TRADING STRATEGY BASED ON INTRADAY ABNORMAL VOLUME IN THE STOCK EXCHANGE OF THAILAND

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กลยุทธ์การซื้อขายโดยใช้ปริมาณการซื้อขายที่ผิดปกติระหว่างวันในตลาดหลักทรัพย์แห่งประเทศไทย

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ณัฐวุฒิ เดชบดินทร์ : กลยุทธ์การซื้อขายโดยใช้ปริมาณการซื้อขายที่ผิดปกติระหว่างวันในตลาดหลักทรัพย์แห่งประเทศไทย (TRADING STRATEGY BASED ON INTRADAY ABNORMAL VOLUME IN THE STOCK EXCHANGE OF THAILAND) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: ดร. พีรพงศ์ ทั่งวัฒโนทัย, 86 หน้า.

วิทยานิพนธ์ฉบับนี้นำเสนอกลยุทธ์การซื้อขายโดยอิงจากการสังเกตุและการคาดการณ์ของปริมาณการซื้อขายที่ผิดปกติของหุ้นในตลาดหลักทรัพย์แห่งประเทศไทย ตั้งแต่เดือนกรกฎาคม พ.ศ. 2553 ถึงเดือนมิถุนายน พ.ศ. 2559 การศึกษานี้พบว่าเหตุการณ์ปริมาณการซื้อขายที่ผิดปกติ (abnormal volume events) ซึ่งกำหนดโดยมีปริมาณการซื้อขายมาตรฐาน (standardized volume) และปริมาณทิศทางการซื้อขายมาตรฐาน (standardized directional volume) ที่สูงผิดปกตินั้นถูกตามมาด้วยผลตอบแทนส่วนเกิน (excess returns) ที่เป็นบวก กลยุทธ์การซื้อขายโดยอิงจากเหตุการณ์เหล่านี้ได้ถูกทดสอบเพื่อยืนยันว่าเหตุการณ์ดังกล่าวสามารถนำมาใช้ประโยชน์ได้ และการทดสอบชี้ให้เห็นว่ากลยุทธ์ข้างต้นสามารถสร้างอัลฟ่า (alpha) ที่เป็นบวกหลังจากหักค่าคอมมิชชั่นในการซื้อขายแล้ว ในส่วนของงานวิจัยก่อนหน้านี้ได้แสดงให้เห็นว่าเหตุการณ์ปริมาณการซื้อขายที่ผิดปกติมักมาพร้อมกับผลตอบแทนส่วนเกินที่มีขนาดใหญ่ซึ่งเกิดขึ้นภายในวันซื้อขายเดียวกัน วิทยานิพนธ์ฉบับนี้จึงได้ต่อยอดกลยุทธ์การซื้อขายข้างต้นด้วยการพยายามดักจับผลตอบแทนส่วนเกินขนาดใหญ่ในวันที่เกินเหตุการณ์นั้นๆ โดยได้พัฒนาอัลกอริทึมซึ่งสามารถทำนายเหตุการณ์เหล่านั้นด้วยความแม่นยำสูง (precision) และได้นำไปรวมเข้ากับกลยุทธ์ข้างต้นทำให้สามารถทำการซื้อได้ก่อนสิ้นวัน นอกจากนี้การจำลองพอร์ตการซื้อขายบนข้อมูลนอกกลุ่มตัวอย่าง (out-of-sample data) ได้แสดงว่ากลยุทธ์การซื้อขายระหว่างวันสามารถสร้างผลตอบแทนส่วนเกินที่เพิ่มขึ้น

ภาควิชา	การธนาคารและการเงิน	ลายมือชื่อนิสิต	....
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This thesis proposes a trading strategy which trades based on the observation and prediction of abnormal volume events of stocks listed on the Stock Exchange of Thailand (SET) during July 2010 to June 2016. This research found that a positive excess return follows an abnormal volume event defined by the abnormally-high standardized volume and standardized directional volume. To confirm that such events are exploitable, a strategy that trades on those events is tested and found that they generate positive alphas even after including commission fees. Previous work has shown that typically an abnormal volume event is accompanied by a substantial excess return on the same day. Thus, this thesis further improved the strategy by attempting to capture the excess returns on the same day as abnormal volume events. An algorithm capable of predicting those events with high precision is developed and integrated into the strategy, enabling trade initiation before the end of the day. A portfolio simulation on out-of-sample data shows that the intra-day strategy generates incremental excess returns.

Department: Banking and Finance Student's Signature ....

Field of Study: Financial Engineering Advisor's Signature ....

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CHAPTER 1

INTRODUCTION

1.1 Background and motivation

Trading volume is one of the most common market data available in an equity market across the globe after prices (such as open, high, low, and close price). Professional traders around the world use volume as one of their trading tools to either screen out liquid stocks, determine the market participant's interest in a particular asset or even use it directly to forecast future stock price movement.

In general, a rise in volume is believed to confirm the price uptrend. In opposition, a decline in volume is thought to hint a weakness of the trend and a reversal is imminent as people are no longer confident in the direction and the trend-following behavior dissipates. This belief has been proven to exist by many academic works, for instance, the very first empirical study done by Ying (1966) which stated that there exist a positive correlation between absolute price change and volume of the Standard & Poor's 500 Composite Index. In other words, on average the increase (decrease) in the index price goes together with the rise (decline) in the volume. Later Miller (1977) point out that an increased in volume leads to a higher probability that investor will investigate the stock. However, when coupled with short-selling constraint, the only choice left for new investors is to buy which result in an upward pressure on the stock price. In addition to the equity market, Karpoff (1987) reviewed multiple articles and confirmed that this correlated behavior exists throughout many time frames ranging from minutes to weekly and instruments such as common stocks and futures contract on market indices, commodities, and bond. It is important to point out that this behavior is right on average but not always the case because this inefficiency is well known and the market participants will trade on this while at the same time introduce more noise on to the volume-based signal. Trading solely on the price trend along with a rise and fall of the volume, therefore, does not guarantee a good performance.

There are cases when we can get a clear signal from volume. The phenomenon where volume expands far beyond its normal level is known as abnormal volume event. The distinct advantage provided by abnormal volume event is that the magnitude is so large compared to usual noises. However, the general belief in this area is still unclear plus there are few academic studies done specifically on this topic. One of the literature by Bajo (2010) showed a long-only strategy (for stocks) that achieve up to 36-39% of the yearly market adjusted return (without commission). It is done simply by holding the stocks after they experience abnormal volume events for just one day. On average these abnormal volume events are followed by positive excess returns. Few other literature also suggests that this phenomenon exists in many markets. Looking at returns after the abnormal volume events in Thai market (stocks listed on SET100), I found an evidence that is inconsistent with the result of Bajo (2010). This mismatch raise the question whether the phenomenon or some versions of it exists in Thai market.

It is plausible that the high-frequency tick data could improve the profitability that revolves around abnormal volume events. This data can be considered as a not entirely public information due to the difficulty of data acquisition, in particular for an extended period. Therefore, it is very likely that this data still contains additional unexploited information that may improve the profitability. One of the approaches that this study investigates is to incorporate additional information (from tick data) to the usual definition of abnormal volume events and creates a new variation which exhibits a greater high-volume premium. The second approach utilizes another known phenomenon of an abnormal volume event that is not believed to be exploitable. These events have been shown by Bajo (2010) that they are associated with enormous same date returns. However, these events are known at the end of the day, and thus it is impossible to capture these significant gains. This study investigates the predictability of an abnormal volume event before the end of the day to clarify this issue.

1.2 Research questions and objective of the study

This study investigates an opportunity that revolves around an abnormal volume event for the stocks listed on the SET100 index (Thailand). As mentioned earlier, a preliminary testing reveals that this phenomenon in Thai market is inconsistent to other markets. To clarify this issue, the following questions are explored:

1. To what extent can trading exploit the excess returns following abnormal volume events?
2. Could a high-frequency tick data help improve the profitability?
3. Is it possible to predict an abnormal volume event before the end of the day?

1.3 Scope of the study

This study investigates the relationship between stocks' abnormal volume event and the excess return associated with it. As well as perform a trading simulation on out-of-sample data of the stocks that are members of the SET100 index (Thailand) during the period July 2010 to June 2016.

1.4 Contributions

This study shows a new empirical evidence of the relationship between stocks' abnormal volume event and the excess returns associated with it for the stocks that are members of SET100 index (Thailand). This thesis extends the existing literature by addressing this issue in another market (Thai market). The knowledge obtained could be used by various traders, for instance, retail technical traders and market makers to improve their trading performance or to use as a part of their trading strategy construction/refinement process. The choice of the stock universe also ensures sufficient liquidity allowing the scaling of portfolio size to some extent. It is also possible that this understanding could help increase the speed of price adjustment by reducing the high-volume premium that follows an abnormal volume event. In other words, as more traders take profits regarding the abnormal volume events, the opportunity offered by this study would diminish.

1.5 Organization of the study

The remainder of this study is organized as follows. Chapter 2 provides the literature review and hypothesis development while Chapter 3 covers data used in this research. Chapter 4 describe the research methodology and all relevant formulation. Chapter 5 exhibits the results of this research as well as discuss the obtained result, and lastly, Chapter 6 concludes the study. Both references and the appendix are located after Chapter 6.

CHAPTER 2

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

This chapter reviewed three distinct findings as well as formed the hypotheses. Section 2.1 presents the existing evidence on the topic of the relationship between abnormal volume event and stock return. Section 2.2 reviews the subject of price adjustment under information asymmetry environment. This behavior raises a potential feature that may improve the stock returns after it experiences an abnormal volume events. Lastly, Section 2.3 explores the anticipation of an abnormal volume event with a prediction algorithm.

2.1 The relationship between abnormal volume event and stock return

Abnormal volume event refers to the case when a stock experiences a sudden large change in trading volume. Pritamani and Singal (2001) studied the price pattern around a significant price change event and concluded that this large price change event tends to be accompanied by a good earning announcement. If this substantial price change goes together with an abnormal volume event, the stock tends to show a price continuation (trending). On the other hand, Gervais, Kaniel, and Mingelgrin (2001) demonstrated an empirical result based on weekly data that a stock tends to exhibit high-volume premium after it experiences an abnormal volume event regardless of earning announcement. This evidence is consistent with Huang and Heian (2010) who showed that the premium after an abnormal volume event is vigorous and persistent across stocks listed on the New York Stock Exchange (NYSE) and the American Stock Exchange (AMEX). They further stated that most of the excess return resides within first four weeks after an abnormal volume event and the return declines as the length of the holding period increases. Also, Bajo (2010), who expanded this topic further by decreasing the timeframe down to daily showed that a positive excess return persists after an abnormal volume event and there is no price-reversal over the following month based on the stocks listed on the Milan Stock Exchange (Italy). Consistent with Gervais et al. (2001), he showed evidence that there are excess returns following abnormal volume events regardless of earnings announcements. In other words, news announcements do not significantly affect the behavior of the excess returns that follow abnormal volume events. He also suggested that this action arises from the exploitation of undisclosed information with a mixture of many positive and few negative private information because buying the stock is easier than short-selling it. This thesis extends previous studies by examining the excess returns following the abnormal volume events defined by abnormally-high standardized volume (V-event) in Thai market.

H1: The excess returns after the abnormal volume events defined by abnormally-high standardized volume are positive.

2.2 Price adjustment under information asymmetry

Information asymmetry refers to a scenario where not every market participants possess the same information which gives rise to an informed and uninformed trader. Theoretical work by Glosten and Milgrom (1985) showed that given this condition the price would adjust to its fair value through a sequence of same-side trades by an informed trader. Another theoretical work by Kyle (1985) suggested that an informed trader and a market maker trade strategically against each other to maximize their profit and thus slow down the price adjustment process. The reason behind is that an informed trader must remain discrete to prevent bid-ask spread widening from matching deals too often but at the same time must be aggressive enough to realized profit using their inside knowledge. This idea of bid-ask spread widening also supported with theoretical works by Easley and O'Hara (1987). The literature explained that for an uninformed market maker to be safe, they must place a small limit order at a favorable price (close to best price) while placing a large limit order at an unfavorable price (far from best price). This action forced the informed trader to either trade slow to get a good price or trade fast and get a bad price. Easley and O'Hara (1992) later extended their market model and stated that the market maker could infer the information held by the informed trader by observing the buy and sell trading behaviors. However, they suggested that watching few concentrated trades may not be informative as those may arise from a liquidity issue. Louhichi (2012) also supported this idea that the asymmetry between buy-initiated volume and sell-initiated volume is more informative (compared to regular volume) in predicting the stock return for the stocks listed on the Euronext market (Paris).

With these concepts, it seems plausible that the asymmetry between buy-initiated volume and sell-initiated volume is the proxy for the information held by an informed investor. In other words, an extreme buy-over-sell (sell-over-buy) volume may reflect the exploitation of positive (negative) information by the informed investor. This thesis inspects the excess returns following the abnormal volume events defined by abnormally-high standardized volume and standardized directional volume (VD-event) in Thai market to test this theory.

H2: The excess returns after the abnormal volume events defined by abnormally-high standardized volume and standardized directional volume are positive.

Aside from directional volume, another feature that could reflect the intention of informed investor is the stock's close-to-close return. It is sensible that a leak of relevant and high-impact private information would force the informed trader to act in a more aggressive manner, and thus contributes to some level of price changes. This thesis examines the excess returns following the abnormal volume events defined by abnormally-high standardized volume and sufficient price change (VP-event) in Thai market to test this concept.

H3: The excess returns after the abnormal volume events defined by abnormally-high standardized volume and sufficient price change are positive.

It is possible that the directional volume and price change features do not hold the same information (not perfectly correlated) and thus might possess a positive synergy that further improves the excess return when used together. This thesis reviews the excess returns following the abnormal volume events defined by abnormally-high standardized volume and standardized directional volume and sufficient price change (VDP-event) in Thai market to investigate this idea.

H4: The excess returns after the abnormal volume events defined by abnormally-high standardized volume and standardized directional volume and sufficient price change are positive.

According to Bajo (2010), these abnormal volume events also tend to show an enormous excess returns on the event date (same-day return). To exploit this phenomenon, a prediction of an abnormal volume event is required such that a trade can be made even before the event is confirmed at the end of the day. In another word, an intraday prediction algorithm for abnormal volume events is needed to capture a portion of those huge same-day excess returns.

2.3 Anticipation of abnormal volume events

Various literature has proposed many end-of-day volume prediction algorithms in the form of a complex time-series model that predicts using intraday volume. For instance, Chen, Chen, Ardell, and Lin (2011) proposed a two-component hierarchical model – a weighted sum between ARMA/GARCH model on daily volume and Gaussianmultinomial model on intraday volume. Yan and Li (2012) proposed an ARMA-EGARCH model on an intraday volume time-series. Satish, Saxena, and Palmer (2014) proposed a three-component model – a dynamically weighted sum of average historical intraday volume, ARMA model on daily volume, and ARMA model on intraday volume. However, the goal for these algorithms is to reduce overall volume tracking error instead of focusing on only the abnormal volume event and so are not suitable for our purpose. Hence, to push the profitability further, this thesis proposes a prediction algorithm based on intraday volume that forecasts the best performing definition of abnormal volume events.

H5: The abnormal volume events can be predicted by an algorithm and exploited to generate positive excess returns.

Portfolio simulations on out-of-sample data are also performed to illustrate the improvement in term of portfolio performance for the four definitions of abnormal volume events (V-event, VD-event, VP-event, and VDP-event) as well as after augmenting the best performing definition with a prediction algorithm. Commission are also factored in to obtain results that are more indicative of the trading strategies' performance in live trading.

H6: There exist an implementable trading strategy based on abnormal volume events, which generates Sharpe ratio higher than the market, and a positive information ratio and alpha.

CHAPTER 3
DATA

This chapter explains the two groups of data used and the methods of the data acquisition. Section 3.1 presents the information regarding high-frequency stock tick data while the Section 3.2 reviews the information on the relevant daily market data.

3.1 Stock tick data

The required data to study the behavior of the excess returns around abnormal volume events are adjusted price (as total return index) and volume. However, this work also explores the asymmetry between buy-initiated volume and sell-initiated volume as well as a prediction of the abnormal volume events. Thus, a high-frequency tick data, containing the timestamp, trade flag (auto matching, big lot, etc.), best bid/ask price, matching price and volume, and the trade side (deduce from up/down tick), is needed. The collected tick data is from Thomson Reuters for the stocks[1] that are members of SET100 index (Thailand) during April 2015 to June 2016[2]. In a case of incomplete data, the tick data for that particular day is replaced with the data from Bloomberg instead and, if not possible, assign it as a zero trading day. The tick data is processed to create the directional volume variable by taking the difference between

[1] Use actual historical constituent to prevent survivorship bias. However, this work intentionally remove U City PCL (U) from the list as the price is too low such that one up/down tick tend to hit the ceiling/floor price.

[2] Due to limitation of data source.

the buy-initiated volume and sell-initiated volume of the auto-matching deals[3]. Both directional volume and matching volume are consolidated into 5-minutes intraday intervals. This procedure creates a total of 55 intervals (bin) that starts at the market opening auction and ends at the market closing auction as shown in Table 1. Note that the auction volume does not possess trade side and therefore not included in the calculation of the directional volume.

3.2 Daily market data

In addition to tick data, this thesis acquires a daily data of SET100 index and all firms that are members of the SET index from Thomson Reuter over the period from April 2010 to June 2016. These data are used to examine the portfolio factor-adjusted performance, to compute excess return, and to double check the quality of the tick data. The data acquired are open and close prices (as total return index), trading volume, market capitalization, and price-to-book ratio. The daily total return of Thai Short-term Government Bond Index obtained from The Thai Bond Market Association (ThaiBMA) is used as a risk-free rate.

[3] Auto matching deals refers to a trade in the main trading board which have an up/down tick.

Table 1: Intraday bins and time intervals

Morning session			
n, bin number	Interval time	n, bin number	Interval time
1	Open1 – 10:05:00	16	11:15:01 – 11:20:00
2	10:05:01 – 10:10:00	17	11:20:01 – 11:25:00
3	10:10:01 – 10:15:00	18	11:25:01 – 11:30:00
4	10:15:01 – 10:20:00	19	11:30:01 – 11:35:00
5	10:20:01 – 10:25:00	20	11:35:01 – 11:40:00
6	10:25:01 – 10:30:00	21	11:40:01 – 11:45:00
7	10:30:01 – 10:35:00	22	11:45:01 – 11:50:00
8	10:35:01 – 10:40:00	23	11:50:01 – 11:55:00
9	10:40:01 – 10:45:00	24	11:55:01 – 12:00:00
10	10:45:01 – 10:50:00	25	12:00:01 – 12:05:00
11	10:50:01 – 10:55:00	26	12:05:01 – 12:10:00
12	10:55:01 – 11:00:00	27	12:10:01 – 12:15:00
13	11:00:01 – 11:05:00	28	12:15:01 – 12:20:00
14	11:05:01 – 11:10:00	29	12:20:01 – 12:25:00
15	11:10:01 – 11:15:00	30	12:25:01 – 12:30:00

Afternoon session			
n, bin number	Interval time	n, bin number	Interval time
31	Open2 – 14:35:00	46	15:45:01 – 15:50:00
32	14:35:01 – 14:40:00	47	15:50:01 – 15:55:00
33	14:40:01 – 14:45:00	48	15:55:01 – 16:00:00
34	14:45:01 – 14:50:00	49	16:00:01 – 16:05:00
35	14:50:01 – 14:55:00	50	16:05:01 – 16:10:00
36	14:55:01 – 15:00:00	51	16:10:01 – 16:15:00
37	15:00:01 – 15:05:00	52	16:15:01 – 16:20:00
38	15:05:01 – 15:10:00	53	16:20:01 – 16:25:00
39	15:10:01 – 15:15:00	54	16:25:01 – 16:30:00
40	15:15:01 – 15:20:00	55	Close
41	15:20:01 – 15:25:00		
42	15:25:01 – 15:30:00		
43	15:30:01 – 15:35:00		
44	15:35:01 – 15:40:00		
45	15:40:01 – 15:45:00		

CHAPTER 4

METHODOLOGY

This chapter explains the methodology and the statistical tests used in this research. Section 4.1 describes the four definitions of abnormal volume events (V-event, VD-event, VP-event, and VDP-event). Section 4.2 formulates the prediction algorithm for abnormal volume events. Section 4.3 outlines the event study methodology used to examine excess returns around the abnormal volume events. Finally, Section 4.4 summarizes the process of the out-of-sample portfolio simulation along with the performance metrics used in the evaluation.

4.1 Definitions of abnormal volume events

This thesis examines four definitions of abnormal volume events. The first one defined by abnormally-high standardized volume (V-event). Second one defined by abnormally-high standardized volume and standardized directional volume (VD-event). Third one defined by abnormally-high standardized volume and sufficient price change (VP-event). And the last one defined by abnormally-high standardized volume and standardized directional volume and sufficient price change (VDP-event).

The criterion to define V-event, which inspired by Bajo (2010), is designed to detect an extreme deviation of trading volume from its normal level. It is done by converting the daily volume into z-score $(V_{i,t})$, which compares with its 66 most recent non-zero-trading daily observation including the current day (roughly three months period) and looks for the occurrence of large value. Thus the V-event occurs for the stock *i* on day *t* when

$$V_{i,t} > c_1,$$

$$\text{where } V_{i,t} = \frac{logv_{i,t} - \mu_{i,t}}{\sigma_{i,t}} \text{ and } c_1 \text{ is a threshold parameter,}$$

$logv_{i,t}$ is the natural logarithm of $(1 + \text{daily volume of stock } i \text{ on day } t)$,

$\mu_{i,t}$ and $\sigma_{i,t}$ are the mean and standard deviation of the 66 most recent non-zero-trading observation on $logv_{i,t}$ including the current day.

To define VD-event, another criterion which checked for an extreme deviation of the asymmetry between buy-initiated volume and sell-initiated volume from its normal level is needed. Similarly, this is done by converting the directional volume[4] into z-score $(D_{i,t})$, which compares using the same look-back period as that of $V_{i,t}$, and looks for the occurrence of large value. The VD-event is said to occur for the stock *i* on day t if

$$V_{i,t} > c_1 \text{ and } D_{i,t} > c_2,$$

$$\text{where } D_{i,t} = \frac{d_{i,t} - \theta_{i,t}}{\eta_{i,t}} \text{ and } c_2 \text{ is a threshold parameter,}$$

$d_{i,t}$ is the daily buy-initiated volume minus sell-initiated volume (excluding auction) of stock i on day t,

[4] Computed as daily buy volume minus daily sell volume. Does not apply natural logarithm function as the empirical skewness is very close to zero.

$\theta_{i,t}$ and $\eta_{i,t}$ are the mean and standard deviation of the 66 most recent non-zero-trading observation on $d_{i,t}$ including the current day.

Adding the sufficient price change condition to the first definition (V-event) altered it into VP-event. The idea is to consider only those abnormal volume event that exhibits an adequate level of close-to-close return $(P_{i,t})$. Therefore, the VP-event occurs for the stock *i* on day *t* when

$$V_{i,t} > c_1 \text{ and } P_{i,t} > \frac{c_3}{100},$$

where $P_{i,t} = \frac{close_{i,t}}{close_{i,t\text{-}1}} - 1$ and c_3 is a threshold parameter,

$close_{i,t}$ is the end-of-day adjusted closing price of stock i on day t.

The last definition of abnormal volume events defined as VDP-event. It is created to examine the potential synergy between the directional volume and price change. The definition of VDP-event is simply the combination of all three criteria. Hence, the VDP-event is said to occur for the stock *i* on day *t* if

$$V_{i,t} > c_1, D_{i,t} > c_2 \text{ and } P_{i,t} > \frac{c_3}{100}$$

Note that in the case of an event, an increase in trading tends to last for a few consecutive days. The definitions take only the first abnormal volume event and reject any repeated events that occur within the 22 subsequent days to make the event unique.

4.2 Prediction algorithm for abnormal volume events

The prediction algorithm extends the criteria for the definitions of abnormal volume events from daily data to intraday data. The core idea of this algorithm is to make a prediction within the same day t that an abnormal volume event supposed to occur by comparing the evolutions of the intraday features (volume, directional volume, and price change) against its normal daily behavior with the z-score method. This approach is possible because the cumulative data would converge to its final end-of-day values as more information accumulates throughout the trading day. Few adjustments are made to the calculation for each feature by replacing the current end-of-day data with an intraday data[5] (cumulative intraday volume, directional volume and intraday price). In fact, this prediction algorithm can operate at any frequency from as fast as every second up to few hours interval. For this thesis, it is decided to use a 5-minute interval to balance between the responsiveness of the algorithm and the simplicity of data handling. The modifications are applied as follows:

$$V_i^n = \frac{logv_i^n - \mu_i^n}{\sigma_i^n}$$

where $logv_i^n$ is the natural logarithm of $(1 +$ cumulative intraday volume from the start of the day up to n^{th} interval of stock $i)$

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[5] Trading session for each day is split into 55 equal intervals with duration of 5-minute each (*see Intraday bin and time interval* in Table 1) with the last interval as the closing auction, therefore, the value for n ranges from 1 to 54 (at n = 55 the prediction is no longer necessary). The 65 daily data prior to the current date remains the same.

μ_i^n and σ_i^n are the mean and standard deviation of 66 most recent non-zero-trading observation on $logv_{i,t}$ with the current day replaced by $logv_i^n$

$$D_i^n = \frac{d_i^n - \theta_i^n}{\eta_i^n}$$

where d_i^n is the cumulative intraday buy-initiated volume minus cumulative intraday sell-initiated volume (excluding auction) volume up to n^{th} interval of stock i

θ_i^n and η_i^n are the mean and standard deviation of the 66 most recent non-zero-trading observation on $d_{i,t}$ with the current day replaced by d_i^n

$$P_i^n = \frac{intraday\ close_i^n}{last\ close_i} - 1$$

where $intraday\ close_i^n$ is the current day adjusted close price at n^{th} interval and $last\ close_i$ is the yesterday adjusted close price (end-of-day) for stock i

The thresholds are also altered to be time interval-dependent to reflect the reduction in uncertainty as more information disclosed throughout the day. The modifications for these thresholds are made such that they can control the degree of conservativeness in the prediction behavior as well as keep the formulations simple (selected a linear model for this purpose). The earliest possible prediction designed to be at the end of the first 5 minutes of trading (n = 1) with some starting threshold parameter *b*. This parameter controls the degree of conservativeness because if the value is high, it would require the intraday feature to exhibits even more extreme value. This increase the likelihood that the day will end up as an abnormal volume event. The final prediction can be made at last moment right before the closing call auction (n = 54) because the decision could then executed during the auction (n = 55).

Since the definition for abnormal volume event is predefined, the end-of-day threshold cannot change, and so the time interval-dependent threshold must converge to this value. Note that at n = 54, the information regarding directional volume is fully revealed as it does not include the volume of the auction and thus the threshold must be equal to its ending threshold. On the other hand, volume and price still require the last piece of information after the closing auction to be complete. Aside, the intraday stock price also tends to fluctuate a lot. Hence, the threshold regarding the intraday price change is kept as constant to promote generalization.

$$V_i^n > b_1\left(\frac{55-n}{54}\right) + c_1\left(\frac{n-1}{54}\right)$$

$$D_i^n > b_2\left(\frac{54-n}{53}\right) + c_2\left(\frac{n-1}{53}\right)$$

$$P_i^n > \frac{c_3}{100}$$

with b_1 and b_2 as the 1st interval threshold parameters,

c_1, c_2, c_3 as the parameter associated with the definition of abnormal volume event (end-of-day) and n as an integer correspond to the position of 5-minute intraday interval ranging from 1 to 54

As an example (with illustration in Figure 5), the prediction of VD-event is made (with parameters b_1, b_2, c_1, c_2) for the stock *i* within day *t* at the end of n^{th} 5-minute interval when

$$V_i^n > b_1\left(\frac{55-n}{54}\right) + c_1\left(\frac{n-1}{54}\right) \text{ and } D_i^n > b_2\left(\frac{54-n}{53}\right) + c_2\left(\frac{n-1}{53}\right)$$

Figure 5: A sample illustration on the intraday prediction of VD-event within day t

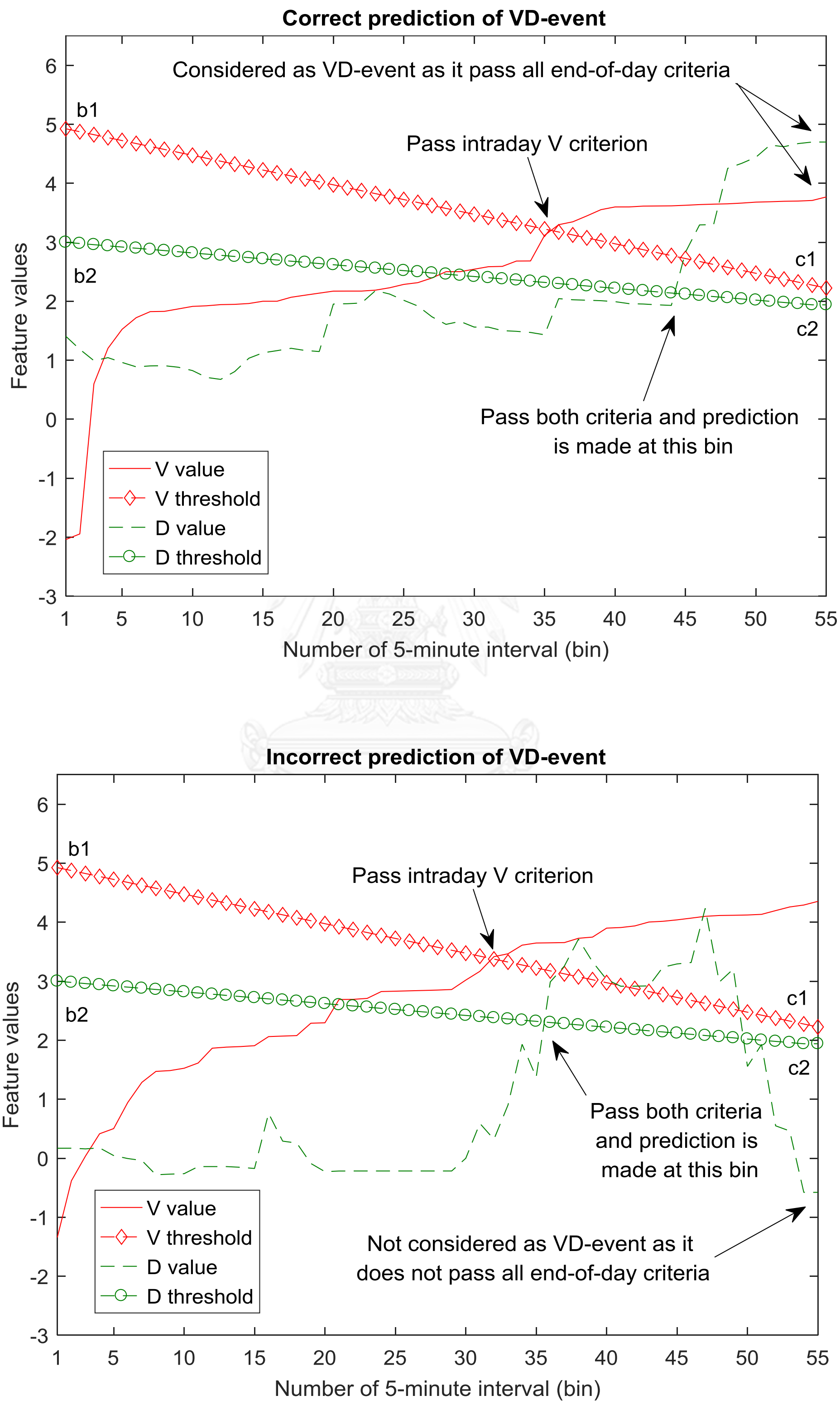
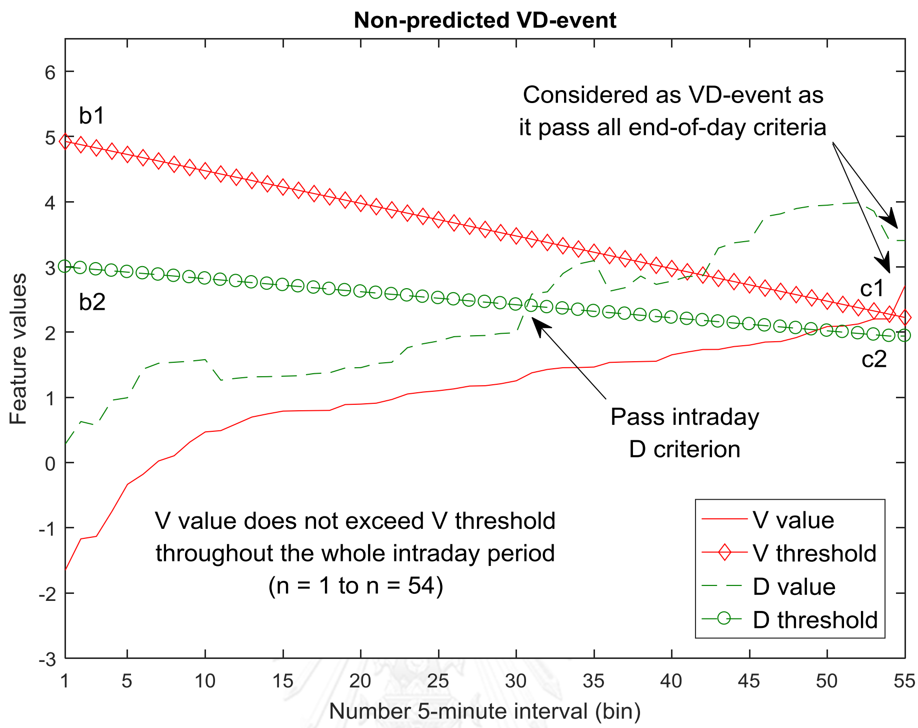


Figure 5 (continued)



4.3 Event study analysis

The excess (abnormal) returns[6] or ARs around the abnormal volume events examined according to the standard event study methodology. The *market adjusted* and *market and risk adjusted (CAPM) returns* are estimated for a 28 days window [-5,+22] around the abnormal volume events. Both alpha and beta values for CAPM are determined by a linear regression of daily returns on 50 days window [-55,-6] before an event as shown in Figure 1. The significance of the average excess return tested by both parametric T test and non-parametric Wilcoxon signed ranked test. Due to this

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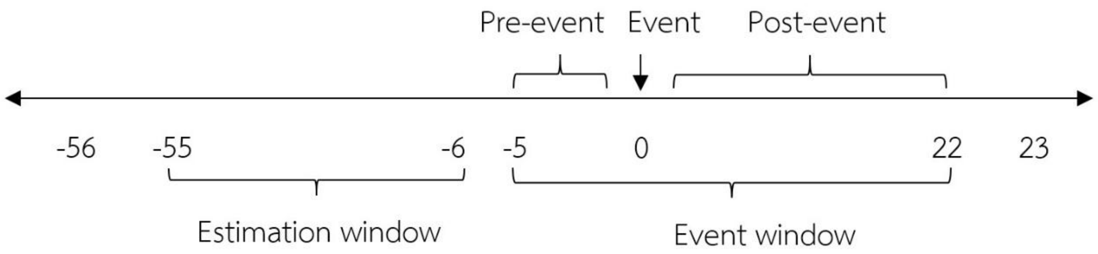
[6] All returns on day *t* are calculated as log($close_t$ /$close_{t-1}$) except at day 0 (event date) and day 1 that are calculated as log($open_1$ /$close_{-1}$) and log($close_1$ /$open_1$), respectively, to reflect the appropriate realizable excess returns.

