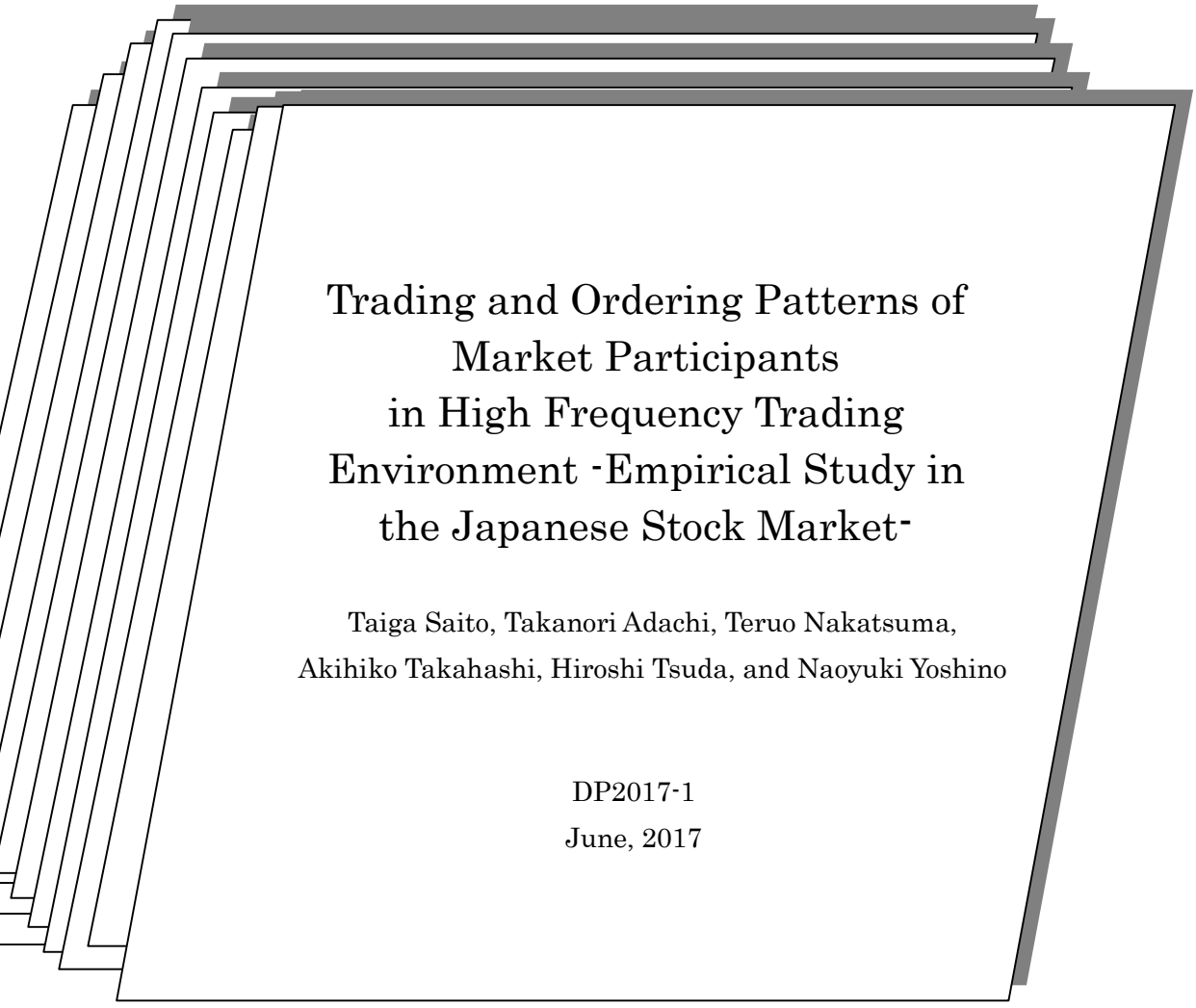

FSA Institute Discussion Paper Series

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DP2017-1
June, 2017

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Trading and Ordering Patterns of Market Participants in High Frequency Trading Environment -Empirical Study in the Japanese Stock Market- *

