5521	25.17***	3.35***	5,430	0.6288	17.43***	2.93***
1	3,965	0.4893	21.92***	2.91***	5,430	0.6790	19.31***	3.24***
2	3,883	0.3433	14.95***	1.99**	5,430	0.5102	14.50***	2.43**
3	3,895	0.2739	12.03***	1.60	5,430	0.4670	13.20***	2.22**
4	3,915	0.2810	12.52***	1.66*	5,430	0.4806	13.63***	2.29**
5	3,891	0.2923	13.25***	1.76*	5,430	0.4408	12.47***	2.09**
6	3,915	0.2516	11.32***	1.50	5,430	0.4555	13.24***	2.22**
7	3,858	0.2186	9.78***	1.30	5,430	0.3719	10.63***	1.78**
8	3,876	0.2059	9.29***	1.23	5,430	0.3858	11.19***	1.88**
9	3,829	0.2204	9.95***	1.32	5,430	0.3529	10.04***	1.68*
10	3,834	0.1926	8.57***	1.14	5,430	0.3281	9.33***	1.57

Note: ***, **,* indicate p-value significant at 1%, 5% and 10% level.

Similar with Table 5 and 6, by analyzing daily abnormal turnover around capital announcements, we can get the same conclusion from the above Table that the test statistics could be overestimated if the cross-correlation is not considered and the assumption of the distribution of announcements may have significant effects on the estimation results.

Table 8: Daily Abnormal Turnover around Takeover Announcement

This table shows the mean of abnormal volume turnover for takeover announcement from ordinary common stock listed in the ASX from 1994 to 2007. Volume turnover is trading volume divided by outstanding shares. Log abnormal volume turnover is the difference between observed log volume turnover and the average log volume turnover estimated from t = -40 to t = -11. The t-value is the t-value of independent corporate announcements and I assume these events occur randomly. The adjusted t-value is the t-value of dependent corporate announcements. The t-test and adjusted t-value are used to test whether the mean is significantly different from zero or not.

	Unmodified data				Modified data			
Event day	N	Mean	t-value	adjusted t-value	N	Mean	t-value	adjusted t-value
-10	913	0.0770	2.03**	0.20	1,353	0.0990	1.96**	0.21
-9	919	0.0350	0.92	0.09	1,353	0.0751	1.53	0.17
-8	908	0.0268	0.72	0.07	1,353	-0.0273	-0.54	-0.06
-7	922	0.0610	1.54	0.15	1,353	0.0707	1.39	0.15
-6	925	0.0176	0.45	0.04	1,353	0.0254	0.51	0.06
-5	919	0.0678	1.62*	0.16	1,353	0.0523	0.95	0.10
-4	933	0.0848	2.15**	0.21	1,353	0.1251	2.40**	0.26
-3	928	0.1515	3.65***	0.35	1,353	0.1804	3.25***	0.35
-2	891	0.1780	4.30***	0.41	1,353	0.0593	1.01	0.11
-1	889	0.3501	7.80***	0.75	1,353	0.1198	1.75*	0.19
0	998	1.1319	20.82***	2.00**	1,353	1.1802	17.06***	1.85*
1	1,004	1.2535	25.25***	2.43**	1,353	1.3854	21.38***	2.31**
2	984	0.9168	19.30***	1.86*	1,353	1.0508	16.65***	1.80*
3	974	0.6877	15.15***	1.46	1,353	0.8548	14.17***	1.53
4	952	0.6120	12.69***	1.22	1,353	0.7190	11.84***	1.28
5	952	0.6408	14.32***	1.38	1,353	0.6989	11.61***	1.26
6	953	0.5331	11.70***	1.13	1,353	0.6140	10.13***	1.10
7	925	0.4782	11.06***	1.06	1,353	0.5088	8.66***	0.94
8	938	0.4181	9.60***	0.92	1,353	0.5889	10.10***	1.09
9	945	0.4330	9.52***	0.92	1,353	0.5561	9.02***	0.98
10	921	0.4156	8.45***	0.81	1,353	0.4922	7.71***	0.83

Note: ***, **,* indicate p-value significant at 1%, 5% and 10% level.

Similar to Tables 5, 6 and 7, we obtain the same conclusion from the above Table that the test statistics could be overestimated if the cross-correlation is not considered and the assumption of the distribution of announcements may have significant effects on the estimation results.

In summary, from Tables 5, 6, 7 and 8, we can see that the trading volume increases significantly before all unscheduled announcements if the t-values are not adjusted for the correlation between events. These results are consistent with Chae (2005) who claims that trading volume increases before unscheduled announcements because uninformed traders have no timing information. Uninformed traders cannot predict informed trading patterns before unscheduled announcements. They trade as usual. But informed traders know the information in advance, and increase their trading demand. Consequently, total trading levels may increase before unscheduled announcements. However, after adjusting for the correlation between events, t-values are only significant on days 0, 1 and 2. In other words, the change in trading volume is not statistically significant before unscheduled announcements. This result may be due to little information leakage, or the absence of market maker activity in the Australian market. Most investors do not have the skills to anticipate the true announcement date and content depending on limited information. Investors will not change their trading strategy in the absence of new information.

Following the addition of a small number to the volume turnover for companies which have no trading on some days, the sample size in the column 6 of each table becomes larger than the sample size in the column 2 of each Table. I obtain similar results for the unmodified data; the announcements have effects on the trading volume only on the announcement day and the following two days. The exception is capital announcement, where the adjusted t-values are significant from day 0 to day 10. These results confirm the conclusion that the abnormal trading volume does not change before unscheduled announcements, but increases on and after unscheduled announcements.

3.3.3 Comparing volume around scheduled and unscheduled announcements

Comparing Table 3 with Tables 5, 6, 7 and 8, it can be seen that the mean of the log abnormal volume turnover for scheduled announcements is less than for other announcements. Earnings announcements are the most important announcements, as measured by their effect on the stock price, which in turn has a great influence on the trading volume. The release date for earnings announcements is publicly known. Investors have the opportunity to trade before the announcement. They can trade smoothly at any time before the announcement. After the announcement, investors trade only if their expectations are different from the published announcement. This means that investors spread their trading around the earnings announcement. In contrast, uninformed traders trade as usual before unscheduled announcement but trade intensively after unscheduled announcements. This is why trading volume after earnings announcements is less than after unscheduled announcements. For both scheduled and unscheduled announcements, trading volume does not change before these announcements if we control the correlation across announcements. This implies that there is little information leakage in Australian stock market not only before the scheduled announcements, but also before unscheduled announcements. This finding is not consistent with findings for studies based on NYSE and AMEX data. This is possibly due to the differences in market characteristics and trading systems between the U.S.A. and Australia. Market makers are absent on the Australian Market. This may lead to different outcomes because market makers could notice an information asymmetry and then increase the bid-ask spread in response. This may be one of the reasons why trading volume decreases before scheduled announcements. However, on the ASX there are no market makers. The market is order-driven. As a result, a certain level of information asymmetry may not be noticed by uninformed traders. This is why trading volume does not change before scheduled announcements. In addition, the NYSE and AMEX are much larger than the ASX. There are many top analysts in the market. Thus, the effects of information asymmetry on trading volume become stronger and more sensitive on the NYSE and AMEX. That is another explanation why the results for the ASX are different from the findings for the U.S. markets.

In addition, I compare the cumulative log abnormal volume turnover between scheduled and unscheduled announcements. Figure 3.1 shows the cumulative log abnormal volume turnover derived from (1) and (3) from t=-10 to t=+10 for unmodified turnover.

Figure 3.2 presents the cumulative log abnormal volume turnover derived from (2) and (3) using the modified turnover.

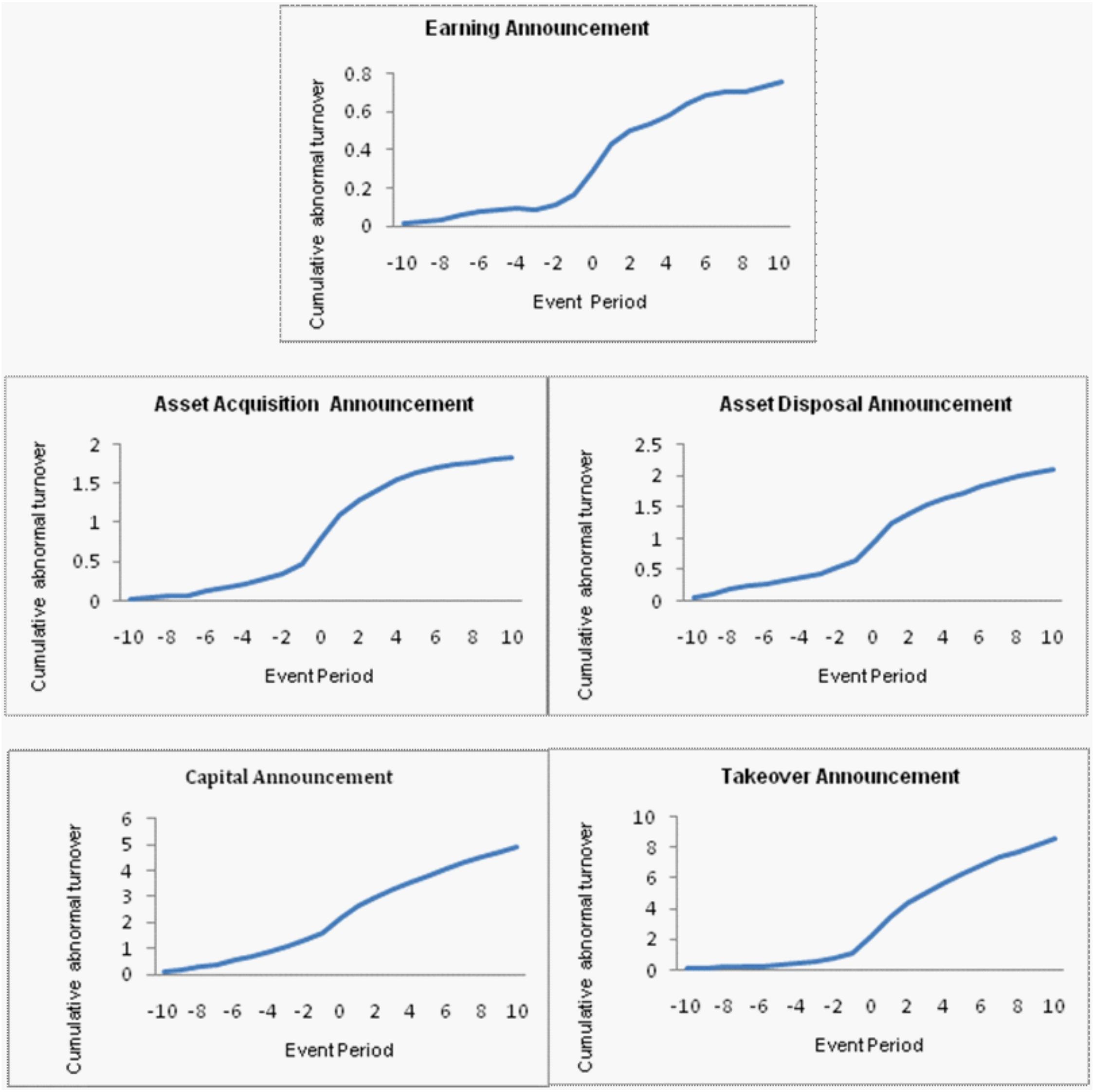

Figure 3.1: Cumulative log abnormal volume turnover from t=-10 to t=+10 from unmodified data. Volume turnover is trading volume divided by outstanding shares. Log abnormal volume turnover is difference between log volume turnover and benchmark which is average log volume turnover estimated from t=-40 to t=-11.