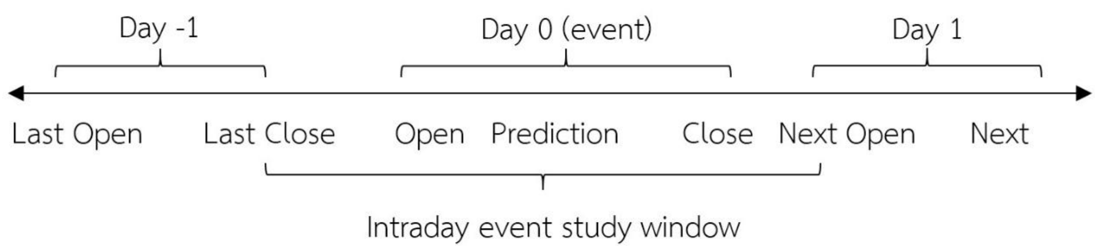
timeline, the excess return following the abnormal volume event is analyzed through the 22-day cumulative average abnormal returns or CAAR[1,22], and the same-day excess returns of the abnormal volume events are calculated by the same-day average abnormal returns or AAR[0].

Figure 1: Event study timeline in relative to event day



Similarly, this thesis employs an intraday event study to examine the excess returns of the predictions of the abnormal volume events according to the timeline shown in Figure 2. The window centered on the event date split into five timestamps; Last Close (day -1), Open, Prediction, Close, and Next Open (day 1). With this timeline, the incremental exploitable excess returns that follow the predictions of abnormal volume events is calculated as CAAR[After prediction till next open].

Figure 2: Intraday event study timeline centered on the event date



The calculation and the statistical test of AAR and CAAR are done as follows:

$$\text{Market adjusted } AR_{i,t} = R_{i,t} - R_{SET100,t}$$

$$\text{Market and risk adjusted } AR_{i,t} = R_{i,t} - R_{riskfree,t} - \alpha_i - \beta_i(R_{i,t} - R_{SET100,t})$$

$$\text{Average abnormal return at day } t\text{, } AAR_t = \sum_{i=1}^{N} \frac{AR_{i,t}}{N}$$

$$\text{Cumulative abnormal return of event } i\text{, } CAR_i[T_0, T_1] = \sum_{t=T_0}^{T_1} AR_{i,t}$$

$$\text{Cumulative average abnormal return } CAAR[T_0, T_1] = \sum_{t=T_0}^{T_1} AAR_t$$

Statistical parametric T test on abnormal return

$H_0: AAR = 0, H_a: AAR \neq 0$

$$t_{AAR,t} = \sqrt{N}\frac{AAR_t}{S_{AAR,t}} \quad \text{and} \quad S_{AAR,t}^2 = \frac{\sum_{i=1}^{N}\left(AR_{i,t} - AAR_t\right)^2}{N-1}$$

$H_0: CAAR = 0, H_a: CAAR \neq 0$

$$t_{CAAR} = \sqrt{N}\frac{CAAR}{S_{CAAR}} \quad \text{and} \quad S_{CAAR}^2 = \frac{\sum_{i=1}^{N}(CAR_i - CAAR)^2}{N-1}$$

Statistical non-parametric Wilcoxon signed rank test on abnormal return

$H_0: median(AR) = 0, H_a: median(AR) \neq 0$

$$W_t = \sum_{i=1}^{N} rank(|AR_t|)\, \mathbb{I}_{(0,\infty)}(AR_t)$$

$$z_{AAR,t} = \frac{W_t - E[W_t]}{\sqrt{V(W_t)}} \quad , \quad V(W_t) = \frac{N(N+1)(2N+1)}{24} \quad \text{and} \quad E[W_t] = \frac{N(N+1)}{4}$$

$H_0: median(CAR) = 0, H_a: median(CAR) \neq 0$

$$W = \sum_{i=1}^{N} rank(|CAR|)\, \mathbb{I}_{(0,\infty)}(CAR)$$

$$z_{CAAR} = \frac{W - E[W]}{\sqrt{V(W)}} \quad , \quad V(W) = \frac{N(N+1)(2N+1)}{24} \quad \text{and} \quad E[W] = \frac{N(N+1)}{4}$$

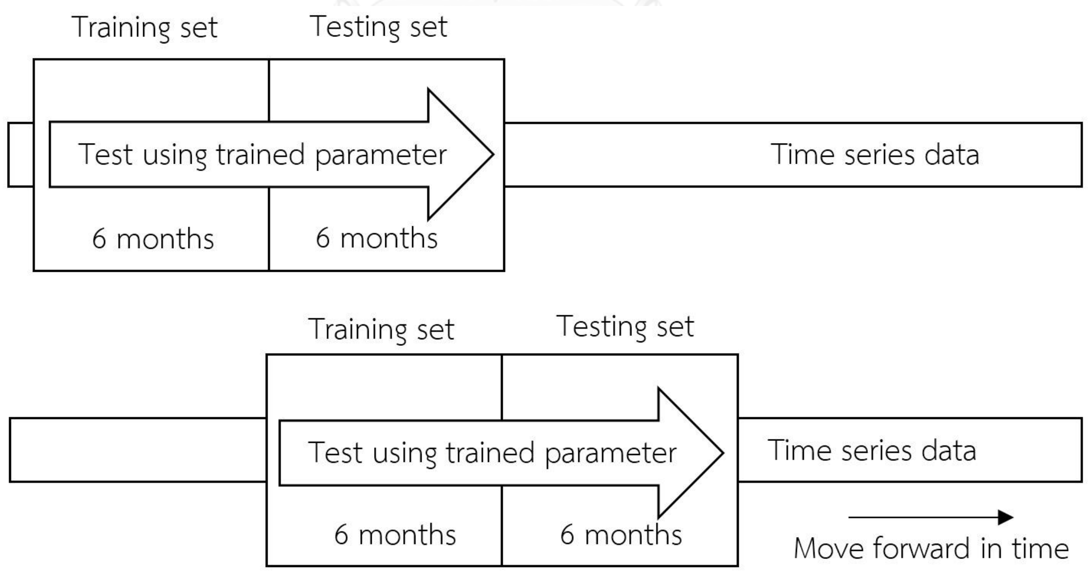
Where $\mathbb{I}_{(0,\infty)}(x)$ is an indicator function which takes a value 1 when x falls within $(0, \infty)$ and 0 otherwise.

4.4 Out-of-sample portfolio simulation

This thesis formulates a trading strategy to show that abnormal volume events are exploitable. When a stock experiences an abnormal volume event, it is added to the portfolio using the opening price of the next day and held for 22 trading days. The rebalance is done daily at the opening call auction to maintain an equally weighted portfolio with a 15% limit on the maximum weight of any stock. The purpose of the maximum weight is to limit idiosyncratic risk toward a single stock, and this value is inspired from the SEC regulation (ทน.87/2558) impose on Thai mutual fund under single entity limit section. After a prediction of abnormal volume event, the portfolio must perform additional rebalance[7] to reach equal weight as new stock is added to the portfolio. Upon incorrect prediction (confirmed after market close), the predicted stock is removed from the portfolio at the next day opening auction. The commission fee set at a constant rate of 0.15% of traded value.

This work implements a sliding window methodology to examine the out-of-sample performance with a window size of 1-year as shown in Figure 3 to check for the robustness of each strategy. The data in each window splits into two equal portions with the first half as a training session and the later as a testing session.

Figure 3: Sliding window methodology



[7] Incur extra bid-ask spread round-trip cost from buying at ask price and selling at bid price.

The uniform grid optimization (with finite boundary) executes on a training session which searches for a set of a parameter that gives a highest in-sample after-commission portfolio performance (information ratio) along with a statistically positive CAAR[1,22]. Since the strategy is long-only, the market risk exposure is expected to be high and therefore it is reasonable to measure the performance in relative to the market (benchmark) instead of the absolute measurement. Additionally, having a statistically positive CAAR is expected to help reduce the likelihood of parameter overfitting by having a sufficient number of trades. The out-of-sample performance is simulated with the obtained parameter using the data in a testing session, and its *ex-post* performance gauged by the Sharpe ratio (Sharpe, 1966), information ratio (Treynor & Black, 1973), and 4-factor alpha (Carhart, 1997) which calculated as follows:

$$\text{Sharpe ratio} = \frac{\text{mean}(R_{port} - R_{riskfree})}{\text{stddev}(R_{port} - R_{riskfree})}\sqrt{days}$$

$$\text{Information ratio} = \frac{\text{mean}(R_{port} - R_{SET100})}{\text{stddev}(R_{port} - R_{SET100})}\sqrt{days}$$

$$\text{4-factor } \alpha = R_{port} - R_{riskfree} - \beta_{SET100}\left(R_{SET100} - R_{riskfree}\right) - \beta_{HML}HML - \beta_{SMB}SMB - \beta_{PR1YR}PR1MO$$

The variable *days*[8] refers to the number of trading days. *HML* is the excess return between high and low book-to-market value stocks. *SMB* represents the excess return

[8] If annualized, the number of days would be used as 252. Else the actual number of trading days is used instead.

between small and big market capitalization stocks. *PR1MO* represents an excess return between the previous winner and loser stocks. The factor's daily excess return computed as the return on equally weighted long top 30% and short bottom 30% stocks (in the SET universe) of its factor. Unlike earlier works, the *HML* and *SMB* factor portfolios (Figure 4a and 4b) rebalanced on a daily basis under frictionless market condition. However, the differences should not be significant as the fundamental values tend to be stable. The *PR1MO* or momentum factor portfolio (Figure 4c) also rebalanced without commission on a daily basis with a look-back period of 1-month (22 trading days) to focus on short-term momentum effect. The alpha and betas values for the factor model are obtained through linear regression. All returns used in these calculations are daily log returns.

Figure 4a: HML factor portfolio construction

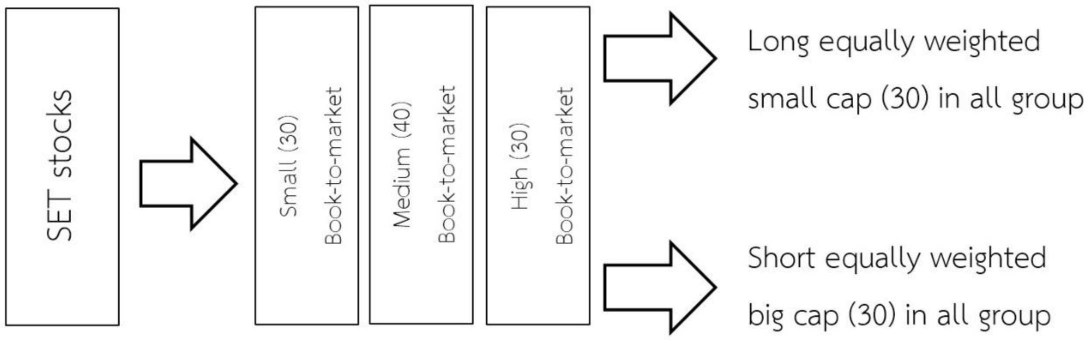


Figure 4b: SMB factor portfolio construction

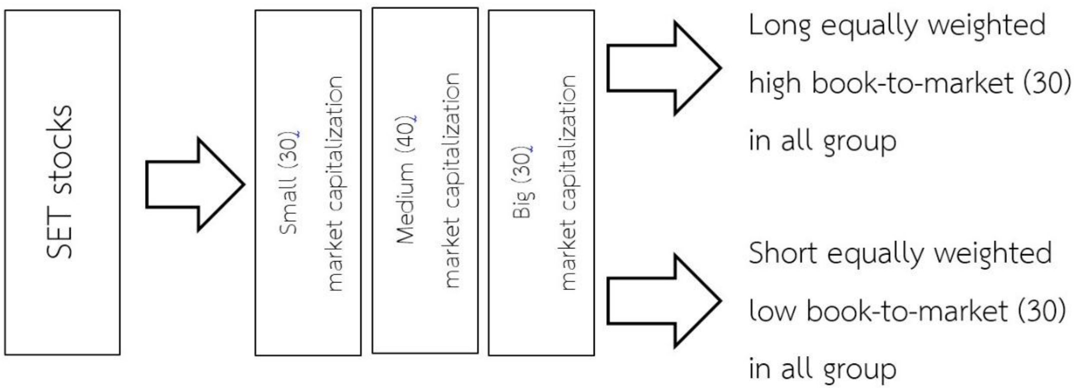
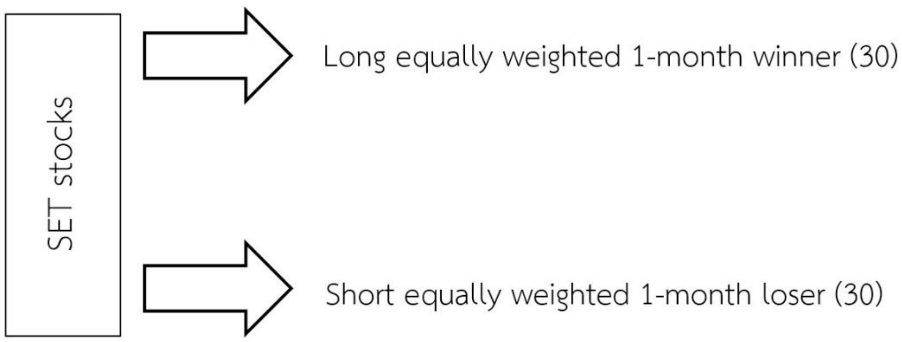


Figure 4c: PR1MO factor portfolio construction



CHAPTER 5
RESULT AND DISCUSSION

In this chapter, three distinct groups of results are offered and discussed. Section 5.1 presents the excess returns that follow different definitions of abnormal volume events. Section 5.2 shows the incremental excess returns of the prediction algorithm on best performing definition of abnormal volume events. And lastly, Section 5.3 exhibits the out-of-sample portfolio performance of trading strategies that trade on these abnormal volume events.

5.1 The excess returns following the abnormal volume events

In this subsection, I present the excess returns that follow each definition of abnormal volume events (hypothesis 1 to 4). The four definitions are abnormally-high standardized volume (V-event), abnormally-high standardized volume and standardized directional volume (VD-event), abnormally-high standardized volume and sufficient price change (VP-event), and finally, abnormally-high standardized volume and standardized directional volume and sufficient price change (VDP-event). The excess returns examined is the 22-day cumulative average abnormal returns following the events or in short CAAR[1,22]. A detailed statistics represent only one set of a parameter per definition as an example. However, the APPENDIX contains the complete results that include other sets of a parameter. The evidence presents on two periods due to the limitation of tick data; the short period which covers July 2015 to June 2016 (1-year) and the extended period that covers July 2010 to June 2016 (6-year).

5.1.1 First definition: V-event

As shown in Panel A of Table 2, based on July 2015 to June 2016 (1-year data) the CAAR[1,22] for V-event reaches as high as 1.516% on a *market adjusted* basis and 2.338% on a *market and risk adjusted* basis for threshold parameter c_1 = 2.225. Both values are statistically significant (by both tests). The CAAR slowly accumulates and reaches the maximum value at the end of 22-day (roughly 1-month or 4-week) as shown in Figure 6 and 7. In the long run from July 2010 to June 2016 (6-year data), there is weak evidence to supports that V-event with the same threshold parameter c_1 = 2.225 exhibits a positive CAAR[1,22] as shown in Panel A of Table 3. The *market adjusted* CAAR[1,22] reaches up to 0.450% and is significant at 10% level for only the parametric test while the *market and risk adjusted* CAAR[1,22] rises to 1.341% (and is significant by both statistical tests). The shape of CAARs (both adjustment method) resemble the short run profile in the sense that they both show a negative excess returns on day 1 and accumulate up until day 22 at a much slower rate as illustrated in Figure 8 and 9. The vast difference in CAARs between 1-year and 6-year suggests that the excess return following V-event is heavily dependent on the market condition and on average an economically significant *market adjusted* return should not be expected to follow the V-event.

In addition to this particular definition with the threshold parameter of c_1 = 2.225, a strong significantly positive *market adjusted* CAAR (both statistical tests) also exist for other sets of a parameter based on the 1-year data. The parameter ranges from c_1 = 1.975 to 2.35 (see Table V in APPENDIX) which suggests that the definition is somewhat robust. However, based on 6-year data, a significance at 10% level (only parametric test) for the *market adjusted* CAAR is found only at the parameter c_1 = 2.225. This poor robustness along with a weak significance raise the likelihood that the rejection of the null hypothesis (Ha: CAAR[1,22] is significantly different from zero) is a result of type I error. This result further explains that the *market adjusted* return following V-event is dependent on the market condition, and on average a significant positive value should not be expected. Upon closer inspection, it is not the case where a majority of the following *market adjusted* returns are close to zero but rather a mixture of a comparable amount of slightly more positive and less negative 22-day returns. However, the *market and risk adjusted* CAAR suggest otherwise. The parameter c_1 that shows a substantial significance for both statistical tests span roughly from c_1 = 1.725 to 2.475 (both 1-year and 6-year data). This result caused by a negative regression alpha value (result not included), which when used to adjust the excess returns on a daily basis (22 days in total) along with a beta close to one, a small negative alpha value could overstate the entire CAAR[1,22].

The evidence does not support that V-event is followed by a positive excess return for the stocks that are members of SET100 index which contradict with hypothesis 1. For *market adjusted* return, the 6-year data exhibits a weak significance on CAAR[1,22] for only the parametric test and one parameter which is likely to be a result of type 1 error. However, in a strong bull and bear market conditions (1-year data), there is substantial evidence which supports this phenomenon similar to previous literature (Gervais, Kaniel et al., 2001; Bajo, 2010). A possible explanation could due to the lack of small stocks used in this research, unlike prior literature which includes all stocks listed in their respective market. The typical family-firm status or agency problem between management and shareholders among small stocks might be the key that provides a consistent positive *market adjusted* returns that follow V-event. On the other hand, with the issue that the negative regression alpha value might overstate the *market and risk adjusted* return, the result obtained may not be as reliable as in the *market adjusted* basis.

5.1.2 Second definition: VD-event

By incorporating the asymmetry between buy and sell volume in addition to the standard volume (VD-event), the average excess return increase while the number of events decreases. As shown in Panel B of Table 2, based on the 1-year data the

CAAR[1,22] for VD-event reaches as high as 2.060% on a *market adjusted* basis and 3.089% on a *market and risk adjusted* basis for threshold parameters c_1 = 2.225 and c_2 = 2.1. Both values are statistically significant. These excess returns are higher than the CAARs of V-event while the standard deviations remain at a comparable level. Both CAAR profiles for VD-event also show a more stable growth when compared to V-event as illustrated in Figure 6 and 7. The definition of VD-event excludes many V-events that are followed by a negative excess return. Suggesting that the directional volume does carry additional information which agrees with earlier theoretical (Glosten & Milgrom, 1985; Kyle, 1985; Easley & O'Hara, 1987; Easley & O'Hara, 1992) and empirical (Louhichi, 2012) literatures.

In addition to the selected definition with threshold parameters c_1 = 2.225 and c_2 = 2.1, a significantly positive *market adjusted* CAAR (both statistical tests) also exist for other sets of a parameter based on the last 1-year data (similar to V-event). The significant parameters span over an area (see Table VI in APPENDIX) which also suggests that the definition is robust. For *market and risk adjusted* CAAR, the significance covers an even larger area. Compared to the V-event with the same c_1 parameter, the VD-event exhibits a higher CAAR (both adjustment method) along with a better significance for many c_2 parameters which further reinforced the idea that directional volume has more information content than normal volume.

The evidence supports that VD-event is followed by a positive excess return for the stocks that are members of SET100 index which is consistent with hypothesis 2. However, the long-run behavior of VD-event is inconclusive due to the limited data source. Nevertheless, there is still a possibility that in the long run (on average) VD-event is still followed by a positive excess return. The reason is that the definition is both robust and the short-run (1-year) data showed that introducing directional volume can remove many of those V-events that are followed by negative excess returns. A possible explanation for this phenomenon is that the directional volume could be treated as a non-conventional market data when compared to prices and volume. This data is not available in daily frequency (based on Reuters and Bloomberg) but instead, must be obtained/construct via tick data. It increases the difficulty of the strategy backtesting process. Therefore, it is possible the directional volume still contains additional information which can be used to better forecast the future stock returns.

5.1.3 Third definition: VP-event

As shown in Panel C of Table 2, based on the 1-year data the CAAR[1,22] for VP-event reaches 1.733% on a *market adjusted* basis and 2.756% on a *market and risk adjusted* basis threshold parameters c_1 = 2.225 and c_3 = 0. Both numbers are statistically significant. These excess returns are slightly higher than the CAARs of V-event but lower than VD-event. The standard deviations remain at a comparable level.

The number of events also lies in between those two definitions. This result suggests that the price change might be inferior to the directional volume regarding the information content embedded inside. The CAAR profiles for both adjustment methods are also similar to other definitions as shown in Figure 6 and 7. However, based on the long-run (6-year) data, there is weak evidence to support that VP-event with same threshold parameters c_1 = 2.225 and c_3 = 0 exhibits a positive CAAR[1,22] as shown in Panel B of Table 3. The *market adjusted* CAAR[1,22] reaches up to 0.245% but fails to show significance at 10% level for both statistical tests while the *market and risk adjusted* CAAR[1,22] rise to 1.461% and is significant by both statistical tests. The CAAR profiles for both adjustment methods also resemble the definition of V-event as shown in Figure 8 and 9.

In addition to this definition with threshold parameters of c_1 = 2.225 and c_3 = 0, a significantly positive *market adjusted* CAARs (both statistical tests) also exist for other sets of a parameter based on the last 1-year data. However, these parameters (with significant CAAR) does not span over a continuous area as in VD-event case but instead in small clumps (see Table VII in APPENDIX). Suggesting that these results might overfit to some outlier, and the definition is not robust. Based on 6-year data, all sets of a parameter fail to shows a significant *market adjusted* CAAR which further reinforced that the VP-event is not stable. On the other hand, the *market and risk adjusted* CAAR exhibit a significant excess returns for many sets of a parameter that span over a large area in the grid. This contradiction between adjustment methods could arise due to the regression alpha as mentioned earlier which potentially overstates the *market and risk adjusted* CAAR as well as the statistic values for both tests.

The evidence does not support that VP-event is followed by a positive excess return for the stocks that are members of SET100 index which opposes the hypothesis 3. For *market adjusted* return, the 6-year data exhibits no evidence to support this phenomenon at 10% level for both statistical tests. Although there is substantial evidence that supports this behavior based on 1-year data, the obtained result might be overfitted and does not reflect its generalized response. These results also imply that a profitable *market adjusted* return should not be expected to follow VP-event. This observation suggests that the level of price change may contain less information content than the directional volume which is not surprising since prices (open, high, low, and close) are the most traditional data used to forecast the future stock returns. Investors around the globe consistently search for a method to extract information out of prices, and thus they should not possess as much additional information as the directional volume. Similar to V-event, the result on the *market and risk adjusted* return is inconclusive as it may be overstated unlike the *market adjust* return.

5.1.4 Forth definition: VDP-event

As shown in Panel D of Table 2, based on the 1 year data the CAAR[1,22] for VDP-event reaches up to 2.025% on a *market adjusted* basis and 2.987% on a *market and risk adjusted* basis for threshold parameters c_1 = 2.225, c_2 = 1.975, and c_3 = 0. Compared to VD-event, these excess returns are slightly less while the number of events reduces by seven (145 to 138). Both (adjustment methods) CAAR profiles for VPD-event almost coincide with the VD-event as shown in Figure 6 and 7. The evidence suggests that adding the level of price change on to VD-event does not increase the information content as the set of events is almost the same. It also concludes that the price change and directional volume has no positive synergy.

In addition to the designated definition with threshold parameters c_1 = 2.225, c_2 = 1.975, and c_3 = 0, a significantly strong positive *market adjusted* CAAR (both statistical tests) also exist for other sets of parameter based on the last 1-year data. The parameters span over a volume through all three parameters centered on c_1 = 2.1, c_2 = 2.1, and c_3 = 0 (see Table VIII in APPENDIX) which suggests that this definition is robust. This property is likely to inherit from the definition of VD-event. For *market and risk adjusted* CAAR, the parameters with significant CAAR[1,22] cover an even larger volume. Compared to the VD-event with the same c_1 and c_2 parameters, the VDP-event exhibit a lower CAAR (both adjustment methods) values for many c_3 parameters which further reinforced the idea that price change does not contain additional information content after volume and there is no synergy between these two features.

The evidence supports that VDP-event is followed by a positive excess return for the stocks that are members of SET100 index which is consistent with hypothesis 4. However, the long-run behavior of VDP-event cannot be confirmed.

Table 2: Excess returns around abnormal volume events based on data from July 2015 to June 2016

Panel A: V-event (c1 = 2.225)

	Market adjusted				Market and risk adjusted				
Window	*CAAR(%)*	*SD(%)*	*T Test*	*Sign Test*	*CAAR(%)*	*SD(%)*	*T Test*	*Sign Test*	*N*
[-5,-1]	-0.521	5.839	-1.43	-1.21	-0.288	5.691	-0.81	-0.18	258
[0]	1.023	4.520	3.64***	3.86***	1.024	4.570	3.6***	3.78***	258
[1,22]	1.516	9.731	2.5**	2.79***	2.338	11.508	3.26*	3.22***	258

Panel B: VD-event (c1 = 2.225, c2 = 2.1)

	Market adjusted				Market and risk adjusted				
Window	*CAAR(%)*	*SD(%)*	*T Test*	*Sign Test*	*CAAR(%)*	*SD(%)*	*T Test*	*Sign Test*	*N*
[-5,-1]	-0.765	5.551	-1.66*	-1.03	-0.344	5.394	-0.77	0.25	145
[0]	3.543	3.246	13.14***	9.48***	3.590	3.207	13.48***	9.5***	145
[1,22]	2.060	9.742	2.55**	2.45**	3.089	11.431	3.25***	2.82***	145

Panel C: VP-event (c1 = 2.225, c3 = 0)

	Market adjusted				Market and risk adjusted				
Window	*CAAR(%)*	*SD(%)*	*T Test*	*Sign Test*	*CAAR(%)*	*SD(%)*	*T Test*	*Sign Test*	*N*
[-5,-1]	-0.576	6.483	-1.23	-0.01	-0.179	6.266	-0.4	1.39	193
[0]	3.333	3.242	14.28***	10.76***	3.378	3.254	14.42***	10.84***	193
[1,22]	1.733	9.699	2.48**	2.66***	2.756	10.889	3.52***	3.25***	193

Panel D: VDP-event (c1 = 2.225, c2 = 1.975, c3 = 0)

	Market adjusted				Market and risk adjusted				
Window	*CAAR(%)*	*SD(%)*	*T Test*	*Sign Test*	*CAAR(%)*	*SD(%)*	*T Test*	*Sign Test*	*N*
[-5,-1]	-0.242	5.461	-0.52	0.31	0.185	5.267	0.41	1.66*	138
[0]	3.805	3.122	14.32***	9.66***	3.856	3.070	14.75***	9.75***	138
[1,22]	2.025	10.054	2.37**	2.28**	2.987	11.727	2.99***	2.61***	138

Notes: The table analyzes the relationship between a different definition of abnormal volume events and its excess returns. The threshold parameters associated with these definitions are selected to represent most significant results. The cumulative average abnormal returns (CAAR) are computed both with a market adjusted and a market and risk adjusted (CAPM). The statistical significance is calculated using the parametric student's T test and non-parametric Wilcoxon singed rank test. ***, **, * indicate that the coefficients are significantly different from zero at 1%, 5%, and 10% levels respectively.