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Abstract

In this study, we investigate ordering patterns of different types of market participants in Tokyo Stock Exchange (TSE) by examining order records of the listed stocks. Firstly, we categorize the virtual servers in the trading system of TSE, each of which is linked to a single trading participant, by the ratio of cancellation and execution in the order placement as well as the number of executions at the opening of the afternoon session. Then, we analyze ordering patterns of the servers in the categories in short intervals for the top 10 highest trading volume stocks. By classifying the intervals into four cases by returns, we observe how different types of market participants submit or execute orders in the market situations. Moreover, we investigate the shares of the executed volumes for the different types of servers in the swings and roundabouts of the Nikkei 225 index, which were observed in July, August, and September in 2015. The main findings of this study are as follows: Server type A, which supposedly includes non-market making proprietary traders with high-speed algorithmic strategies, executes and places orders along with the direction of the market. The shares of the execution and order volumes along with the market direction increase when the stock price moves sharply. Server type B, which presumably includes servers employing a market making strategy with high cancellation and low execution ratio, shifts its market making price ranges in the rapid price movements. We observe that passive servers in Server type B have a large share and buy at low levels in the price falls. Also, Server type B, as well as Server type A, makes profit in the price falling days and particularly, the aggressive servers in the server type make most of the profit. Server type C, which is assumed to include servers receiving orders from small investors, constantly has a large share of execution and order volume.

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1 Introduction

High frequency trading environment has become common globally because of the advancements in information technology in the financial industry. While this enables millisecond high-speed trading of traders with algorithmic strategies, highly volatile intraday price movements, represented by the Flash Crash in 2010 in the U.S. stock market, have been observed in financial markets. In Japan, since Arrowhead, the high-speed execution system, was first introduced in 2010 and especially the tick sizes were narrowed in 2014 in TSE, we have come to observe large intraday stock price movements. Since excessively volatile markets are undesirable for investor protection, identifying the cause of the price instability is important from the regulatory perspective.

Although it has been said that this price instability in the high-speed trading environment might be caused by the high frequency traders (HFTs), the mechanisms are yet unknown. Following studies investigate HFTs' trading behaviors and their impacts on stock markets: Riordan and Storkenmaier [1] explores the relation between the latency of trading and the price discovery by using the data of DAX. Menkveld [2] analyzes HFTs' trading strategies across two different stock markets. O ' Hara [3] discusses effects of the high frequency trading environment on the financial market including trading strategies of the market participants. Kirilenko et al. [4] examines HFTs' trading patterns in the flash crash, which took place on 6th May 2010, with E-mini S&P futures contract data. Boehmer et al. [5] analyzes influences of the short-selling banning in 2008 on the market activities. Hasbrouck and Saar [6] investigates impacts of the low-latency trading on the market qualities using NASDAQ data. Carrion [7] examines trading performances of HFTs and their influences on the market with the NASDAQ data. Brogaard et al. [8] explores relations between HFTs' trading volumes and the stock returns in NASDAQ by the use of the state space model. Particularly, it decomposes the stock return into the overshoot and price efficiency effects, and examines the relation between these effects and the trading volumes of HFTs. Hosaka [9] analyzes HFTs' trading and ordering patterns and their impacts in TSE comparing those of the other servers, and concludes that HFTs provide liquidities in the market and help stabilize the stock prices.

On the other hand, our study investigates trading strategies and ordering patterns of four different types of market players, one of which presumably includes non-market making proprietary traders with high-speed algorithmic strategies, in TSE. This focuses on the order placement/cancellation and execution patterns in the short periods of different market situations using not only executed records, but also limit/cancellation/modification orders submitted. This study provides new insights on what is happening in the price movements; who are trading and submitting what type of orders, especially for traders with non-market making strategies.

In particular, we take the following procedure. First, we examine ordering and trading patterns of each ID of virtual servers, which is linked to a single market participant, by using order data of stocks listed in TSE. In detail, we calculate the following ratios for all the server IDs with all the order data of listed stocks as of 8th July 2015 when the Nikkei 225 index declined by 2.69%: cancellation and execution ratio, number of executions at the opening of the afternoon session, and the average volume per order. After classifying the server IDs based on the ratios into four groups, we investigate executed volumes and changes in volume of orders in 10 second periods for the top 10 large trading volume

stocks, which we consider to be representatives of the price movements of the index, in four different market situations depending on the return in the short intervals; price decline more than 0.10%, price decline less than 0.10%, price increase less than 0.10%, and price increase more than 0.10%.