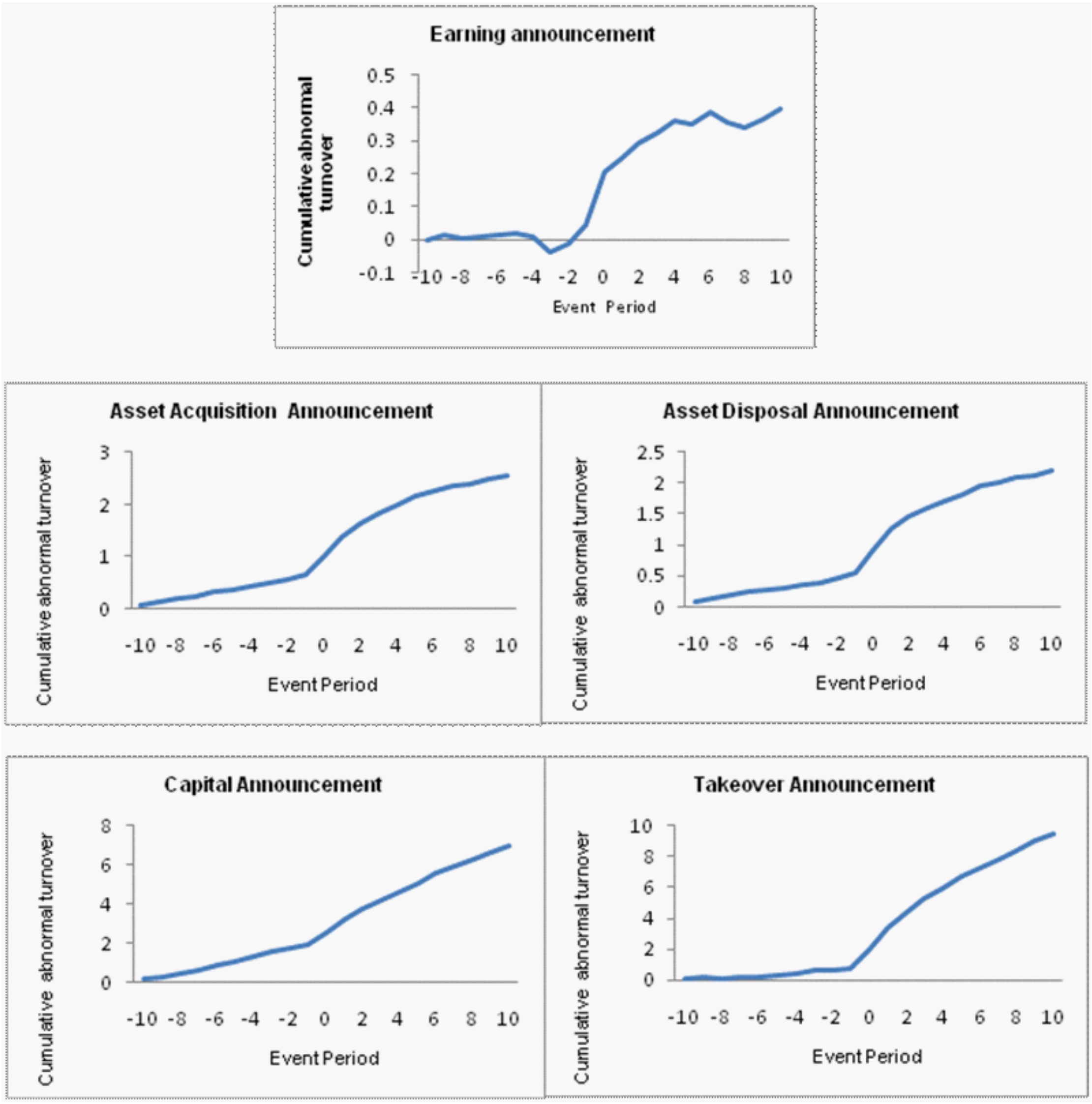

Figure 3.2: Cumulative log abnormal volume turnover from t=-10 to t=+10 from modified data.Volume turnover is trading volume divided by outstanding shares. Difference between log volume turnover and benchmark which is average log volume turnover estimated from t=-40 to t=-11 is abnormal volume turnover, where all volume turnovers add 0.00000255.

The trading volume increases during the event period for all announcements. However, the trading turnover decreases at day -3 for the earnings announcements. All unscheduled announcements show an increasing trend from day -10 to day 10. A sharp increase starts from announcement day (Day=0) and continues for several day after the announcement. In contrast with Tables 3 to 7, it can be seen that the adjusted t-value is not significant before any announcement. Thus, there is no meaning in analyzing the trend before these announcements.

3.4 Robustness Analysis

In this section I use different methods to test the hypotheses. For an event study, we can either change the estimation period, or use the one-factor trading volume market model. First, I extend the estimation period, and test the cross-sectional average log abnormal volume turnover change around the announcements using a 45 days (one and half month) estimation period. I use the different estimation period to assure the robustness of the above results. Second, I test the cross-sectional average log abnormal volume turnover change around the announcements using the trading volume market model. Brown and Warner (1985) find that the inter-correlations between announcements could be reduced to zero by using the market model to derive the abnormal return. Hence, the inter-correlations have been ignored in previous studies.

3.4.1 Changing estimation period

Different estimation periods have been used in the literature. For example, Bamber (1987) uses a time period from 3rd Jan 1977 to 30th March 1981 as estimation period, while Llorente, Michaely, Saar and Wang (2002) use a 200 trading day estimation period. In order to test the robustness of my results, in this subsection I change the estimation period from 30 days ($t = -40$ to $t = -11$) to 45 days ($t = -55$ to $t = -11$), to test whether the results are the same as in the last subsection. I use 21 log abnormal volume turnover during the event period ($t = -10$ to $t = +10$) to calculate the correlation coefficients across scheduled and unscheduled announcements. These are shown in Table 13 in Appendix A. The correlation coefficients across scheduled announcements are smaller than across unscheduled announcements. The average log abnormal volume turnover ($t = -10$ to $t = +10$) for earnings announcements, asset acquisitions, asset disposals, capital and takeover announcements are presented in Tables 14, 15, 16, 17 and 18 in Appendix A. Using (1) and (3) with the unmodified data, the mean of the abnormal volume turnover is shown on the left of each table. Using (2) and (3) with modified data, the mean abnormal volume turnover is shown on the right of each table. The adjusted t-values calculated by (4) are presented in the columns 5 and 9. The correlations across these announcements have a significant effect on the t-values, even though they are quite small.

The results presented in Tables 14–18 are consistent with those in Tables 3–7. The trading volume does not change significantly before scheduled or unscheduled announcements. All announcements have the same effect on trading volume; trading volume only changes on the announcement day and, and remains abnormally high for the following day or the following two days. The exception is capital announcements for which adjusted t-values are significant a longer period. The mean of the log abnormal volume turnover for scheduled announcement is less than for other announcements. This implies that the results are unchanged after changing estimation period from 30 days ($t = -40$ to $t = -11$) to 45 days ($t = -55$ to $t = -11$). Thus we can say that the estimation results are robust.

3.4.2 Trading volume market model

Following Tkac (1999), I use the one-factor trading volume market model to perform the second robustness check. Volume turnover is trading volume divided by the number of outstanding shares. The log abnormal volume turnover, $\xi_{i,t}$, is the difference between observed log volume turnover and the log volume turnover estimated by the one-factor market model. It is

(5) $$\xi_{i,t} = \tau_{i,t} - \hat{\alpha}_i - \hat{\beta}_i \tau_{M,t},$$

where $\hat{\alpha}_i$ and $\hat{\beta}_i$ are estimated coefficients by the model, $\tau_{i,t}$ is the log volume turnover, $\tau_{M,t}$ is the log market volume turnover, which is the ratio of the sum of daily volume of each stock to the sum of daily outstanding share of each stock listed on ASX. The coefficients are estimated for the period from $t = -40$ to $t = -11$. Brown and Warner (1985) argue that the inter-correlations among abnormal returns derived from the market model could be zero. But this ignores a fact that if firms are in the same industry and have commonality in liquidity, inter-correlations among abnormal returns based on market model could still be positive. I use 21 log abnormal volume turnover during the event period ($t = -10$ to $t = +10$) to calculate the correlation coefficients across announcements. These are shown in Table 19 of Appendix B. The correlation coefficients across scheduled announcements are smaller than across unscheduled announcements. The average log abnormal volume turnover ($t = -10$ to $t = +10$) for earnings announcements, asset acquisitions, asset disposals, capital and takeover announcements are presented in Tables 20, 21, 22, 23 and 24 respectively in Appendix B. Using (1) and (5) with the modified data, the mean of the abnormal volume turnover is on the left of each table. Using (2) and (5) with the modified data, the mean of abnormal volume turnover is shown on the right of each table. The adjusted t-values calculated by (4) are presented in the columns 5 and 9.

The results presented in Tables 20–24 are consistent with those in Tables 3 and 5–7 and in Tables 14–18. The adjusted t-values are still not significant for the trading volume before scheduled and unscheduled announcements. The trading volume increases on and after scheduled and unscheduled announcements. The t-values for the trading volume on the earnings announcements day is still significant, but at 10% significant level for modified data. The mean of the log abnormal volume turnover for scheduled announcements is still less than for other announcements as shown in Tables 3 & 5–7 and Table 14–18. This implies that the significance of the estimation results remain unchanged after using the trading volume market model to estimate the log abnormal volume turnover. As a result, we can say the estimation results are robust.

Chapter 4

The Effect of Information Asymmetry on Trading Volume

In this section I discuss information asymmetry, and consider whether this could explain the increase in trading volume on the announcement day. Chae (2005) discusses several commonly used proxies for information asymmetry: company size, the number of analysts, the bid–ask spread, and industry dummies. Easley, Kiefer and O'Hara (1996), Easley, Kiefer, O'Hara and Paperman (1996), Easley, O'Hara and Paperman (1998), Easley, Engle, O'Hara and Wu (2001) and Easley, Hvidkjaer and O'Hara (2002) calculate the probability of information-based trading (PIN) to measure the degree of information asymmetry. Easley, Kiefer and O'Hara (1996) construct a microstructure model to estimate the probability of trading based on private information. The basic idea is that they assign probabilities to new information and no new information, and to good news and bad news if there is new information. Based on their private information, informed traders deliver buy or sell orders depending on whether the news is good or bad. When there is no new information, the share trades smoothly. But when there is some private information, the demand from the informed traders changes dramatically. The market maker observes the change in the number of buy and sell orders, and can determine whether there are information asymmetries or not using Easley's model.

In this thesis, I consider the probability of information-based trading (PIN) and the bid-ask spread as measures of information asymmetry separately. All data are from the SIRCA from 1996 to 2007. In addition, I use the log abnormal volume turnover (0,1) of the five announcements from last section.

4.1 Data

I collect the orders from buyers and seller for each ordinary common stock intraday from SIRCA. I then calculate total number of the daily buyers and sellers of each stock.

I also use five types of corporate announcement: earnings, asset acquisition, asset disposal, capital and takeover announcements in this section. To match with the number of buyers and sellers, I shorten the sample period from 1994 to 2007 to 1996 to 2006. The number of each announcement type is shown in Table 9. In order to calculate the PIN as proxy of information asymmetry, I need the number of buyers and sellers for at least 40 days before and 40 days after announcements. After applying this restriction, I have a sample of 8,455 earnings, 7,980 asset acquisition, 3,890 asset disposal, 3,790 capital, and 844 takeover announcements.

Similarly, the intraday bid and ask price for each ordinary common stock is collected from SIRCA for the period 1996 to 2006. The bid-ask spread is the ratio of the difference between the best ask price and the best bid price multiplied by two to the sum of the best bid price and the best ask price. The daily bid-ask spread is the average of the intraday data.

In order to obtain company size, I multiply the last traded price by the number of shares in issue. I collect last traded price, the number of outstanding shares and trading volume from SIRCA.

Table 9: Numbers of the Announcements

This table shows the number of each announcement for only one announcement of each firm on the announcement day and the number of announcements after filter. All the announcements are collected from SIRCA database from 1996 to 2006. "No of announcements after filter" means the numbers of buyers and sellers at least 40 days before and 40 days after announcements.

ASX	Earnings	Asset acquisition	Asset Disposal	Capital	Takeover
No. of announcements before filter	9,584	9,641	4,625	4,364	1,049
No. of announcements after filter	8,455	7,980	3,890	3,790	844

4.2 Methodology

I use the market microstructure to build a structural model in order to estimate the extent of private information. I use the number of buy and sell orders observed from market data to calculate the probability of information-based trading (PIN) to measure the degree of information asymmetry for each announcement respectively.