Figure 6: Market adjusted CAAR relative to event day for different definition of abnormal volume events using data from July 2015 to June 2016

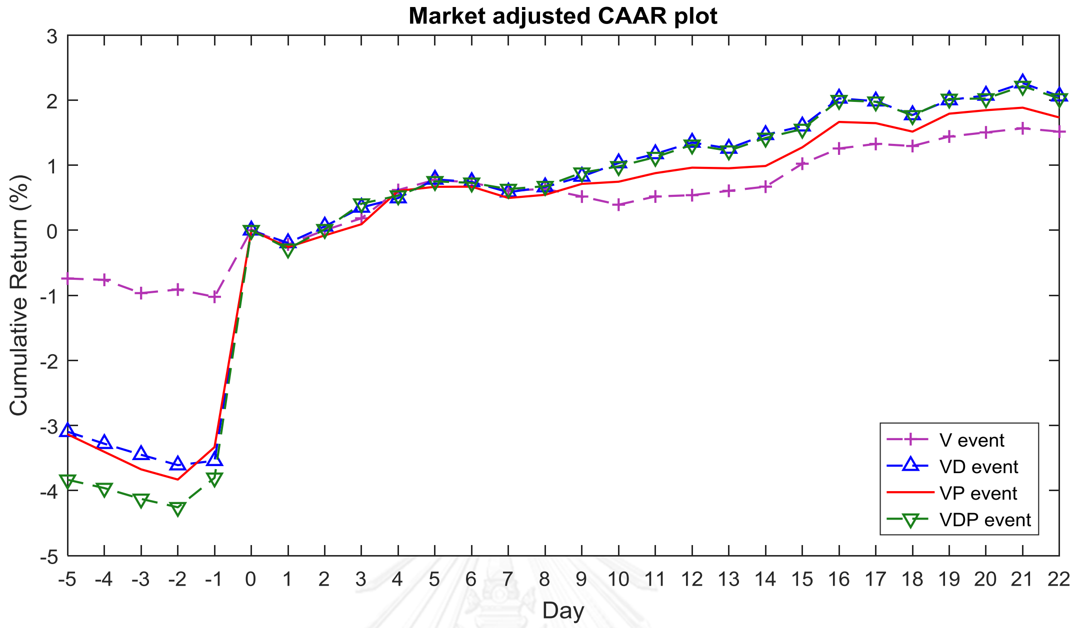


Figure 7: Market and risk adjusted CAAR relative to event day for different abnormal volume event using data from July 2015 to June 2016

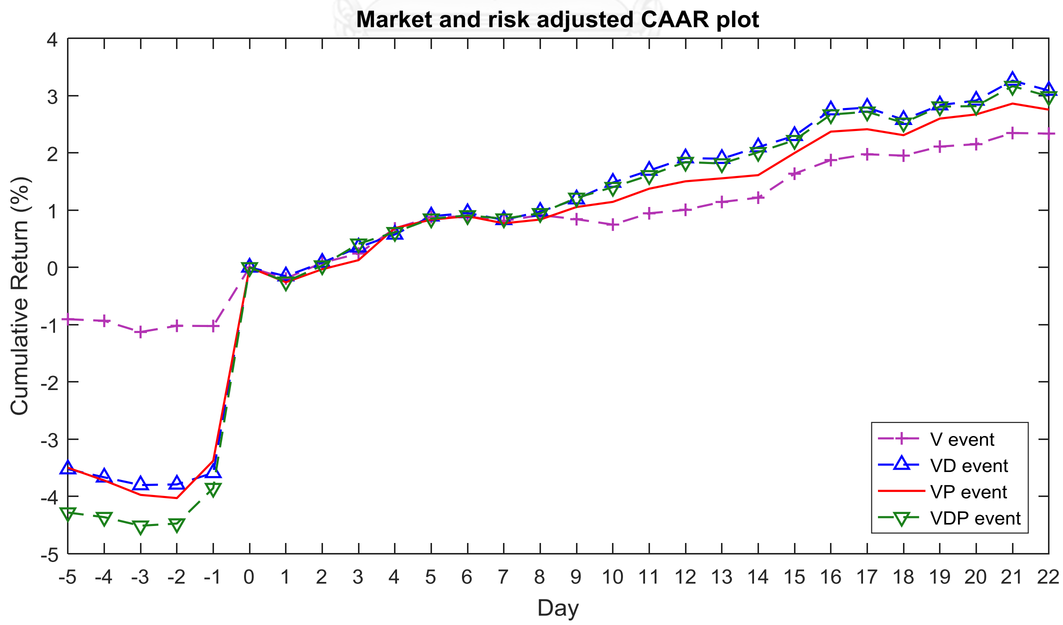


Table 3: Excess returns around abnormal volume events based on data from July 2010 to June 2016

Panel A: V-event (c1 = 2.225)

	Market adjusted				Market and risk adjusted				
Window	*CAAR(%)*	*SD(%)*	*T Test*	*Sign Test*	*CAAR(%)*	*SD(%)*	*T Test*	*Sign Test*	*N*
[-5,-1]	0.406	5.129	2.97***	4.42***	0.727	5.145	5.3***	7.69***	1408
[0]	2.104	4.376	18.04***	17.88***	2.124	4.353	18.31***	18.07***	1408
[1,22]	0.450	9.572	1.76*	0.29	1.341	10.522	4.77***	4.21***	1408

Panel B: VP-event (c1 = 2.225, c3 = 0)

	Market adjusted				Market and risk adjusted				
Window	*CAAR(%)*	*SD(%)*	*T Test*	*Sign Test*	*CAAR(%)*	*SD(%)*	*T Test*	*Sign Test*	*N*
[-5,-1]	0.928	5.167	5.99***	9.19***	1.313	5.075	8.63***	12.4***	1113
[0]	3.825	3.242	39.36***	27.74***	3.837	3.218	39.78***	27.84***	1113
[1,22]	0.245	9.915	0.8	-0.77	1.461	10.688	4.55***	3.83***	1113

Notes: The table analyzes the relationship between a different definition of abnormal volume events and its excess returns. The threshold parameters associated with these definitions are selected to represent most significant results. The cumulative average abnormal returns (CAAR) are computed both with a market adjusted and a market and risk adjusted (CAPM) approach. The statistical significance is calculated using the parametric student's T test and non-parametric Wilcoxon singed rank test. ***, **, * indicate that the coefficients are significantly different from zero at 1%, 5%, and 10% levels respectively.

Figure 8: Market adjusted CAAR relative to event day for different definition of abnormal volume events using data from July 2010 to June 2016

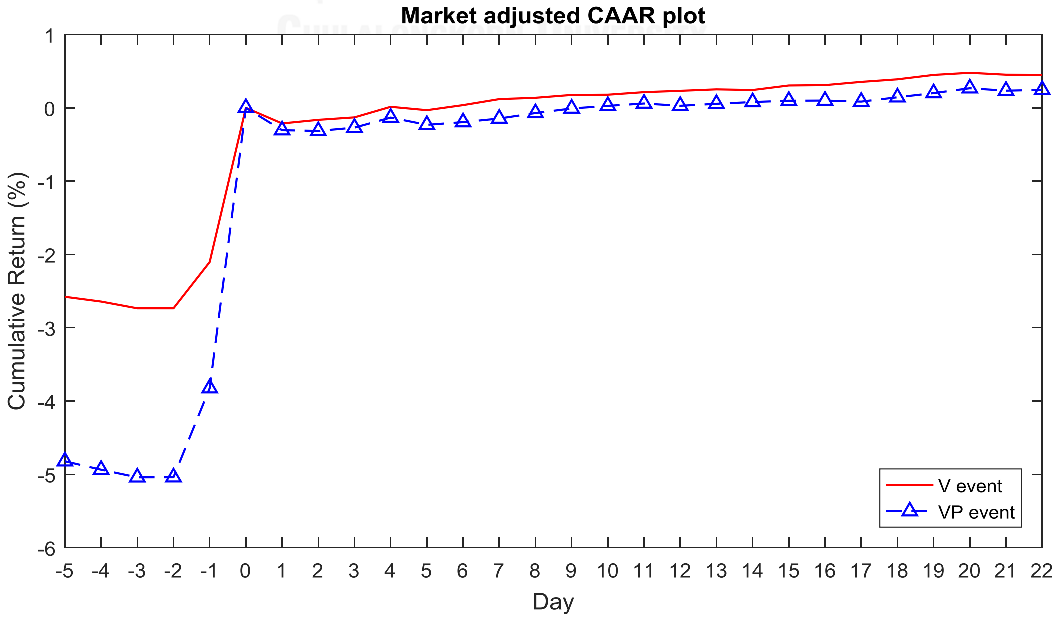
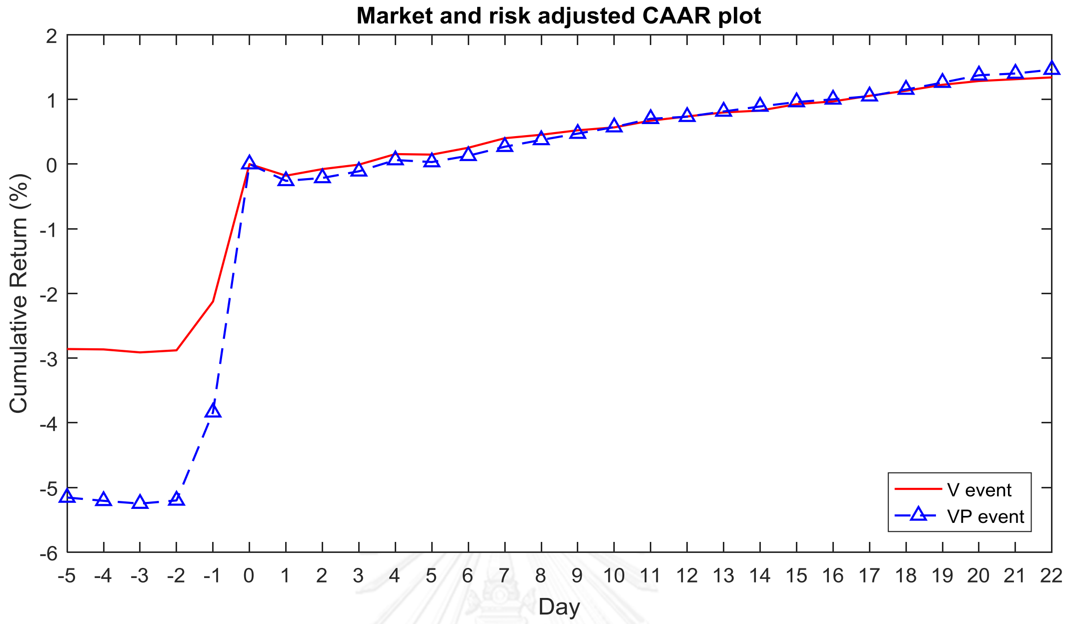


Figure 9: Market and risk adjusted CAAR relative to event day for different abnormal volume event using data from July 2010 to June 2016



5.2 The incremental returns from the prediction of abnormal volume events

The predictability of the best performing definition of an abnormal volume event is examined to push the strategy further. The thesis checks on the magnitude of an average excess return that belongs to the day that an abnormal volume event occurs and found it to be consistent with Bajo (2010). According to Table 2 and 3, the excess returns (both adjustment methods) on the event day or AAR[0] for all four definitions of abnormal volume events are significant (both statistical tests) and are much larger than their CAAR[1,22]. This result suggests that predicting the abnormal volume event before it confirms at the market close could provide an additional exploitable return and thus advance the strategy. Note that the result in this section only covers the period from July 2015 to June 2016 (1-year data) since it required the tick data.

The best performing definition of abnormal volume event is VD-event (see Section 5.3) with the best in-sample parameters of c_1 = 2.225 and c_2 = 2.6 (training period from June 2015 to December 2015). The average incremental return examined is the CAAR with the window [after prediction till next day open] and is computed as a raw return. However, it should not deviate significantly from the *market adjusted* value as on average an intraday market return is minuscule. A detailed statistics represent only one set of a parameter as an example. However, the Table IX in APPENDIX contains the complete results that include other sets of a parameter *b*.

According to Table 4, the prediction algorithm with parameters b_1 = 6.225 and b_2 = 1.6 can anticipate a VD-event at a very high precision[9] of 94% which results in a significant incremental CAAR of 0.986% (both statistical tests) and is consistent with hypothesis 5. The magnitude of the average exploited return reaches almost a quarter of the whole event day return. For the missed events[10], the average incremental return is 0.703% and is significant at 5% level (both statistical tests). The CAAR profiles in Figure 10 also illustrate the returns behavior between the predicted events and missed events to be highly similar.

[9] Precision is calculated as the number of correct prediction divided by total of number prediction

[10] Missed event refers to the event that fails to be predicted by the algorithm. Therefore, to compare with the prediction, a prediction mark is assumed using the average prediction timing (n = 50)

Table 4: Statistics of the prediction of abnormal volume events

Panel A: Returns around the prediction of VD-event (c1 = 2.225, c2 = 2.6) with starting threshold b1 = 6.225 and b2 = 1.6

	Prediction					Missed event				
Timestamp	*AAR(%)*	*SD(%)*	*T Test*	*Sign Test*	*N*	*AAR(%)*	*SD(%)*	*T Test*	*Sign Test*	*N*
Open	0.360	2.762%	1.3	3.97***	99	0.854	1.074	4.96***	4.31***	39
Prediction	3.088	2.936%	10.46***	7.84***	99	3.123	2.834	6.88***	5.07***	39
Close	0.649	1.610%	4.01***	3.74***	99	0.650	1.661	2.44**	2.11**	39
Next Open	0.336	1.093%	3.06***	3.2***	99	0.053	1.319	0.25	0.38	39
Window	*CAAR(%)*	*SD(%)*	*T Test*	*Sign Test*	*N*	*CAAR(%)*	*SD(%)*	*T Test*	*Sign Test*	*N*
After prediction till next open	0.986	1.703	5.76***	5.24***	99	0.703	1.979	2.22**	2.05**	39

Panel B: Prediction statistics

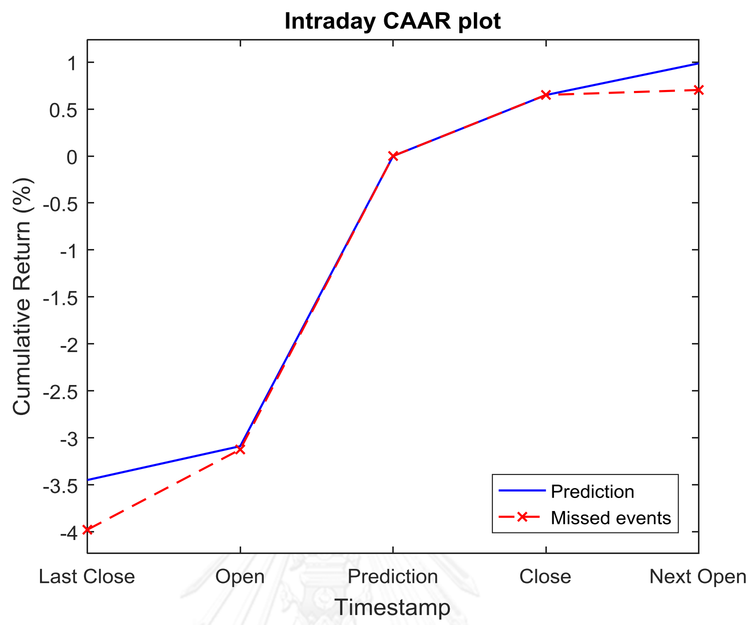
	N	*Performance metrics*	
Correct predictions (true positive)	93	Precision	94%
Incorrect predictions (false positive)	6	Recall	70%
Missed events (false negative)	39		

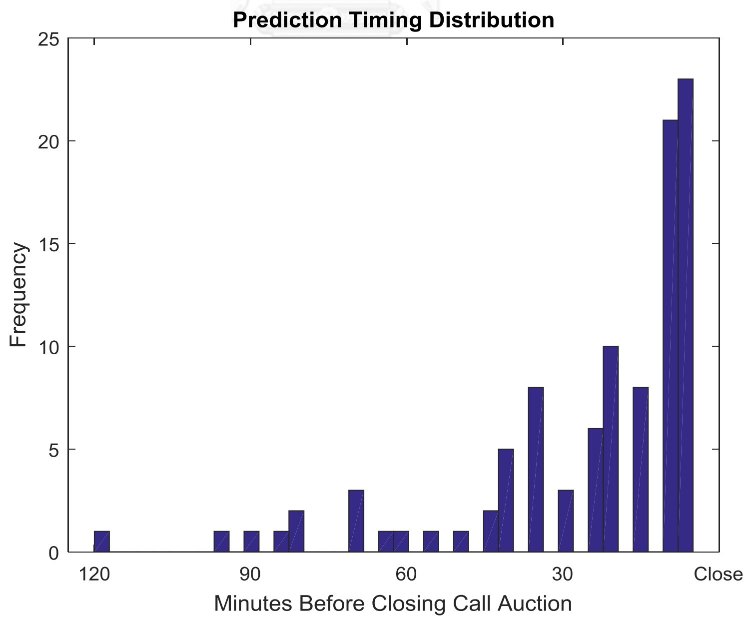
Panel C: Prediction timing

	Bin Number (n)	*Minutes Before Closing Call Auction*
Average	50.0606	19.70
Last prediction	54	0
First prediction	31	115

Notes: The table analyzes the relationship between the intraday prediction of VD-event and its incremental excess returns. The intraday CAAR is computed as raw returns but should not deviate significantly from its market adjusted value as on average the intraday market returns in minuscule. The missed events CAAR is calculated by assuming the prediction mark at 50^{th} bin to match the average prediction timing. The statistical significance is calculated using the parametric student's T test and non-parametric Wilcoxon singed rank test. ***, **, * indicate that the coefficients are significantly different from zero at 1%, 5%, and 10% levels respectively.

Figure 10: Intraday CAAR around the prediction of VD event and its prediction timing based on data from July 2015 to June 2016





The evidence suggests that the algorithm prioritizes on getting the least incorrect predictions (high precision) rather than the coverage of all events (high recall[11]). This predictive performance is achieved by delaying the prediction timing because the uncertainty of the daily data decreases as information accumulates throughout the day. The decline in risk is particularly important to the directional volume as the cumulative directional volume can either increase or decrease, unlike the cumulative volume which is strictly non-decreasing. Based on this setting, the earliest prediction made is 115 minutes before closing call auction (n = 31) while most of the predictions are concentrated within the last 15 minutes resulting in an average of 19.7 minutes (n = 50.0606) before closing call auction. The empirical distribution of the prediction timing is also shown in Figure 10 which resembles an exponential function. The shape of the distribution appears as expected due to the parameter b_1 which sets at a very high level. It forced the algorithm to be conservative and thus prioritizes precision over recall. If both the values b_1 and b_2 are low, the algorithm would predict in a more aggressive manner. Precision will drops while the recall increases. The average prediction timing would also decrease, and the distribution would change. For the average incremental returns, predicting earlier would exploit a larger portion of these large event day returns but will be diluted by those incorrect predictions. The dilution is found to be the dominant factor and cause a net reduction (see Table IX in APPENDIX).

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[11] Recall is calculated as number of correct prediction divided by total number of events

5.3 Out-of-sample portfolio performance of different trading strategies

A portfolio simulation on out-of-sample data is done to reflect the performance of the strategy under an environment close to real trading. Due to the limitation of tick data, the simulation for a portfolio that trades on the observation of VD-event and VDP-event as well as the prediction enhanced portfolio only covers the short testing period (January 2016 to June 2016, half year). On the other hand, the simulation for a portfolio related to V-event and VP-event would include both short and long testing period (January 2011 to June 2016, 5.5-year) to allow a fair comparison. Note that the market's Sharpe ratio for the short and the long testing period is 0.956 and 0.179, respectively. Both the training and testing performance comparisons of different portfolios are also illustrated in Figure 11 to 14.

Without the commission, trading on an observation of V-event does generate a Sharpe ratio higher than the market, a positive information ratio, and a significant 4-factor alpha at 5% level as shown in Table 5 and 6. However, after including the commission fee, all performance indicators drop and the long testing period portfolio fails to achieve a significant 4-factor alpha. This reduction mainly attributes to the design of the rebalancing policy as the stocks must be equally weighted on a daily basis, especially when a stock is introduced or removed from the portfolio. The massive changes in portfolio's composition induce a high turnover rate which caused this substantial reduction by amplifying the total transaction cost. An example in Panel

A of Table 6 illustrates that the magnitude of all performance indicators reduced by more than half because of the commission fee. This observation also agrees with the event study results. According to the short period, the V-event strategy appears to be able to generate an economically significant return (after commission alpha) while in the extended period this strategy no longer able to sustain this performance due to weak robustness. The factor analysis also reveals that the V-event strategy allocated most of its risk into market risk and some into size and momentum risk. This evidence supports that the definition of V-event is followed by a mixture of slightly more positive and less negative excess returns as the momentum factor (winner minus loser) can explain the portfolio movement.

Trading on the observation of VD-event improves all performance indicators when compared to the V-event strategy. Even after commission, the VD-event strategy is still able to generate both a relatively high Sharpe ratio and information ratio as well as a significant 4-factor alpha at 1% level. It turns out that this definition rejects many of those V-events that followed by a negative excess returns. Similarly, the effect of commission fee persists in the same manner as in V-event strategy which reduces the magnitude of alpha by 0.023% as shown in Panel B of Table 5. This result suggests that having less number of events does not lessen the burden of commission fee from daily rebalancing. This evidence shows that the definition of VD-event is both robust and is expected to be followed by a positive excess return (larger high-volume premium than V-event). The factor analysis also shows that the VD-event strategy allocated more of its risk into momentum risk and less into market risk when compared to V-event, suggesting that adding directional volume move the strategy closer to those momentum-based trading styles. Note that VD-event strategy also showed the best out-of-sample performance and thus the best in-sample definition of VD-event (c_1 = 2.225 and c_2 = 2.6) is subjects to an augmentation with a prediction algorithm.

The portfolio that trades on the observation of VP-event exhibits an out-of-sample performance that does not surpass V-event strategy both before and after commission. All three performance indicators report an inferior value when compared to V-event strategy. In the long testing period, the VP-event strategy does not even generate a significantly positive alpha (before commission) at 10% level as shown in Panel B of Table 6. Even though the VP-event strategy exhibits a better training performance than V-event strategy (see Figure 11 and 13), it does not perform well under out-of-sample testing which reflects the potential overfitting problem of the definition as mentioned earlier in Section 5.1.3. The factor analysis illustrates that the market, size and momentum factor (with comparable betas) explains the returns of VP-event portfolio similarly to the V-event strategy. This evidence reinforced the theory that price change is both unstable and does not hold an incremental information content that can improve the profitability, unlike directional volume.

The portfolio that trades on the observation of VDP-event shows an out-of-sample performance that is slightly worse than VD-event strategy. According to Panel D of Table 5, all performance indicators and the coefficients of factor analysis does not deviate much from the VD-event. This evidence suggests that adding the price change criterion into VD-event does not improve the profitability of the definition which agrees with the results from event study analysis. It also reinforced the theory that the price change does not hold a significant incremental information along with no positive synergy toward the directional volume, and thus unable to improve the out-of-sample performance.

The intraday VD-event anticipation strategy is the result of final augmentation which exhibits the best out-of-sample performance as shown in Panel E of Table 5. As expected from the intraday event study result, the performance improves as a consequence of this development, reaching a Sharpe ratio of 2.169, an information of 1.205, and a significantly positive 4-factor alpha of 0.185% at 1% level (after commission). The beta values and the commission effects on alpha obtained from factor analysis are highly similar to those of VD-event strategy suggesting that the prediction is made conservatively and preserve most of the portfolio's daily returns by not introducing unnecessary turnover from an incorrect prediction. This evidence is also consistent with hypothesis 6 which stated that there exist an implementable trading strategy based on abnormal volume events, which generates Sharpe ratio higher than the market, and a positive information ratio and alpha.

It is important to note that all strategies exhibit an extremely high portfolio turnover. The alpha of each portfolio decreases by roughly 0.025% after the inclusion of commission fee. Back calculating gives an average daily portfolio turnover of 8.333% or approximately a yearly turnover of 2100%.

Table 5: Different portfolio performance on out-of-sample data (testing session: January 2016 to June 2016)

Panel A: V-event strategy

Performance indicators	After commission	Before commission
Sharpe ratio	1.628	1.919
Information ratio	0.642	1.015

Carhart's factor model	*Coeff.*	*SE*	*T Stat*	*p-value*	*Coeff.*	*SE*	*T Stat*	*p-value*
4-factor alpha (%)	0.102	0.053	1.421	0.039	0.125	0.053	1.871	0.011
Market beta	0.683	0.056	12.259	0.000	0.683	0.056	12.283	0.000
Value beta	0.087	0.104	0.837	0.404	0.083	0.103	0.799	0.426
Size beta	0.134	0.112	1.199	0.233	0.138	0.112	1.230	0.221
Momentum beta	0.477	0.093	5.110	0.000	0.475	0.093	5.093	0.000
Adjusted R^2	0.666				0.666			

Panel B: VD-event strategy

Performance indicators	After commission	Before commission
Sharpe ratio	1.981	2.238
Information ratio	1.011	1.287

Carhart's factor model	*Coeff.*	*SE*	*T Stat*	*p-value*	*Coeff.*	*SE*	*T Stat*	*p-value*
4-factor alpha (%)	0.170	0.062	2.727	0.007	0.193	0.062	3.104	0.002
Market beta	0.598	0.071	8.370	0.000	0.597	0.071	8.376	0.000
Value beta	0.112	0.133	0.841	0.402	0.111	0.132	0.841	0.402
Size beta	0.141	0.144	0.984	0.327	0.140	0.143	0.977	0.330
Momentum beta	0.764	0.120	6.381	0.000	0.765	0.119	6.406	0.000
Adjusted R^2	0.535				0.536			

Table 5 (continued)

Panel C: VP-event strategy

Performance indicators	After commission	Before commission
Sharpe ratio	1.565	1.871
Information ratio	0.543	0.996

Carhart's factor model	*Coeff.*	*SE*	*T Stat*	*p-value*	*Coeff.*	*SE*	*T Stat*	*p-value*
4-factor alpha (%)	0.079	0.037	2.135	0.035	0.103	0.037	2.778	0.006
Market beta	0.737	0.042	17.354	0.000	0.731	0.043	17.153	0.000
Value beta	0.082	0.079	1.037	0.302	0.084	0.079	1.054	0.294
Size beta	0.202	0.085	2.368	0.020	0.197	0.086	2.293	0.024
Momentum beta	0.360	0.071	5.063	0.000	0.364	0.071	5.098	0.000
Adjusted R^2	0.783				0.780			

Panel D: VDP-event strategy

Performance indicators	After commission	Before commission
Sharpe ratio	1.909	2.165
Information ratio	0.981	1.267

Carhart's factor model	*Coeff.*	*SE*	*T Stat*	*p-value*	*Coeff.*	*SE*	*T Stat*	*p-value*
4-factor alpha (%)	0.162	0.062	2.598	0.011	0.185	0.062	2.977	0.004
Market beta	0.626	0.071	8.776	0.000	0.624	0.071	8.776	0.000
Value beta	0.103	0.133	0.775	0.440	0.103	0.132	0.777	0.439
Size beta	0.145	0.143	1.009	0.315	0.144	0.143	1.007	0.316
Momentum beta	0.739	0.120	6.183	0.000	0.739	0.119	6.200	0.000
Adjusted R^2	0.548				0.548			

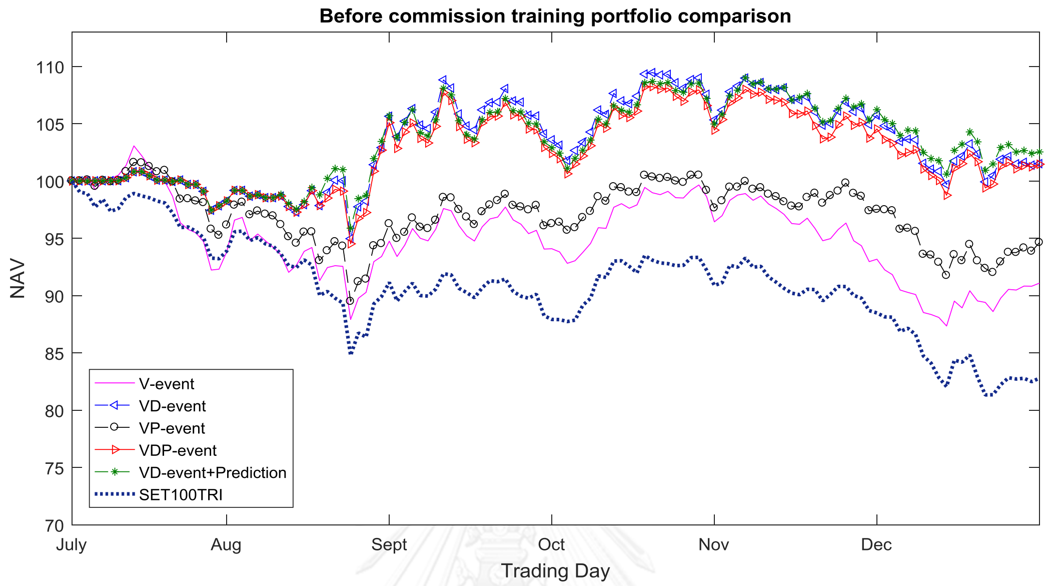
Panel E: Intraday VD-event anticipation strategy

Performance indicators	After commission	Before commission
Sharpe ratio	2.169	2.450
Information ratio	1.205	1.513

Carhart's factor model	*Coeff.*	*SE*	*T Stat*	*p-value*	*Coeff.*	*SE*	*T Stat*	*p-value*
4-factor alpha (%)	0.185	0.062	3.003	0.003	0.210	0.061	3.422	0.001
Market beta	0.586	0.071	8.303	0.000	0.586	0.070	8.335	0.000
Value beta	0.086	0.131	0.658	0.512	0.089	0.131	0.683	0.496
Size beta	0.107	0.142	0.752	0.454	0.103	0.141	0.731	0.466
Momentum beta	0.756	0.118	6.386	0.000	0.759	0.118	6.435	0.000
Adjusted R^2	0.538				0.541			

Notes: The table detailed the out-of-sample performance of a portfolio that trades on the observation and prediction of abnormal volume event. The commission fee is set at 0.15% of traded value and intraday rebalancing incur bid-ask spread cost. All reported values are based on daily frequency except Sharpe ratio and information ratio which represent as 6-month values (121 days). The market's Sharpe ratio for this period is 0.956.