Moreover, we analyze the large stock price movements in the swings and roundabouts of the Nikkei 225 index, which occurred in July, August, and September 2015, by examining the shares of the executed volume for the top 10 large trading volume stocks for the four server types. In detail, we classify the 10 second intervals by the return and the thinness of the orders, which is defined as the return divided by the executed volume in the Japanese yen (JPY), and observe the shares of the selling and buying executed volumes for the four server types.

The main findings of this study are as follows. Server type A, which supposedly includes non-market making proprietary traders with high-speed algorithmic strategies, executes and places orders along with the market direction. In particular, the share of trading volume as well as the order volume along with the market direction increases as the stock price moves sharply. Server type B, which presumably includes servers employing a market making strategy with high cancellation and low execution ratio, shifts its market making price ranges in the rapid price movements. Server type C, which is assumed to contain servers receiving orders from small investors, constantly has a large share of execution and order volume regardless of the market situations. In the market falls of the swings and roundabouts for the Nikkei 225 index, Server type A has large shares of selling volumes for the 10 representative stocks. In the days of index rebound, two patterns are observed. The first one is that the market is highly liquid and Server type C has the largest share of buying volume in the price rises. The second one is that the market is thin and Server type A has a high share of buying volume in the price rises as well as selling volume in the price falls. Also, in a quiet market where most of the price movements are small, we observe similar trading patterns to the days in the swings and roundabouts for each server type.

Furthermore, we investigate at which level Server type B buys in the price falls and how much P&L this server type as well as Server type A makes in price falling days. We observe that passive servers in Server type B have a large share and buy at low levels in the price falls. Also, Server type B as well as Server type A makes profit in the price falling days and particularly, the aggressive servers in the server type make most of the profit.

This paper is organized as follows. Section 2 explains the details of the data provided by Japan Exchange Group (JPX) and the methodology to classify the server IDs into the four categories depending on the ratios which represent the features of trading or ordering patterns. Section 3 presents analyses of the trading and ordering patterns of the server types in the swing and the roundabouts as well as in a quiet market. Section 4 investigates the price levels where Server type B buys in the price falls and how much profit this server type as well as Server type A makes. Finally, Section 5 concludes.

2 Methodology

2.1 Data set

We use order data of all the listed stocks in TSE on 8th July 2015 for the classification of server IDs. The details of the data set are as follows. All the order records are labeled with either of the following types:

1. new order,
2. executed order,
3. order modification canceling an old status,
4. order modification with a new status,
5. canceled order,
6. expired order.

Moreover, each order record accompanies the following information: order volume, buy or sell, order price, time stamp, order ID, server ID and last traded price. First, let us fix the ticker symbol of the stock k and the trading date. Let $N^{(k)}$ be the number of all orders for the stock in the day. For the i-th order ($1 \leq i \leq N^{(k)}$) of the day for the stock, we define a collection of the information $\mathbf{x}_i = (x_{i1}^{(k)}, x_{i2}^{(k)}, x_{i3}^{(k)}, x_{i4}^{(k)}, x_{i5}^{(k)}, x_{i6}^{(k)}, x_{i7}^{(k)}, x_{i8}^{(k)})$, where $x_{i1}^{(k)} \in \{1,2,3,4,5,6,7\}$, $x_{i2}^{(k)} \in \boldsymbol{R}$, $x_{i3}^{(k)} \in \{0,1\}$, $x_{i4}^{(k)} \in (0,\infty)$, $x_{i5}^{(k)} \in [0,T]$, $x_{i6}^{(k)} \in \mathcal{O}$, $x_{i7}^{(k)} \in \mathcal{S}$, $x_{i8}^{(k)} \in \boldsymbol{R}$. Here, $\mathcal{O}$ is the set of the order IDs and $\mathcal{S}$ is the set of the server IDs. $x_{i1}^{(k)}, x_{i2}^{(k)}, x_{i3}^{(k)}, x_{i4}^{(k)}, x_{i5}^{(k)}, x_{i6}^{(k)}, x_{i7}^{(k)}$ and $x_{i8}^{(k)}$ represent the order status, the order volume, buy or sell, the order price, the time stamp, the order ID, the server ID and the previous price, respectively. $x_{i,2}^{(k)}$, the order volume, takes a positive value if it is a new order or an order modification with a new status, and a negative value if it is a cancellation order or an order modification canceling an old status. $x_{i,3}^{(k)}$ is 0 for a buying order and 1 for a selling order. The times 0 and T correspond to 9:00:00 a.m. and 3:00:00 p.m. JST, respectively, which are the opening and closing times of the Tokyo stock market.