The number of buy and sell orders can be observed in the market. It can change dramatically, especially when there is new information arriving. Therefore, Easley, Hvidkjaer and O'Hara. (2002, page 2194) claim that "private information is not directly observable, it cannot be measured directly; its presence can only be inferred from market data." Based on this idea, Easley, Kiefer and O'Hara (1996), Easley, Kiefer, O'Hara and Paperman (1996), Easley, O'Hara and Paperman (1998), Easley, Engle, O'Hara and Wu (2001) and Easley, Hvidkjaer and O'Hara (2002) assume a probability, α, of new information and probability, $1-\alpha$ no new information. When there is a new information occurred, there is a probability, δ, of good news and probability, $1-\delta$ of bad news. Informed traders will use the private information to submit buy or sell orders depending on the news is good or bad. When there is no new information, the share trades smoothly. The number of buy and sell orders are denoted by ϵ_b and ϵ_s. When there is some information arriving, the demand from the informed traders changes dramatically. We denote an order from informed traders as μ.

The following Figure shows the sequential trade tree.

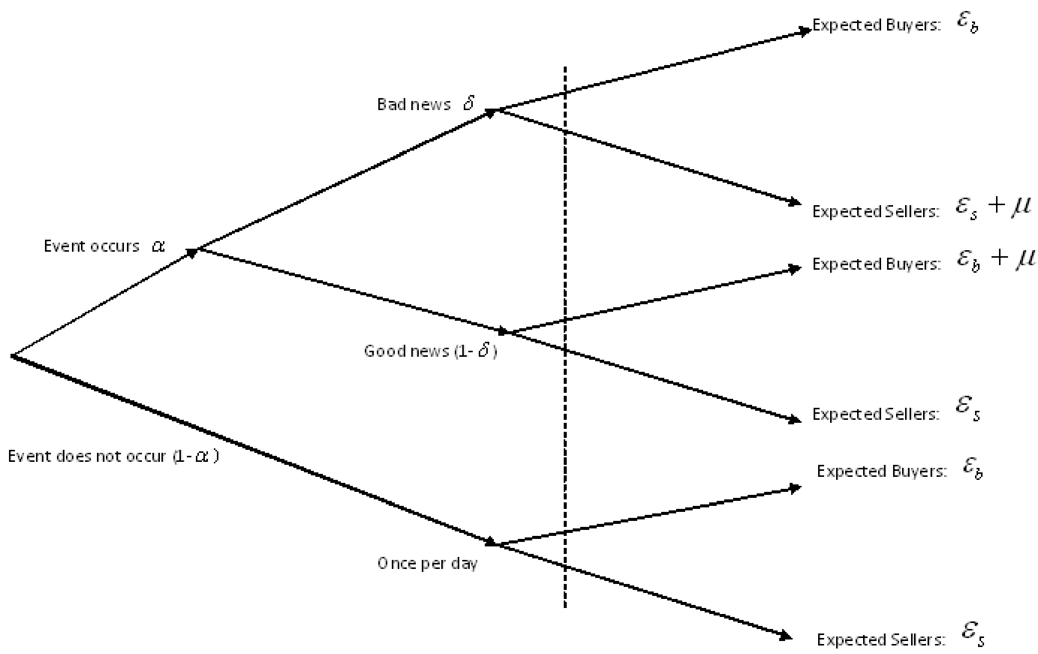

Figure 4.1: Tree diagram of the trading process. α denotes the probability of an information event, δ is the probability of bad news, μ denotes the orders from informed traders, ϵ_b and ϵ_s denote the number of buy and sell orders from uninformed traders. (This Figure is from Easley, Hvidkjaer and O'Hara 2002, Figure 1).)

They assume that throughout each day traders submit buy or sell orders following a Poisson process[6]. Then the likelihood function for the Poisson distributed trading orders for a single day is

$$\begin{aligned} L(\theta \mid B, S) &= (1-\alpha)\, e^{-\epsilon_b} \frac{\epsilon_b^B}{B!} e^{-\epsilon_s} \frac{\epsilon_s^S}{S!} \\ &\quad + \alpha\delta e^{-\epsilon_b} \frac{\epsilon_b^B}{B!} e^{-(\mu+\epsilon_s)} \frac{(\mu+\epsilon_s)^S}{S!} \\ &\quad + \alpha(1-\delta)\, e^{-(\mu+\epsilon_b)} \frac{(\mu+\epsilon_b)^B}{B!} e^{-\epsilon_s} \frac{\epsilon_s^S}{S!}, \end{aligned} \tag{6}$$

where B and S denote total buys and sells for the day respectively, and $\theta \equiv (\alpha, \mu, \epsilon_b, \epsilon_s, \delta)$. The above likelihood function shows the sum of the likelihood of informed traders trading with good, $\alpha(1-\delta)$, or bad, $\alpha\delta$, news events, and uninformed traders trading without any news, $(1-\alpha)$, for one day. The reason for considering these three situations together

[6]Poisson distribution is a discrete probability distribution. It expresses events occurring probability in a fixed period of time.

is the number of buy and sell orders changes every day due to demand from informed traders with good and bad news, and uninformed traders. Therefore, the number of buy and sell orders should be at a level such that the likelihood (6) is maximized.

However, due to exogenous influences, such as macroeconomic variables, and other reasons, such as individual's psychology, preference, or ability, changes of B and S on a single day are not a reliable indicator of information asymmetry. Therefore, I choose to maximize likelihood from -40 days to +40 days around the announcement. The likelihood is assumed to be independent across trading days[7], such that the likelihood function from -40 to +40 days is as follows

$$V = L(\theta \mid M) = \prod_{i=-40,\ldots+40} L(\theta \mid B_i, S_i), \tag{7}$$

where (B_i, S_i) is trade data for day i. The above likelihood is maximized by choosing $\theta \equiv (\alpha, \mu, \epsilon_b, \epsilon_s, \delta)$. Then, by Figure 4.1, we see that the total orders for trade due to information is $\epsilon_b + \epsilon_s + \mu$, which is the sum of the trading orders from bad news $\delta(\epsilon_b + \epsilon_s + \mu)$ and good news $(1-\delta)(\epsilon_b + \epsilon_s + \mu)$. The total orders from uninformed traders are $\epsilon_b + \epsilon_s$. The total number of trades is then equal to $\alpha(\epsilon_b + \epsilon_s + \mu) + (1-\alpha)(\epsilon_b + \epsilon_s) = \alpha\mu + \epsilon_b + \epsilon_s$ and the total orders from informed traders is $\alpha\mu$. The probability of information-based trading (PIN) is defined as the ratio of total orders from informed traders to the total orders:

$$PIN \equiv \frac{\alpha\mu}{\alpha\mu + \epsilon_b + \epsilon_s}. \tag{8}$$

From the above model, it can be seen that the degree of information asymmetry is measurable when we have values for $(\alpha, \mu, \epsilon_b, \epsilon_s, \delta)$, which can be obtained by maximizing (7).[8].

[7]The independence is tested and confirmed by Easley, Kiefer, O'Hara and Paperman (1996).

[8]There is some doubt about the identification of PIN as a priced risk factor (Speigel and Wang 2005, and Mohanram and Rajgopal 2008). Speigel and Wang (2005) argue that PIN could capture a stock's liquidity characteristics but whether liquidity is systematic risk is unclear. Mohanram and Rajgopal (2008)

The advantage of the Easley model is that it provides a way to increase computing efficiency, especially for large samples. Easley, Kiefer, O'Hara and Paperman (1996), Easley, O'Hara and Paperman (1998) and Easley, Engle, O'Hara and Wu (2001) use the quadratic hill-climbing algorithm GRADX from the GQOPT package to maximize the likelihood function. In this thesis, due to license limitations with the GQOPT package, I use the simplex search method implemented in the MATLAB *fminsearch* function[9] to maximize likelihood.

A shortcoming of using the MATLAB *fminsearch* function is that the process may not reach global optimum of the objective function because of the selection of initial values. By looking at the number of buy and sell orders, and using repeated simulation, I find that initial values for buys, ϵ_b, sells, ϵ_s, and orders from informed traders μ, should be around the mean of buys and sells. And the result is consistent with the result obtained using Excel *Solver*. This means that the initial values have been chosen appropriately. Moreover, boundary solutions are avoided using MATLAB with the method of initial value selection. This is important because choosing initial values with large bias may lead to an incorrect estimation of the result. The solutions for α have a substantial influence on the estimate of PIN. Furthermore, choosing correct initial parameters could also help the MATLAB estimation. In addition, using MATLAB to estimate PIN is highly efficient, especially for a large number of trades per day. This is another advantage of MATLAB relative to GRADX, STATA or SAS.

A disadvantage of PIN is pointed out by Easley, Hvidkjaer and O'Hara (2002) and Vega (2006). They claim that there would be an errors-in-variables (EIV) bias in the estimation of PIN in empirical analysis due to the maximization of likelihood. Therefore, I use instrumental variables to control for this bias in the regressions. The principle for

find that PIN could be working well for small firms. In this thesis, the data I am using is from Australia Stock and Exchange. Compared with U.S., most of firms in Australia are small firms. Therefore, using PIN as a proxy for information asymmetry in the thesis does not introduce significant bias.

[9]Some papers use STATA or SAS to maximize the factorized likelihood function. For example, Brown, Hillegeist and Kin (2004) use the modified Newton-Raphson method implemented in the STATA *ml* procedure to maximize the likelihood function.

choosing a proper instrumental variable is to find a variable which is correlated with PIN but not correlated with the error. Chae (2005) shows that firm size and information asymmetry are negatively related. Easley, Kiefer, O'Hara and Paperman (1996) discuss spreads and PIN, and find that they are positively correlated. Finally, Easley Hvidkjaer and O'Hara (2002) find that PIN is negatively correlated with trading volume across stocks. I use the log of the mean of firm size for 40 days before the announcement, the mean of the bid-ask spread for 40 days before announcement, and the log of the mean trading volume for 40 days before announcement as instrumental variables. I use PIN as the dependent variable, log mean of firm size, mean of bid-ask spread, and log mean of trading volume as independent variables to run the OLS regression, and then test the residual to determine whether it is white noise. If the residual is white noise, these instrumental variables should be uncorrelated with the error.

To test whether the information asymmetry could affect the trading volume by increasing on the announcement day, I use the PIN and the bid-ask spread as proxies for information asymmetry separately. Firstly, the mean abnormal trading turnover (0, +1) is used as dependent variable, the PIN as independent variable. The regression is as follows:

$$\xi_i = \alpha_1 + \alpha_2 PIN_i + \mu_i, \tag{9}$$

where $PIN_i = \beta_1 + \beta_2 Lnsize_i + \beta_3 Spread_i + \beta_4 Lnvolume_i + e_i$

I use the above regression to run two-stage least squares. *Lnsize*, *Spread* and *lnvolume* are used as instrumental variables. Second, I choose the mean abnormal trading turnover (0, +1) as the dependent variable and the mean of bid-ask spread as the independent variable to run an OLS regression. The regression is as follows:

$$\xi_i = \gamma_1 + \gamma_2 Spread_i + \nu_i. \tag{10}$$

I choose the day 0 to +1 as the event date, because after-hours announcements have become more prevalent over the last 20 years. I do not have the data about which announcements are made after hours. This means that I cannot control for after-hours announcements. As Berkman and Truong (2006) observe, if after-hours announcements are not adjusted for, the announcement window should include the day after the announcement to ensure that the change of volume of after-hours announcements are included.

4.3 Regression results

In this section I present the results discussing the effect of information asymmetry on abnormal trading volume. The White heteroscedasticity method corrects for heteroscedasticity without altering the values of the coefficients.

Firstly, I show the result of white noise test for five announcements in Table 10.

Table 10: White Heteroskedasticity Test

This table shows the p-value of white heteroskedasticity test which tests whether the residual is white noise. I use PIN as dependent variable, log mean of firm size, mean of bid-ask spread and log mean of trading volume as independent variables to run OLS regression.

	Earnings	Asset acquisition	Asset Disposal	Capital	Takeover
p-value	0.00000***	0.00000***	0.00000***	0.00000***	0.00000***
E$[IV_i/e_i] \neq 0$	reject	reject	reject	reject	reject

Note: ***, **,* indicate p-value significant at 1%, 5% and 10% level.

From the above table, it can be seen that the residual of PIN and the instrumental variables regression is uncorrelated with the error. The log of mean firm size, mean of bid-ask spread, and log of mean trading volume are appropriate instrumental variables for controlling the measurement error for the PIN estimated from the maximized likelihood function.