Figure 11: Comparison between different training portfolio performance from July 2015 to December 2015



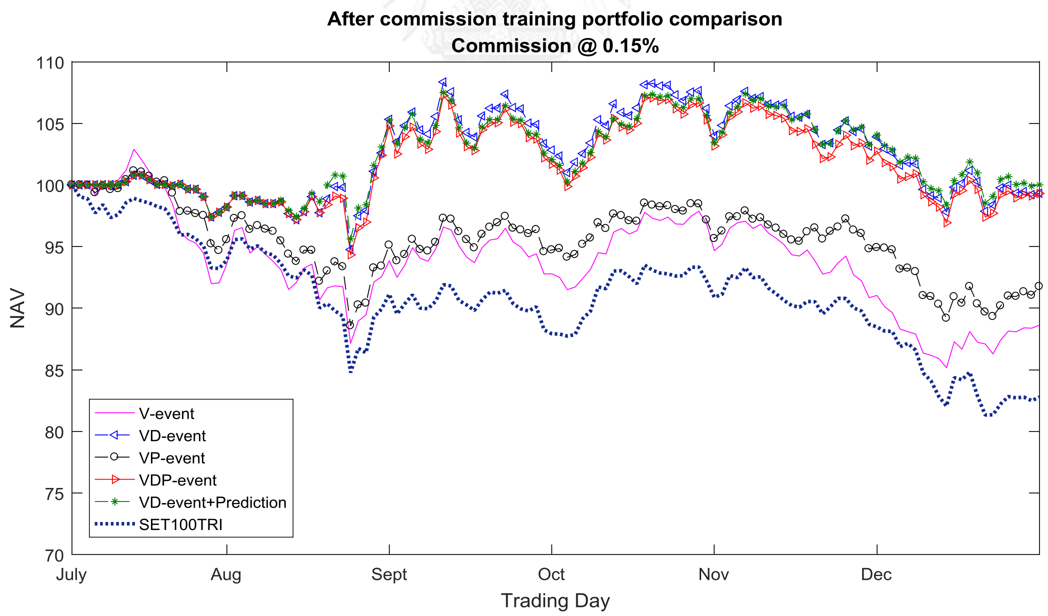


Figure 12: Comparison between different out-of-sample portfolios performance from January 2016 to June 2016

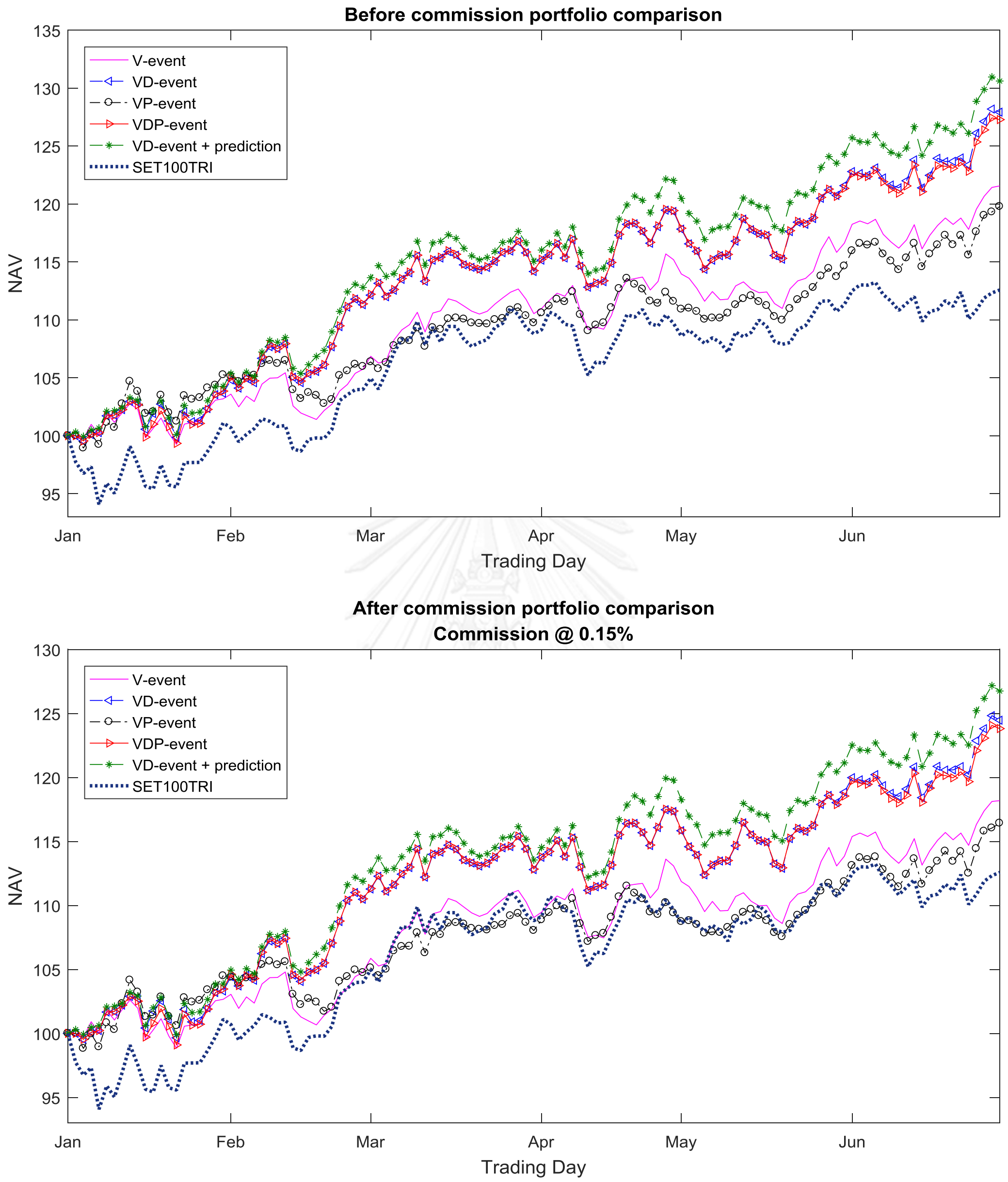


Table 6: Different portfolio performance on out-of-sample data (testing session: January 2011 to June 2016)

Panel A: V-event strategy

Performance indicators	After commission	Before commission
Sharpe ratio	0.389	0.697
Information ratio	0.271	0.717

Carhart's factor model	*Coeff.*	*SE*	*T Stat*	*p-value*	*Coeff.*	*SE*	*T Stat*	*p-value*
4-factor alpha (%)	0.015	0.017	0.870	0.384	0.035	0.017	2.050	0.041
Market beta	0.730	0.015	48.356	0.000	0.729	0.015	48.328	0.000
Value beta	-0.049	0.034	-1.447	0.148	-0.050	0.034	-1.471	0.141
Size beta	0.167	0.023	7.337	0.000	0.168	0.023	7.379	0.000
Momentum beta	0.061	0.022	2.812	0.005	0.061	0.022	2.801	0.005
Adjusted R^2	0.651				0.651			

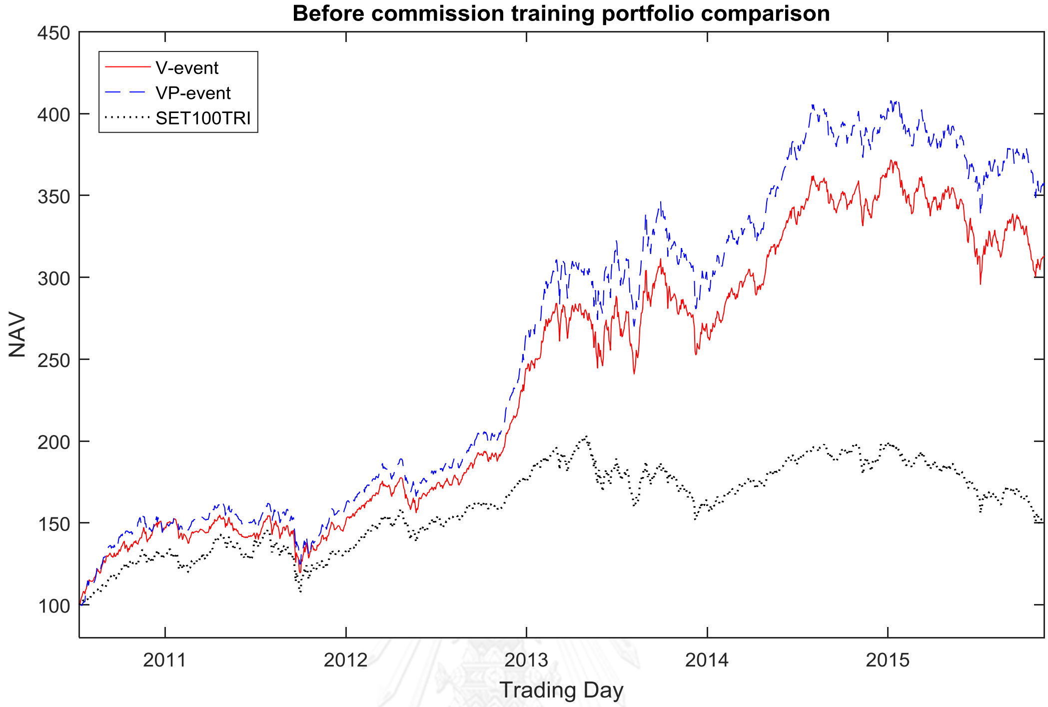
Panel B: VP-event strategy

Performance indicators	After commission	Before commission
Sharpe ratio	0.316	0.609
Information ratio	0.135	0.512

Carhart's factor model	*Coeff.*	*SE*	*T Stat*	*p-value*	*Coeff.*	*SE*	*T Stat*	*p-value*
4-factor alpha (%)	0.010	0.017	0.554	0.579	0.028	0.017	1.598	0.110
Market beta	0.671	0.015	48.396	0.000	0.671	0.015	43.302	0.000
Value beta	-0.035	0.035	-1.003	0.316	-0.035	0.035	-1.001	0.317
Size beta	0.183	0.023	7.861	0.000	0.184	0.023	7.897	0.000
Momentum beta	0.069	0.022	3.083	0.002	0.068	0.022	3.060	0.002
Adjusted R^2	0.598				0.597			

Notes: The table detailed the out-of-sample performance of a portfolio that trades on the observation and prediction of abnormal volume event. The commission fee is set at 0.15% of traded value. All reported values are based on daily frequency except Sharpe ratio and information ratio which is annualized. The market's annualized Sharpe ratio for this period is 0.179.

Figure 13: Comparison between different training portfolio performance from July 2010 to December 2015



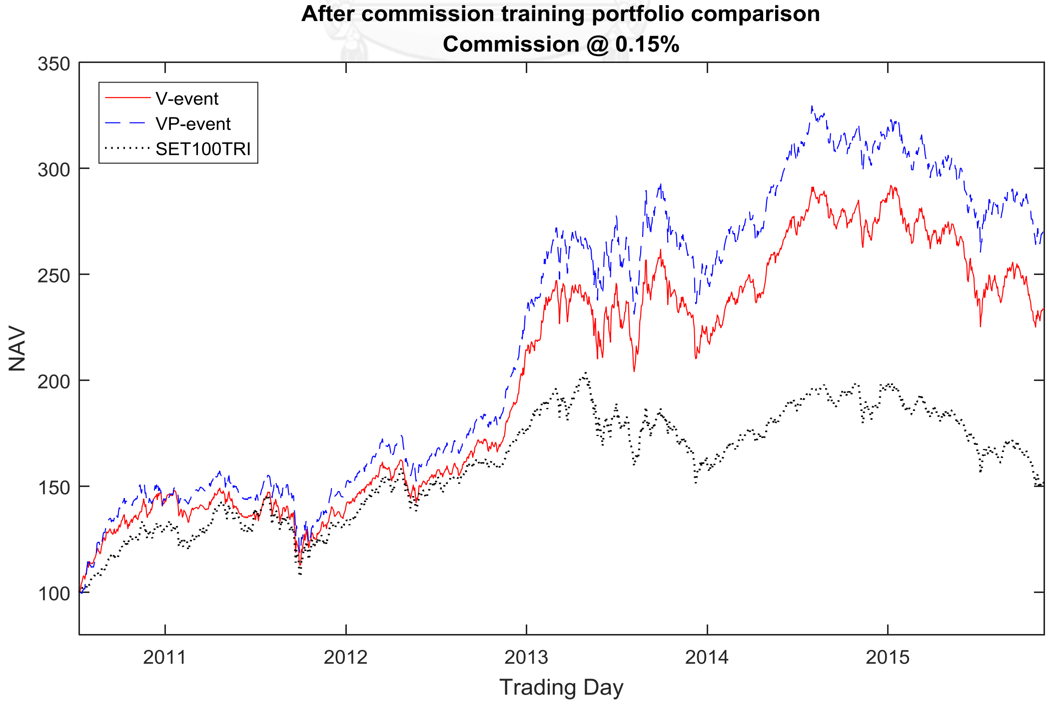
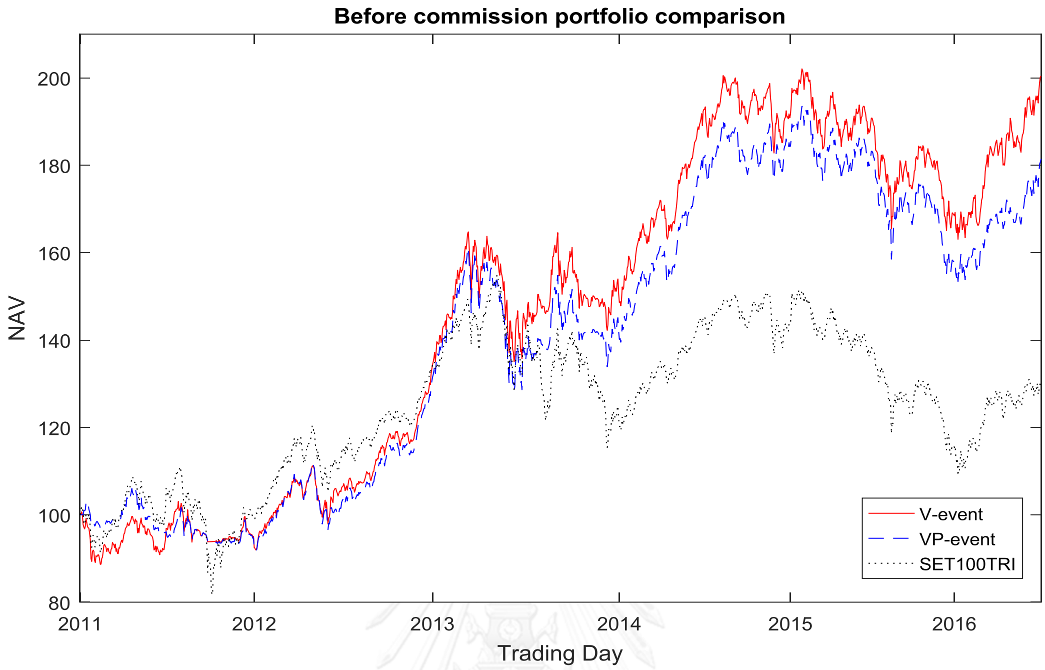
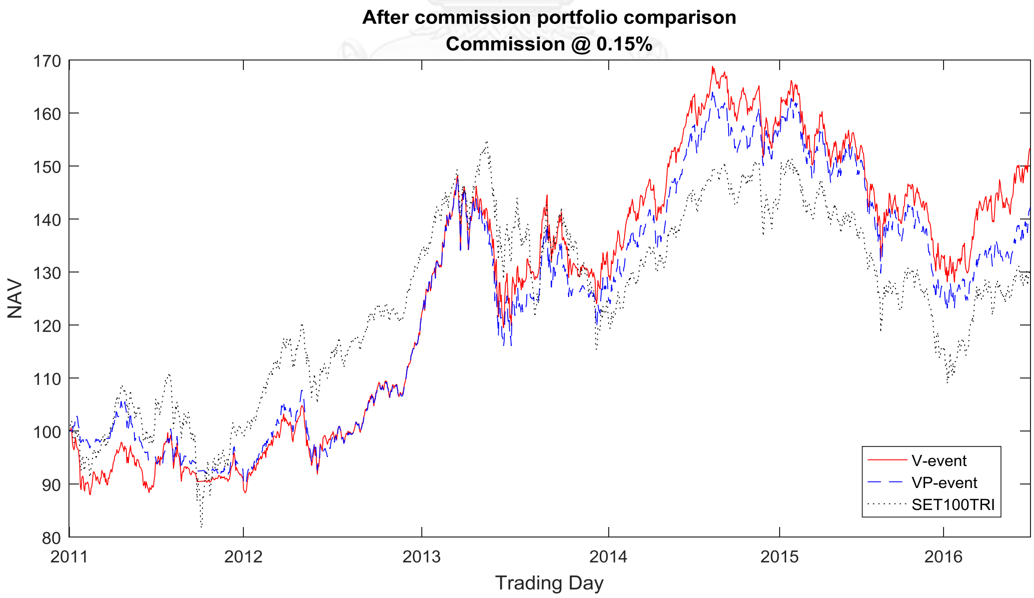


Figure 14: Comparison between different out-of-sample portfolios performance from January 2011 to June 2016





CHAPTER 6

CONCLUSION

This research investigates the relationship between abnormal volume events and the associated excess returns as well as proposes a robust trading strategy for the stock listed on SET100 index (Thailand). In contrast to previous literature, a stock that experiences an abnormal volume event (V-event) does not follow by a high-volume premium that persists through time. However, this high-volume premium exists under some particular market condition (strong bull and bear).

Incorporating the asymmetry between buy-initiated volume and sell-initiated volume (VD-event) further improves the excess returns. Previous theoretical (Glosten and Milgrom, 1985; Kyle, 1985; Easley and O'Hara, 1992) and empirical (Louhichi, 2012) literature suggest that an unbalanced trading sequence possesses the non-public information held by an informed trader and can be utilized to improve the prediction of the future stock returns. The evidence concludes that directional volume contains incremental information after volume. On the other hand, integrating the level of price change instead of directional volume (VP-event) does not improve the excess returns. The evidence suggests that the price change (close-to-close returns) contains less information than the directional volume. The robustness of this definition also found to be very low. According to the results of VDP-event, these two features do not exhibit a positive synergy that can further improve the following excess returns. An out-of-sample portfolio simulation later illustrates that the best performing strategy is based on the VD-event.

It is possible to predict the arrival of the VD-event at a very high precision if not far in advance. The proposed algorithm, which predicts based on the intraday data, can anticipate these events within the day and generate a significantly positive incremental returns. The algorithm signifies the importance of high-frequency data that, if handled correctly, can further improve the profitability of a trading strategy while introducing a slightly more risk. Also, this thesis finds the relationship between an abnormal volume event and the same-day excess return to be consistent with earlier findings.

The results of the portfolio simulation on out-of-sample data agree with the event study findings. All performance indicators improve after the definition of abnormal volume events is changed from V-event to VD-event and reach their peak after combined with the prediction algorithm (adding the price change does not improve the out-of-sample performance). Even though the intraday VD-event anticipation strategy is tested in the short period, the market condition for training (bear market) is entirely different from the testing period (bull market). This evidence suggests that the proposed strategy have a potential to be robust because it can outperform in both market conditions. A longer study period that includes other market conditions would further help validate the strategy’s robustness.

The 4-factor analysis helps explain the underlying trading style for each strategy. As expected, all portfolios showed a significant market beta since there is no short position involved in the simulations. The value of momentum beta increases when the definition changes from V-event to VD-event. The reason is that the VD-event strategy relies more on the high-volume premium in a similar manner to those short-term momentum-based strategies than V-event strategy. For size and value beta, both values are either small or insignificant which suggests that all definitions of abnormal volume event are probably not related to these two fundamentals.

This paper also used one strong assumption that the market has an infinite liquidity meaning that there is no market impact and price does not move as marketable orders get executed. This effect is especially significant since the proposed strategy exhibit a high trading activity (turnover) as deduced earlier from the impact of commission fee on daily alpha. A further testing on the intraday VD-event anticipation strategy under real market liquidity (depth of market) is recommended to obtain results that are even better indicative of the trading strategy performance in live trading.

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APPENDIX

Table I: Stocks used in this research based on historical SET100 constituent

	2010H2	2011H1	2011H2	2012H1	2012H2	2013H1	2013H2	2014H1	2014H2	2015H1	2015H2	2016H1
1	ADVANC	ADVANC	ADVANC	ADVANC	ADVANC	AAV	AAV	AAV	AAV	AAV	AAV	AAV
2	AMATA	AMATA	AJ	AJ	AJ	ADVANC	ADVANC	ADVANC	ADVANC	ADVANC	ADVANC	ADVANC
3	AOT	AOT	AMATA	AMATA	AMATA	AJ	AMATA	AMATA	AMATA	AMATA	AMATA	AMATA
4	AP	AP	AOT	AOT	AOT	AMATA	AOT	AOT	AOT	ANAN	ANAN	ANAN
5	ASP	ASP	AP	AP	AP	AOT	AP	AP	AP	AOT	AOT	AOT
6	BANP U	BANPU	ASP	ASP	ASP	AP	BANPU	ASP	BANPU	AP	AP	AP
7	BAY	BAY	BANPU	BANPU	BANPU	BANPU	BAY	BANPU	BAY	BANPU	ASP	BA
8	BBL	BBL	BAY	BAY	BAY	BAY	BBL	BAY	BBL	BAY	BA	BANPU
9	BCP	BCP	BBL	BBL	BBL	BBL	BCH	BBL	BCH	BBL	BANPU	BBL
10	BEC	BEC	BCP	BCP	BCP	BCH	BCP	BCH	BCP	BCH	BBL	BCP
11	BECL	BECL	BEC	BEC	BEC	BCP	BEC	BCP	BEC	BCP	BCP	BDMS
12	BDMS	BDMS	BECL	BECL	BECL	BEC	BECL	BDMS	BECL	BEC	BDMS	BEAUTY
13	BH	BH	BDMS	BDMS	BDMS	BECL	BDMS	BEC	BDMS	BECL	BEAUTY	BEC
14	BIGC	BIGC	BH	BH	BH	BDMS	BH	BECL	BH	BDMS	BEC	BEM
15	BLA	BLA	BIGC	BIGC	BIGC	BH	BIGC	BH	BIGC	BH	BECL	BH
16	BLAND	BLAND	BLA	BJC	BJC	BIGC	BJC	BIGC	BJC	BIGC	BH	BJCHI
17	BMCL	BTS	BLAND	BLA	BLA	BJC	BLA	BJC	BJCHI	BJC	BJCHI	BLA
18	BTS	CCET	BTS	BLAND	BLAND	BLA	BLAND	BLA	BLA	BJCHI	BLAND	BLAND
19	CCET	CENTEL	CENTEL	BTS	BTS	BLAND	BTS	BLAND	BLAND	BLAND	BMCL	BTS
20	CENTEL	CK	CK	CENTEL	CENTEL	BTS	CENTEL	BMCL	BMCL	BMCL	BTS	CBG
21	CK	CPALL	CPALL	CK	CK	CENTEL	CK	BTS	BTS	BTS	CBG	CENTEL
22	CPALL	CPF	CPF	CPALL	CPALL	CK	CPALL	CENTEL	CENTEL	CENTEL	CENTEL	CHG
23	CPF	CPN	CPN	CPF	CPF	CPALL	CPF	CHG	CK	CK	CK	CK
24	CPN	DCC	DCC	CPN	CPN	CPF	CPN	CK	CPALL	CPALL	CKP	CKP
25	DCC	DELTA	DELTA	DCC	DCC	CPN	DCC	CPALL	CPF	CPF	CPALL	CPALL
26	DELTA	DTAC	DTAC	DELTA	DELTA	DCC	DELTA	CPF	CPN	CPN	CPF	CPF
27	DTAC	EGCO	EGCO	DTAC	DTAC	DELTA	DEMCO	CPN	DCC	DELTA	CPN	CPN
28	EGCO	ESSO	ESSO	EGCO	EGCO	DTAC	DTAC	DCC	DELTA	DEMCO	DELTA	DELTA
29	ESSO	GFPT	GFPT	ESSO	ESSO	EGCO	EGCO	DELTA	DTAC	DTAC	DEMCO	DTAC
30	GFPT	GJS	GJS	GFPT	GFPT	ESSO	ESSO	DTAC	EARTH	EARTH	DTAC	EARTH
31	GJS	GLOBAL	GLOBAL	GLOBAL	GLOBAL	GFPT	GLOBAL	EGCO	EGCO	EGCO	EARTH	EGCO
32	GLOW	GLOW	GLOW	GLOW	GLOW	GLOBAL	GLOW	ERW	ERW	ERW	EGCO	EPG
33	GSTEL	GSTEL	GSTEL	GSTEL	GSTEL	GLOW	GOLD	ESSO	ESSO	GFPT	ERW	GL
34	HANA	HANA	HANA	GUNKUL	GUNKUL	GSTEL	GSTEL	GFPT	GFPT	GLOBAL	GFPT	GLOW

Table I (continued)

35	HEMRAJ	HEMRAJ	HEMRAJ	HANA	HANA	GUNKUL	GUNKUL	GLOBAL	GLOBAL	GLOW	GLOBAL	GPSC
36	HMPRO	HMPRO	HMPRO	HEMRAJ	HEMRAJ	HEMRAJ	HEMRAJ	GLOW	GLOW	GUNKUL	GLOW	GUNKUL
37	IRPC	IRPC	IRPC	HMPRO	HMPRO	HMPRO	HMPRO	GUNKUL	GUNKUL	HANA	GUNKUL	HANA
38	ITD	ITD	ITD	IRPC	INTUCH	INTUCH	INTUCH	HEMRAJ	HEMRAJ	HMPRO	HANA	HMPRO
39	IVL	IVL	IVL	ITD	IRPC	IRPC	IRPC	HMPRO	HMPRO	ICHI	HMPRO	ICHI
40	JAS	JAS	JAS	IVL	ITD	ITD	ITD	INTUCH	INTUCH	IFEC	ICHI	INTUCH
41	KBANK	KBANK	KBANK	JAS	IVL	IVL	IVL	IRPC	IRPC	INTUCH	INTUCH	IRPC
42	MBKET	MBKET	MBKET	KBANK	JAS	JAS	JAS	ITD	ITD	IRPC	IRPC	ITD
43	BCH	BCH	KGI	KBS	KBANK	KBANK	KBANK	IVL	IVL	ITD	ITD	IVL
44	KKP	KKP	BCH	BCH	KBS	KKP	KCE	JAS	JAS	IVL	IVL	JAS
45	KSL	KKC	KKP	KKP	KGI	KSL	KKP	JMART	KBANK	JAS	JAS	KBANK
46	KTB	KSL	KKC	KSL	BCH	KTB	KTB	KBANK	KCE	KBANK	KBANK	KCE
47	KYE	KTB	KSL	KTB	KKP	KTC	KTC	KCE	KKP	KCE	KCE	KKP
48	LANNA	KYE	KTB	LANNA	KSL	LANNA	LH	KKP	KTB	KKP	KKP	KTB
49	LH	LANNA	LANNA	LH	KTB	LH	LOXLEY	KTB	KTC	KTB	KTB	KTC
50	LOXLEY	LH	LH	LHBANK	KTC	LOXLEY	LPN	KTC	LH	KTC	KTC	LH
51	LPN	LOXLEY	LOXLEY	LOXLEY	LANNA	LPN	MAJOR	LH	LOXLEY	KTIS	LH	LHBANK
52	MAJOR	LPN	LPN	LPN	LH	MAJOR	MAKRO	LOXLEY	LPN	LH	LHBANK	LPN
53	MAKRO	MAJOR	MAJOR	MAJOR	LHBANK	MAKRO	MALEE	LPN	M	LOXLEY	LOXLEY	M
54	MCOT	MAKRO	MAKRO	MAKRO	LOXLEY	MALEE	MBK	MAJOR	MAJOR	LPN	LPN	MAJOR
55	MILL	MCOT	MCOT	MCOT	LPN	MINT	MCOT	MBK	MC	M	M	MINT
56	MINT	MINT	MCS	MCS	MAJOR	PF	MDX	MCOT	MCOT	MAJOR	MAJOR	PLANB
57	PDI	PDI	MINT	MINT	MAKRO	PS	MINT	MINT	MEGA	MC	MC	PLAT
58	PS	PS	PDI	PHATRA	MALEE	PTL	PF	PS	MINT	MEGA	MINT	PS
59	PSL	PSL	PHATRA	PS	MCOT	PTT	PS	PTT	NOK	MINT	MONO	PTG
60	PTT	PTT	PS	PSL	MINT	PTTEP	PTT	PTTEP	NYT	NOK	PS	PTT
61	PTTAR	PTTAR	PSL	PTL	PF	PTTGC	PTTEP	PTTGC	PS	PS	PSL	PTTEP
62	PTTC	PTTC	PTL	PTT	PS	QH	PTTGC	QH	PSL	PSL	PTT	PTTGC
63	PTTEP	PTTEP	PTT	PTTEP	PTL	RATCH	QH	RATCH	PTT	PTG	PTTEP	QH
64	QH	QH	PTTEP	PTTGC	PTT	RML	RATCH	ROBINS	PTTEP	PTT	PTTGC	ROBINS
65	RATCH	RATCH	PTTGC	QH	PTTEP	ROBINS	ROBINS	RS	PTTGC	PTTEP	QH	RS
66	RCL	RCL	QH	RATCH	PTTGC	ROJNA	ROJNA	SAMART	QH	PTTGC	RATCH	S
67	ROBINS	ROBINS	RATCH	ROBINS	QH	SAMART	RS	SC	RATCH	QH	ROBINS	SAMART
68	ROJNA	ROJNA	RCL	SAMART	RATCH	SAMTEL	SAMART	SCB	ROBINS	RATCH	RS	SAMTEL
69	SAMART	SAMART	ROBINS	SAMTEL	RML	SAT	SAMTEL	SCC	RS	ROBINS	S	SAWAD
70	SAMTEL	SAMTEL	SAMART	SAT	ROBINS	SC	SAT	SCCC	SAMART	SAMART	SAMART	SCB
71	SAT	SAT	SAMTEL	SC	SAMART	SCB	SC	SF	SCB	SAWAD	SAPPE	SCC
72	SC	SCB	SAT	SCB	SAMTEL	SCC	SCB	SIRI	SCC	SCB	SAWAD	SCCC

Table I (continued)

73	SCB	SCC	SCB	SCC	SAT	SCCC	SCC	SPALI	SCCC	SCC	SCB	SCN
74	SCC	SCCC	SCC	SCCC	SC	SF	SCCC	SPCG	SIRI	SCCC	SCC	SGP
75	SCCC	SGP	SCCC	SF	SCB	SGP	SF	SRICHA	SPALI	SF	SF	SIRI
76	SGP	SIRI	SF	SGP	SCC	SIRI	SIRI	SSI	SPCG	SGP	SGP	SPALI
77	SIRI	SMT	SGP	SIRI	SCCC	SPALI	SPALI	STA	SRICHA	SIM	SIRI	SPCG
78	SPALI	SPALI	SIRI	SMT	SF	SPCG	SPCG	STEC	STA	SIRI	SPALI	STEC
79	SSI	SSI	SMT	SPALI	SGP	SSI	SRICHA	STPI	STEC	SPALI	SPCG	STPI
80	STA	STA	SPALI	SSI	SIRI	STA	SSI	SVI	STPI	SPCG	STEC	SVI
81	STEC	STEC	SSI	STA	SPALI	STEC	STA	TASCO	SVI	STA	STPI	TASCO
82	STPI	STPI	STA	STEC	STA	STPI	STEC	TCAP	TASCO	STEC	SVI	TCAP
83	SVI	SVI	STEC	STPI	STEC	SVI	STPI	TFD	TCAP	STPI	TCAP	THAI
84	TASCO	TASCO	STPI	SVI	STPI	TASCO	TCAP	THAI	THAI	SVI	THAI	THCOM
85	TCAP	TCAP	SVI	TASCO	SVI	TCAP	THAI	THCOM	THCOM	TCAP	THCOM	TICON
86	THAI	THAI	TASCO	TCAP	TASCO	THAI	THCOM	THRE	THRE	THAI	TICON	TISCO
87	THCOM	THCOM	TCAP	THAI	TCAP	THCOM	THRE	TICON	THREL	THCOM	TISCO	TMB
88	TICON	TICON	THAI	THCOM	THAI	THRE	TISCO	TISCO	TICON	THREL	TMB	TOP
89	TISCO	TISCO	THCOM	TICON	THCOM	TICON	TMB	TMB	TISCO	TICON	TOP	TPIPL
90	TMB	TMB	TISCO	TISCO	TICON	TISCO	TOP	TOP	TMB	TISCO	TPIPL	TRUE
91	TOP	TOP	TMB	TMB	TISCO	TMB	TPIPL	TPIPL	TOP	TMB	TRUE	TTA
92	TPIPL	TPIPL	TOP	TOP	TMB	TOP	TRUE	TRUE	TPIPL	TOP	TTA	TTCL
93	TRUE	TRUE	TPIPL	TPC	TOP	TPIPL	TTA	TTA	TRUE	TPIPL	TTCL	TTW
94	TSTH	TSTH	TRUE	TPIPL	TPIPL	TRUE	TTCL	TTCL	TTA	TRUE	TTW	TU
95	TTA	TTA	TTA	TRUE	TRUE	TTA	TTW	TTW	TTCL	TTA	TU	UNIQ
96	TTW	TTW	TTCL	TTA	TTA	TTCL	TU	TU	TTW	TTCL	UNIQ	UV
97	TU	TU	TTW	TTCL	TTCL	TTW	TVO	UV	TU	TTW	UV	VGI
98	TVO	TVO	TU	TTW	TTW	TU	UV	VGI	UV	TU	VGI	VNG
99	VNG	VNG	TVO	TU	TU	TVO	VGI	WHA	VGI	UV	WHA	WHA
100	–	–	VNG	TVO	TVO	WORK	WHA	–	WHA	VGI	–	WORK

Notes:

Many securities used in this research has been delisted, however, most historical daily market data can still be acquired via Thomson Reuter database. In both 2014H1 and 2015H1 list, U City PCL (ticker U) is removed from the list as the price is too low such that one up/down tick tend to hit the ceiling/floor price. In both 2010H2 and 2011H1 list, there is no available data for Phatra Capital PCL (ticker PHATRA) and so it is remove from the universe.

Table II: Descriptive statistics of V values

Percentile	2010H2	2011H1	2011H2	2012H1	2012H2	2013H1	2013H2	2014H1	2014H2	2015H1	2015H2	2016H1	All
0.1	-3.31	-3.16	-3.40	-3.20	-2.90	-2.93	-3.55	-3.24	-2.93	-2.92	-3.12	-3.04	-3.50
1	-2.48	-2.33	-2.56	-2.29	-2.28	-2.27	-2.61	-2.34	-2.31	-2.27	-2.44	-2.27	-2.52
5	-1.79	-1.75	-1.83	-1.67	-1.64	-1.59	-1.98	-1.60	-1.72	-1.67	-1.76	-1.55	-1.78
10	-1.45	-1.39	-1.46	-1.34	-1.30	-1.25	-1.61	-1.26	-1.40	-1.34	-1.37	-1.21	-1.40
20	-1.01	-0.97	-0.99	-0.91	-0.88	-0.79	-1.18	-0.81	-0.95	-0.94	-0.92	-0.77	-0.94
30	-0.66	-0.65	-0.64	-0.58	-0.56	-0.45	-0.85	-0.47	-0.64	-0.63	-0.61	-0.43	-0.61
40	-0.35	-0.35	-0.34	-0.30	-0.28	-0.18	-0.57	-0.19	-0.35	-0.36	-0.32	-0.15	-0.31
50	-0.06	-0.10	-0.06	-0.04	-0.02	0.08	-0.30	0.08	-0.09	-0.11	-0.06	0.10	-0.05
60	0.21	0.15	0.21	0.21	0.24	0.33	-0.04	0.35	0.18	0.14	0.22	0.37	0.21
70	0.53	0.43	0.49	0.50	0.52	0.60	0.23	0.63	0.47	0.42	0.51	0.65	0.50
80	0.88	0.76	0.83	0.82	0.89	0.93	0.57	0.98	0.81	0.76	0.85	0.98	0.85
90	1.38	1.22	1.28	1.29	1.39	1.39	1.07	1.45	1.31	1.26	1.35	1.44	1.35
95	1.78	1.62	1.66	1.69	1.81	1.79	1.46	1.85	1.73	1.67	1.76	1.84	1.78
99	2.58	2.36	2.37	2.45	2.62	2.48	2.21	2.62	2.51	2.52	2.54	2.56	2.64
99.9	3.46	3.21	3.15	3.32	3.69	3.53	2.88	3.52	3.47	3.44	3.78	3.49	3.83
Observations	12,276	11,781	12,500	12,000	12,500	12,100	12,400	11,979	12,400	11,800	12,375	12,000	146,111
Zero Trading	7	32	104	2	3	7	2	0	4	0	16	67	244
V Values	12,269	11,749	12,396	11,998	12,497	12,093	12,398	11,979	12,396	11,800	12,359	11,933	145,867
Mean	-0.051	-0.092	-0.075	-0.029	0.014	0.078	-0.294	0.089	-0.059	-0.072	-0.031	0.116	-0.035
Median	-0.063	-0.100	-0.059	-0.041	-0.023	0.078	-0.301	0.076	-0.093	-0.112	-0.060	0.103	-0.051
StdDev	1.100	1.018	1.067	1.025	1.054	1.025	1.041	1.060	1.047	1.019	1.066	1.037	1.090
Skewness	0.112	0.104	-0.046	0.111	0.222	0.059	0.071	0.063	0.193	0.253	0.147	0.053	0.127
Kurtosis	2.934	3.049	2.962	3.040	3.133	3.052	2.995	3.062	2.998	3.144	3.120	3.034	3.337

Notes:

The number of V values used in the analysis during 2015H2 is less than shown. This is to allow a proper comparison between different definitions of abnormal volume event by omitting the day with corrupted missing D values (see below in Zero Trading for D values). However, the result does not affected significantly when all V values are used.