The cross-sectional regressions of five announcements using PIN as a proxy for information asymmetry are shown in the Table 11. I use a two-stage least squares regression to control the EIV of estimated PIN from the maximized likelihood. The cross-sectional regression results using the unmodified log abnormal volume turnover (0,+1) as the dependent variable are in Panel A. The cross-sectional regression using modified log abnormal volume turnover (0,+1) which is equal to the actual turnover plus 0.00000255 as the dependent variable is shown in the Panel B. I show the effect of PIN as a proxy for information asymmetry on the scheduled and unscheduled announcement days on the third row of each panel. The value for PIN used in Table 11 is fitted by the instrumental variable. The t-value is below the corresponding coefficients.

Table 11: Regression Analysis for PIN

This table shows the result of regression of log abnormal trading turnover on the announcement with PIN as proxy of information asymmetry. The coefficients are estimated from the cross-sectional regressions for each announcement. In the panel A, the mean abnormal trading turnover (0, +1) from unmodified turnover is as dependent variable, the PIN for each announcement as independent variable. In the panel B, the mean abnormal trading turnover (0, +1) from modified data is as dependent variable, the fitted PIN for each announcement as independent variable. The log of firm size, the mean bid-ask spread and the log trading volume as instrumental variable fit the estimated PIN. The t-value is given beneath their corresponding coefficients. The adjusted R^2 and F-statistic of each regression are shown in the last two rows of each Panel respectively.

Coefficient	Earnings	Asset acquisition	Asset Disposal	Capital	Takeover
Panel A:Using Unmodified Turnover					
intercept	0.1252	-0.0009	-0.2359	-0.2971	-0.2434
t-value	2.17**	-2.32**	-4.65***	-2.35**	-1.34
PIN	0.0326	0.0098	2.0595	2.6856	5.1792
t-value	0.15	5.71***	8.97***	6.10***	6.96***
adjusted R^2	-0.0039	-0.3713	-3.3456	-6.1819	-8.8822
F-statistic	0.015	17.95***	64.17***	29.90***	38.37***
Panel B: Using Modified Turnover					
intercept	0.1215	-0.4843	-0.5896	-1.2891	-0.7858
t-value	1.38	-9.05***	-7.93***	-6.46***	-3.19***
PIN	0.0221	3.2431	3.7059	6.5040	7.3359
t-value	0.07	13.72***	10.65***	9.12***	7.05***
adjusted R^2	-0.0103	-2.8462	-5.8672	-15.91	-13.42
F-statistic	0.0033	152.71***	101.37***	63.42***	43.77***

Note: ***, **,* indicate p-value significant at 1%, 5% and 10% level.

From the above Table, it can be seen that the PIN does not affect the abnormal turnover change on the scheduled announcement days. The increase in trade on the scheduled announcement days may be explained by the investors' expectations being different from the published announcement. Before the scheduled announcement day, investors know the date on which the announcement will be made. Every investor has their own expectation. When the announcement is made, investors trade if the announcement is different from their expectation. This does not require any information asymmetry. Another reason that may cause the increase in abnormal turnover is investors' different ex post opinions of the content of the announcement. Some investors will think that a given announcement is good news; others will think that it is bad news. These different opinions will lead to trade. However, the t-values for the unscheduled announcement are all significantly positive. This means that PIN can explain the increase in abnormal turnover on the days on which unscheduled announcements are made. The unmodified data and modified data give the same conclusion.

The cross-sectional regression for the five announcements using the bid-ask spread as proxy for information asymmetry is shown in Table 12. The cross-sectional regressions using actual log abnormal volume turnover (0,+1) as dependent variable are shown in the Panel A. The cross-sectional regressions by using modified log abnormal volume turnover (0,+1) as dependent variable shown in the Panel B. I show the effect of bid-ask spread as proxy for information asymmetry on scheduled and unscheduled announcement days on the third row of each panel. The t-value is shown below the corresponding coefficients.

Table 12: Regression Analysis for Bid-Ask Spread

This table shows the result of regression of log abnormal trading turnover on the announcement with bid-ask spread as proxy of information asymmetry. The coefficients are estimated from the cross-sectional regressions for each announcement. In the panel A, the mean abnormal trading turnover (0, +1) from unmodified turnover is as dependent variable, the mean of bid-ask spread 40 days before each announcement as independent variable. In the panel B, the mean abnormal trading turnover (0, +1) from modified data is as dependent variable, the mean of bid-ask spread 40 days before each announcement as independent variable. The t-value is given beneath their corresponding coefficients. The adjusted R^2 and F-statistic of each regression are shown in the last two rows of each Panel respectively

Coefficient	Earnings	Asset acquisition	Asset Disposal	Capital	Takeover
Panel A:Using Unmodified Turnover					
intercept	0.1439	0.0011	0.1920	0.3792	1.0972
t-value	7.91***	7.20***	7.50***	11.81***	12.83***
Spread	-0.2217	0.0174	3.1381	2.5084	1.5667
t-value	-0.57	5.70***	4.16***	4.18***	0.50
adjusted R^2	-0.0064	0.2700	1.2995	0.7312	0.0113
F-statistic	0.51	22.50***	47.91***	27.12***	1.08
Panel B: Using modified Turnover					
intercept	0.1039	0.1494	0.2467	0.3522	1.0554
t-value	4.86***	7.21***	8.65***	7.86***	3.49***
Spread	0.4935	6.7526	3.0174	5.6797	13.895
t-value	1.42	11.85***	4.60***	6.63***	1.53
adjusted R^2	0.0134	3.3762	1.0327	1.9170	0.4349
F-statistic	2.1267	278.57***	41.38***	74.78***	4.5993**

Note: ***, **,* indicate p-value significant at 1%, 5% and 10% level.

We obtain similar results to those obtained using PIN as a proxy for information asymmetry. The information asymmetry does not explain why the abnormal turnover increases on scheduled announcement days, but it can explain why the abnormal turnover increases on the unscheduled announcement days. However, the coefficient for bid-ask spread for the takeover is not significant. This is because bid-ask spread can be influenced by liquidity and volatility. Smith, White, Robinson and Nason (1997) find an abnormally high volatility and liquidity immediately after takeover announcements.

Chapter 5

Conclusion

The thesis studies change in trading volume around scheduled and unscheduled announcements, and the impact of information asymmetry on trading volume. The thesis contains three important findings. The first is that the change in trading volume is not significant before scheduled announcements. This could be explained by two causes. The first is due to the different characteristic of financial markets in the U.S and Australian securities exchanges. In the U.S. financial markets, market makers play an important role in facilitating trades. A common reason given in previous studies of the U.S. market for a decrease in trading activity before scheduled announcements is the reluctance of market makers to trade against informed traders. However, there are no market makers on the Australian Securities Exchange. Traders are not as sensitive to information asymmetries as market markers. That is why trading activity and trading volume do not change before announcements on the Australian Securities Exchange. This finding is an important contribution to the literature as it provides more perspectives for analyzing the reaction of trading volume to announcements. The second reason is because of less information leakage on the ASX. This is confirmed by the very small difference in the pre- and post announcement PIN. The thesis shows that the underlying dynamics of the Australian market are different; casting doubts upon the validity of generalizing market characteristics from U.S. based studies.

The second important finding is that the result of the estimation of reactions of trading volume to unscheduled announcements changes significantly if the cross-correlation between corporate events is considered. Many papers assume that corporate events are independent of each other. Then they find that trading volume increases significantly before unscheduled announcements when the informed traders trade intensively before the unscheduled information is released. However, corporate events could be correlated, especially among the major corporate events. Moreover, trading volume of one stock could change just due to the change of trading volume of another stock or new macroeconomic information could lead to contemporaneous change in trading volume of stocks. If the sample size is large, a small correlation may have significant impact on the t-values. Ignoring the correlation then can result in overestimated t-values. From the differences between the results with and without cross-correlation, we can see the importance of considering cross-correlation. The thesis presents different results to those based on U.S. data after considering the cross-correlations. It sheds light on the literature on the response of trading volume to unscheduled announcements.

The third important finding is that the increase in trading volume on scheduled announcement days is not due to the information asymmetry but the information asymmetry could help to explain the increase in trading volume on the unscheduled announcement days. The effect of information asymmetry on trading volume is tested using PIN and bid-ask spread as proxies for information asymmetry. The trading volume increases as a result of investors rebalancing their portfolios based on their surprise at the content of the scheduled announcement. Hence, information asymmetry does not have significant effect on trading volume. But the information asymmetry could help to explain the increase in trading volume on the unscheduled announcement days. This is consistent with the literature but in a different market environment. Moreover, using PIN and bid-ask spread as proxies for information asymmetry gives similar results. This reconfirms their suitability as proxies for information asymmetry.

This thesis also shows that trading volume increases after scheduled and unscheduled announcements. This is consistent with literature when the market has market makers. In addition, the size of the trading volume increase after scheduled announcements is less than after unscheduled announcements. This is because some investors have completed trading before the scheduled announcement based on their analysis of the firm's historical performance or published information. They trade after scheduled announcement only to the extent that they are surprised. In contrast, before unscheduled announcements, most of investors have no private information, and trade as usual. A sudden unscheduled announcement could cause a jump in trading regardless of whether the information released is good or bad, because traders' beliefs or expectations will change dramatically with the announcement. Trading volume then increases significantly as investors rebalance their portfolios in response to changed expectations about the stock.

The method used in the thesis to incorporate correlations between corporate events can be used to examine other issues involving interactions between trading volume, returns, cash flow, and capital structure in future studies.

Appendix

Appendix A: Robustness Check (estimation period)

Table 13:Correlation for Adjust t-statistics of Changing Estimation Period

This table shows the average correlation of each corporate event for five announcements. I use 21 days of event period for individual event to calculate the correlation. The number of unique correlations is n(n-1)/2. N is the number of sample events. There are five types of corporate announcement: earnings, asset acquisition, asset disposal, capital and takeover announcements. For the panel A, I use unmodified turnover, it means some turnovers are 0 for the stock does not trade while the market is opening. For the Panel B, I use modified data, it means I plus a constant number 0.00000255 to the actual turnover.

Announcements	Earnings	Asset acquisition	Asset Disposal	Capital	Takeover
Panel A: Using Unmodified Turnover					
Correlation	0.001301	0.006767	0.004146	0.010285	0.079219
Panel B: Using Modified Turnover					
Correlation	0.000899	0.003909	0.002872	0.006305	0.059604

Table 14: Robustness Check (changing estimation period) Daily Abnormal Turnover around Earnings Announcement

This table shows the mean of abnormal volume turnover for earnings announcement from ordinary common stock listed in the ASX from 1994 to 2007. Volume turnover is trading volume divided by outstanding shares. Log abnormal volume turnover is the difference between observed log volume turnover and the average log volume turnover estimated from t = -55 to t = -11. The t-value is the t-value of independent corporate announcements and I assume these events occur randomly. The adjusted t-value is the t-value of dependent corporate announcements. The t-test and adjusted t-value are used to test whether the mean is significantly different from zero or not.

	Unmodified data				Modified data			
Event day	N	Mean	t-value	adjusted t-value	N	Mean	t-value	adjusted t-value
-10	8,345	0.0169	1.28	0.31	12,765	-0.0044	-0.23	-0.07
-9	8,381	0.0072	0.52	0.12	12,765	0.0144	0.72	0.20
-8	8,340	0.0068	0.48	0.11	12,765	-0.0102	-0.50	-0.14
-7	8,380	0.0212	1.53	0.36	12,765	0.0088	0.44	0.12
-6	8,386	0.0142	1.01	0.24	12,765	0.0054	0.27	0.08
-5	8,302	0.0025	0.17	0.04	12,765	0.0047	0.23	0.07
-4	7,953	0.0125	0.86	0.20	12,765	-0.0039	-0.19	-0.05
-3	7,681	-0.0061	-0.40	-0.10	12,765	-0.0397	-1.83*	-0.52
-2	8,290	0.0171	1.19	0.28	12,765	0.0282	1.36	0.38
-1	8,426	0.0565	4.06***	0.97	12,765	0.0596	2.92***	0.83
0	8,794	0.1162	8.40***	2.00**	12,765	0.1573	7.93***	2.24**
1	8,404	0.1331	9.36***	2.23**	12,765	0.0416	1.93*	0.55
2	8,430	0.0682	4.68***	1.12	12,765	0.0472	2.26***	0.64
3	8,539	0.0257	1.81*	0.43	12,765	0.0309	1.50	0.42
4	8,534	0.0480	3.43***	0.82	12,765	0.0370	1.80*	0.51
5	8,444	0.0592	4.17***	0.99	12,765	-0.0121	-0.57	-0.16
6	8,589	0.0429	3.02***	0.72	12,765	0.0361	1.73*	0.49
7	8,507	0.0107	0.75	0.18	12,765	-0.0319	-1.53	-0.43
8	8,560	-0.0018	-0.13	-0.03	12,765	-0.0138	-0.66	-0.19
9	8,613	0.0205	1.44	0.34	12,765	0.0240	1.15	0.33
10	8,626	0.0251	1.76*	0.42	12,765	0.0307	1.48	0.42

Note: ***, **,* indicate p-value significant at 1%, 5% and 10% level.