Table III: Descriptive statistics of D values

Percentile	2015H2	2016H1	All
0.1	-4.38	-4.80	-4.66
1	-2.82	-2.63	-2.76
5	-1.57	-1.56	-1.58
10	-1.11	-1.07	-1.11
20	-0.66	-0.60	-0.65
30	-0.38	-0.34	-0.39
40	-0.20	-0.16	-0.20
50	-0.04	0.00	-0.04
60	0.11	0.09	0.13
70	0.31	0.29	0.32
80	0.57	0.61	0.61
90	1.05	1.16	1.14
95	1.61	1.82	1.75
99	3.21	3.59	3.39
99.9	5.36	5.83	5.62
Observations	12,375	12,000	24,375
Zero Trading	1,655	67	1,722
D Values	10,720	11,933	22,653
Mean	-0.023	0.033	0.006
Median	-0.041	0.000	-0.041
StdDev	1.019	1.070	1.062
Skewness	0.437	0.715	0.580
Kurtosis	7.691	8.186	7.703

Table IV: Descriptive statistics of P values

Percentile	2010H2	2011H1	2011H2	2012H1	2012H2	2013H1	2013H2	2014H1	2014H2	2015H1	2015H2	2016H1	All
0.1	-0.11	-0.08	-0.13	-0.07	-0.07	-0.11	-0.10	-0.09	-0.08	-0.10	-0.11	-0.08	-0.10
1	-0.05	-0.05	-0.08	-0.05	-0.04	-0.07	-0.07	-0.05	-0.05	-0.05	-0.06	-0.05	-0.06
5	-0.03	-0.03	-0.04	-0.03	-0.02	-0.04	-0.04	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03
10	-0.02	-0.02	-0.03	-0.02	-0.02	-0.03	-0.03	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
20	-0.01	-0.01	-0.02	-0.01	-0.01	-0.02	-0.02	-0.01	-0.01	-0.01	-0.02	-0.01	-0.01
30	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
40	0.00	0.00	-0.01	0.00	0.00	-0.01	-0.01	0.00	0.00	-0.01	-0.01	0.00	0.00
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
80	0.02	0.01	0.02	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
90	0.03	0.02	0.03	0.02	0.02	0.03	0.03	0.02	0.02	0.02	0.02	0.03	0.03
95	0.05	0.04	0.04	0.03	0.03	0.05	0.04	0.03	0.03	0.03	0.03	0.04	0.04
99	0.09	0.06	0.08	0.06	0.06	0.08	0.08	0.06	0.06	0.06	0.06	0.06	0.07
99.9	0.16	0.09	0.13	0.10	0.10	0.12	0.12	0.10	0.10	0.11	0.10	0.11	0.11
Observations	12,276	12,276	11,781	12,500	12,000	12,500	12,100	12,400	11,979	12,400	11,800	12,375	12,000
Zero Trading	7	7	32	104	2	3	7	2	0	4	0	16	67
P Values	12,269	12,269	11,749	12,396	11,998	12,497	12,093	12,398	11,979	12,396	11,800	12,359	11,933
Mean	-0.051	0.002	0.000	0.000	0.001	0.002	0.000	-0.001	0.002	0.000	0.000	-0.001	0.001
Median	-0.063	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
StdDev	1.100	0.025	0.021	0.027	0.019	0.018	0.027	0.027	0.020	0.019	0.021	0.022	0.021
Skewness	0.112	1.157	0.165	0.189	0.387	0.951	0.278	0.294	0.384	0.517	0.742	-0.318	0.501
Kurtosis	2.934	12.648	7.882	8.944	6.450	14.286	5.969	8.746	6.947	16.049	12.741	11.937	4.613

Notes:

The number of P values used in the analysis during 2015H2 is less than shown. This is to allow a proper comparison between different definitions of abnormal volume event by omitting the day with corrupted missing D values (see below in Zero Trading for D values). However, the result does not affected significantly when all P values are used.

Table V: The 22-day excess returns and the counts of V-event

CAAR[1,22] market adjusted (%)

Data\c1	1.1	1.225	1.35	1.475	1.6	1.725	1.85	1.975	2.1	2.225	2.35	2.475	2.6	2.725	2.85	2.975	3.1	3.225
Period1	0.193	0.201	0.232	0.062	0.104	0.253	0.509	$0.823^{a,d}$	$1.035^{a,d}$	$1.516^{b,f}$	$1.319^{b,f}$	0.924^{d}	0.843^{d}	0.208	0.758	1.348	1.29	1.339
Period2	0.107	0.145	0.282^{a}	0.217	0.23	0.226	0.259	0.28	0.311	0.45^{a}	0.418	0.526	0.498	0.56	0.418	0.247	0.055	-0.472

CAAR[1,22] market and risk adjusted (%)

Data\c1	1.1	1.225	1.35	1.475	1.6	1.725	1.85	1.975	2.1	2.225	2.35	2.475	2.6	2.725	2.85	2.975	3.1	3.225
Period1	0.352	0.441	0.483	0.576	0.616	$0.91^{a,d}$	$1.255^{b,e}$	$1.732^{c,f}$	$1.994^{c,f}$	$2.338^{c,f}$	$1.927^{b,f}$	$1.455^{a,e}$	1.376^{e}	0.903	1.067	1.892^{d}	2.463^{d}	2.592^{d}
Period2	0.235	$0.336^{b,e}$	$0.555^{c,f}$	$0.587^{c,f}$	$0.665^{c,f}$	$0.771^{c,f}$	$0.936^{c,f}$	$1.052^{c,f}$	$1.123^{c,f}$	$1.341^{c,f}$	$1.268^{c,f}$	$1.284^{c,f}$	$1.346^{c,f}$	$1.548^{c,f}$	$1.245^{b,e}$	$1.13^{a,e}$	0.972	0.352

Number of events

Data\c1	1.1	1.225	1.35	1.475	1.6	1.725	1.85	1.975	2.1	2.225	2.35	2.475	2.6	2.725	2.85	2.975	3.1	3.225
Period1	742	699	654	586	536	470	423	358	303	258	220	172	142	114	90	73	54	45
Period2	4145	3862	3573	3249	2949	2605	2310	1982	1676	1408	1160	932	754	595	477	365	286	214

Notes:

The table analyzes the relationship between abnormal volume event and the excess returns (in percentage) according to the event study. The definition of abnormal volume events is V-event with different threshold values (c1) ranging from 1.1 to 3.225 with equal spacing. The data of Period1 correspond to dataset from July 2015 – June 2016 while Period2 correspond to July 2010 – June 2016. The cumulative average abnormal returns are reported for [1,22] window period. The excess log returns are computed both with a market adjusted and a market and risk adjusted (CAPM) approach. The statistical significance is calculated using the parametric student's T test and non-parametric Wilcoxon singed rank test. The superscript a, b, c and superscript d, e, f indicate that the coefficients are significantly different from zero at the 10%, 5%, and 1% level based on parametric test and non-parametric test respectively.

Table VI: The 22-day excess returns and the counts of VD-event

CAAR[1,22] market adjusted (%)

c1\c2	1.1	1.225	1.35	1.475	1.6	1.725	1.85	1.975	2.1	2.225	2.35	2.475	2.6	2.725	2.85	2.975	3.1	3.225
1.1	0.581	0.538	0.34	0.402	0.454	0.528	0.693	0.664	0.61	0.572	0.367	0.431	0.822	0.604	0.309	0.269	-0.184	0.002
1.225	0.576	0.532	0.314	0.395	0.342	0.408	0.568	0.59	0.662	0.656	0.377	0.532	0.724	0.479	0.21	0.188	-0.216	-0.05
1.35	0.666	0.604	0.474	0.56	0.532	0.57	0.828[a]	0.852[a]	0.811	0.841	0.624	0.75	0.981[a]	0.657	0.391	0.379	0.043	0.04
1.475	0.44	0.433	0.33	0.309	0.358	0.387	0.756	0.831	0.858	0.95[a]	0.73	0.838	1.094[a,d]	0.807	0.6	0.537	0.149	0.064
1.6	0.497	0.5	0.373	0.401	0.505	0.539	0.629	0.758	0.826	0.801	0.716	0.699	0.978	0.684	0.544	0.456	0.091	0.068
1.725	0.657	0.661	0.691	0.888	0.911	0.961	1.013[a]	1.223[b,d]	1.339[b,e]	1.418[b,e]	1.338[b,e]	1.273[a,e]	1.573[b,e]	1.193[a]	1.172	0.977	0.653	0.573
1.85	0.554	0.513	0.572	0.732	0.79	0.906	0.936	1.165[a,d]	1.28[a,e]	1.347[b,e]	1.383[b,e]	1.27[a,d]	1.616[b,e]	1.199[a]	1.128	0.997	0.705	0.552
1.975	0.856	0.773	0.843	0.996	1.077[a,d]	1.152[a,d]	1.366[b,e]	1.57[b,e]	1.616[b,e]	1.579[b,e]	1.531[b,e]	1.382[a,d]	1.422[a,d]	1.158	1.037	0.665	0.633	0.698
2.1	0.949	1.062	1.09	1.299[a,d]	1.323[a,d]	1.361[a,d]	1.406[b,d]	1.609[b,e]	1.671[b,e]	1.63[b,e]	1.606[b,d]	1.437[a,d]	1.501[a,d]	1.202	1.228	0.858	0.95	1.08
2.225	1.366[a,d]	1.526[b,e]	1.564[b,e]	1.786[b,e]	1.832[b,e]	1.92[b,e]	1.807[b,e]	2.029[b,e]	2.06[b,e]	2.021[b,e]	2.005[b,e]	1.762[b,d]	1.769[b,d]	1.404	1.384	0.859	0.963	1.104
2.35	1.124	1.289	1.331	1.197	1.182	1.328	1.228	1.366	1.462	1.218	1.306	1.31	1.257	1.033	1.044	0.516	0.546	0.572
2.475	0.593	0.759	0.78	0.867	1.008	1.184	1.352	1.424	1.697[a,d]	1.606[d]	1.652[d]	1.661[d]	1.614	1.543	1.401	0.904	0.892	0.793
2.6	0.116	0.286	0.261	0.32	0.474	0.544	0.775	0.838	1.021	1.204	1.257	1.257	1.136	1.038	0.801	0.507	0.483	0.435
2.725	-0.561	-0.561	-0.687	-0.567	-0.421	-0.343	-0.032	0.047	0.264	0.172	0.172	0.172	0.076	0.076	-0.251	-0.543	-0.596	-0.687
2.85	1.186	1.186	1.054	1.245	1.42	1.42	1.93	1.978	1.993	2.024	2.013	2.013	1.981	1.981	1.601	1.367	1.352	1.344
2.975	1.308	1.308	1.148	1.148	1.357	1.357	1.778	1.832	1.846	1.913	1.896	1.896	1.78	1.78	1.323	1.323	1.304	1.089
3.1	1.643	1.643	1.425	1.425	1.75	1.75	2.411	2.519	2.569	2.742	2.742	2.742	2.6	2.6	1.909	1.909	1.909	1.909
3.225	1.467	1.467	1.208	1.208	1.308	1.308	2.016	2.121	2.16	2.316	2.316	2.316	2.127	2.127	1.286	1.286	1.248	1.248

CAAR[1,22] market and risk adjusted (%)

c1\c2	1.1	1.225	1.35	1.475	1.6	1.725	1.85	1.975	2.1	2.225	2.35	2.475	2.6	2.725	2.85	2.975	3.1	3.225
1.1	1.113[b,e]	1.024[b,e]	0.8[a]	0.864[a,d]	0.974[a,d]	1.01[b,d]	1.099[b,d]	0.986[a]	1.082[a,d]	1.161[b,d]	0.938	1.003	1.386[b,e]	1.113	0.891	1.086	0.631	0.567
1.225	1.089[b,e]	1.024[b,e]	0.769	0.829	0.875[a]	0.921[a]	0.956[a]	0.931	1.151[b]	1.265[b,d]	1.019	1.177[a,d]	1.351[b,d]	1.041	0.877	1.007	0.598	0.463
1.35	1.165[b,e]	1.059[b,e]	0.939[a]	1.021[a,d]	1.064[a,d]	1.047[a]	1.294[b,d]	1.27[b,d]	1.269[b,d]	1.516[b,e]	1.395[b,d]	1.5[b,e]	1.768[c,e]	1.351[a,d]	1.163	1.323[a]	0.983	0.668
1.475	1.061[b,d]	0.966[a]	0.89	0.868	0.997[a]	0.988[a]	1.382[b,d]	1.4[b,d]	1.433[b,d]	1.686[c,e]	1.562[b,e]	1.605[b,e]	1.955[c,f]	1.651[b,e]	1.537[b,d]	1.603[b,d]	1.157	0.826
1.6	1.157[b,d]	1.085[a,d]	1.077[a]	1.069[a]	1.23[b,d]	1.255[b,d]	1.41[b,d]	1.443[b,d]	1.514[b,d]	1.622[b,e]	1.609[b,e]	1.544[b,e]	1.935[c,e]	1.645[b,d]	1.574[b,d]	1.575[a]	1.107	0.8
1.725	1.474[b,e]	1.349[b,d]	1.428[b,d]	1.656[b,e]	1.682[b,e]	1.731[b,e]	1.797[c,e]	1.915[c,e]	2.041[c,e]	2.26[c,f]	2.252[c,e]	2.111[c,e]	2.537[c,f]	2.133[b,e]	2.151[b,e]	1.973[b,d]	1.445	1.2
1.85	1.432[b,d]	1.241[a]	1.343[a,d]	1.521[b,d]	1.587[b,d]	1.75[b,e]	1.804[b,e]	1.934[c,e]	2.126[c,e]	2.337[c,f]	2.429[c,f]	2.278[c,e]	2.717[c,f]	2.287[c,e]	2.247[c,e]	2.082[b,d]	1.694[a]	1.268
1.975	1.686[b,e]	1.594[b,e]	1.645[b,e]	1.801[b,e]	1.952[b,e]	2.084[c,e]	2.397[c,f]	2.607[c,f]	2.69[c,f]	2.672[c,f]	2.625[c,f]	2.502[c,f]	2.624[c,f]	2.377[c,e]	2.221[b,e]	1.904[b]	1.795[a]	1.638
2.1	1.867[b,e]	1.842[b,e]	1.895[b,e]	2.153[c,e]	2.212[c,e]	2.33[c,e]	2.435[c,e]	2.668[c,f]	2.763[c,f]	2.744[c,f]	2.702[c,e]	2.563[c,e]	2.677[c,e]	2.436[b,e]	2.422[b,e]	2.129[b,d]	2.154[b,d]	2.048[a]
2.225	2.232[b,e]	2.244[b,e]	2.31[b,e]	2.617[c,e]	2.641[c,e]	2.817[c,f]	2.781[c,f]	3.036[c,f]	3.089[c,f]	3.096[c,f]	3.058[c,f]	2.823[c,e]	2.932[c,e]	2.689[b,e]	2.739[b,e]	2.385[b,d]	2.422[b,d]	2.374[a,d]
2.35	1.687[a]	1.927[b,d]	2.002[b,d]	1.93[b,d]	1.837[a]	2.137[b,d]	1.964[b,d]	2.141[b,d]	2.265[b,d]	2.11[b,d]	2.177[b,d]	2.3[b,d]	2.34[b,d]	2.105[a,d]	2.174[a,d]	1.824	1.825	1.805
2.475	1.007	1.24	1.3	1.352	1.53	1.892[a,d]	2.038[a,d]	2.152[a,d]	2.475[b,e]	2.344[b,e]	2.436[b,e]	2.587[b,e]	2.649[b,e]	2.564[b,e]	2.381[a,e]	1.996	1.956	1.874
2.6	0.451	0.69	0.686	0.816	1.018	1.299	1.423	1.538	1.721	1.849	1.961[d]	1.961[d]	1.919	1.801	1.536	1.366	1.128	1.12
2.725	0.122	0.122	0.102	0.169	0.394	0.754	0.994	0.972	1.197	1.12	1.12	1.12	1.181	1.181	0.825	0.85	0.539	0.538
2.85	1.739	1.739	1.744	1.863	2.094	2.094	2.486[a,d]	2.442[a]	2.526[a]	2.544[a]	2.592[a]	2.592[a]	2.747[a]	2.747[a]	2.319	2.482	2.108	2.139
2.975	2.009	2.009	2.021	2.021	2.311	2.311	2.662	2.613	2.72	2.819	2.885	2.885	2.941	2.941	2.44	2.44	2.029	1.979
3.1	3.614[a]	3.614[a]	3.686[a]	3.686[a]	4.23[b,d]	4.23[b,d]	4.903[b,e]	4.918[b,d]	5.179[b,e]	5.561[b,e]	5.561[b,e]	5.561[b,e]	5.777[b,e]	5.777[b,e]	5.116[a,d]	5.116[a,d]	4.586[a]	4.586[a]
3.225	3.487[a,d]	3.487[a,d]	3.564[a,d]	3.564[a,d]	3.985[b,d]	3.985[b,d]	4.726[b,e]	4.734[b,e]	5.024[b,e]	5.449[b,e]	5.449[b,e]	5.449[b,e]	5.695[b,e]	5.695[b,e]	4.913[a,d]	4.913[a,d]	4.271	4.271

Table VI (continued)

Number of events

c1\c2	1.1	1.225	1.35	1.475	1.6	1.725	1.85	1.975	2.1	2.225	2.35	2.475	2.6	2.725	2.85	2.975	3.1	3.225
1.1	509	491	477	460	441	418	401	385	357	335	310	294	279	264	245	224	211	189
1.225	474	459	445	427	409	389	373	358	335	316	294	281	267	256	240	220	206	187
1.35	433	420	405	392	377	363	349	337	320	301	281	270	259	249	234	214	202	182
1.475	392	380	364	358	346	334	320	307	294	279	264	253	244	236	223	204	195	176
1.6	353	345	330	326	313	305	296	284	273	262	249	239	228	221	210	193	185	168
1.725	309	300	290	286	277	270	262	252	239	228	218	212	203	199	188	174	166	156
1.85	278	271	266	260	250	244	238	228	219	208	201	195	187	183	174	161	155	146
1.975	234	228	225	220	214	209	201	194	188	183	178	173	168	164	157	147	141	132
2.1	198	195	193	189	182	180	175	170	165	160	156	151	147	143	136	128	124	114
2.225	173	169	167	164	159	157	154	150	145	142	138	136	132	128	123	115	111	103
2.35	143	140	138	136	130	129	126	121	116	111	108	107	103	101	97	90	89	85
2.475	116	114	112	111	107	106	103	99	96	91	90	89	85	84	82	77	77	74
2.6	92	91	90	88	84	83	81	77	75	71	70	70	67	66	65	59	58	57
2.725	70	70	69	68	64	63	60	58	56	53	53	53	51	51	50	47	46	45
2.85	54	54	53	52	50	50	47	46	45	42	41	41	39	39	38	35	34	34
2.975	44	44	43	43	41	41	39	38	37	35	34	34	33	33	32	32	31	30
3.1	31	31	30	30	28	28	26	25	24	22	22	22	21	21	20	20	19	19
3.225	27	27	26	26	25	25	23	22	21	19	19	19	18	18	17	17	16	16

Notes:
The table analyzes the relationship between abnormal volume event and the excess returns (in percentage) according to the event study. The definition of abnormal volume event is VD-event with different threshold values (c1 and c2) both ranging from 1.1 to 3.225 with equal spacing. This results correspond to dataset from July 2015 – June 2016. The cumulative average abnormal returns are reported for [1,22] window period. The excess log returns are computed both with a market adjusted and a market and risk adjusted (CAPM) approach. The statistical significance is calculated using the parametric student's T test and non-parametric Wilcoxon singed rank test. The superscript a, b, c and superscript d, e, f indicate that the coefficients are significantly different from zero at the 10%, 5%, and 1% level based on parametric test and non-parametric test respectively.

Table VII: The 22-day excess returns and the counts of VP-event

Panel A. Period1

CAAR[1,22] market adjusted (%)

c1\c3	-4.5	-4	-3.5	-3	-2.5	-2	-1.5	-1	-0.5	0	0.5	1	1.5	2	2.5	3	3.5	4
1.1	0.432	0.493[d]	0.451	0.593[a,d]	0.704[b,e]	0.704[b,e]	0.781[b,e]	0.791[b,e]	0.823[b,e]	0.869[b,e]	0.835[b,e]	0.742[b,d]	0.758[b,d]	0.613	0.584	0.215	0.11	-0.31
1.225	0.344	0.357	0.395	0.459	0.509	0.503	0.572	0.641[a]	0.626[a]	0.668[a]	0.702[a,d]	0.614[d]	0.68[a]	0.593	0.509	0.25	0.037	-0.419
1.35	0.398	0.358	0.335	0.421	0.432	0.449	0.397	0.45	0.484	0.634	0.608	0.563	0.62	0.603	0.463	0.091	0.104	-0.582
1.475	0.175	0.248	0.224	0.299	0.375	0.32	0.411	0.548	0.593	0.793[a]	0.744[a]	0.746	0.715	0.528	0.345	0.086	-0.02	-0.716
1.6	0.236	0.264	0.231	0.341	0.365	0.383	0.535	0.691	0.696	0.781[a]	0.742	0.692	0.646	0.565	0.292	0.145	-0.186	-0.64
1.725	0.393	0.462	0.354	0.478	0.458	0.451	0.627	0.779	0.749	0.854[a,d]	0.783	0.64	0.643	0.689	0.201	0.111	-0.205	-0.576
1.85	0.63	0.723[d]	0.65	0.652	0.667	0.664	0.801[d]	0.925[a,d]	0.894[a,d]	0.912[a,d]	0.839[d]	0.549	0.583	0.549	0.088	0.008	-0.357	-0.688
1.975	0.97[a,e]	0.965[a,e]	1.019[a,e]	1.005[a,e]	0.958[a,e]	0.898[d]	0.978[a,e]	1.058[a,e]	0.996[a,e]	0.998[a,e]	0.9[d]	0.666	0.721	0.784	0.437	0.229	-0.133	-0.484
2.1	1.053[a,e]	1.012[a,e]	0.912[d]	0.888[d]	0.739	0.729	0.857	0.995[d]	1.027[a,e]	1.055[d]	0.989[d]	0.687	0.755	0.823	0.349	0.301	0.125	-0.095
2.225	1.411[b,e]	1.356[b,e]	1.272[a,e]	1.274[a,e]	1.296[a,e]	1.239[a,e]	1.313[a,e]	1.384[b,e]	1.404[b,e]	1.733[b,f]	1.673[b,e]	1.297[a,d]	1.414[a,e]	1.432[a,e]	0.856	1.017	0.792	0.353
2.35	1.411[b,e]	1.349[a,e]	1.094[e]	1.035[e]	1.01[d]	0.917	0.903	0.942[d]	0.991[d]	1.301[a,d]	1.198[d]	0.802	0.924	1.18	0.961	1.077	0.9	0.537
2.475	0.775	0.681	0.571	0.526	0.584	0.465	0.496	0.484	0.497	0.865	0.718	0.227	0.427	0.727	0.703	0.595	0.378	0.148
2.6	0.51	0.388	0.327	0.309	0.259	0.11	0.114	-0.04	-0.04	0.437	0.474	-0.201	-0.11	0.312	0.253	0.378	0.012	-0.474
2.725	-0.319	-0.579	-0.708	-0.657	-0.707	-0.871	-0.935	-1.003	-1.003	-0.41	-0.378	-1.005	-0.985	-0.512	-0.459	-0.47	-0.849	-1.284
2.85	0.278	-0.05	-0.2	-0.2	-0.238	-0.261	-0.28	-0.226	0.303	0.975	1.047	0.602	0.697	0.465	0.633	0.761	0.162	-0.488
2.975	0.713	0.297	0.124	0.124	0.101	0.077	0.06	0.057	0.762	0.484	0.484	0.11	0.135	-0.214	-0.088	0.05	0.117	-0.35
3.1	1.577	0.97	0.569	0.569	0.589	0.568	0.556	0.556	0.563	0.454	0.454	-0.365	-0.347	-0.486	0.301	0.301	0.244	-0.324
3.225	1.433	0.653	0.11	0.11	0.248	0.205	0.173	0.173	0.164	-0.003	-0.003	0.064	0.064	-0.112	0.139	0.139	0.289	-0.311

CAAR[1,22] market and risk adjusted (%)

c1\c3	-4.5	-4	-3.5	-3	-2.5	-2	-1.5	-1	-0.5	0	0.5	1	1.5	2	2.5	3	3.5	4
1.1	0.743[b,e]	0.799[b,e]	0.784[b,e]	0.941[b,f]	1.029[c,f]	1.074[c,f]	1.229[c,f]	1.254[c,f]	1.278[c,f]	1.411[c,f]	1.348[c,f]	1.271[c,f]	1.321[c,f]	1.315[c,f]	1.302[c,f]	1.068[b,e]	1.096[a,e]	0.905[d]
1.225	0.763[b,e]	0.757[b,e]	0.802[b,e]	0.903[b,e]	0.995[c,f]	1.02[b,e]	1.146[c,f]	1.206[c,f]	1.185[c,f]	1.284[c,f]	1.323[c,f]	1.198[c,f]	1.241[c,e]	1.26[b,e]	1.257[b,e]	1.15[b,e]	1.169[a,d]	0.91
1.35	0.795[b,d]	0.751[a,d]	0.703[a]	0.804[b,d]	0.843[b,d]	0.86[b,d]	0.85[b,d]	0.896[b,d]	0.966[b,e]	1.24[c,e]	1.24[c,e]	1.146[b,e]	1.215[b,e]	1.213[b,e]	1.135[b,e]	1[a,d]	1.243[b,d]	0.851
1.475	0.758[a]	0.872[a,d]	0.826[a]	0.889[a]	0.965[b,d]	0.852[a]	0.987[b,d]	1.131[b,d]	1.237[c,e]	1.494[c,e]	1.498[c,e]	1.413[c,e]	1.399[c,e]	1.127[b,d]	1.118[a,d]	1.124[a,d]	1.142[a]	0.738
1.6	0.836[a,d]	0.884[a,d]	0.817[a,d]	0.925[a,d]	0.933[a,d]	0.914[a]	1.155[b,e]	1.316[c,e]	1.323[c,e]	1.491[c,e]	1.506[c,e]	1.38[b,e]	1.3[b,e]	1.206[b,d]	1.174[a,d]	1.308[a,d]	1.097	0.911
1.725	1.135[b,e]	1.193[b,e]	1.065[b,e]	1.201[b,e]	1.215[b,e]	1.281[b,e]	1.523[c,f]	1.7[c,f]	1.655[c,f]	1.826[c,f]	1.783[c,f]	1.578[b,e]	1.605[c,e]	1.626[b,e]	1.268[a,d]	1.43[a,d]	1.147	1.015
1.85	1.414[c,f]	1.507[c,f]	1.433[c,f]	1.473[c,f]	1.493[c,f]	1.599[c,f]	1.808[c,f]	1.964[c,f]	1.998[c,f]	2.067[c,f]	2.007[c,f]	1.645[b,e]	1.709[c,e]	1.613[b,e]	1.209[a]	1.256	0.989	0.904
1.975	1.946[c,f]	1.95[c,f]	2.069[c,f]	2.161[c,f]	2.061[c,f]	2.07[c,f]	2.183[c,f]	2.277[c,f]	2.263[c,f]	2.252[c,f]	2.175[c,f]	1.921[c,f]	1.97[c,e]	2.039[c,e]	1.747[b,e]	1.761[b,d]	1.501	1.413
2.1	2.088[c,f]	2.071[c,f]	1.976[c,f]	2.034[c,f]	1.855[c,e]	1.813[c,e]	1.94[c,f]	2.136[c,f]	2.212[c,f]	2.293[c,f]	2.239[c,f]	1.879[b,e]	1.954[b,e]	1.994[b,e]	1.579[a,d]	1.783[a,d]	1.811[a,d]	1.81[a,d]
2.225	2.265[c,f]	2.266[c,f]	2.225[c,f]	2.313[c,f]	2.223[c,f]	2.141[c,f]	2.238[c,f]	2.342[c,f]	2.389[c,f]	2.756[c,f]	2.705[c,f]	2.421[c,f]	2.587[c,f]	2.571[c,f]	2.153[b,e]	2.528[b,e]	2.44[b,e]	2.319[b,d]
2.35	2.113[c,f]	2.122[c,f]	2.004[b,f]	2.042[b,f]	2.009[b,e]	1.947[b,e]	1.925[b,e]	2.044[b,e]	2.142[b,e]	2.419[c,e]	2.303[b,e]	1.958[b,d]	2.14[b,e]	2.439[b,e]	2.263[b,e]	2.55[b,e]	2.578[b,e]	2.439[b,e]
2.475	1.345[e]	1.326[e]	1.255[d]	1.312[d]	1.331[d]	1.198	1.188	1.277	1.314	1.652[a]	1.478	1.054	1.279	1.748[d]	1.766	1.736	1.733	1.793
2.6	0.916[d]	0.844	0.786	0.92	0.866	0.696	0.679	0.639	0.639	1.053	1.11	0.624	0.606	1.241	1.23	1.353	1.118	0.948
2.725	0.475	0.275	0.234	0.484	0.499	0.28	0.184	0.178	0.178	0.718	0.705	0.075	0.066	0.84	1.166	1.147	1.039	0.926
2.85	0.632	0.373	0.322	0.322	0.332	0.258	0.292	0.338	1.012	1.651	1.651	1.216	1.251	1.228	1.723	1.821	1.801	1.746
2.975	1.389	1.028	1	1	1.068	0.987	1.046	1.056	1.972	1.612	1.612	1.259	1.134	0.846	1.413	1.525	1.905	2.373
3.1	3.323[b,d]	2.828[a]	2.723	2.723	3.053	2.989	3.154	3.154	3.453[a]	3.37	3.37	2.684	2.545	2.409	3.869[a]	3.869[a]	3.987	3.42
3.225	3.333[a,d]	2.703	2.557	2.557	2.874	2.783	2.991	2.991	3.381	3.266	3.266	3.582	3.582	3.41	4.149	4.149	4.312	3.729

Table VII (continued)

Number of events

c1\c3	-4.5	-4	-3.5	-3	-2.5	-2	-1.5	-1	-0.5	0	0.5	1	1.5	2	2.5	3	3.5	4
1.1	724	721	716	709	697	682	664	658	648	615	605	569	550	503	468	409	358	314
1.225	682	679	668	657	645	631	619	608	602	573	564	530	507	461	431	375	332	295
1.35	635	629	620	609	598	583	572	561	555	521	512	484	466	432	404	354	311	279
1.475	570	562	550	543	531	520	514	502	492	465	458	431	416	389	362	317	281	255
1.6	515	509	498	493	480	468	460	453	445	415	408	387	380	351	323	282	252	234
1.725	452	446	435	428	418	407	401	391	387	364	358	335	329	302	286	253	230	213
1.85	401	396	386	377	371	364	357	350	344	323	318	298	292	271	256	227	207	192
1.975	330	326	321	310	307	301	296	290	284	267	262	245	238	223	212	189	173	159
2.1	278	273	268	261	256	252	247	243	240	228	223	207	203	194	185	164	147	133
2.225	240	235	228	222	218	214	210	209	206	193	188	177	172	165	156	140	125	115
2.35	203	199	192	187	183	179	176	174	171	161	157	150	145	137	130	118	104	98
2.475	157	154	151	146	142	139	138	134	133	126	122	116	110	103	98	90	78	75
2.6	131	129	125	122	117	113	111	107	107	102	99	92	86	81	76	73	62	58
2.725	96	94	91	90	86	83	81	79	79	74	73	70	68	63	59	57	48	45
2.85	73	71	68	68	64	63	62	61	59	54	53	50	48	46	42	41	33	29
2.975	57	56	53	53	49	48	47	47	45	42	42	39	38	38	34	33	28	24
3.1	38	37	35	35	31	30	29	29	28	27	27	25	24	24	21	21	18	17
3.225	30	29	27	27	24	23	22	22	21	20	20	19	19	19	18	18	17	16

Panel B. Period2

CAAR[1,22] market adjusted (%)

c1\c3	-4.5	-4	-3.5	-3	-2.5	-2	-1.5	-1	-0.5	0	0.5	1	1.5	2	2.5	3	3.5	4
1.1	0.161	0.172	0.177	0.192	0.189	0.181	0.18	0.154	0.142	0.143	0.148	0.115	0.136	0.035	0.02	-0.024	-0.077[d]	-0.183[e]
1.225	0.226	0.215	0.232	0.23	0.206	0.176	0.148	0.174	0.155	0.133	0.163	0.126	0.117	0.044	0.053	0.005	-0.054	-0.129[d]
1.35	0.368	0.343	0.35	0.339	0.334	0.32	0.321	0.319	0.314	0.27	0.299	0.235	0.228	0.151	0.129	0.092	0.079	-0.044
1.475	0.288	0.314	0.307	0.291	0.295	0.262	0.27	0.283	0.259	0.267	0.268	0.252	0.235	0.164	0.159	0.117	0.088	-0.029
1.6	0.24	0.258	0.275	0.277	0.264	0.236	0.216	0.205	0.185	0.2	0.185	0.169	0.162	0.146	0.095	0.052	-0.021	-0.086
1.725	0.205	0.21	0.201	0.189	0.149	0.143	0.15	0.149	0.146	0.131	0.114	0.073	0.085	0.11	-0.005	-0.024	-0.027	0.013
1.85	0.224	0.233	0.248	0.219	0.206	0.211	0.212	0.21	0.165	0.121	0.102	0.015	0.023	0.044	-0.064	-0.028	-0.046	0.041
1.975	0.255	0.228	0.259	0.242	0.222	0.209	0.19	0.185	0.146	0.116	0.109	0.021	0.024	0.077	-0.01	-0.02	-0.059	-0.025
2.1	0.291	0.257	0.279	0.239	0.196	0.187	0.206	0.188	0.148	0.156	0.149	0.072	0.1	0.172	0.12	0.084	0.039	0.092
2.225	0.316	0.298	0.298	0.265	0.254	0.261	0.278	0.256	0.196	0.245	0.22	0.13	0.223	0.277	0.233	0.228	0.223	0.203
2.35	0.305	0.301	0.244	0.191	0.196	0.175	0.205	0.189	0.15	0.111	0.059	-0.043	0.055	0.176	0.14	0.182	0.192	0.113
2.475	0.437	0.463	0.425	0.352	0.388	0.35	0.379	0.325	0.273	0.287	0.223	0.08	0.171	0.27	0.259	0.249	0.267	0.098
2.6	0.439	0.46	0.369	0.352	0.372	0.331	0.321	0.252	0.228	0.225	0.192	0.082	0.17	0.311	0.351	0.353	0.372	0.295
2.725	0.514	0.508	0.425	0.404	0.474	0.445	0.434	0.381	0.378	0.431	0.393	0.285	0.371	0.511	0.627	0.564	0.585	0.564
2.85	0.37	0.351	0.246	0.204	0.294	0.28	0.262	0.226	0.295	0.403	0.362	0.302	0.43	0.446	0.555	0.538	0.556	0.4
2.975	0.218	0.153	0.075	0.053	0.12	0.165	0.095	0.094	0.207	0.099	0.03	0.007	0.056	0.016	0.062	0.168	0.375	0.269
3.1	0.266	0.116	-0.014	-0.067	-0.025	0.069	-0.026	-0.033	0.011	-0.051	-0.144	-0.233	-0.146	-0.134	-0.012	0.127	0.098	0.029
3.225	-0.272	-0.377	-0.517	-0.582	-0.563	-0.362	-0.366	-0.377	-0.324	-0.395	-0.378	-0.285	-0.141	-0.141	-0.01	0.065	0.116	-0.069

Table VII (continued)

CAAR[1,22] market and risk adjusted (%)

c1\c3	-4.5	-4	-3.5	-3	-2.5	-2	-1.5	-1	-0.5	0	0.5	1	1.5	2	2.5	3	3.5	4
1.1	0.358[b,e]	0.378[b,e]	0.391[b,f]	0.436[c,f]	0.456[c,f]	0.474[c,f]	0.513[c,f]	0.515[c,f]	0.515[c,f]	0.551[c,f]	0.55[c,f]	0.527[c,f]	0.579[c,f]	0.52[c,f]	0.533[b,f]	0.502[b,e]	0.5[b,e]	0.333
1.225	0.467[c,f]	0.45[c,f]	0.476[c,f]	0.508[c,f]	0.52[c,f]	0.499[c,f]	0.523[c,f]	0.587[c,f]	0.589[c,f]	0.608[c,f]	0.642[c,f]	0.608[c,f]	0.61[c,f]	0.599[c,f]	0.642[c,f]	0.616[c,f]	0.604[b,f]	0.444[d]
1.35	0.688[c,f]	0.676[c,f]	0.682[c,f]	0.7[c,f]	0.722[c,f]	0.708[c,f]	0.764[c,f]	0.806[c,f]	0.825[c,f]	0.842[c,f]	0.882[c,f]	0.819[c,f]	0.831[c,f]	0.787[c,f]	0.802[c,f]	0.805[c,f]	0.852[c,f]	0.652[b,e]
1.475	0.703[c,f]	0.757[c,f]	0.75[c,f]	0.769[c,f]	0.803[c,f]	0.766[c,f]	0.808[c,f]	0.842[c,f]	0.832[c,f]	0.893[c,f]	0.899[c,f]	0.897[c,f]	0.916[c,f]	0.875[c,f]	0.927[c,f]	0.889[c,f]	0.876[c,f]	0.662[b,e]
1.6	0.753[c,f]	0.786[c,f]	0.804[c,f]	0.841[c,f]	0.846[c,f]	0.821[c,f]	0.85[c,f]	0.88[c,f]	0.88[c,f]	0.946[c,f]	0.936[c,f]	0.944[c,f]	0.955[c,f]	0.955[c,f]	0.965[c,f]	0.94[c,f]	0.877[c,f]	0.766[b,e]
1.725	0.829[c,f]	0.847[c,f]	0.84[c,f]	0.854[c,f]	0.848[c,f]	0.858[c,f]	0.919[c,f]	0.97[c,f]	0.998[c,f]	0.986[c,f]	0.974[c,f]	0.952[c,f]	0.989[c,f]	1.035[c,f]	0.879[c,f]	0.848[c,f]	0.902[c,f]	0.934[c,e]
1.85	0.985[c,f]	1.006[c,f]	1.027[c,f]	1.027[c,f]	1.044[c,f]	1.095[c,f]	1.164[c,f]	1.191[c,f]	1.208[c,f]	1.195[c,f]	1.167[c,f]	1.104[c,f]	1.122[c,f]	1.148[c,f]	1.02[c,f]	1.006[c,f]	1.041[c,f]	1.154[c,f]
1.975	1.14[c,f]	1.135[c,f]	1.179[c,f]	1.21[c,f]	1.222[c,f]	1.252[c,f]	1.272[c,f]	1.302[c,f]	1.296[c,f]	1.27[c,f]	1.273[c,f]	1.2[c,f]	1.181[c,f]	1.234[c,f]	1.158[c,f]	1.059[c,f]	1.079[c,f]	1.123[c,e]
2.1	1.214[c,f]	1.22[c,f]	1.25[c,f]	1.256[c,f]	1.259[c,f]	1.287[c,f]	1.341[c,f]	1.332[c,f]	1.306[c,f]	1.331[c,f]	1.34[c,f]	1.275[c,f]	1.272[c,f]	1.318[c,f]	1.275[c,f]	1.205[c,f]	1.239[c,f]	1.282[c,f]
2.225	1.287[c,f]	1.312[c,f]	1.33[c,f]	1.348[c,f]	1.367[c,f]	1.384[c,f]	1.433[c,f]	1.421[c,f]	1.381[c,f]	1.461[c,f]	1.447[c,f]	1.38[c,f]	1.464[c,f]	1.507[c,f]	1.499[c,f]	1.489[c,f]	1.534[c,f]	1.613[c,f]
2.35	1.274[c,f]	1.297[c,f]	1.287[c,f]	1.274[c,f]	1.353[c,f]	1.368[c,f]	1.401[c,f]	1.413[c,f]	1.387[c,f]	1.396[c,f]	1.353[c,f]	1.297[c,f]	1.392[c,f]	1.501[c,f]	1.48[c,f]	1.533[c,f]	1.614[c,f]	1.53[c,e]
2.475	1.369[c,f]	1.414[c,f]	1.425[c,f]	1.384[c,f]	1.501[c,f]	1.48[c,f]	1.528[c,f]	1.51[c,f]	1.484[c,f]	1.524[c,f]	1.47[c,f]	1.393[c,f]	1.497[c,f]	1.635[c,f]	1.632[c,f]	1.665[c,f]	1.729[c,f]	1.626[c,f]
2.6	1.375[c,f]	1.407[c,f]	1.368[c,f]	1.392[c,f]	1.504[c,f]	1.483[c,f]	1.513[c,f]	1.471[c,f]	1.459[c,f]	1.488[c,f]	1.473[c,f]	1.433[c,f]	1.524[c,f]	1.712[c,f]	1.732[c,f]	1.771[c,f]	1.837[c,f]	1.837[c,f]
2.725	1.655[c,f]	1.659[c,f]	1.662[c,f]	1.667[c,f]	1.806[c,f]	1.794[c,f]	1.838[c,f]	1.78[c,f]	1.772[c,f]	1.867[c,f]	1.835[c,f]	1.785[c,f]	1.886[c,f]	2.078[c,f]	2.197[c,f]	2.215[c,f]	2.312[c,f]	2.327[c,f]
2.85	1.371[b,e]	1.374[b,e]	1.371[b,e]	1.314[b,e]	1.501[b,e]	1.513[b,e]	1.585[c,e]	1.52[b,e]	1.601[c,e]	1.741[c,e]	1.701[c,e]	1.688[c,e]	1.858[c,f]	1.941[c,f]	2.054[c,f]	2.133[c,f]	2.23[c,f]	2.157[c,e]
2.975	1.372[b,e]	1.357[b,e]	1.395[b,e]	1.326[b,e]	1.481[b,e]	1.563[b,e]	1.508[b,e]	1.48[b,e]	1.595[b,e]	1.505[b,d]	1.452[b,d]	1.465[a,d]	1.598[b,e]	1.647[b,e]	1.748[b,e]	1.952[b,e]	2.223[b,e]	2.306[b,e]
3.1	1.447[b,e]	1.393[a,d]	1.417[a,d]	1.328[a,d]	1.507[a,d]	1.662[b,e]	1.604[b,d]	1.566[a,d]	1.593[a,d]	1.581[a,d]	1.511[a]	1.472[a]	1.549[a,d]	1.629[a,d]	1.798[a,d]	2.061[b,e]	2.089[b,e]	2.076[b,d]
3.225	0.855	0.822	0.797	0.702	0.936	1.23	1.253	1.215	1.245	1.261	1.29	1.468	1.662[a]	1.74[a]	1.934[a]	2.201[b,d]	2.316[b,d]	2.191[a]

Number of events

c1\c3	-4.5	-4	-3.5	-3	-2.5	-2	-1.5	-1	-0.5	0	0.5	1	1.5	2	2.5	3	3.5	4
1.1	4065	4040	4012	3971	3915	3874	3812	3764	3682	3531	3491	3327	3165	2959	2772	2497	2221	1922
1.225	3785	3765	3731	3687	3629	3586	3530	3477	3405	3284	3239	3083	2939	2752	2579	2322	2071	1803
1.35	3488	3460	3426	3380	3329	3286	3232	3189	3123	3005	2967	2834	2709	2553	2386	2148	1913	1674
1.475	3174	3144	3112	3070	3019	2985	2943	2903	2839	2731	2699	2566	2454	2322	2168	1953	1749	1530
1.6	2866	2842	2813	2773	2727	2690	2650	2614	2559	2453	2428	2325	2229	2105	1952	1772	1590	1394
1.725	2522	2496	2464	2427	2392	2356	2318	2274	2221	2138	2114	2026	1951	1850	1738	1586	1419	1247
1.85	2225	2204	2176	2138	2102	2070	2035	2005	1960	1877	1855	1778	1720	1637	1539	1408	1267	1122
1.975	1896	1880	1856	1820	1787	1759	1735	1709	1663	1595	1579	1506	1456	1385	1309	1202	1092	966
2.1	1595	1572	1553	1522	1493	1465	1447	1426	1390	1338	1323	1264	1225	1167	1107	1019	925	820
2.225	1338	1315	1296	1271	1242	1219	1207	1194	1165	1113	1098	1052	1022	979	928	863	790	697
2.35	1096	1076	1057	1039	1010	992	982	968	946	906	895	865	839	803	768	716	653	580
2.475	876	857	840	827	801	787	779	767	752	728	718	695	675	643	617	584	529	470
2.6	706	691	679	669	644	633	625	613	601	584	578	556	539	520	494	469	428	374
2.725	544	527	519	511	493	484	476	467	458	444	440	426	416	400	380	360	335	298
2.85	428	415	406	399	382	375	369	362	352	339	336	324	316	305	289	274	253	229
2.975	322	313	307	304	290	283	280	275	269	261	259	250	244	240	227	216	202	184
3.1	245	238	233	231	220	214	212	207	203	198	196	190	186	184	172	166	158	148
3.225	176	171	168	167	157	153	152	148	144	140	139	135	133	130	123	120	115	107

Notes:
The table analyzes the relationship between abnormal volume event and the excess returns (in percentage) according to the event study. The abnormal volume event VP-event with different threshold values (c1 and c3) ranging from 1.1 to 3.225 and -4.5 to 4 with equal spacing. The Period1 for panel A correspond to dataset from July 2015 – June 2016 while Period2 for panel B correspond to July 2010 – June 2016. The cumulative average abnormal returns are reported for [1,22] window period. The excess log returns are computed both with a market adjusted and a market and risk adjusted (CAPM) approach. The statistical significance is calculated using the parametric student's T test and non-parametric Wilcoxon singed rank test. The superscript a, b, c and superscript d, e, f indicate that the coefficients are significantly different from zero at the 10%, 5%, and 1% level based on parametric test and non-parametric test respectively.

Table VIII: The 22-day excess returns and the counts of VDP-event

Panal A. c3 = 4

CAAR[1,22] market adjusted (%)

c1\c2	1.1	1.225	1.35	1.475	1.6	1.725	1.85	1.975	2.1	2.225	2.35	2.475	2.6	2.725	2.85	2.975	3.1	3.225
1.1	-0.303	-0.247	-0.341	-0.349	-0.294	-0.298	-0.099	-0.184	-0.266	-0.249	-0.459	-0.384	0.025	-0.317	-0.459	-0.332	-0.434	-0.433
1.225	-0.188	-0.125	-0.364	-0.335	-0.429	-0.51	-0.309	-0.332	-0.363	-0.305	-0.529	-0.403	-0.152	-0.361	-0.509	-0.334	-0.437	-0.442
1.35	-0.356	-0.291	-0.414	-0.332	-0.272	-0.194	0.085	0.071	-0.035	0.059	-0.158	-0.173	-0.01	-0.23	-0.351	-0.155	-0.214	-0.259
1.475	-0.506	-0.449	-0.499	-0.511	-0.422	-0.336	0	-0.039	-0.149	0.011	-0.223	-0.203	-0.049	-0.244	-0.343	-0.142	-0.173	-0.372
1.6	-0.499	-0.476	-0.499	-0.433	-0.373	-0.275	-0.073	-0.13	-0.261	-0.165	-0.245	-0.224	-0.061	-0.269	-0.257	-0.265	-0.3	-0.463
1.725	-0.381	-0.403	-0.349	-0.036	-0.009	0.111	0.427	0.38	0.24	0.386	0.155	0.182	0.361	0.104	0.247	0.107	0.065	-0.169
1.85	-0.644	-0.676	-0.658	-0.353	-0.274	-0.107	0.248	0.19	0.102	0.233	0.203	0.224	0.42	0.142	0.3	0.208	0.187	-0.089
1.975	-0.241	-0.382	-0.36	-0.024	0.06	0.12	0.765	0.77	0.669	0.568	0.543	0.463	0.488	0.349	0.494	0.234	0.212	-0.091
2.1	0.288	0.227	0.259	0.666	0.678	0.678	1.185	1.235	1.125	1.014	1	0.908	0.952	0.801	0.813	0.585	0.656	0.401
2.225	0.536	0.468	0.508	0.948	1.061	1.061	1.39	1.454	1.331	1.207	1.198	1.092	1.024	0.856	0.918	0.732	0.813	0.487
2.35	0.61	0.641	0.691	0.664	0.791	0.791	1.068	1.131	0.979	0.593	0.707	0.707	0.617	0.645	0.716	0.737	0.722	0.334
2.475	0.015	0.015	0.068	0.212	0.369	0.369	1.234	1.327	1.327	0.83	0.894	0.894	0.781	0.781	0.781	0.781	0.763	0.441
2.6	-0.747	-0.747	-0.747	-0.581	-0.398	-0.398	0.665	0.746	0.746	0.683	0.763	0.763	0.612	0.612	0.612	0.612	0.578	0.5
2.725	-2.445	-2.445	-2.445	-2.271	-2.074	-2.074	-0.561	-0.442	-0.442	-0.563	-0.563	-0.563	-0.563	-0.563	-0.563	-0.563	-0.646	-0.788
2.85	-0.987	-0.987	-0.987	-0.672	-0.672	-0.672	0.374	0.374	0.374	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.161	0.148
2.975	-0.712	-0.712	-0.712	-0.712	-0.712	-0.712	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	-0.049	-0.461
3.1	-0.597	-0.597	-0.597	-0.597	-0.597	-0.597	0.467	0.467	0.467	0.467	0.467	0.467	0.467	0.467	0.467	0.467	0.365	0.365
3.225	-0.602	-0.602	-0.602	-0.602	-0.602	-0.602	0.538	0.538	0.538	0.538	0.538	0.538	0.538	0.538	0.538	0.538	0.434	0.434

CAAR[1,22] market and risk adjusted (%)

c1\c2	1.1	1.225	1.35	1.475	1.6	1.725	1.85	1.975	2.1	2.225	2.35	2.475	2.6	2.725	2.85	2.975	3.1	3.225
1.1	0.863[d]	0.883[d]	0.807	0.744	0.88	0.988[d]	1.082[d]	0.812	0.628	0.797	0.616	0.673	1.034	0.703	0.841	1.316	1.246	0.993
1.225	1.094[d]	1.149[e]	0.837	0.794	0.924	0.913	1.005	0.852	0.784	0.996	0.815	0.889	0.979	0.815	0.962	1.347	1.276	0.986
1.35	1.058[d]	1.116[d]	1.087[d]	1.053	1.152	1.223[d]	1.513[a,d]	1.367[d]	1.106	1.433[a,d]	1.266	1.236	1.253	1.043	1.162	1.577	1.539	1.316
1.475	0.792	0.855	0.902	0.811	0.95	0.982	1.386	1.22	0.978	1.378	1.243	1.249	1.339	1.198	1.253	1.686	1.69	1.401
1.6	1.02	1.072	1.17	1.181	1.313	1.405	1.711[a,d]	1.51[a]	1.251	1.522[a]	1.469	1.481	1.585	1.442	1.484	1.709	1.714	1.456
1.725	1.174	1.025	1.209	1.568[a]	1.627[a]	1.739[a,d]	2.044[b,d]	1.83[a]	1.543	1.916[a,d]	1.722[a]	1.698	1.817[a]	1.657	1.851[a]	1.832	1.741	1.556
1.85	0.863	0.688	0.887	1.216	1.366	1.592	1.948[b,d]	1.708[a]	1.609	1.958[a,d]	1.913[a]	1.89[a]	2.025[a,d]	1.855[a]	2.077[a,d]	2.111[a]	2.161[a]	1.819
1.975	1.644[d]	1.388	1.436	1.922[a,d]	2.145[a,d]	2.279[a,e]	3.007[c,e]	3.052[c,e]	2.944[b,e]	2.824[b,e]	2.796[b,e]	2.701[b,e]	2.717[b,e]	2.705[b,e]	2.813[b,e]	2.574[b,d]	2.638[b,d]	2.284[a]
2.1	2.21[a,e]	1.925[d]	1.988[e]	2.602[b,e]	2.764[b,e]	2.764[b,e]	3.319[c,f]	3.497[c,f]	3.379[c,f]	3.246[c,e]	3.228[b,e]	3.119[b,e]	3.15[b,e]	3.146[b,e]	3.088[b,e]	2.886[b,e]	2.973[b,e]	2.658[a,d]
2.225	2.533[b,d]	2.205[d]	2.282[a,d]	3.008[b,e]	3.183[b,e]	3.183[b,e]	3.529[c,e]	3.74[c,f]	3.607[c,e]	3.459[b,e]	3.445[b,e]	3.32[b,e]	3.243[b,e]	3.241[b,e]	3.321[b,e]	3.185[b,e]	3.286[b,e]	2.999[a,d]
2.35	2.372[a,d]	2.449[a,d]	2.543[a,d]	2.643[a,e]	2.842[b,e]	2.842[b,e]	2.891[b,e]	3.115[b,e]	2.948[b,e]	2.584[b,d]	2.713[b,d]	2.713[b,d]	2.609[a,d]	2.734[a,d]	2.824[b,e]	2.852[b,d]	2.803[a,d]	2.446[d]
2.475	1.647	1.647	1.755	1.855	2.101	2.101	2.773[a,d]	3.064[a,e]	3.064[a,e]	2.588[d]	2.752[a,d]	2.752[a,d]	2.619[d]	2.619[d]	2.619[d]	2.619[d]	2.558[d]	2.313
2.6	0.847	0.847	0.847	0.955	1.248	1.248	2.057	2.387	2.387	2.327	2.535	2.535	2.355	2.355	2.355	2.355	2.017	2.057
2.725	-0.036	-0.036	-0.036	0.083	0.45	0.45	1.741	1.836	1.836	1.738	1.738	1.738	1.738	1.738	1.738	1.738	1.29	1.316
2.85	1.918	1.918	1.918	2.172	2.172	2.172	2.904	2.904	2.904	2.815	2.815	2.815	2.815	2.815	2.815	2.815	2.227	2.276
2.975	2.193	2.193	2.193	2.193	2.193	2.193	2.742	2.742	2.742	2.742	2.742	2.742	2.742	2.742	2.742	2.742	2.12	2.046
3.1	3.455	3.455	3.455	3.455	3.455	3.455	4.308	4.308	4.308	4.308	4.308	4.308	4.308	4.308	4.308	4.308	3.531	3.531
3.225	3.788	3.788	3.788	3.788	3.788	3.788	4.725	4.725	4.725	4.725	4.725	4.725	4.725	4.725	4.725	4.725	3.92	3.92

Table VIII (continued)

Number of events

c1\c2	1.1	1.225	1.35	1.475	1.6	1.725	1.85	1.975	2.1	2.225	2.35	2.475	2.6	2.725	2.85	2.975	3.1	3.225
1.1	267	261	257	251	241	232	220	212	208	196	187	178	168	161	151	138	133	122
1.225	248	244	241	234	224	216	205	200	197	186	177	171	163	158	148	136	131	121
1.35	231	227	223	217	211	205	196	191	188	177	168	164	158	153	144	132	128	117
1.475	219	215	211	206	200	194	186	180	178	170	162	158	153	149	141	129	126	115
1.6	204	199	195	191	185	180	174	169	167	160	153	149	144	140	134	124	121	112
1.725	186	181	177	172	167	162	156	151	149	142	136	134	130	128	122	114	111	107
1.85	168	163	161	156	150	147	142	137	136	129	126	124	120	118	112	104	102	98
1.975	138	135	134	128	125	123	117	113	112	111	108	108	105	103	99	95	93	89
2.1	114	113	112	108	106	106	102	99	98	97	94	94	91	89	86	84	83	79
2.225	98	97	96	93	92	92	90	87	86	85	82	82	81	79	78	76	75	72
2.35	83	82	81	80	79	79	76	73	72	70	67	67	66	65	64	63	63	61
2.475	64	64	63	62	61	61	58	55	55	53	52	52	51	51	51	51	51	49
2.6	50	50	50	49	48	48	45	42	42	41	40	40	39	39	39	39	38	37
2.725	38	38	38	37	36	36	33	32	32	31	31	31	31	31	31	31	30	29
2.85	26	26	26	25	25	25	23	23	23	22	22	22	22	22	22	22	21	21
2.975	22	22	22	22	22	22	21	21	21	21	21	21	21	21	21	21	20	19
3.1	16	16	16	16	16	16	15	15	15	15	15	15	15	15	15	15	14	14
3.225	15	15	15	15	15	15	14	14	14	14	14	14	14	14	14	14	13	13

Panal B. c3 = 2

CAAR[1,22] market adjusted (%)

c1\c2	1.1	1.225	1.35	1.475	1.6	1.725	1.85	1.975	2.1	2.225	2.35	2.475	2.6	2.725	2.85	2.975	3.1	3.225
1.1	0.275	0.285	0.159	0.179	0.191	0.245	0.486	0.446	0.151	0.197	-0.04	-0.058	0.207	-0.04	-0.302	-0.435	-0.591	-0.35
1.225	0.45	0.4	0.199	0.197	0.077	0.121	0.373	0.388	0.246	0.331	-0.021	0.031	0.146	-0.073	-0.298	-0.396	-0.552	-0.402
1.35	0.46	0.401	0.338	0.371	0.318	0.366	0.689	0.722	0.47	0.559	0.231	0.337	0.423	0.098	-0.123	-0.218	-0.325	-0.315
1.475	0.291	0.24	0.237	0.209	0.191	0.185	0.639	0.672	0.455	0.631	0.3	0.383	0.489	0.223	0.06	-0.026	-0.175	-0.27
1.6	0.239	0.194	0.131	0.173	0.247	0.309	0.479	0.532	0.362	0.411	0.229	0.217	0.349	0.023	-0.058	-0.137	-0.236	-0.274
1.725	0.194	0.176	0.232	0.481	0.473	0.549	0.809	0.902	0.726	0.843	0.665	0.602	0.726	0.297	0.322	0.126	0.092	-0.02
1.85	-0.041	-0.087	-0.019	0.255	0.287	0.394	0.671	0.77	0.652	0.748	0.712	0.633	0.813	0.323	0.313	0.143	0.126	-0.071
1.975	0.501	0.359	0.439	0.778	0.796	0.85	1.352[a,d]	1.389[a,d]	1.227[d]	1.133	1.023	0.835	0.842	0.553	0.513	0.132	0.112	0.175
2.1	0.578	0.661	0.687	1.089	1.019	1.019	1.392[a,d]	1.454[a,d]	1.274	1.169	1.047	0.896	0.928	0.549	0.71	0.377	0.434	0.58
2.225	1.029	1.136	1.17	1.617[a,d]	1.618[a,d]	1.618[a,d]	1.866[b,e]	1.924[b,e]	1.666[a,d]	1.582[a,d]	1.457	1.233	1.174	0.715	0.839	0.338	0.399	0.564
2.35	0.91	1.118	1.16	1.2	1.185	1.185	1.411	1.471	1.358	1.04	1.142	1.164	1.1	0.827	0.989	0.556	0.544	0.597
2.475	0.391	0.615	0.663	0.781	0.982	0.982	1.666	1.754[d]	1.754[d]	1.382	1.437	1.469	1.393	1.3	1.3	0.907	0.892	0.795
2.6	-0.18	0.05	0.05	0.187	0.421	0.421	1.259	1.35	1.35	1.298	1.367	1.367	1.269	1.149	1.149	0.642	0.616	0.564
2.725	-1.515	-1.515	-1.515	-1.368	-1.126	-1.126	0.047	0.147	0.147	0.05	0.05	0.05	0.05	0.05	0.05	-0.455	-0.514	-0.617
2.85	-0.085	-0.085	-0.085	0.159	0.306	0.306	1.094	1.094	1.094	1.024	0.977	0.977	0.977	0.977	0.977	0.326	0.27	0.26
2.975	-0.451	-0.451	-0.451	-0.451	-0.3	-0.3	0.261	0.261	0.261	0.261	0.181	0.181	0.181	0.181	0.181	0.181	0.118	-0.177
3.1	-0.644	-0.644	-0.644	-0.644	-0.416	-0.416	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.481	0.398	0.398
3.225	-0.091	-0.091	-0.091	-0.091	-0.091	-0.091	0.938	0.938	0.938	0.938	0.938	0.938	0.938	0.938	0.938	0.938	0.874	0.874

Table VIII (continued)

CAAR[1,22] market and risk adjusted (%)

c1\c2	1.100	1.225	1.350	1.475	1.600	1.725	1.850	1.975	2.100	2.225	2.350	2.475	2.600	2.725	2.850	2.975	3.100	3.225
1.1	0.947[a,d]	0.964[a,d]	0.799	0.79	0.83	0.934[d]	1.042[a,d]	0.854	0.606	0.75	0.567	0.499	0.752	0.42	0.399	0.499	0.427	0.414
1.225	1.164[b,e]	1.153[b,e]	0.922[d]	0.86	0.765	0.841	0.961	0.871	0.783	0.963	0.695	0.726	0.771	0.477	0.517	0.549	0.478	0.367
1.35	1.042[a,d]	1.014[a,d]	1.037[a]	1.027[a]	0.985	1.017	1.321[b,d]	1.251[a]	0.939	1.248[a,d]	1.029	1.11	1.144	0.741	0.753	0.803	0.802	0.595
1.475	0.932	0.946	1	0.957	0.915	0.864	1.339[b,d]	1.279[a]	1.021	1.424[b,d]	1.172	1.209	1.328[a]	1.033	1.069	1.146	1.038	0.791
1.6	0.991	0.979	1.003	1.017	1.084	1.122	1.338[a]	1.293[a]	1.07	1.343[a]	1.222	1.219	1.325	1.003	1.089	1.134	1.028	0.815
1.725	1.145	1.048	1.155	1.463[a,d]	1.436[a,d]	1.488[a,d]	1.712[b,d]	1.694[b,d]	1.494[a]	1.845[b,e]	1.71[a,d]	1.63[a,d]	1.723[a,d]	1.264	1.424	1.277	1.133	0.988
1.85	0.964	0.814	0.972	1.312	1.351	1.49[a,d]	1.751[b,d]	1.734[b,d]	1.636[a,d]	1.946[b,e]	1.928[b,e]	1.814[b,d]	1.962[b,e]	1.455	1.504	1.381	1.344	0.991
1.975	1.668[a,d]	1.486[d]	1.533[a,d]	1.954[b,e]	2.013[b,e]	2.111[b,e]	2.641[c,f]	2.683[c,f]	2.509[c,e]	2.478[c,e]	2.341[b,e]	2.18[b,e]	2.208[b,e]	1.928[a,d]	1.869[a]	1.579	1.545	1.53
2.1	1.734[a,d]	1.689[a,d]	1.734[a,d]	2.236[b,e]	2.144[b,e]	2.144[b,e]	2.525[c,e]	2.656[c,e]	2.461[b,e]	2.426[b,e]	2.27[b,e]	2.184[b,d]	2.185[b,d]	1.879[a]	2.003[a]	1.755	1.742	1.78
2.225	2.076[a,d]	2.032[a,d]	2.086[a,d]	2.682[b,e]	2.581[b,e]	2.581[b,e]	2.823[b,e]	2.957[c,e]	2.664[b,e]	2.638[b,e]	2.468[b,d]	2.28[b,d]	2.289[a,d]	1.973[a]	2.186[a]	1.866	1.854	1.966
2.35	1.93[a]	2.248[a,d]	2.317[b,d]	2.494[b,e]	2.361[a,d]	2.361[a,d]	2.384[b,d]	2.54[b,e]	2.406[b,d]	2.194[a,d]	2.279[a,d]	2.389[a,d]	2.306[a,d]	2.023	2.297[a,d]	2.068	2.028	2.062
2.475	1.357	1.686	1.769	1.846	2.07[d]	2.07[d]	2.582[b,e]	2.793[b,e]	2.793[b,e]	2.418[a,d]	2.538[a,e]	2.681[b,e]	2.58[a,e]	2.473[a,d]	2.473[a,d]	2.212[d]	2.164	2.128
2.6	0.836	1.17	1.17	1.256	1.519	1.519	2.139[d]	2.387[a,d]	2.387[a,d]	2.328[d]	2.479[a,d]	2.479[a,d]	2.348[d]	2.208	2.208	1.866	1.599	1.6
2.725	0.042	0.042	0.042	0.132	0.43	0.43	1.376	1.436	1.436	1.337	1.337	1.337	1.337	1.337	1.337	1.175	0.825	0.832
2.85	1.458	1.458	1.458	1.622	1.694	1.694	2.175	2.175	2.175	2.092	2.14	2.14	2.14	2.14	2.14	1.966	1.494	1.531
2.975	1.388	1.388	1.388	1.388	1.464	1.464	1.836	1.836	1.836	1.836	1.88	1.88	1.88	1.88	1.88	1.88	1.388	1.306
3.1	3.156	3.156	3.156	3.156	3.369	3.369	4.074	4.074	4.074	4.074	4.074	4.074	4.074	4.074	4.074	4.074	3.421	3.421
3.225	4.226	4.226	4.226	4.226	4.226	4.226	5.073[a,d]	5.073[a,d]	5.073[a,d]	5.073[a,d]	5.073[a,d]	5.073[a,d]	5.073[a,d]	5.073[a,d]	5.073[a,d]	5.073[a,d]	4.4	4.4