Table 15: Robustness Check (changing estimation period)
Daily Abnormal Turnover around Asset Acquisition Announcement

This table shows the mean of abnormal volume turnover for asset acquisition announcement from ordinary common stock listed in the ASX from 1994 to 2007. Volume turnover is trading volume divided by outstanding shares. Log abnormal volume turnover is the difference between observed log volume turnover and the average log volume turnover estimated from t = -55 to t = -11. The t-value is the t-value of independent corporate announcements and I assume these events occur randomly. The adjusted t-value is the t-value of dependent corporate announcements. The t-test and adjusted t-value are used to test whether the mean is significantly different from zero or not.

	Unmodified data				Modified data			
Event day	N	Mean	t-value	adjusted t-value	N	Mean	t-value	adjusted t-value
-10	9,059	0.0334	2.81***	0.32	11,146	0.0849	4.89***	0.73
-9	9,094	0.0224	1.87*	0.21	11,146	0.0922	5.23***	0.78
-8	8,995	0.0182	1.51	0.17	11,146	0.0583	3.33***	0.50
-7	9,062	0.0105	0.87	0.10	11,146	0.0633	3.58***	0.54
-6	8,993	0.0527	4.28***	0.49	11,146	0.0887	4.93***	0.74
-5	8,984	0.0428	3.49***	0.40	11,146	0.0689	3.77***	0.56
-4	8,984	0.0535	4.41***	0.50	11,146	0.0640	3.51***	0.53
-3	9,005	0.0671	5.44***	0.62	11,146	0.0868	4.73***	0.71
-2	8,998	0.0629	4.97***	0.57	11,146	0.0752	4.01***	0.60
-1	8,923	0.1270	10.10***	1.16	11,146	0.0876	4.49***	0.67
0	9,328	0.3108	23.62***	2.70***	11,146	0.3537	17.67***	2.65***
1	9,253	0.2986	23.14***	2.65***	11,146	0.3941	20.07***	3.01***
2	9,068	0.1996	15.69***	1.79*	11,146	0.2872	14.79***	2.22**
3	8,952	0.1315	10.17***	1.16	11,146	0.2120	11.00***	1.65*
4	8,967	0.1173	9.17***	1.05	11,146	0.1724	8.87***	1.33
5	8,944	0.0871	6.79***	0.78	11,146	0.1502	7.84***	1.17
6	8,901	0.0717	5.64***	0.65	11,146	0.1354	7.15***	1.07
7	8,839	0.0364	2.81***	0.32	11,146	0.0848	4.41***	0.66
8	8,858	0.0261	2.01**	0.23	11,146	0.0698	3.66***	0.55
9	8,835	0.0345	2.63***	0.30	11,146	0.0815	4.23***	0.63
10	8,858	0.0261	2.02**	0.23	11,146	0.0922	4.87***	0.73

Note: ***, **,* indicate p-value significant at 1%, 5% and 10% level.

Table 16: Robustness Check (changing estimation period) Daily Abnormal Turnover around Asset Disposal Announcement

This table shows the mean of abnormal volume turnover for asset disposal announcement from ordinary common stock listed in the ASX from 1994 to 2007. Volume turnover is trading volume divided by outstanding shares. Log abnormal volume turnover is the difference between observed log volume turnover and the average log volume turnover estimated from t = -55 to t = -11. The t-value is the t-value of independent corporate announcements and I assume these events occur randomly. The adjusted t-value is the t-value of dependent corporate announcements. The t-test and adjusted t-value are used to test whether the mean is significantly different from zero or not.

	Unmodified data				Modified data			
Event day	N	Mean	t-value	adjusted t-value	N	Mean	t-value	adjusted t-value
-10	4,054	0.0701	4.02***	0.84	5,219	0.0815	3.29***	0.82
-9	4,038	0.0678	3.85***	0.81	5,219	0.0567	2.22**	0.56
-8	4,049	0.0658	3.67***	0.77	5,219	0.0725	2.90***	0.73
-7	4,026	0.0674	3.70***	0.78	5,219	0.0619	2.48**	0.62
-6	4,004	0.0303	1.58	0.33	5,219	0.0228	0.90	0.23
-5	4,036	0.0594	3.31***	0.70	5,219	0.0581	2.27**	0.57
-4	4,022	0.0380	2.05**	0.43	5,219	0.0451	1.72*	0.43
-3	4,023	0.0784	4.35***	0.91	5,219	0.0539	2.04**	0.51
-2	4,019	0.0919	5.08***	1.07	5,219	0.0736	2.77***	0.69
-1	4,026	0.1234	6.43***	1.35	5,219	0.1008	3.62***	0.91
0	4,232	0.3005	14.74***	3.10***	5,219	0.3537	12.56***	3.14***
1	4,118	0.2959	15.07***	3.17***	5,219	0.3615	12.91***	3.23***
2	4,035	0.1727	8.78***	1.85*	5,219	0.2205	8.08***	2.02**
3	4,005	0.1150	5.94***	1.25	5,219	0.1275	4.69***	1.17
4	4,001	0.1078	5.67***	1.19	5,219	0.1321	4.93***	1.23
5	4,029	0.0971	5.13***	1.08	5,219	0.1209	4.52***	1.13
6	4,004	0.1115	5.86***	1.23	5,219	0.1298	4.86***	1.22
7	3,973	0.0820	4.26***	0.90	5,219	0.0818	3.06***	0.77
8	3,985	0.0684	3.61***	0.76	5,219	0.0855	3.23***	0.81
9	3,951	0.0622	3.20***	0.67	5,219	0.0376	1.39	0.35
10	3,992	0.0580	3.10***	0.65	5,219	0.0814	3.14***	0.79

Note: ***, **,* indicate p-value significant at 1%, 5% and 10% level.

Table 17: Robustness Check (changing estimation period) Daily Abnormal Turnover around Capital Announcement

This table shows the mean of abnormal volume turnover for capital announcement from ordinary common stock listed in the ASX from 1994 to 2007. Volume turnover is trading volume divided by outstanding shares. Log abnormal volume turnover is the difference between observed log volume turnover and the average log volume turnover estimated from t = -55 to t = -11. The t-value is the t-value of independent corporate announcements and I assume these events occur randomly. The adjusted t-value is the t-value of dependent corporate announcements. The t-test and adjusted t-value are used to test whether the mean is significantly different from zero or not.

	Unmodified data				Modified data			
Event day	N	Mean	t-value	adjusted t-value	N	Mean	t-value	adjusted t-value
-10	3,796	0.1065	5.30***	0.70	5,430	0.1819	5.61***	0.95
-9	3,794	0.0972	4.81***	0.64	5,430	0.1603	5.05***	0.85
-8	3,792	0.1501	7.15***	0.95	5,430	0.1872	5.69***	0.96
-7	3,841	0.1195	5.69***	0.75	5,430	0.2243	6.84***	1.15
-6	3,865	0.1732	8.34***	1.11	5,430	0.2948	8.91***	1.50
-5	3,844	0.1953	9.28***	1.23	5,430	0.2795	8.44***	1.42
-4	3,836	0.1726	7.79***	1.03	5,430	0.2528	7.32***	1.23
-3	3,855	0.2274	10.24***	1.36	5,430	0.3176	9.09***	1.53
-2	3,777	0.2728	12.55***	1.66	5,430	0.2565	6.96***	1.17
-1	3,728	0.3189	14.12***	1.87	5,430	0.1989	5.16***	0.87
0	4,000	0.5761	26.40***	3.50***	5,430	0.6771	18.72***	3.15***
1	3,965	0.5126	23.06***	3.06***	5,430	0.7292	20.72***	3.49***
2	3,883	0.3683	16.14***	2.14**	5,430	0.5582	15.82***	2.67***
3	3,895	0.2984	13.19***	1.75*	5,430	0.5165	14.62***	2.46**
4	3,915	0.3042	13.59***	1.80*	5,430	0.5295	15.00***	2.53**
5	3,891	0.3149	14.27***	1.89*	5,430	0.4886	13.83***	2.33**
6	3,915	0.2730	12.29***	1.63	5,430	0.5032	14.65***	2.47**
7	3,858	0.2393	10.80***	1.43	5,430	0.4194	11.98***	2.02**
8	3,876	0.2266	10.28***	1.36	5,430	0.4323	12.53***	2.11**
9	3,829	0.2443	11.08***	1.47	5,430	0.4012	11.37***	1.92*
10	3,834	0.2117	9.47***	1.26	5,430	0.3758	10.70***	1.80*

Note: ***, **,* indicate p-value significant at 1%, 5% and 10% level.

Table 18: Robustness Check (changing estimation period)
Daily Abnormal Turnover around Takeover Announcement

This table shows the mean of abnormal volume turnover for takeover announcement from ordinary common stock listed in the ASX from 1994 to 2007. Volume turnover is trading volume divided by outstanding shares. Log abnormal volume turnover is the difference between observed log volume turnover and the average log volume turnover estimated from t = -55 to t = -11. The t-value is the t-value of independent corporate announcements and I assume these events occur randomly. The adjusted t-value is the t-value of dependent corporate announcements. The t-test and adjusted t-value are used to test whether the mean is significantly different from zero or not.

	Unmodified data				Modified data			
Event day	N	Mean	t-value	adjusted t-value	N	Mean	t-value	adjusted t-value
-10	913	0.0822	2.13**	0.20	1,353	0.1282	2.51**	0.28
-9	919	0.0358	0.94	0.09	1,353	0.1041	2.10**	0.23
-8	908	0.0285	0.76	0.07	1,353	0.0022	0.04	0.004
-7	922	0.0648	1.63	0.16	1,353	0.1003	1.94*	0.21
-6	925	0.0201	0.51	0.05	1,353	0.0548	1.09	0.12
-5	919	0.0731	1.73*	0.17	1,353	0.0813	1.46	0.16
-4	933	0.0911	2.29**	0.22	1,353	0.1531	2.87***	0.32
-3	928	0.1564	3.75***	0.36	1,353	0.2124	3.79***	0.42
-2	891	0.1781	4.27***	0.41	1,353	0.0868	1.48	0.16
-1	889	0.3519	7.87***	0.76	1,353	0.1494	2.17**	0.24
0	998	1.1321	20.95***	2.01**	1,353	1.2090	17.30***	1.92*
1	1,004	1.2495	25.26***	2.43**	1,353	1.4141	21.71***	2.40**
2	984	0.9131	19.25***	1.85*	1,353	1.0792	17.07***	1.89*
3	974	0.6906	15.34***	1.48	1,353	0.8857	14.57***	1.61
4	952	0.6124	12.83***	1.23	1,353	0.7508	12.22***	1.35
5	952	0.6333	14.27***	1.37	1,353	0.7271	12.05***	1.33
6	953	0.5332	11.96***	1.15	1,353	0.6422	10.48***	1.16
7	925	0.4755	11.12***	1.07	1,353	0.5384	9.17***	1.02
8	938	0.4191	9.78***	0.94	1,353	0.6211	10.64***	1.18
9	945	0.4276	9.39***	0.90	1,353	0.5834	9.50***	1.05
10	921	0.4197	8.65***	0.83	1,353	0.5186	8.13***	0.90

Note: ***, **,* indicate p-value significant at 1%, 5% and 10% level.

Appendix B: Robustness Check (volume market model)

Table 19: Correlation for Adjusted t-statistics

This table shows the average correlation of each corporate event for five announcements. I use 21 days of event period for individual event to calculate the correlation. The number of unique correlations is n(n-1)/2. N is the number of sample events. There are five types of corporate announcement: earnings, asset acquisition, asset disposal, capital and takeover announcements. For the panel A, I use unmodified turnover, it means some turnovers are 0 for the stock does not trade while the market is opening. For the Panel B, I use modified data, it means I plus a constant number 0.00000255 to the actual turnover.