Number of events

c1\c2	1.1	1.225	1.35	1.475	1.6	1.725	1.85	1.975	2.1	2.225	2.35	2.475	2.6	2.725	2.85	2.975	3.1	3.225
1.1	401	390	383	371	352	338	322	310	290	275	254	241	226	216	201	187	177	162
1.225	368	360	352	340	324	313	300	290	275	261	242	230	218	211	197	184	174	159
1.35	339	333	323	314	301	294	285	277	264	250	232	221	210	204	191	178	170	154
1.475	309	302	294	289	279	273	263	253	246	235	221	209	200	195	183	170	165	149
1.6	283	275	268	264	255	250	243	234	229	220	210	199	191	186	175	163	159	144
1.725	246	240	234	230	224	219	212	204	199	190	181	174	168	166	156	146	141	133
1.85	219	213	210	206	199	196	191	183	180	172	166	160	154	151	145	135	131	124
1.975	182	178	176	172	167	165	159	154	152	150	146	141	137	134	130	123	119	112
2.1	159	156	155	151	146	146	142	138	136	134	130	126	123	119	115	110	107	100
2.225	137	134	133	130	126	126	124	121	119	118	114	113	111	107	105	100	97	92
2.35	111	108	107	105	101	101	98	95	94	91	88	87	86	84	82	78	78	76
2.475	85	83	82	81	79	79	76	73	73	71	70	69	68	67	67	65	65	64
2.6	67	66	66	65	63	63	60	57	57	56	55	55	54	53	53	51	50	49
2.725	51	51	51	50	48	48	45	44	44	43	43	43	43	43	43	41	40	39
2.85	37	37	37	36	35	35	33	33	33	32	31	31	31	31	31	29	28	28
2.975	31	31	31	31	30	30	29	29	29	29	28	28	28	28	28	28	27	26
3.1	20	20	20	20	19	19	18	18	18	18	18	18	18	18	18	18	17	17
3.225	17	17	17	17	17	17	16	16	16	16	16	16	16	16	16	16	15	15

Table VIII (continued)

Panal C. c3 = 0

CAAR[1,22] market adjusted (%)

c1\c2	1.1	1.225	1.35	1.475	1.6	1.725	1.85	1.975	2.1	2.225	2.35	2.475	2.6	2.725	2.85	2.975	3.1	3.225
1.1	0.652	0.586	0.438	0.495	0.48	0.521	0.727	0.689	0.536	0.524	0.391	0.418	0.643	0.461	0.208	0.126	-0.082	0.099
1.225	0.657	0.567	0.363	0.442	0.355	0.404	0.63	0.637	0.62	0.646	0.456	0.578	0.582	0.377	0.158	0.1	-0.113	0.031
1.35	0.785[a]	0.698	0.578	0.684	0.632	0.628	0.961[a]	0.969[a]	0.844	0.9[a]	0.685	0.825	0.827	0.509	0.29	0.235	0.104	0.127
1.475	0.591	0.557	0.49	0.465	0.502	0.459	0.942[a]	1.006[a]	0.927[a]	1.039[a]	0.783	0.93	0.943	0.663	0.509	0.423	0.249	0.18
1.6	0.562	0.539	0.412	0.441	0.573	0.619	0.808	0.87	0.836	0.837	0.651	0.692	0.794	0.509	0.432	0.348	0.212	0.211
1.725	0.464	0.43	0.447	0.655	0.702	0.815	1.084[a]	1.205[a,d]	1.192[a,d]	1.243[a,d]	1.09[d]	1.082[d]	1.178[d]	0.8	0.842	0.623	0.544	0.461
1.85	0.292	0.213	0.248	0.466	0.562	0.691	0.977	1.105[d]	1.154[a,d]	1.192[a,d]	1.158[d]	1.106	1.235[a,d]	0.809	0.808	0.658	0.586	0.426
1.975	0.652	0.469	0.528	0.75	0.888	0.964[d]	1.399[b,e]	1.507[b,e]	1.489[b,e]	1.409[a,e]	1.352[a,d]	1.195	1.22	0.928	0.893	0.501	0.522	0.593
2.1	0.774	0.833	0.845	1.141	1.164	1.191[d]	1.524[b,d]	1.582[b,d]	1.573[b,d]	1.484[a,d]	1.454[a]	1.279	1.329	1.003	1.142	0.76	0.855	1.01
2.225	1.251	1.35[d]	1.371[d]	1.694[a,e]	1.737[b,e]	1.772[b,e]	1.972[b,e]	2.025[b,e]	1.974[b,e]	1.901[b,e]	1.88[b,e]	1.629[a]	1.599[a]	1.2	1.302	0.758	0.863	1.033
2.35	0.765	0.943	0.962	0.904	0.88	0.972	1.136	1.18	1.276	0.996	1.083	1.101	1.061	0.821	0.991	0.473	0.503	0.537
2.475	0.067	0.246	0.256	0.35	0.508	0.621	1.144	1.198	1.493	1.364	1.41	1.437	1.396	1.317	1.356	0.863	0.851	0.756
2.6	-0.583	-0.398	-0.439	-0.39	-0.209	-0.209	0.424	0.463	0.666	0.842	0.894	0.894	0.824	0.714	0.714	0.455	0.43	0.381
2.725	-1.805	-1.805	-1.805	-1.683	-1.487	-1.487	-0.565	-0.492	-0.239	-0.33	-0.33	-0.33	-0.327	-0.327	-0.327	-0.631	-0.687	-0.782
2.85	0.596	0.596	0.596	0.817	0.955	0.955	1.567	1.567	1.567	1.522	1.496	1.496	1.55	1.55	1.55	1.304	1.286	1.278
2.975	0.581	0.581	0.581	0.581	0.75	0.75	1.291	1.291	1.291	1.291	1.252	1.252	1.252	1.252	1.252	1.252	1.231	1.005
3.1	0.625	0.625	0.625	0.625	0.905	0.905	1.824	1.824	1.824	1.824	1.824	1.824	1.824	1.824	1.824	1.824	1.82	1.82
3.225	0.105	0.105	0.105	0.105	0.105	0.105	1.147	1.147	1.147	1.147	1.147	1.147	1.147	1.147	1.147	1.147	1.097	1.097

CAAR[1,22] market and risk adjusted (%)

c1\c2	1.1	1.225	1.35	1.475	1.6	1.725	1.85	1.975	2.1	2.225	2.35	2.475	2.6	2.725	2.85	2.975	3.1	3.225
1.1	1.153[b,e]	1.051[b,e]	0.909[a,d]	0.968[a,d]	0.96[a,d]	0.935[a]	1.077[b,d]	0.963[a]	0.913	1.016[a]	0.863	0.854	1.092	0.835	0.662	0.847	0.66	0.635
1.225	1.104[b,e]	1.017[b,e]	0.836	0.927[a,d]	0.878	0.865	0.97[a]	0.941	1.027[a]	1.162[a]	1.005	1.094	1.092	0.803	0.7	0.822	0.625	0.524
1.35	1.227[b,e]	1.133[b,e]	1.103[b,d]	1.236[b,e]	1.196[b,d]	1.091[a]	1.433[b,d]	1.407[b,d]	1.251[b]	1.521[b,e]	1.367[b,d]	1.454[b,d]	1.431[b,d]	1.016	0.88	1.023	0.926	0.742
1.475	1.159[b,d]	1.121[a,d]	1.106[a]	1.064[a]	1.122[a]	1.006	1.528[b,d]	1.547[b,d]	1.44[b,d]	1.726[c,e]	1.525[b,d]	1.588[b,e]	1.634[b,e]	1.342[a]	1.286[a]	1.333[a]	1.139	0.92
1.6	1.234[b,d]	1.164[a]	1.117[a]	1.116[a]	1.285[b]	1.271[a]	1.543[b,d]	1.536[b,d]	1.473[b,d]	1.649[b,e]	1.514[b,d]	1.477[b,d]	1.625[b,d]	1.352[a]	1.349[a]	1.369	1.172	0.995
1.725	1.319[b,d]	1.187[a]	1.219[a]	1.472[b,d]	1.53[b,d]	1.559[b,d]	1.843[b,e]	1.881[b,e]	1.846[b,d]	2.075[c,e]	1.973[b,e]	1.854[b,e]	2.001[b,e]	1.609[a]	1.693[a]	1.506	1.266	1.143
1.85	1.178[a]	1.012	1.101	1.346[a]	1.483[a,d]	1.591[b,d]	1.871[b,e]	1.914[b,e]	1.983[b,e]	2.206[c,e]	2.206[c,e]	2.079[b,e]	2.221[b,e]	1.794[b,d]	1.83[b,d]	1.661[a]	1.509	1.201
1.975	1.51[b,d]	1.341[a]	1.385[a,d]	1.613[b,d]	1.81[b,e]	1.89[b,e]	2.338[c,e]	2.487[c,f]	2.482[c,e]	2.454[c,e]	2.397[c,e]	2.234[b,e]	2.287[b,e]	2.009[b,d]	1.939[b]	1.623	1.616	1.609
2.1	1.776[b,d]	1.709[a,d]	1.755[a,e]	2.108[b,e]	2.147[b,e]	2.183[b,e]	2.52[c,e]	2.635[c,e]	2.633[c,e]	2.604[c,e]	2.555[c,e]	2.375[b,e]	2.411[b,e]	2.144[b,d]	2.246[b,d]	1.969[a]	1.99[a]	2.048[a]
2.225	2.176[b,e]	2.139[b,e]	2.199[b,e]	2.619[c,e]	2.611[c,e]	2.656[c,e]	2.869[c,e]	2.987[c,f]	2.924[c,e]	2.903[c,e]	2.857[c,e]	2.57[b,e]	2.619[b,e]	2.347[b,d]	2.53[b,d]	2.185[a]	2.217[a]	2.349[a]
2.35	1.572	1.839[a]	1.908[a]	1.924[a]	1.79	1.946[a]	1.954[a]	2.076[a]	2.176[a,d]	1.983[a]	2.051[a]	2.144[a]	2.11[a]	1.859	2.104[a]	1.805	1.806	1.838
2.475	0.766	1.027	1.097	1.154	1.326	1.518	1.921	2.073[a]	2.387[a,d]	2.206[a,d]	2.305[a,d]	2.422[a,e]	2.387[a,d]	2.294[a,d]	2.308[a,d]	1.979	1.937	1.912
2.6	0.045	0.311	0.31	0.448	0.647	0.647	1.127	1.287	1.443	1.55	1.666	1.666	1.597	1.466	1.466	1.406	1.164	1.157
2.725	-0.411	-0.411	-0.411	-0.342	-0.103	-0.103	0.668	0.705	0.901	0.805	0.805	0.805	0.86	0.86	0.86	0.888	0.571	0.572
2.85	1.702	1.702	1.702	1.844	1.91	1.91	2.315	2.315	2.315	2.25	2.294	2.294	2.407	2.407	2.407	2.581	2.2	2.231
2.975	2.04	2.04	2.04	2.04	2.129	2.129	2.487	2.487	2.487	2.487	2.548	2.548	2.548	2.548	2.548	2.548	2.127	2.078
3.1	4.429[a]	4.429[a]	4.429[a]	4.429[a]	4.695[a]	4.695[a]	5.434[b,d]	5.434[b,d]	5.434[b,d]	5.434[b,d]	5.434[b,d]	5.434[b,d]	5.434[b,d]	5.434[b,d]	5.434[b,d]	5.434[b,d]	4.892[a]	4.892[a]
3.225	4.418	4.418	4.418	4.418	4.418	4.418	5.277[a,d]	5.277[a,d]	5.277[a,d]	5.277[a,d]	5.277[a,d]	5.277[a,d]	5.277[a,d]	5.277[a,d]	5.277[a,d]	5.277[a,d]	4.617	4.617

Table VIII (continued)

Number of events

c1\c2	1.1	1.225	1.35	1.475	1.6	1.725	1.85	1.975	2.1	2.225	2.35	2.475	2.6	2.725	2.85	2.975	3.1	3.225
1.1	469	457	444	428	411	394	376	361	335	319	297	281	266	250	232	213	200	181
1.225	436	427	414	397	380	365	350	337	315	300	280	267	254	242	227	209	195	178
1.35	393	386	373	361	348	338	326	316	300	284	266	256	244	234	220	202	191	173
1.475	355	348	335	329	318	310	298	287	276	265	251	240	230	222	210	194	186	168
1.6	322	316	304	300	288	282	275	265	256	248	237	228	216	209	199	184	177	161
1.725	284	277	268	264	256	249	242	233	223	215	206	201	191	187	177	165	158	149
1.85	254	248	243	238	229	224	220	211	203	195	189	184	176	171	163	152	146	138
1.975	212	207	204	200	195	191	185	178	172	170	165	160	155	151	145	137	132	124
2.1	178	176	174	171	166	165	161	157	152	150	146	141	137	133	127	121	117	109
2.225	154	151	149	147	144	143	141	138	133	132	128	126	123	119	115	109	105	99
2.35	127	124	122	121	117	117	114	111	107	104	101	100	98	96	93	88	87	84
2.475	102	100	98	97	95	95	92	89	87	84	83	82	80	79	78	75	75	73
2.6	81	80	79	77	75	75	72	69	68	66	65	65	63	62	62	58	57	56
2.725	59	59	59	58	56	56	53	52	51	50	50	50	49	49	49	46	45	44
2.85	44	44	44	43	42	42	40	40	40	39	38	38	37	37	37	34	33	33
2.975	34	34	34	34	33	33	32	32	32	32	31	31	31	31	31	31	30	29
3.1	21	21	21	21	20	20	19	19	19	19	19	19	19	19	19	19	18	18
3.225	17	17	17	17	17	17	16	16	16	16	16	16	16	16	16	16	15	15

Panal D. c3 = -2

CAAR[1,22] market adjusted (%)

c1\c2	1.1	1.225	1.35	1.475	1.6	1.725	1.85	1.975	2.1	2.225	2.35	2.475	2.6	2.725	2.85	2.975	3.1	3.225
1.1	0.57	0.556	0.365	0.379	0.408	0.5	0.662	0.621	0.492	0.446	0.279	0.347	0.736	0.519	0.278	0.251	-0.227	-0.017
1.225	0.56	0.513	0.317	0.332	0.275	0.359	0.533	0.542	0.537	0.523	0.284	0.445	0.632	0.388	0.177	0.169	-0.26	-0.069
1.35	0.598	0.556	0.44	0.472	0.449	0.506	0.78	0.79	0.665	0.685	0.512	0.663	0.887	0.563	0.354	0.355	0.002	0.021
1.475	0.318	0.337	0.242	0.212	0.248	0.298	0.708	0.769	0.708	0.782	0.612	0.747	0.996[a]	0.712	0.566	0.514	0.108	0.044
1.6	0.424	0.405	0.247	0.274	0.363	0.421	0.661	0.723	0.699	0.657	0.563	0.599	0.871	0.578	0.506	0.431	0.047	0.048
1.725	0.606	0.584	0.559	0.761	0.785	0.84	1.061[a]	1.199[a,d]	1.209[a,d]	1.266[a,d]	1.177[a,d]	1.171[a,d]	1.467[b,e]	1.091	1.147	0.958	0.614	0.554
1.85	0.389	0.316	0.351	0.514	0.572	0.695	0.926	1.072	1.133[a,d]	1.176[a,d]	1.207[a,d]	1.157[d]	1.503[b,e]	1.087	1.099	0.975	0.661	0.526
1.975	0.788	0.615	0.674	0.831	0.917	0.999[d]	1.459[b,e]	1.57[b,e]	1.555[b,e]	1.489[b,e]	1.436[a,d]	1.278[a,d]	1.309[a,d]	1.031	1	0.631	0.582	0.672
2.1	0.838	0.896	0.908	1.126	1.147	1.182[d]	1.501[b,d]	1.596[b,d]	1.588[b,d]	1.514[a,d]	1.485[a,d]	1.305	1.359	1.043	1.18	0.812	0.905	1.058
2.225	1.287	1.382[a,d]	1.403[a,d]	1.636[a,e]	1.676[b,e]	1.72[b,e]	1.91[b,e]	2.01[b,e]	1.961[b,e]	1.906[b,e]	1.886[b,e]	1.63[a,d]	1.624[a]	1.235	1.336	0.808	0.913	1.08
2.35	0.806	0.978	0.997	0.845	0.82	0.922	1.08	1.17	1.265	0.99	1.076	1.078	1.061	0.821	0.991	0.473	0.503	0.537
2.475	0.062	0.238	0.247	0.339	0.494	0.622	1.133	1.186	1.474	1.352	1.398	1.404	1.396	1.317	1.356	0.863	0.851	0.756
2.6	-0.564	-0.382	-0.423	-0.374	-0.195	-0.195	0.43	0.469	0.669	0.842	0.894	0.894	0.824	0.714	0.714	0.455	0.43	0.381
2.725	-1.76	-1.76	-1.76	-1.639	-1.445	-1.445	-0.538	-0.465	-0.218	-0.33	-0.33	-0.33	-0.327	-0.327	-0.327	-0.631	-0.687	-0.782
2.85	0.603	0.603	0.603	0.819	0.953	0.953	1.551	1.551	1.551	1.522	1.496	1.496	1.55	1.55	1.55	1.304	1.286	1.278
2.975	0.59	0.59	0.59	0.59	0.754	0.754	1.279	1.279	1.279	1.291	1.252	1.252	1.252	1.252	1.252	1.252	1.231	1.005
3.1	0.637	0.637	0.637	0.637	0.905	0.905	1.778	1.778	1.778	1.824	1.824	1.824	1.824	1.824	1.824	1.824	1.82	1.82
3.225	0.149	0.149	0.149	0.149	0.149	0.149	1.133	1.133	1.133	1.147	1.147	1.147	1.147	1.147	1.147	1.147	1.097	1.097

Table VIII (continued)

CAAR[1,22] market and risk adjusted (%)

c1\c2	1.1	1.225	1.35	1.475	1.6	1.725	1.85	1.975	2.1	2.225	2.35	2.475	2.6	2.725	2.85	2.975	3.1	3.225
1.1	1.099[b,e]	1.091[b,e]	0.886[a,d]	0.898[a,d]	0.927[a,d]	0.983[a,d]	1.07[b,d]	0.947[a]	0.968[a]	1.049[a]	0.845	0.908	1.301[a,d]	0.973	0.811	1.037	0.528	0.574
1.225	1.043[b,e]	1.046[b,e]	0.824[a,d]	0.83[d]	0.804	0.87	0.923[a]	0.887	1.031[a]	1.147[a]	0.922	1.08	1.261[a,d]	0.895	0.796	0.957	0.492	0.47
1.35	1.042[b,e]	1.037[b,e]	0.965[a,d]	0.999[a,d]	0.98[a]	0.985[a]	1.252[b,d]	1.216[b,d]	1.132[a]	1.382[b,d]	1.285[b,d]	1.404[b,e]	1.663[b,e]	1.187[a]	1.061	1.251[a]	0.881	0.677
1.475	0.928[a]	0.96[a]	0.872	0.83	0.88	0.893	1.327[b,d]	1.333[b,d]	1.276[b]	1.543[b,e]	1.447[b,d]	1.505[b,e]	1.848[c,e]	1.486[b,d]	1.44[a]	1.532[b]	1.054	0.836
1.6	1.105[a,d]	1.067[a]	1.002	0.992	1.063[a]	1.115[a]	1.41[b,d]	1.393[b]	1.369[b]	1.494[b,d]	1.474[b,d]	1.436[b,d]	1.82[b,e]	1.468[a]	1.47[a]	1.5[a]	0.997	0.811
1.725	1.464[b,e]	1.377[b,d]	1.354[a,d]	1.59[b,e]	1.595[b,e]	1.588[b,d]	1.81[b,e]	1.874[b,e]	1.89[b,e]	2.127[c,e]	2.113[c,e]	2.001[b,e]	2.423[c,f]	1.951[b,e]	2.051[b,d]	1.896[b,d]	1.329	1.214
1.85	1.288[a]	1.131	1.219[a]	1.403[a]	1.456[b]	1.559[b,d]	1.772[b,d]	1.838[b,d]	1.959[b,e]	2.19[c,e]	2.28[c,e]	2.158[c,e]	2.598[c,f]	2.091[b,e]	2.14[b,e]	1.998[b,d]	1.569	1.275
1.975	1.615[b,d]	1.456[a,d]	1.499[a,d]	1.661[b,d]	1.801[b,e]	1.859[b,e]	2.368[c,e]	2.509[c,f]	2.505[c,e]	2.499[c,f]	2.446[c,e]	2.312[c,e]	2.425[c,e]	2.162[b,e]	2.101[b,d]	1.806[a]	1.66	1.652
2.1	1.762[b,d]	1.696[b,d]	1.741[b,d]	2.011[b,e]	2.046[b,e]	2.059[b,e]	2.379[c,e]	2.533[c,e]	2.528[c,e]	2.522[c,e]	2.472[c,e]	2.32[b,e]	2.421[b,e]	2.163[b,d]	2.262[b,d]	1.995[a]	2.016[a]	2.074[a]
2.225	2.187[b,e]	2.152[b,e]	2.21[b,e]	2.535[c,e]	2.526[c,e]	2.544[c,e]	2.745[c,e]	2.914[c,f]	2.851[c,e]	2.859[c,e]	2.813[c,e]	2.563[b,e]	2.659[b,e]	2.394[b,d]	2.574[b,e]	2.241[a,d]	2.274[a]	2.406[a,d]
2.35	1.555	1.812[a]	1.878[a]	1.798[a]	1.664	1.784[a]	1.788[a]	1.96[a]	2.053[a]	1.895[a]	1.96[a]	2.088[a]	2.11[a]	1.859	2.104[a]	1.805	1.806	1.838
2.475	0.7	0.955	1.021	1.077	1.243	1.393	1.784	1.928	2.232[a,d]	2.095[a,d]	2.191[a,d]	2.35[a,d]	2.387[a,d]	2.294[a,d]	2.308[a,d]	1.979	1.937	1.912
2.6	0.023	0.285	0.283	0.42	0.615	0.615	1.087	1.243	1.396	1.55	1.666	1.666	1.597	1.466	1.466	1.406	1.164	1.157
2.725	-0.434	-0.434	-0.434	-0.366	-0.133	-0.133	0.622	0.658	0.849	0.805	0.805	0.805	0.86	0.86	0.86	0.888	0.571	0.572
2.85	1.624	1.624	1.624	1.762	1.823	1.823	2.215	2.215	2.215	2.25	2.294	2.294	2.407	2.407	2.407	2.581	2.2	2.231
2.975	1.93	1.93	1.93	1.93	2.013	2.013	2.357	2.357	2.357	2.487	2.548	2.548	2.548	2.548	2.548	2.548	2.127	2.078
3.1	4.146[a]	4.146[a]	4.146[a]	4.146[a]	4.386[a]	4.386[a]	5.072[a,d]	5.072[a,d]	5.072[a,d]	5.434[b,d]	5.434[b,d]	5.434[b,d]	5.434[b,d]	5.434[b,d]	5.434[b,d]	5.434[b,d]	4.892[a]	4.892[a]
3.225	4.073	4.073	4.073	4.073	4.073	4.073	4.861[a,d]	4.861[a,d]	4.861[a,d]	5.277[a,d]	5.277[a,d]	5.277[a,d]	5.277[a,d]	5.277[a,d]	5.277[a,d]	5.277[a,d]	4.617	4.617

Number of events

c1\c2	1.1	1.225	1.35	1.475	1.6	1.725	1.85	1.975	2.1	2.225	2.35	2.475	2.6	2.725	2.85	2.975	3.1	3.225
1.1	501	482	471	454	436	413	396	380	353	332	306	290	275	259	241	222	208	188
1.225	464	449	438	421	404	384	368	353	331	313	290	277	263	251	236	218	203	186
1.35	421	409	397	385	372	358	344	332	316	298	277	266	254	243	229	211	199	181
1.475	380	368	356	350	340	328	314	301	289	276	260	249	239	230	218	201	192	175
1.6	340	333	320	316	305	297	288	276	266	257	244	235	223	215	205	190	182	167
1.725	297	289	280	276	268	262	254	244	232	223	213	208	198	193	183	171	163	155
1.85	265	259	254	248	240	235	230	219	210	201	194	189	181	176	168	157	151	144
1.975	221	216	213	208	204	200	193	185	179	176	171	166	161	157	151	143	137	130
2.1	186	184	182	178	173	172	168	162	157	154	150	145	141	137	131	125	121	113
2.225	162	159	157	154	151	150	148	143	138	136	132	130	126	122	118	112	108	102
2.35	132	129	127	125	121	121	118	113	109	105	102	101	98	96	93	88	87	84
2.475	104	102	100	99	97	97	94	91	89	85	84	83	80	79	78	75	75	73
2.6	82	81	80	78	76	76	73	70	69	66	65	65	63	62	62	58	57	56
2.725	60	60	60	59	57	57	54	53	52	50	50	50	49	49	49	46	45	44
2.85	45	45	45	44	43	43	41	41	41	39	38	38	37	37	37	34	33	33
2.975	35	35	35	35	34	34	33	33	33	32	31	31	31	31	31	31	30	29
3.1	22	22	22	22	21	21	20	20	20	19	19	19	19	19	19	19	18	18
3.225	18	18	18	18	18	18	17	17	17	16	16	16	16	16	16	16	15	15

Table VIII (continued)

Panal E. c3 = -4

CAAR[1,22] market adjusted (%)

c1\c2	1.1	1.225	1.35	1.475	1.6	1.725	1.85	1.975	2.1	2.225	2.35	2.475	2.6	2.725	2.85	2.975	3.1	3.225
1.1	0.556	0.538	0.328	0.39	0.437	0.526	0.707	0.668	0.545	0.502	0.329	0.374	0.76	0.537	0.302	0.261	-0.202	-0.017
1.225	0.563	0.517	0.285	0.366	0.307	0.388	0.582	0.594	0.593	0.582	0.337	0.472	0.659	0.409	0.203	0.18	-0.234	-0.069
1.35	0.641	0.578	0.432	0.508	0.483	0.536	0.831[a]	0.843[a]	0.723	0.746	0.565	0.688	0.911	0.582	0.377	0.364	0.026	0.021
1.475	0.411	0.402	0.283	0.25	0.303	0.349	0.758	0.82	0.762	0.848	0.667	0.773	1.021[a]	0.729	0.587	0.522	0.132	0.044
1.6	0.441	0.438	0.299	0.326	0.433	0.486	0.724	0.788	0.767	0.737	0.649	0.629	0.899	0.599	0.53	0.441	0.072	0.048
1.725	0.596	0.592	0.611	0.809	0.835	0.906	1.125[a,d]	1.263[b,d]	1.275[b,d]	1.348[b,e]	1.265[a,e]	1.197[a,d]	1.49[b,e]	1.104	1.16	0.962	0.635	0.554
1.85	0.419	0.367	0.413	0.574	0.632	0.771	0.999	1.145[a,d]	1.209[a,d]	1.269[a,e]	1.303[a,e]	1.186[a,d]	1.527[b,e]	1.101	1.113	0.979	0.683	0.526
1.975	0.695	0.605	0.662	0.815	0.898	0.999[d]	1.447[b,e]	1.555[b,e]	1.54[b,e]	1.494[b,e]	1.443[b,e]	1.288[a,d]	1.319[a,d]	1.048	1.019	0.64	0.608	0.672
2.1	0.763	0.877	0.889	1.099	1.119	1.189[d]	1.499[b,d]	1.591[b,e]	1.583[b,d]	1.532[b,d]	1.505[a,d]	1.331[a]	1.384[a]	1.077	1.211	0.837	0.929	1.058
2.225	1.201	1.363[a,d]	1.382[a,d]	1.608[b,e]	1.646[b,e]	1.734[b,e]	1.919[b,e]	2.017[b,e]	1.969[b,e]	1.916[b,e]	1.897[b,e]	1.648[a,d]	1.643[a,d]	1.268	1.366	0.836	0.939	1.08
2.35	0.784	0.951	0.969	0.821	0.796	0.945	1.1	1.189	1.281	1.014	1.099	1.101	1.085	0.853	1.018	0.482	0.513	0.537
2.475	0.063	0.232	0.241	0.329	0.478	0.659	1.156	1.208	1.487	1.37	1.414	1.421	1.413	1.337	1.375	0.87	0.857	0.756
2.6	-0.557	-0.38	-0.42	-0.373	-0.2	-0.135	0.476	0.515	0.711	0.88	0.931	0.931	0.864	0.759	0.759	0.455	0.43	0.381
2.725	-1.818	-1.818	-1.818	-1.7	-1.512	-1.445	-0.538	-0.465	-0.218	-0.33	-0.33	-0.33	-0.327	-0.327	-0.327	-0.631	-0.687	-0.782
2.85	0.603	0.603	0.603	0.819	0.953	0.953	1.551	1.551	1.551	1.522	1.496	1.496	1.55	1.55	1.55	1.304	1.286	1.278
2.975	0.59	0.59	0.59	0.59	0.754	0.754	1.279	1.279	1.279	1.291	1.252	1.252	1.252	1.252	1.252	1.252	1.231	1.005
3.1	0.637	0.637	0.637	0.637	0.905	0.905	1.778	1.778	1.778	1.824	1.824	1.824	1.824	1.824	1.824	1.824	1.82	1.82
3.225	0.149	0.149	0.149	0.149	0.149	0.149	1.133	1.133	1.133	1.147	1.147	1.147	1.147	1.147	1.147	1.147	1.097	1.097