Announcements	Earnings	Asset acquisition	Asset Disposal	Capital	Takeover
Panel A: Using Unmodified Turnover					
Correlation	0.001108	0.006245	0.004081	0.009705	0.078675
Panel B: Using Modified Turnover					
Correlation	0.001046	0.003738	0.003202	0.006230	0.057718

Table 20: Robustness Check (volume market model)
Daily Abnormal Turnover around Earnings Announcement

This table shows the mean of abnormal volume turnover for earnings announcement from ordinary common stock listed in the ASX from 1994 to 2007. Volume turnover is trading volume divided by outstanding shares. The log abnormal volume turnover is the residual of one-factor market model. The coefficients are estimated from the estimated period t = -40 to t = -11. The t-value is the t-value of independent corporate announcements and I assume these events occur randomly. The adjusted t-value is the t-value of dependent corporate announcements. The t-test and adjusted t-value are used to test whether the mean is significantly different from zero or not.

	Unmodified data				Modified data			
Event day	N	Mean	t-value	adjusted t-value	N	Mean	t-value	adjusted t-value
-10	8,345	-0.0160	-1.19	-0.31	12,765	-0.0377	-1.96**	-0.52
-9	8,381	-0.0214	-1.50	-0.39	12,765	-0.0011	-0.06	-0.02
-8	8,340	-0.0379	-1.10	-0.28	12,765	-0.0037	-0.19	-0.05
-7	8,380	0.0087	0.61	0.16	12,765	0.0053	0.26	0.07
-6	8,386	-0.0833	-1.07	-0.28	12,765	-0.0064	-0.31	-0.08
-5	8,302	-0.0257	-1.76	-0.45	12,765	-0.0162	-0.79	-0.21
-4	7,953	0.0112	0.43	0.11	12,765	-0.0032	-0.15	-0.04
-3	7,681	-0.0712	-1.42	-0.36	12,765	-0.0071	-0.33	-0.09
-2	8,290	-0.0118	-0.66	-0.17	12,765	0.0121	0.58	0.15
-1	8,426	0.0284	1.94*	0.50	12,765	0.0477	2.31**	0.61
0	8,794	0.0887	6.06***	1.56	12,765	0.1318	6.46***	1.71*
1	8,404	0.1239	8.30***	2.13**	12,765	0.1329	6.27***	1.66*
2	8,430	0.0026	0.04	0.01	12,765	0.0727	3.41***	0.90
3	8,539	-0.0401	-0.74	-0.19	12,765	0.0537	2.58***	0.68
4	8,534	0.0303	2.03**	0.52	12,765	0.0448	2.14**	0.56
5	8,444	0.0376	2.49**	0.64	12,765	0.0234	1.11	0.29
6	8,589	0.0293	1.97*	0.51	12,765	0.0406	1.93*	0.51
7	8,507	0.0010	0.06	0.02	12,765	-0.0226	-1.07	-0.28
8	8,560	-0.0093	-0.61	-0.16	12,765	-0.0061	-0.29	-0.08
9	8,613	0.0108	0.70	0.18	12,765	0.0223	1.05	0.28
10	8,626	0.0129	0.86	0.22	12,765	0.0356	1.69*	0.45

Note: ***, **,* indicate p-value significant at 1%, 5% and 10% level.

Table 21: Robustness Check (volume market model)
Daily Abnormal Turnover around Asset Acquisition Announcement

This table shows the mean of abnormal volume turnover for asset acquisition announcement from ordinary common stock listed in the ASX from 1994 to 2007. Volume turnover is trading volume divided by outstanding shares. The log abnormal volume turnover is the residual of one-factor market model. The coefficients are estimated from the estimated period t = -40 to t = -11. The t-value is the t-value of independent corporate announcements and I assume these events occur randomly. The adjusted t-value is the t-value of dependent corporate announcements. The t-test and adjusted t-value are used to test whether the mean is significantly different from zero or not.

	Unmodified data				Modified data			
Event day	N	Mean	t-value	adjusted t-value	N	Mean	t-value	adjusted t-value
-10	9,059	0.0173	1.42	0.17	11,146	0.0618	3.60***	0.55
-9	9,094	0.0068	0.55	0.07	11,146	0.0675	3.85***	0.59
-8	8,995	0.0020	0.16	0.02	11,146	0.0337	1.93*	0.30
-7	9,062	-0.0042	-0.33	-0.04	11,146	0.0385	2.16**	0.33
-6	8,993	0.0312	2.45**	0.29	11,146	0.0575	3.17***	0.49
-5	8,984	0.0233	1.83*	0.22	11,146	0.0311	1.69*	0.26
-4	8,984	0.0443	3.49***	0.42	11,146	0.0357	1.92*	0.29
-3	9,005	0.0543	4.05***	0.48	11,146	0.0734	3.90***	0.60
-2	8,998	0.0409	3.07***	0.37	11,146	0.0508	2.65***	0.41
-1	8,923	0.1071	7.99***	0.95	11,146	0.0573	2.89***	0.44
0	9,328	0.2937	19.54***	2.33**	11,146	0.3292	16.13***	2.47**
1	9,253	0.2920	21.24***	2.53**	11,146	0.3791	19.04***	2.92***
2	9,068	0.1945	13.93***	1.66*	11,146	0.2907	14.69***	2.25**
3	8,952	0.1221	8.78***	1.04	11,146	0.2095	10.67***	1.63
4	8,967	0.1127	7.89***	0.94	11,146	0.1629	8.14***	1.25
5	8,944	0.0822	5.96***	0.71	11,146	0.1368	6.90***	1.06
6	8,901	0.0649	4.85***	0.58	11,146	0.1279	6.58***	1.01
7	8,839	0.0314	2.24**	0.27	11,146	0.0779	3.94***	0.60
8	8,858	0.0141	1.00	0.12	11,146	0.0619	3.13***	0.48
9	8,835	0.0261	1.88*	0.22	11,146	0.0656	3.32***	0.51
10	8,858	0.0134	0.97	0.12	11,146	0.0804	4.16***	0.64

Note: ***, **,* indicate p-value significant at 1%, 5% and 10% level.

Table 22: Robustness Check (volume market model)
Daily Abnormal Turnover around Asset Disposal Announcement

This table shows the mean of abnormal volume turnover for asset disposal announcement from ordinary common stock listed in the ASX from 1994 to 2007. Volume turnover is trading volume divided by outstanding shares. The log abnormal volume turnover is the residual of one-factor market model. The coefficients are estimated from the estimated period t = -40 to t = -11. The t-value is the t-value of independent corporate announcements and I assume these events occur randomly. The adjusted t-value is the t-value of dependent corporate announcements. The t-test and adjusted t-value are used to test whether the mean is significantly different from zero or not.

	Unmodified data				Modified data			
Event day	N	Mean	t-value	adjusted t-value	N	Mean	t-value	adjusted t-value
-10	4,054	0.0553	3.11***	0.66	5,219	0.0686	2.80***	0.67
-9	4,038	0.0429	2.31**	0.49	5,219	0.0464	1.83*	0.43
-8	4,049	0.0494	2.66***	0.56	5,219	0.0411	1.63	0.39
-7	4,026	0.0552	2.54**	0.54	5,219	0.0246	0.98	0.23
-6	4,004	0.0062	0.31	0.07	5,219	-0.0176	-0.68	-0.16
-5	4,036	0.0439	2.29**	0.48	5,219	0.0320	1.22	0.29
-4	4,022	0.0172	0.78	0.17	5,219	0.0082	0.30	0.07
-3	4,023	0.0555	2.79***	0.59	5,219	0.0139	0.51	0.12
-2	4,019	0.0677	3.52***	0.75	5,219	0.0364	1.33	0.32
-1	4,026	0.0867	4.21***	0.89	5,219	0.0582	2.07**	0.49
0	4,232	0.2844	12.23***	2.59***	5,219	0.3353	11.65***	2.77***
1	4,118	0.2770	12.61***	2.67***	5,219	0.3497	12.31***	2.93***
2	4,035	0.1735	6.74***	1.43	5,219	0.1947	7.05***	1.68*
3	4,005	0.1244	4.07***	0.86	5,219	0.1075	3.89***	0.92
4	4,001	0.0952	3.56***	0.75	5,219	0.1182	4.34***	1.03
5	4,029	0.0937	3.53***	0.75	5,219	0.1080	3.96***	0.94
6	4,004	0.0895	4.24***	0.90	5,219	0.1081	3.93***	0.93
7	3,973	0.0608	2.44**	0.52	5,219	0.0460	1.69*	0.40
8	3,985	0.0912	2.78***	0.59	5,219	0.0695	2.57**	0.61
9	3,951	0.0738	1.99**	0.42	5,219	0.0028	0.10	0.02
10	3,992	0.0838	2.00**	0.42	5,219	0.0611	2.24**	0.53

Note: ***, **,* indicate p-value significant at 1%, 5% and 10% level.

Table 23: Robustness Check (volume market model)
Daily Abnormal Turnover around Capital Announcement

This table shows the mean of abnormal volume turnover for capital announcement from ordinary common stock listed in the ASX from 1994 to 2007. Volume turnover is trading volume divided by outstanding shares. The log abnormal volume turnover is the residual of one-factor market model. The coefficients are estimated from the estimated period t = -40 to t = -11. The t-value is the t-value of independent corporate announcements and I assume these events occur randomly. The adjusted t-value is the t-value of dependent corporate announcements. The t-test and adjusted t-value are used to test whether the mean is significantly different from zero or not.

	Unmodified data				Modified data			
Event day	N	Mean	t-value	adjusted t-value	N	Mean	t-value	adjusted t-value
-10	3,796	0.0618	3.08***	0.42	5,430	0.0936	2.89***	0.49
-9	3,794	0.0568	2.73***	0.37	5,430	0.0633	1.98**	0.34
-8	3,792	0.1019	4.79***	0.65	5,430	0.0990	2.99***	0.51
-7	3,841	0.0733	3.38***	0.46	5,430	0.1150	3.46***	0.59
-6	3,865	0.1213	5.70***	0.78	5,430	0.1895	5.72***	0.97
-5	3,844	0.1435	6.59***	0.90	5,430	0.1707	5.15***	0.87
-4	3,836	0.1221	5.32***	0.73	5,430	0.1407	4.02***	0.68
-3	3,855	0.1740	7.53***	1.03	5,430	0.2125	6.05***	1.03
-2	3,777	0.2137	9.32***	1.27	5,430	0.1512	4.06***	0.69
-1	3,728	0.2662	11.16***	1.52	5,430	0.1105	2.78***	0.47
0	4,000	0.5272	22.69***	3.10***	5,430	0.5812	15.51***	2.63***
1	3,965	0.4768	20.34***	2.78***	5,430	0.6391	17.43***	2.95***
2	3,883	0.3235	13.33***	1.82*	5,430	0.4673	12.89***	2.18**
3	3,895	0.2452	8.83***	1.21	5,430	0.4356	11.94***	2.02**
4	3,915	0.2501	9.82***	1.34	5,430	0.4474	12.39***	2.10**
5	3,891	0.2733	11.75***	1.60	5,430	0.4007	11.04***	1.87*
6	3,915	0.2451	10.34***	1.41	5,430	0.4289	11.99***	2.03**
7	3,858	0.2010	7.95***	1.08	5,430	0.3628	10.02***	1.70*
8	3,876	0.1903	8.11***	1.11	5,430	0.3654	10.28***	1.74*
9	3,829	0.2048	8.47***	1.16	5,430	0.3269	8.85***	1.50
10	3,834	0.1716	7.19***	0.98	5,430	0.2998	8.15***	1.38

Note: ***, **,* indicate p-value significant at 1%, 5% and 10% level.

Table 24: Robustness Check (volume market model)
Daily Abnormal Turnover around Takeover Announcement

This table shows the mean of abnormal volume turnover for takeover announcement from ordinary common stock listed in the ASX from 1994 to 2007. Volume turnover is trading volume divided by outstanding shares. The log abnormal volume turnover is the residual of one-factor market model. The coefficients are estimated from the estimated period t = -40 to t = -11. The t-value is the t-value of independent corporate announcements and I assume these events occur randomly. The adjusted t-value is the t-value of dependent corporate announcements. The t-test and adjusted t-value are used to test whether the mean is significantly different from zero or not.