CAAR[1,22] market and risk adjusted (%)

c1\c2	1.1	1.225	1.35	1.475	1.6	1.725	1.85	1.975	2.1	2.225	2.35	2.475	2.6	2.725	2.85	2.975	3.1	3.225
1.1	1.079[b,e]	1.025[b,e]	0.811[a,d]	0.876[a,d]	0.963[a,e]	1.012[a,d]	1.112[b,d]	0.991[a,d]	1.017[a,d]	1.1[a,d]	0.908	0.958	1.349[b,e]	1.072	0.92	1.117	0.638	0.574
1.225	1.056[b,e]	1.008[b,e]	0.763	0.824[d]	0.844[d]	0.902[d]	0.969[a]	0.935	1.082[a]	1.2[b,d]	0.987	1.13[a]	1.311[a,d]	0.998	0.907	1.039	0.605	0.47
1.35	1.122[b,e]	1.033[b,e]	0.925[a,d]	0.992[a,d]	1.022[a,d]	1.019[a]	1.299[b,d]	1.266[b,d]	1.185[b]	1.436[b,e]	1.349[b,d]	1.453[b,e]	1.711[b,e]	1.289[a]	1.172	1.334[a]	0.993	0.677
1.475	1.012[a,d]	0.937[a,d]	0.874	0.834	0.951	0.956	1.389[b,d]	1.397[b,d]	1.343[b,d]	1.601[b,e]	1.514[b,e]	1.555[b,e]	1.896[c,e]	1.588[b,e]	1.549[b,d]	1.616[b,d]	1.168	0.836
1.6	1.11[a,d]	1.038[a,d]	1.021[a]	1.012	1.158[a]	1.201[a,d]	1.493[b,d]	1.48[b,d]	1.459[b,d]	1.574[b,e]	1.558[b,e]	1.491[b,d]	1.872[b,e]	1.578[b,d]	1.585[b,d]	1.588[a]	1.118	0.811
1.725	1.425[b,e]	1.298[a,d]	1.369[b,d]	1.6[b,e]	1.606[b,e]	1.675[b,e]	1.896[c,e]	1.962[c,e]	1.982[c,e]	2.207[c,f]	2.197[c,e]	2.054[c,e]	2.472[c,f]	2.063[b,e]	2.167[b,e]	1.989[b,d]	1.459	1.214
1.85	1.341[b,d]	1.144	1.239[a]	1.419[b,d]	1.471[b,d]	1.657[b,e]	1.867[b,e]	1.937[b,e]	2.059[c,e]	2.278[c,f]	2.369[c,f]	2.214[c,e]	2.65[c,f]	2.211[b,e]	2.264[c,e]	2.098[b,d]	1.706[a]	1.275
1.975	1.584[b,e]	1.486[a,d]	1.529[a,d]	1.687[b,d]	1.823[b,e]	1.982[b,e]	2.481[c,f]	2.624[c,f]	2.624[c,f]	2.61[c,f]	2.561[c,f]	2.434[c,e]	2.548[c,f]	2.294[b,e]	2.239[b,e]	1.92[a]	1.81[a]	1.652
2.1	1.755[b,e]	1.728[b,e]	1.772[b,e]	2.034[b,e]	2.068[b,e]	2.218[b,e]	2.533[c,f]	2.688[c,f]	2.688[c,f]	2.673[c,f]	2.629[c,e]	2.486[c,e]	2.589[c,e]	2.343[b,e]	2.447[b,e]	2.153[b,d]	2.179[b,d]	2.074[a]
2.225	2.148[b,e]	2.158[b,e]	2.214[b,e]	2.529[c,e]	2.52[c,e]	2.698[c,f]	2.896[c,f]	3.066[c,f]	3.01[c,f]	3.021[c,f]	2.98[c,f]	2.74[c,e]	2.839[c,e]	2.588[b,e]	2.769[b,e]	2.414[b,d]	2.452[b,d]	2.406[a,d]
2.35	1.464	1.712[a]	1.774[a]	1.694	1.561	1.871[a]	1.876[a]	2.048[a,d]	2.142[b,d]	1.992[a,d]	2.057[a,d]	2.183[a,d]	2.207[a,d]	1.965[a]	2.206[a,d]	1.855	1.856	1.838
2.475	0.617	0.861	0.923	0.975	1.133	1.513	1.895[a]	2.038[a,d]	2.334[b,e]	2.207[a,d]	2.301[a,e]	2.455[b,e]	2.495[b,e]	2.406[a,e]	2.421[a,e]	2.035[d]	1.994[d]	1.912
2.6	-0.124	0.127	0.124	0.251	0.435	0.726	1.19	1.346	1.496	1.65	1.764	1.764	1.7	1.575	1.575	1.406	1.164	1.157
2.725	-0.793	-0.793	-0.793	-0.732	-0.515	-0.133	0.622	0.658	0.849	0.805	0.805	0.805	0.86	0.86	0.86	0.888	0.571	0.572
2.85	1.624	1.624	1.624	1.762	1.823	1.823	2.215	2.215	2.215	2.25	2.294	2.294	2.407	2.407	2.407	2.581	2.2	2.231
2.975	1.93	1.93	1.93	1.93	2.013	2.013	2.357	2.357	2.357	2.487	2.548	2.548	2.548	2.548	2.548	2.548	2.127	2.078
3.1	4.146[a]	4.146[a]	4.146[a]	4.146[a]	4.386[a]	4.386[a]	5.072[a,d]	5.072[a,d]	5.072[a,d]	5.434[b,d]	5.434[b,d]	5.434[b,d]	5.434[b,d]	5.434[b,d]	5.434[b,d]	5.434[b,d]	4.892[a]	4.892[a]
3.225	4.073	4.073	4.073	4.073	4.073	4.073	4.861[a,d]	4.861[a,d]	4.861[a,d]	5.277[a,d]	5.277[a,d]	5.277[a,d]	5.277[a,d]	5.277[a,d]	5.277[a,d]	5.277[a,d]	4.617	4.617

Table VIII (continued)

Number of events

c1\c2	1.1	1.225	1.35	1.475	1.6	1.725	1.85	1.975	2.1	2.225	2.35	2.475	2.6	2.725	2.85	2.975	3.1	3.225
1.1	506	487	474	457	438	415	398	382	355	334	309	293	278	263	245	224	210	188
1.225	470	455	442	424	406	386	370	355	333	315	293	280	266	255	240	220	205	186
1.35	429	416	402	388	374	360	346	334	318	300	280	269	257	247	233	213	201	181
1.475	388	376	361	354	343	331	317	304	292	278	263	252	242	234	222	203	194	175
1.6	348	341	326	322	310	302	293	281	271	261	248	238	226	219	209	192	184	167
1.725	304	296	286	282	274	267	259	249	237	227	217	211	201	197	187	173	165	155
1.85	271	265	260	254	246	240	235	224	215	205	198	192	184	180	172	159	153	144
1.975	228	222	219	214	210	205	198	190	184	180	175	170	165	161	155	145	139	130
2.1	193	190	188	184	179	177	173	167	162	158	154	149	145	141	135	127	123	113
2.225	168	164	162	159	156	154	152	147	142	140	136	134	130	126	122	114	110	102
2.35	136	133	131	129	125	124	121	116	112	108	105	104	101	99	96	89	88	84
2.475	108	106	104	103	101	100	97	94	92	88	87	86	83	82	81	76	76	73
2.6	85	84	83	81	79	78	75	72	71	68	67	67	65	64	64	58	57	56
2.725	61	61	61	60	58	57	54	53	52	50	50	50	49	49	49	46	45	44
2.85	45	45	45	44	43	43	41	41	41	39	38	38	37	37	37	34	33	33
2.975	35	35	35	35	34	34	33	33	33	32	31	31	31	31	31	31	30	29
3.1	22	22	22	22	21	21	20	20	20	19	19	19	19	19	19	19	18	18
3.225	18	18	18	18	18	18	17	17	17	16	16	16	16	16	16	16	15	15

Notes:
The table analyzes the relationship between abnormal volume event and the excess returns (in percentage) according to the event study. The abnormal volume event is VDP-event with different threshold values of c1 and c2 both ranging from 1.1 to 3.225 and with c3 ranging from -4 to 4 with equal spacing. Each panel represent different c3 value while different c1 and c2 values are shown within the grid. This results correspond to dataset from July 2015 – June 2016. The cumulative average abnormal returns are reported for [1,22] window period. The excess log returns are computed both with a market adjusted and a market and risk adjusted (CAPM) approach. The statistical significance is calculated using the parametric student's T test and non-parametric Wilcoxon singed rank test. The superscript a, b, c and superscript d, e, f indicate that the coefficients are significantly different from zero at the 10%, 5%, and 1% level based on parametric test and non-parametric test respectively.

Table IX: The intraday raw returns, precision and recall of prediction of VD-event

Prediction CAAR[After prediction till next open] (%)

b1\b2	0.1	0.6	1.1	1.6	2.1	2.6	3.1	3.6	4.1	4.6	5.1	5.6	6.1	6.6	7.1	7.6	8.1	8.6
0.225	0.846[c,f]	0.953[c,f]	0.907[c,f]	0.904[c,f]	0.952[c,f]	0.949[c,f]	0.868[c,f]	0.7[c,f]	0.692[c,f]	0.704[c,f]	0.733[c,f]	0.724[c,f]	0.706[c,f]	0.729[c,f]	0.705[c,f]	0.687[c,f]	0.638[c,f]	0.621[c,f]
0.725	0.741[c,f]	0.747[c,f]	0.781[c,f]	0.83[c,f]	0.855[c,f]	0.844[c,f]	0.824[c,f]	0.689[c,f]	0.704[c,f]	0.7[c,f]	0.711[c,f]	0.769[c,f]	0.731[c,f]	0.728[c,f]	0.695[c,f]	0.693[c,f]	0.647[c,f]	0.63[c,f]
1.225	0.662[c,f]	0.703[c,f]	0.704[c,f]	0.738[c,f]	0.883[c,f]	0.868[c,f]	0.864[c,f]	0.739[c,f]	0.734[c,f]	0.757[c,f]	0.718[c,f]	0.768[c,f]	0.745[c,f]	0.728[c,f]	0.707[c,f]	0.729[c,f]	0.669[c,f]	0.647[c,f]
1.725	0.733[c,f]	0.689[c,f]	0.719[c,f]	0.721[c,f]	0.875[c,f]	0.853[c,f]	0.813[c,f]	0.809[c,f]	0.768[c,f]	0.776[c,f]	0.789[c,f]	0.829[c,f]	0.805[c,f]	0.795[c,f]	0.777[c,f]	0.804[c,f]	0.735[c,f]	0.701[c,f]
2.225	0.756[c,f]	0.721[c,f]	0.706[c,f]	0.765[c,f]	0.886[c,f]	0.876[c,f]	0.857[c,f]	0.876[c,f]	0.843[c,f]	0.839[c,f]	0.83[c,f]	0.845[c,f]	0.824[c,f]	0.813[c,f]	0.821[c,f]	0.83[c,f]	0.761[c,f]	0.74[c,f]
2.725	0.819[c,f]	0.785[c,f]	0.78[c,f]	0.757[c,f]	0.893[c,f]	0.885[c,f]	0.874[c,f]	0.894[c,f]	0.867[c,f]	0.871[c,f]	0.859[c,f]	0.872[c,f]	0.859[c,f]	0.856[c,f]	0.849[c,f]	0.849[c,f]	0.806[c,f]	0.779[c,f]
3.225	0.764[c,f]	0.784[c,f]	0.858[c,f]	0.837[c,f]	0.85[c,f]	0.837[c,f]	0.828[c,f]	0.838[c,f]	0.833[c,f]	0.834[c,f]	0.846[c,f]	0.857[c,f]	0.859[c,f]	0.849[c,f]	0.855[c,f]	0.856[c,f]	0.817[c,f]	0.799[c,f]
3.725	0.875[c,f]	0.861[c,f]	0.875[c,f]	0.861[c,f]	0.874[c,f]	0.872[c,f]	0.861[c,f]	0.861[c,f]	0.856[c,f]	0.851[c,f]	0.839[c,f]	0.866[c,f]	0.905[c,f]	0.89[c,f]	0.894[c,f]	0.879[c,f]	0.845[c,f]	0.823[c,f]
4.225	0.829[c,f]	0.811[c,f]	0.819[c,f]	0.814[c,f]	0.85[c,f]	0.848[c,f]	0.842[c,f]	0.84[c,f]	0.867[c,f]	0.862[c,f]	0.849[c,f]	0.864[c,f]	0.886[c,f]	0.882[c,f]	0.881[c,f]	0.871[c,f]	0.836[c,f]	0.836[c,f]
4.725	0.911[c,f]	0.899[c,f]	0.894[c,f]	0.894[c,f]	0.882[c,f]	0.887[c,f]	0.888[c,f]	0.874[c,f]	0.902[c,f]	0.896[c,f]	0.882[c,f]	0.887[c,f]	0.916[c,f]	0.911[c,f]	0.91[c,f]	0.895[c,f]	0.853[c,f]	0.834[c,f]
5.225	0.957[c,f]	0.945[c,f]	0.939[c,f]	0.939[c,f]	0.929[c,f]	0.921[c,f]	0.922[c,f]	0.92[c,f]	0.949[c,f]	0.943[c,f]	0.929[c,f]	0.934[c,f]	0.958[c,f]	0.953[c,f]	0.946[c,f]	0.936[c,f]	0.895[c,f]	0.888[c,f]
5.725	0.902[c,f]	0.898[c,f]	0.904[c,f]	0.909[c,f]	0.887[c,f]	0.883[c,f]	0.876[c,f]	0.868[c,f]	0.897[c,f]	0.892[c,f]	0.877[c,f]	0.882[c,f]	0.886[c,f]	0.89[c,f]	0.883[c,f]	0.883[c,f]	0.827[c,f]	0.821[c,f]
6.225	0.948[c,f]	0.944[c,f]	0.95[c,f]	0.986[c,f]	0.963[c,f]	0.959[c,f]	0.959[c,f]	0.959[c,f]	0.959[c,f]	0.953[c,f]	0.938[c,f]	0.938[c,f]	0.952[c,f]	0.922[c,f]	0.918[c,f]	0.918[c,f]	0.897[c,f]	0.891[c,f]
6.725	0.921[c,f]	0.918[c,f]	0.923[c,f]	0.956[c,f]	0.932[c,f]	0.937[c,f]	0.937[c,f]	0.937[c,f]	0.895[c,f]	0.889[c,f]	0.873[c,f]	0.873[c,f]	0.887[c,f]	0.892[c,f]	0.888[c,f]	0.888[c,f]	0.885[c,f]	0.878[c,f]
7.225	0.915[c,f]	0.911[c,f]	0.917[c,f]	0.949[c,f]	0.925[c,f]	0.93[c,f]	0.93[c,f]	0.93[c,f]	0.888[c,f]	0.882[c,f]	0.873[c,f]	0.873[c,f]	0.887[c,f]	0.891[c,f]	0.887[c,f]	0.887[c,f]	0.887[c,f]	0.881[c,f]
7.725	0.896[c,f]	0.892[c,f]	0.892[c,f]	0.898[c,f]	0.872[c,f]	0.877[c,f]	0.877[c,f]	0.873[c,f]	0.873[c,f]	0.867[c,f]	0.857[c,f]	0.857[c,f]	0.88[c,f]	0.884[c,f]	0.874[c,f]	0.874[c,f]	0.874[c,f]	0.874[c,f]
8.225	0.925[c,f]	0.92[c,f]	0.92[c,f]	0.92[c,f]	0.895[c,f]	0.9[c,f]	0.895[c,f]	0.89[c,f]	0.89[c,f]	0.884[c,f]	0.874[c,f]	0.874[c,f]	0.87[c,f]	0.874[c,f]	0.868[c,f]	0.868[c,f]	0.868[c,f]	0.868[c,f]
8.725	0.856[c,f]	0.851[c,f]	0.851[c,f]	0.851[c,f]	0.83[c,f]	0.836[c,f]	0.836[c,f]	0.831[c,f]	0.831[c,f]	0.824[c,f]	0.814[c,f]	0.814[c,f]	0.81[c,f]	0.814[c,f]	0.807[c,f]	0.807[c,f]	0.807[c,f]	0.807[c,f]

Missed event CAAR[After 50th bin till next open] (%)

b1\b2	0.1	0.6	1.1	1.6	2.1	2.6	3.1	3.6	4.1	4.6	5.1	5.6	6.1	6.6	7.1	7.6	8.1	8.6
0.225	2.041[a,d]	1.976[a,d]	2.041[a,d]	1.509	1.723[a]	1.43[a]	1.012	1.943[a,d]	1.114	1.097	0.989	1.229	1.003	1.127	1.008	1.077	0.925	0.925
0.725	1.686[b,d]	1.802[b,d]	1.894[b,e]	1.916[b,e]	1.623[b,d]	1.183[a,d]	1.226[a,d]	1.377[a,d]	1.272[a]	1.267[b,d]	0.902	1.101[d]	0.946	0.97[a]	0.931	1.024[a]	0.984	0.984
1.225	1.791[b,f]	1.791[b,f]	1.632[b,e]	1.782[c,f]	1.782[c,f]	1.865[c,f]	1.447[b,e]	1.358[b,d]	1.262[b,d]	0.831	1.105[b,e]	0.907[a,d]	0.971[a]	0.937[a]	0.975[a,d]	0.975[a,d]	0.94[a,d]	1.002[a]
1.725	1.275[b,e]	1.275[b,e]	1.275[b,e]	1.261[b,e]	1.191[b,e]	1.191[b,e]	0.858[a]	0.692	0.914[a,d]	0.977[a,d]	0.849[a]	0.817[a]	0.791	0.791	0.759	0.816	0.816	0.679
2.225	1.129[c,e]	1.129[c,e]	1.129[c,e]	1.206[b,e]	1.206[b,e]	1.024[b,e]	1.024[b,e]	1.111[c,e]	1.111[c,e]	1.123[c,e]	0.929[b,e]	0.929[b,e]	0.892[b,e]	0.892[b,e]	0.956[b,e]	0.956[b,e]	0.828[b,d]	0.828[b,d]
2.725	0.912[c,e]	0.912[c,e]	0.912[c,e]	0.912[c,e]	0.954[c,e]	0.954[c,e]	0.843[b,e]	0.843[b,e]	0.843[b,e]	0.843[b,e]	0.8[b,e]	0.8[b,e]	0.803[b,d]	0.803[b,d]	0.73[b,d]	0.73[b,d]	0.73[b,d]	0.571
3.225	0.793[b,e]	0.793[b,e]	0.793[b,e]	0.793[b,e]	0.797[b,d]	0.797[b,d]	0.797[b,d]	0.797[b,d]	0.797[b,d]	0.797[b,d]	0.797[b,d]	0.726[b,e]	0.726[b,e]	0.726[b,e]	0.573	0.573	0.573	0.718[b,d]
3.725	0.706[b,d]	0.706[b,d]	0.706[b,d]	0.706[b,d]	0.706[b,d]	0.706[b,d]	0.591	0.591	0.591	0.591	0.591	0.591	0.591	0.699[a,d]	0.699[a,d]	0.699[a,d]	0.699[a,d]	0.699[a,d]
4.225	0.543	0.543	0.543	0.543	0.647[a]	0.647[a]	0.647[a]	0.647[a]	0.647[a]	0.647[a]	0.647[a]	0.647[a]	0.647[a]	0.589	0.589	0.589	0.589	0.589
4.725	0.787[b,e]	0.787[b,e]	0.787[b,e]	0.787[b,e]	0.705[a,d]	0.705[a,d]	0.705[a,d]	0.705[a,d]	0.705[a,d]	0.705[a,d]	0.705[a,d]	0.705[a,d]	0.705[a,d]	0.705[a,d]	0.705[a,d]	0.705[a,d]	0.727[b,d]	0.727[b,d]
5.225	0.635[a,d]	0.635[a,d]	0.635[a,d]	0.635[a,d]	0.635[a,d]	0.635[a,d]	0.635[a,d]	0.635[a,d]	0.635[a,d]	0.635[a,d]	0.623[a]	0.623[a]	0.623[a]	0.623[a]	0.623[a]	0.623[a]	0.623[a]	0.623[a]
5.725	0.787[b,e]	0.733[b,e]	0.733[b,e]	0.733[b,e]	0.733[b,e]	0.733[b,e]	0.733[b,e]	0.733[b,e]	0.733[b,e]	0.733[b,e]	0.733[b,e]	0.733[b,e]	0.733[b,e]	0.733[b,e]	0.733[b,e]	0.733[b,e]	0.733[b,e]	0.733[b,e]
6.225	0.703[b,e]	0.703[b,e]	0.703[b,e]	0.703[b,e]	0.703[b,e]	0.703[b,e]	0.703[b,e]	0.703[b,e]	0.703[b,e]	0.703[b,e]	0.703[b,e]	0.703[b,e]	0.703[b,e]	0.47	0.47	0.47	0.47	0.47
6.725	0.758[b,e]	0.758[b,e]	0.758[b,e]	0.758[b,e]	0.758[b,e]	0.758[b,e]	0.758[b,e]	0.758[b,e]	0.556[a,d]	0.556[a,d]	0.556[a,d]	0.556[a,d]	0.556[a,d]	0.556[a,d]	0.556[a,d]	0.556[a,d]	0.556[a,d]	0.556[a,d]
7.225	0.556[a,d]	0.556[a,d]	0.556[a,d]	0.556[a,d]	0.556[a,d]	0.556[a,d]	0.556[a,d]	0.556[a,d]	0.556[a,d]	0.556[a,d]	0.556[a,d]	0.556[a,d]	0.556[a,d]	0.556[a,d]	0.556[a,d]	0.556[a,d]	0.556[a,d]	0.556[a,d]
7.725	0.594[b,d]	0.594[b,d]	0.594[b,d]	0.594[b,d]	0.594[b,d]	0.594[b,d]	0.594[b,d]	0.594[b,d]	0.594[b,d]	0.594[b,d]	0.594[b,d]	0.594[b,d]	0.594[b,d]	0.594[b,d]	0.594[b,d]	0.594[b,d]	0.594[b,d]	0.594[b,d]
8.225	0.594[b,d]	0.594[b,d]	0.594[b,d]	0.594[b,d]	0.594[b,d]	0.701[b,e]	0.701[b,e]	0.701[b,e]	0.701[b,e]	0.701[b,e]	0.701[b,e]	0.701[b,e]	0.701[b,e]	0.701[b,e]	0.701[b,e]	0.701[b,e]	0.701[b,e]	0.701[b,e]
8.725	0.752[c,f]	0.752[c,f]	0.752[c,f]	0.752[c,f]	0.752[c,f]	0.752[c,f]	0.752[c,f]	0.752[c,f]	0.752[c,f]	0.752[c,f]	0.752[c,f]	0.752[c,f]	0.752[c,f]	0.752[c,f]	0.752[c,f]	0.752[c,f]	0.752[c,f]	0.752[c,f]

Table IX (continued)

Precision (%)

b1\b3	0.1	0.6	1.1	1.6	2.1	2.6	3.1	3.6	4.1	4.6	5.1	5.6	6.1	6.6	7.1	7.6	8.1	8.6
0.225	31.02	34.44	38.58	44.33	51.65	58.49	62.94	66.49	69.49	72.78	75.93	78.34	81.46	83.11	83.67	84.83	86.62	87.23
0.725	45.56	48.81	52.56	56.42	61.81	66.67	69.71	73.17	75.47	76.77	79.87	81.51	83.80	85.61	86.86	86.86	89.47	89.47
1.225	63.44	65.19	67.05	69.01	72.84	74.68	77.12	80.27	82.52	84.89	87.97	89.31	91.41	92.13	92.13	92.13	94.35	94.35
1.725	71.60	72.05	76.32	77.85	81.69	82.27	83.45	84.67	85.93	87.88	89.92	90.63	92.06	92.80	92.80	92.80	94.31	94.31
2.225	78.72	79.29	79.86	81.62	84.73	86.72	87.40	87.40	90.24	90.24	90.98	92.50	93.28	94.07	94.07	94.07	94.87	94.87
2.725	84.13	85.48	85.48	85.48	89.83	90.60	90.60	91.38	92.17	92.17	93.81	94.64	95.50	96.36	96.36	96.36	97.25	97.25
3.225	86.78	87.50	89.74	89.74	92.11	92.92	92.92	92.92	92.92	92.92	93.75	94.59	95.45	96.33	96.33	96.33	97.22	97.22
3.725	91.15	91.15	91.96	91.96	93.64	93.64	93.64	93.64	93.64	93.64	93.64	94.50	95.37	96.26	96.26	96.26	97.17	97.17
4.225	91.89	91.89	92.73	92.73	93.58	93.58	93.58	93.58	94.44	94.44	94.44	94.44	96.23	96.23	96.23	96.23	97.14	97.14
4.725	93.40	93.40	93.40	93.40	94.29	94.29	94.29	94.29	95.19	95.19	95.19	95.19	96.12	96.12	96.12	96.12	97.06	97.06
5.225	93.33	93.33	93.33	93.33	94.23	94.23	94.23	94.23	95.15	95.15	95.15	95.15	96.08	96.08	96.08	96.08	97.03	97.03
5.725	93.14	93.14	93.14	93.14	94.06	94.06	94.06	94.06	95.00	95.00	95.00	95.00	95.96	95.96	95.96	95.96	96.94	96.94
6.225	93.00	93.00	93.00	93.94	94.90	94.90	94.90	94.90	94.90	94.90	94.90	94.90	95.88	96.88	96.88	96.88	96.88	96.88
6.725	92.78	92.78	92.78	93.75	94.74	94.74	94.74	94.74	95.74	95.74	95.74	95.74	96.77	96.77	96.77	96.77	96.77	96.77
7.225	92.78	92.78	92.78	93.75	94.74	94.74	94.74	94.74	95.74	95.74	95.74	95.74	96.77	96.77	96.77	96.77	96.77	96.77
7.725	94.57	94.57	94.57	94.57	95.60	95.60	95.60	95.60	95.60	95.60	95.60	95.60	96.67	96.67	96.67	96.67	96.67	96.67
8.225	96.67	96.67	96.67	96.67	97.75	97.75	97.75	97.75	97.75	97.75	97.75	97.75	97.75	97.75	97.75	97.75	97.75	97.75
8.725	97.70	97.70	97.70	97.70	98.84	98.84	98.84	98.84	98.84	98.84	98.84	98.84	98.84	98.84	98.84	98.84	98.84	98.84

Recall (%)

b1\b3	0.1	0.6	1.1	1.6	2.1	2.6	3.1	3.6	4.1	4.6	5.1	5.6	6.1	6.6	7.1	7.6	8.1	8.6
0.225	94.70	94.70	94.70	94.70	94.70	93.94	93.94	93.18	93.18	93.18	93.18	93.18	93.18	93.18	93.18	93.18	93.18	93.18
0.725	93.18	93.18	93.18	93.18	93.18	92.42	92.42	90.91	90.91	90.15	90.15	90.15	90.15	90.15	90.15	90.15	90.15	90.15
1.225	89.39	89.39	89.39	89.39	89.39	89.39	89.39	89.39	89.39	89.39	88.64	88.64	88.64	88.64	88.64	88.64	88.64	88.64
1.725	87.88	87.88	87.88	87.88	87.88	87.88	87.88	87.88	87.88	87.88	87.88	87.88	87.88	87.88	87.88	87.88	87.88	87.88
2.225	84.09	84.09	84.09	84.09	84.09	84.09	84.09	84.09	84.09	84.09	84.09	84.09	84.09	84.09	84.09	84.09	84.09	84.09
2.725	80.30	80.30	80.30	80.30	80.30	80.30	80.30	80.30	80.30	80.30	80.30	80.30	80.30	80.30	80.30	80.30	80.30	80.30
3.225	79.55	79.55	79.55	79.55	79.55	79.55	79.55	79.55	79.55	79.55	79.55	79.55	79.55	79.55	79.55	79.55	79.55	79.55
3.725	78.03	78.03	78.03	78.03	78.03	78.03	78.03	78.03	78.03	78.03	78.03	78.03	78.03	78.03	78.03	78.03	78.03	78.03
4.225	77.27	77.27	77.27	77.27	77.27	77.27	77.27	77.27	77.27	77.27	77.27	77.27	77.27	77.27	77.27	77.27	77.27	77.27
4.725	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
5.225	74.24	74.24	74.24	74.24	74.24	74.24	74.24	74.24	74.24	74.24	74.24	74.24	74.24	74.24	74.24	74.24	74.24	74.24
5.725	71.97	71.97	71.97	71.97	71.97	71.97	71.97	71.97	71.97	71.97	71.97	71.97	71.97	71.97	71.97	71.97	71.97	71.97
6.225	70.45	70.45	70.45	70.45	70.45	70.45	70.45	70.45	70.45	70.45	70.45	70.45	70.45	70.45	70.45	70.45	70.45	70.45
6.725	68.18	68.18	68.18	68.18	68.18	68.18	68.18	68.18	68.18	68.18	68.18	68.18	68.18	68.18	68.18	68.18	68.18	68.18
7.225	68.18	68.18	68.18	68.18	68.18	68.18	68.18	68.18	68.18	68.18	68.18	68.18	68.18	68.18	68.18	68.18	68.18	68.18
7.725	65.91	65.91	65.91	65.91	65.91	65.91	65.91	65.91	65.91	65.91	65.91	65.91	65.91	65.91	65.91	65.91	65.91	65.91
8.225	65.91	65.91	65.91	65.91	65.91	65.91	65.91	65.91	65.91	65.91	65.91	65.91	65.91	65.91	65.91	65.91	65.91	65.91
8.725	64.39	64.39	64.39	64.39	64.39	64.39	64.39	64.39	64.39	64.39	64.39	64.39	64.39	64.39	64.39	64.39	64.39	64.39

Table IX (continued)

	Average prediction timing (%)																	
b1\b3	0.1	0.6	1.1	1.6	2.1	2.6	3.1	3.6	4.1	4.6	5.1	5.6	6.1	6.6	7.1	7.6	8.1	8.6
0.225	12.94	14.02	15.64	18.35	21.71	24.72	27.20	30.42	32.39	34.64	36.63	38.55	39.79	41.11	41.84	42.58	43.70	44.45
0.725	17.91	19.15	20.03	21.70	23.90	25.92	27.71	30.56	32.52	34.66	36.56	38.57	39.73	41.10	41.83	42.56	43.65	44.49
1.225	25.53	26.13	26.72	27.64	28.48	29.74	30.82	33.27	34.62	36.66	38.42	40.05	41.11	42.13	42.88	43.43	44.36	45.02
1.725	32.67	32.88	33.49	33.89	34.68	35.28	35.71	37.31	38.01	39.45	40.89	41.86	42.57	43.34	44.02	44.60	45.24	45.76
2.225	37.79	37.99	37.99	38.60	39.17	39.77	40.09	40.78	41.41	42.02	42.68	43.37	43.94	44.49	44.96	45.34	45.85	46.22
2.725	40.88	41.11	41.31	41.45	42.36	42.46	42.58	43.01	43.13	43.37	43.72	44.23	44.65	45.16	45.51	45.85	46.33	46.63
3.225	43.59	43.93	44.25	44.30	44.54	44.59	44.78	45.04	45.05	45.19	45.39	45.74	46.05	46.45	46.69	46.94	47.32	47.53
3.725	45.79	45.86	45.82	45.87	46.13	46.43	46.50	46.57	46.59	46.66	46.93	46.95	47.13	47.56	47.68	47.83	48.13	48.29
4.225	47.14	47.22	47.20	47.25	47.69	47.72	47.77	47.90	47.91	47.96	48.09	48.23	48.48	48.64	48.71	48.85	49.12	49.15
4.725	48.20	48.31	48.35	48.35	48.65	48.67	48.71	48.84	48.84	48.87	48.96	49.08	49.13	49.24	49.30	49.41	49.67	49.69
5.225	48.90	49.00	49.03	49.03	49.29	49.37	49.38	49.42	49.43	49.46	49.54	49.63	49.67	49.76	49.79	49.88	50.17	50.18
5.725	49.46	49.52	49.54	49.55	49.73	49.77	49.78	49.81	49.82	49.85	49.94	50.02	50.05	50.12	50.15	50.21	50.48	50.49
6.225	49.99	50.05	50.07	50.06	50.22	50.27	50.27	50.28	50.29	50.32	50.41	50.42	50.44	50.72	50.73	50.79	50.83	50.84
6.725	50.23	50.29	50.31	50.34	50.45	50.47	50.47	50.48	50.68	50.70	50.80	50.81	50.84	50.91	50.92	50.99	51.01	51.02
7.225	50.59	50.65	50.67	50.70	50.81	50.83	50.83	50.84	51.01	51.03	51.11	51.12	51.15	51.23	51.24	51.29	51.30	51.31
7.725	51.05	51.08	51.08	51.09	51.21	51.23	51.23	51.27	51.27	51.30	51.34	51.34	51.37	51.44	51.47	51.48	51.49	51.49
8.225	51.33	51.36	51.36	51.36	51.48	51.51	51.52	51.54	51.54	51.56	51.61	51.61	51.62	51.70	51.71	51.72	51.73	51.73
8.725	51.51	51.52	51.52	51.52	51.64	51.66	51.66	51.69	51.69	51.71	51.76	51.76	51.77	51.85	51.86	51.87	51.88	51.88

Notes:

The table analyzes the relationship between the prediction of abnormal volume event and the excess returns according to the intraday event study. The definition of abnormal volume event is VD-event with threshold values of c1 = 2.225 and c2 = 2.6 (highest in-sample information ratio along with significant CAAR[1,22]) along with a different prediction parameters of b1 and b2 ranging from 0.225 to 8.725 and from 0.1 to 8.6 with equal spacing. This results correspond to dataset from July 2015 – June 2016. The intraday CAAR is computed as raw returns, however, it should not deviate significantly from its market adjusted value as on average the intraday market returns in very small. The missed events CAAR is calculated by assuming the prediction mark at 50th bin to match the average prediction timing. The statistical significance is calculated using the parametric student's T test and non-parametric Wilcoxon singed rank test. The superscript a, b, c and superscript d, e, f indicate that the coefficients are significantly different from zero at the 10%, 5%, and 1% level based on parametric test and non-parametric test respectively.

VITA

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