	Unmodified data				Modified data			
Event day	N	Mean	t-value	adjusted t-value	N	Mean	t-value	adjusted t-value
-10	913	0.0677	1.76*	0.17	1,353	0.0902	1.79*	0.20
-9	919	0.0001	0.00	0.00	1,353	0.0268	0.53	0.06
-8	908	0.0015	0.04	0.004	1,353	-0.0407	-0.79	-0.09
-7	922	0.0456	1.12	0.11	1,353	0.0467	0.90	0.10
-6	925	-0.0256	-0.63	-0.06	1,353	-0.0223	-0.44	-0.05
-5	919	0.0119	0.25	0.02	1,353	0.0191	0.35	0.04
-4	933	0.0724	1.74*	0.17	1,353	0.0807	1.53	0.17
-3	928	0.1557	3.66***	0.35	1,353	0.1693	3.02***	0.34
-2	891	0.1725	4.15***	0.40	1,353	0.0467	0.78	0.09
-1	889	0.3469	7.31***	0.71	1,353	0.0990	1.42	0.16
0	998	1.0524	13.10***	1.26	1,353	1.1224	16.02***	1.80*
1	1,004	1.2565	23.29***	2.25**	1,353	1.3347	20.42***	2.30**
2	984	0.8502	12.00***	1.16	1,353	1.0165	15.90***	1.79*
3	974	0.7176	15.06***	1.45	1,353	0.8509	13.81***	1.55
4	952	0.6144	11.71***	1.13	1,353	0.7279	11.93***	1.34
5	952	0.6998	10.37***	1.00	1,353	0.6810	11.05***	1.24
6	953	0.4973	9.25***	0.89	1,353	0.5803	9.30***	1.05
7	925	0.4711	10.44***	1.01	1,353	0.4577	7.59***	0.85
8	938	0.4029	8.58***	0.83	1,353	0.5852	9.65***	1.09
9	945	0.4118	8.36***	0.81	1,353	0.5149	7.93***	0.89
10	921	0.4367	8.15***	0.79	1,353	0.4939	7.48***	0.84

Note: ***, **,* indicate p-value significant at 1%, 5% and 10% level.

Appendix C: SAS and Matlab Code

SAS Code

```
libname a 'E:/wei thesis/all announcement data at SAS/';
**************************************;
*     Import All Announcement data;
**************************************;
I give a year example
data a.ann_93_94;
```

```
        infile "E:/wei thesis/all announcement data at Excel/windows/announcements/ann_93_94.csv"
        dlm = ’,’ dsd missover firstobs = 1;
        input code $ identifier anndate:yymmdd8. anntime:hhmmss6.
        entereddate:yymmdd8. enteredtime:hhmmss6. industrysubgroup
        documents type $ Y $ number part $ exchange cat1 subcat1
        cat2 subcat2 cat3 subcat3 cat4 subcat4 cat5 subcat5
        cat6 subcat6 cat7 subcat7 cat8 subcat8 cat9 subcat9
        cat10 subcat10 cat11 subcat11 cat12 subcat12 cat13 subcat13;
        format anndate:date9. entereddate:date9. anntime:time8.
        enteredtime:time8.;
        run;
data a.alldata;
        set a.ann_91_92 a.ann_92_93 a.ann_93_94 a.ann_94_95 a.ann_95_96
        a.ann_96_97 a.ann_97_98 a.ann_98_99 a.ann_99_00 a.ann_00_01
        a.ann_01_02 a.ann_02_03 a.ann_03_04 a.ann_04_05 a.ann_05_06
        a.ann_06_07;
        run;

libname a ’E:/wei thesis/trading volume data at SAS/’;
****************************************;
*       Import trading volume data (dately);
****************************************;
I give a year example
data a.pri_93_4;
        infile "E:/trading volume/pri_93_4.csv" dlm = ’,’ dsd missover
        firstobs = 1;
        input date:yymmdd8. identifier code:$12. highprice lowprice lastprice
        volumetraded valuetraded a b c $ d $ e f g;
        format date:date9.;
        run;
****************************************;
*       Seperate trading volume data (dately) into group;
****************************************;
data a.alldata1;
        set a.pri_91_2 a.pri_92_3 a.pri_93_4;
        run;
data a.alldata2;
        set a.pri_94_5 a.pri_95_6 a.pri_96_7;
        run;
data a.alldata3;
        set a.pri_97_8 a.pri_98_9 a.pri_99_0;
        run;
data a.alldata4;
        set a.pri_00_1 a.pri_01_2;
        run;
```

```
data a.alldata5;
      set a.pri_02_3 a.pri_03_4;
      run;
data a.alldata6;
      set a.pri_04_5 a.pri_05_6;
      run;
data a.alldata7;
      set a.pri_06_7 a.pri_07_8;
      run;

libname a 'E:\wei thesis\trading volume data at SAS\market trading day\';
**************************************;
*       Import market trading date;
**************************************;
data a.market;
      infile "E:\wei thesis\market trading day.csv" dlm = ',' dsd missover
      firstobs = 1;
      input date:yymmdd8. ;
      format date:date9.;
      run;
proc sort data = a.market out=a.market_sort;
      by date;
      run;
```

For analysis announcements, I give Asset Acquisition as a example

```
libname a 'E:/wei thesis/all announcement data at SAS/';
**************************************;
*       select acquisition announcement from all announcement (quarterly);
**************************************;
data a.acquisition_announcement;
      set a.alldata;
      where (cat1=7 and subcat1=1) or (cat2=7 and subcat2=1)
      or (cat3=7 and subcat3=1) or (cat4=7 and subcat4=1)
      or (cat5=7 and subcat5=1) or (cat6=7 and subcat6=1)
      or (cat7=7 and subcat7=1) or (cat8=7 and subcat8=1)
      or (cat9=7 and subcat9=1) or (cat10=7 and subcat10=1)
      or (cat11=7 and subcat11=1) or (cat12=7 and subcat12=1)
      or (cat13=7 and subcat13=1) ;
      run;
proc sort data = a.acquisition_announcement out=a.acquisition_announcement_sort;
      by code identifier anndate anntime industrysubgroup;
      run;
data a.acquisition_announcement_delete;
      set a.acquisition_announcement_sort;
      if anndate=lag(anndate) and code=lag(code) then delete;
```

```
    run;
**************************************;
* select only acquisition announcement(quarterly);
**************************************;
data a.acquisition_announcement_only;
    set a.acquisition_announcement_delete;
    if cat2 ne . then delete;
    run;
proc sort data = a.acquisition_announcement_only out=a.AA_only_sort;
    by code anndate;
    run;

libname a 'E:/wei thesis/trading volume data at SAS/AA';
**************************************;
*Import trading volume match with acquistion announcement by Excel;
**************************************;
I give a group example
data a.volume1_match;
    infile "E:/wei thesis/trading volume match at Excel/trading volume
    match with AA/volume1_match.csv" dlm = ','
    dsd missover firstobs = 2;
    input date:date9. identifier code:$12. highprice lowprice lastprice
    volumetraded valuetraded a b c $ d $ e f g;
    format date:date9.;
    run;
data a.alldata_match_AA;
    set a.volume1_match a.volume2_match a.volume3_match a.volume4_match
    a.volume5_match a.volume6_match a.volume7_match;
    run;
proc sort data = a.alldata_match_AA out=a.allvolume_match_AA_sort;
    by code identifier date highprice lowprice lastprice volumetraded;
    run;
data a.volume_AA;
    set a.allvolume_match_AA_sort;
    keep date code volumetraded;
    run;

libname a 'E:\wei thesis\trading volume dataat SAS\AA';
**************************************;
* Insert market trading date into every stock trading date;
**************************************;
proc sort data = a.volume_AA out= a.volume;
    by code date;
    run;
data a.volumefirst(keep=datefirst code) a.volumelast(keep=datelast code);
```

```
        set a.volume;
        by code ;
        datefirst=date;
        datelast=date;
        format datefirst date9.;
        format datelast date9.;
        if first.code then output a.volumefirst;
        if last.code then output a.volumelast;
        run;
data a.volumefirstlast;
        merge a.volumefirst a.volumelast;
        by code;
        run;
proc sql;
        create table a.tmp as
        select *
        from a.market_sort, a.volumefirstlast
        order by code,date;
        quit;
data a.tmp1;
        set a.tmp;
        if date < datefirst or date>datelast then delete;
        keep code date;
        run;
data a.volume_AA_date;
        merge a.tmp1 a.volume;
        by code date;
        run;
data a.volume_AA_date1;
        set a.volume_AA_date;
        if volumetraded=. Then volumetraded= 0;
        run;

libname a 'E:\wei thesis\AA\';
**************************************;
* Merge only acquisition announcement and volume;
**************************************;
data a.AA_only_no;
        set a.AA_only_sort;
        eventid = _N_;
        ticker = code;
        eventdat = anndate;
        format eventdat:date9.;
        keep eventid ticker eventdat;
        run;
```

```
proc sql;
    create table a.new as
    select *
    from a.volume_AA_date1, a.AA_only_no
    where volume_AA_date1.code=AA_only_no.ticker
    order by AA_only_no.eventid, volume_AA_date1.date;
    quit;
    run;
data a.volumes_AA;
    set a.new;
    if code=ticker and date<eventdat then bef = 1;
    if code=ticker and date>=eventdat then bef = 0;
    keep code volumetraded eventid date eventdat bef;
    run;

libname a 'E:\wei thesis\AA\';
***************************************;
* Event Study;
***************************************;
proc sort data=a.volumes_AA out=a.volumes1_AA;
    by code eventdat date;
    run;
proc means data=a.volumes1_AA noprint;
    by code eventdat;
    output out=a.nvolumes1_AA(drop=_type_ _freq_) sum(bef)= bef_sum;
    run;
data a.estper a.evntper;
    merge a.volumes1_AA(drop=bef) a.nvolumes1_AA;
    by code eventdat;
    if first.eventdat then relday=-bef_sum - 1;
    relday + 1;
    if -40<=relday<=-11 then output a.estper;
    if -10 <= relday <= 10 then output a.evntper;
    run;
proc means data=a.estper noprint;
    by code eventdat;
    output out = a.mmparam_AA mean(volumetraded)=meanvol;
    run;
data a.av_AA;
    merge a.evntper a.mmparam_AA;
    by code eventdat;
    AV = volumetraded/meanvol-1;
    run;
proc sort data=a.av_AA out=a.av_AA1;
    by relday code eventdat;
```

```
        run;
    proc means data=a.av_AA1 n mean t prt;
        title " test for AA";
        var av;
        class relday;
        run;

    libname a 'E:\wei thesis\robustness check\AA\0';
    **************************************;
    * Event Study for changing estimation period;
    **************************************;
    data a.estper a.evntper;
        merge a.turnover1_AA1(drop=bef) a.nturnover1_AA;
        by code eventdat;
        if first.eventdat then relday=-bef_sum - 1;
        relday + 1;
        if -55<=relday<=-11 then output a.estper;
        if -10 <= relday <= 10 then output a.evntper;
        run;
    proc means data=a.estper noprint;
        by code eventdat;
        output out = a.mmparam_AA mean(logturnover)=meanto;
        run;
    data a.merge_AA;
        merge a.evntper a.mmparam_AA;
        by code eventdat;
        run;
    data a.AV_AA;
        set a.merge_AA;
        AV=logturnover-meanto;
        run;
    proc means data=a.av_AA NOPRINT;
        by code eventdat;
        output out= a.car_AA SUM(av)=CAR;
        run;
    proc sort data=a.av_AA out=a.av_AA1;
        by relday code eventdat;
        run;
    proc means data=a.av_AA1 n mean t prt;
        title " test for AA";
        var av;
        class relday;
        run;

    libname a 'E:\wei thesis\skewness';
```

```
**************************************;
* geting market turnover;
**************************************;
proc sort data = a.outstanding_sort out= a.outstanding_sort1;
      by date;
      run;
proc means data=a.outstanding_sort1 noprint;
      var outstanding;
      class date;
      output out=a.market_outstanding
      sum(outstanding)=market_outstanding;
      run;
proc sort data = a.stockvolume1 out= a.stockvolume1_sort1;
      by date;
      run;
proc means data=a.stockvolume1_sort1 noprint;
      var volumetraded;
      class date;
      output out=a.market_volume
      sum(volumetraded)=market_volume;
      run;
data a.merge_market_outstanding_volume;
      merge a.market_outstanding a.market_volume;
      by date;
      run;
data a.logmarket_turnover;
      set a.merge_market_outstanding_volume;
      logmarket_turnover=log(market_volume/market_outstanding);
      run;

libname a 'E:\wei thesis\robustness check\market volume model\AA\0';
**************************************;
* Event Study for trading volume market model;
**************************************;
proc sort data=a.new out=a.new_sort;
      by date;
      run;
data a.new1;
      merge a.new_sort a.logmarket_turnover1;
      by date;
      run;
proc sort data=a.new1 out=a.new1_sort1;
      by code eventdat date;
      run;
data a.turnover_AA1;
```

```
        set a.new1_sort1;
        if code=ticker and date<eventdat then bef = 1;
        if code=ticker and date>=eventdat then bef = 0;
        keep code turnover eventid date eventdat logmarket_turnover bef;
        run;
proc sort data=a.turnover_AA1 out=a.turnover1_AA1;
        by code eventdat date;
        run;
proc means data=a.turnover1_AA1 noprint;
        by code eventdat;
        output out=a.nturnover1_AA(drop=_type_ _freq_) sum(bef)= bef_sum;
        run;
data a.estper a.evntper;
        merge a.turnover1_AA1(drop=bef) a.nturnover1_AA;
        by code eventdat;
        if first.eventdat then relday=-bef_sum - 1;
        relday + 1;
        if -40<=relday<=-11 then output a.estper;
        if -10 <= relday <= 10 then output a.evntper;
        run;
proc reg data=a.estper outest=a.mmparam
        (rename=(intercept=alpha logmarket_turnover=beta)
        keep=code eventdat intercept logmarket_turnover) noprint;
        by code eventdat;
        model turnover=logmarket_turnover;
        run;
        quit;
data a.AV_AA;
        merge a.evntper a.mmparam;
        by code eventdat;
        av=turnover-alpha-beta*logmarket_turnover;
        run;
proc means data=a.av_AA NOPRINT;
        by code eventdat;
        output out=a.car_AA SUM(av)=CAR;
        run;
proc sort data=a.av_AA out=a.av_AA1;
        by relday code eventdat;
        run;
proc means DATA=a.av_AA1 n mean t prt;
        title " test for AA";
        var av;
        class relday;
        run;
```

```
libname a 'E:\wei thesis\bid-ask spread';
*************************************;
*calculate bid-ask spread & NO. of buyers and sellers;
*************************************;
data a.spread;
	set a.trade;
	by StockCode Date;
	spread = (BestAsk-BestBid)*2/(BestAsk+BestBid);
	outtime = time - lag(time);
	if first.date then outtime = .;
	if substr(TradeFlags,1,1)='B' then buysell = 1;
	if substr(TradeFlags,1,1)='S' then buysell = -1;
	if BestAsk <= 0 or BestBid <=0 or BestBid>=BestAsk
	or abs(buysell) ne 1 then spread = .;
	keep StockCode Date outtime spread buysell;
	run;
proc means data=a.spread noprint;
	class StockCode Date;
	weight outtime;
	output out=z.dailyspread n(spread)=cnt mean(spread) = twspread;
	run;
data a.dailyspread;
	set a.dailyspread;
	if _type_ ne 3 then delete;
	drop _type_;
	run;
proc means data = a.spread(where=(buysell=1)) noprint;
	class StockCode date ;
	output out=a.nbuy n(buysell)=buys;
	run;
data a.nbuy(keep=StockCode date buys);
	set a.nbuy(where=(_type_=3));
	run;
proc means data = a.spread(where=(buysell=-1)) noprint;
	class StockCode date ;
	output out=a.nsell n(buysell)=sells;
	run;
data a.nsell(keep=StockCode date sells);
	set a.nsell(where=(_type_=3));
	run;
data a.nbuysell;
	merge a.nbuy a.nsell;
	by StockCode date;
	if buys=. then buys=0;
	if sells=. then sells=0;
```

```
periodm = year(date)*100+month(date);
run;
```

Matlab code

I use AA announcement as an example to show Matlab code

```
*************************************;
* Calculate the correlation cross announcements;
*************************************;
clear
clc
cd('E:\AA correlation\');
load avdata.mat;
eventid = avdata(:,1);
av = avdata(:,3);
ueventid = unique(eventid);
n = length(ueventid);
out=zeros(n*n,1)+NaN;
k=1;
for i=1:n-1
i
xi = find(eventid==ueventid(i));
avxi = av(xi);
for j = i+1:n
xj = find(eventid==ueventid(j));
avxj = av(xj);
if length(avxi)~=length(avxj)
continue
else
x = find(~isnan(avxi) & ~isnan(avxj));
end
if length(x)>5
tmp = corrcoef(avxi(x),avxj(x));
out(k,1) = tmp(2,1);
k=k+1;
end
end
end
csvwrite('out.csv',out);

*************************************;
* Estimate variables for PIN;
*************************************;
% x(1) is mu, x(2) is eb, x(3) is es,
% x(4) is alpha, x(5) is delta.
```

```
warning off all
iii=0;
T=638400;
for jjj=1:40:T
j=0;
for jj=jjj:jjj+39
j=j+1;
B(j)=data(jj,1);
S(j)=data(jj,2);
end
mu_0=log(mean(B(:)));
eb_0=log(mean(B(:)));
es_0=log(mean(S(:)));
i=1;
x0=[mu_0,eb_0,es_0,4,4];
[x,fval]=fminsearch(@(x)-((log(1-1/(1+exp(10-2*x(4))))+log(poisspdf(B(i),exp(x(2))))
+log(poisspdf(S(i),exp(x(3))))+log(1/(1+exp(10-2*x(4))))+log(1/(1
+exp(10-2*x(5))))+log(poisspdf(B(i),exp(x(2))))+log(poisspdf(S(i),exp(x(1))
+exp(x(3))))+log(1/(1+exp(10-2*x(4))))+log(1-1/(1+exp(10-2*x(5))))
+log(poisspdf(B(i),exp(x(1))+exp(x(2))))+log(poisspdf(S(i),exp(x(3)))))/3
+log(exp(log(1-1/(1+exp(10-2*x(4))))+log(poisspdf(B(i),exp(x(2))))
+log(poisspdf(S(i),exp(x(3))))-(log(1-1/(1+exp(10-2*x(4))))
+log(poisspdf(B(i),exp(x(2))))+log(poisspdf(S(i),exp(x(3))))
+log(1/(1+exp(10-2*x(4))))+log(1/(1+exp(10-2*x(5))))
+log(poisspdf(B(i),exp(x(2))))+log(poisspdf(S(i),exp(x(1))+exp(x(3))))
+log(1/(1+exp(10-2*x(4))))+log(1-1/(1+exp(10-2*x(5))))
+log(poisspdf(B(i),exp(x(1))+exp(x(2))))+log(poisspdf(S(i),exp(x(3)))))/3)
+exp(log(1/(1+exp(10-2*x(4))))+log(1/(1+exp(10-2*x(5))))
+log(poisspdf(B(i),exp(x(2))))+log(poisspdf(S(i),exp(x(1))+exp(x(3))))
-(log(1-1/(1+exp(10-2*x(4))))+log(poisspdf(B(i),exp(x(2))))
+log(poisspdf(S(i),exp(x(3))))+log(1/(1+exp(10-2*x(4))))
+log(1/(1+exp(10-2*x(5))))+log(poisspdf(B(i),exp(x(2))))
+log(poisspdf(S(i),exp(x(1))+exp(x(3))))+log(1/(1+exp(10-2*x(4))))
+log(1-1/(1+exp(10-2*x(5))))+log(poisspdf(B(i),exp(x(1))+exp(x(2))))
+log(poisspdf(S(i),exp(x(3)))))/3)+exp(log(1/(1+exp(10-2*x(4))))
+log(1-1/(1+exp(10-2*x(5))))+log(poisspdf(B(i),exp(x(1))+exp(x(2))))
+log(poisspdf(S(i),exp(x(3))))-(log(1-1/(1+exp(10-2*x(4))))
+log(poisspdf(B(i),exp(x(2))))+log(poisspdf(S(i),exp(x(3))))
+log(1/(1+exp(10-2*x(4))))+log(1/(1+exp(10-2*x(5))))
+log(poisspdf(B(i),exp(x(2))))+log(poisspdf(S(i),exp(x(1))+exp(x(3))))
+log(1/(1+exp(10-2*x(4))))+log(1-1/(1+exp(10-2*x(5))))
+log(poisspdf(B(i),exp(x(1))+exp(x(2))))+log(poisspdf(S(i),exp(x(3)))))/3))
......
(log(1-1/(1+exp(10-2*x(4))))+log(poisspdf(B(i+39),exp(x(2))))
+log(poisspdf(S(i+39),exp(x(3))))+log(1/(1+exp(10-2*x(4))))
```

```
+log(1/(1+exp(10-2*x(5))))+log(poisspdf(B(i+39),exp(x(2))))
+log(poisspdf(S(i+39),exp(x(1))+exp(x(3))))+log(1/(1+exp(10-2*x(4))))
+log(1-1/(1+exp(10-2*x(5))))+log(poisspdf(B(i+39),exp(x(1))+exp(x(2))))
+log(poisspdf(S(i+39),exp(x(3)))))/3+log(exp(log(1-1/(1+exp(10-2*x(4))))
+log(poisspdf(B(i+39),exp(x(2))))+log(poisspdf(S(i+39),exp(x(3))))
-(log(1-1/(1+exp(10-2*x(4))))+log(poisspdf(B(i+39),exp(x(2))))
+log(poisspdf(S(i+39),exp(x(3))))+log(1/(1+exp(10-2*x(4))))
+log(1/(1+exp(10-2*x(5))))+log(poisspdf(B(i+39),exp(x(2))))
+log(poisspdf(S(i+39),exp(x(1))+exp(x(3))))+...
log(1/(1+exp(10-2*x(4))))+log(1-1/(1+exp(10-2*x(5))))
+log(poisspdf(B(i+39),exp(x(1))+exp(x(2))))+log(poisspdf(S(i+39),exp(x(3)))))/3)
+exp(log(1/(1+exp(10-2*x(4))))+log(1/(1+exp(10-2*x(5))))
+log(poisspdf(B(i+39),exp(x(2))))+log(poisspdf(S(i+39),exp(x(1))+exp(x(3))))
-(log(1-1/(1+exp(10-2*x(4))))+log(poisspdf(B(i+39),exp(x(2))))
+log(poisspdf(S(i+39),exp(x(3))))+log(1/(1+exp(10-2*x(4))))
+log(1/(1+exp(10-2*x(5))))+log(poisspdf(B(i+39),exp(x(2))))
+log(poisspdf(S(i+39),exp(x(1))+exp(x(3))))+log(1/(1+exp(10-2*x(4))))
+log(1-1/(1+exp(10-2*x(5))))+log(poisspdf(B(i+39),exp(x(1))+exp(x(2))))
+log(poisspdf(S(i+39),exp(x(3)))))/3)+exp(log(1/(1+exp(10-2*x(4))))
+log(1-1/(1+exp(10-2*x(5))))+log(poisspdf(B(i+39),exp(x(1))+exp(x(2))))
+log(poisspdf(S(i+39),exp(x(3))))-(log(1-1/(1+exp(10-2*x(4))))
+log(poisspdf(B(i+39),exp(x(2))))+log(poisspdf(S(i+39),exp(x(3))))
+log(1/(1+exp(10-2*x(4))))+log(1/(1+exp(10-2*x(5))))
+log(poisspdf(B(i+39),exp(x(2))))+log(poisspdf(S(i+39),exp(x(1))+exp(x(3))))
+log(1/(1+exp(10-2*x(4))))+log(1-1/(1+exp(10-2*x(5))))
+log(poisspdf(B(i+39),exp(x(1))+exp(x(2))))+log(poisspdf(S(i+39),exp(x(3)))))/3))),x0);
alpha_opt=(1/(1+exp(10-2*x(4)))); % x(4) is alpha
delta_opt=(1/(1+exp(10-2*x(5)))); % x(5) is delta
mu_opt=exp(x(1)); % x(1) is mu
eb_opt=exp(x(2)); % x(2) is eb
es_opt=exp(x(3)); % x(3) is es
PIN=alpha_opt*mu_opt/(alpha_opt*mu_opt+es_opt+eb_opt);
iii=iii+1
REC_ALL(iii,1)=-fval;
REC_ALL(iii,2)=alpha_opt;
REC_ALL(iii,3)=delta_opt;
REC_ALL(iii,4)=mu_opt;
REC_ALL(iii,5)=eb_opt;
REC_ALL(iii,6)=es_opt;
REC_ALL(iii,7)=PIN;
end
```

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