2.1.1 Remarks on server IDs and limitation of the analysis

Server IDs are the IDs allocated to the virtual servers used for the connections between the trading participants and TSE in the trading system. The participants, who serve as brokers between TSE and their clients, are the registered securities companies in TSE. They own multiple virtual servers, each of which has a limit in trading volume and the server IDs do not overlap among different participants. Generally, orders from different customers of a participant are submitted to TSE through one server ID. However, some server IDs of participants are kept for exclusive use of their special customers, such as hedge funds trading with algorithmic strategies.

Another important point to notice is that participants can specify a server ID in their submission of orders, which means that they can use different server IDs for new submission, modification, and cancellation of a single order whose life is tracked by an order ID. Hence, the Server IDs do not perfectly reflect the behavior of the final investors.

One possible way to capture the behavior of the final investors better is that we bundle the server IDs used for the same order ID and assume a correspondence relation between the bundles and the final investors. However, we focus on server ID based analysis due to the burden of computation.

2.2 Cancellation and execution ratio of servers

Next, we define a cancellation and an execution ratio of servers based on order data on all listed stocks in TSE on 8th July 2015. We have chosen the day when the Nikkei 225 stock index fell significantly, more than 3% from the closing level of the previous day. This is the fifth largest price decline in absolute index value in 2015. In particular, the prices of the Nikkei 225 future contracts dropped significantly in response to the large drop in the Shanghai market, during the lunch break of the underlying stock market. Consequently, large numbers of limit sell orders were placed during the lunch break and the most prices of the stocks opened at lower levels at the beginning of the afternoon session.

Let c_s and h_s be the cancellation and the execution ratio, respectively. We divide the market opening periods, which are from 9:00 a.m. to 11:30 a.m. and from 0:30 p.m. to 3:00 p.m., into 1,800 ten-second intervals. Note that the interval from 11:30 a.m. to 0:30 p.m. is the lunch break when the underlying stock market is closed.

We define them as follows.

$$c_s = \frac{\sum_{k\in K}\sum_{i=1}^{N^{(k)}} 1_{\{x_{i1}^{(k)}=5, x_{i7}^{(k)}=s\}}}{\sum_{k\in K}\sum_{i=1}^{N^{(k)}} 1_{\{x_{i1}^{(k)}=1, x_{i7}^{(k)}=s\}}}, \tag{1}$$

$$h_s = \frac{\sum_{k\in K}\sum_{i=1}^{N^{(k)}} 1_{\{x_{i1}^{(k)}=2, x_{i7}^{(k)}=s\}}}{\sum_{k\in K}\sum_{i=1}^{N^{(k)}} 1_{\{x_{i1}^{(k)}=1, x_{i7}^{(k)}=s\}}}, \tag{2}$$

where K is the set of all the listed stocks in TSE. c_s, the cancellation ratio of the server s, is the number of cancellation orders from the server s divided by the number of new orders submitted by s. Similarly, h_s, the hit ratio of the server s, is the number of executed orders from the server s divided by the number of new orders from s.

Let C1, C2, C3, C4 and C5 be the categories of the servers with the cancellation ratio 0-20%, 20-40%, 40-60%, 60-80%, and 80-100%, respectively. Similarly, let H1, H2, H3, and H4 be the categories with the executed ratio 0-25%, 25-50%, 50-75%, 75-100%, respectively. Table 1 summarizes the numbers and shares of the new, cancellation and executed orders by server type.

		# of servers	Share	# of new orders	Share	# of canceled orders	Share	# of executed orders	Share
C1	H1	143	3%	1,915,078	6%	316	0%	133,418	2%
C1	H2	135	3%	427,087	1%	9,878	0%	146,506	2%
C1	H3	456	10%	826,931	2%	120,702	1%	488,436	6%
C1	H4	316	7%	401,839	1%	58,885	0%	382,960	5%
C2	H1	13	0%	49,213	0%	14,609	0%	7,519	0%
C2	H2	32	1%	125,180	0%	40,959	0%	58,010	1%
C2	H3	214	5%	4,023,461	12%	1,189,379	5%	2,298,612	27%
C2	H4	354	8%	288,256	1%	86,081	0%	268,172	3%
C3	H1	23	1%	49,941	0%	21,227	0%	9,252	0%
C3	H2	489	11%	2,429,534	7%	1,351,270	6%	946,029	11%
C3	H3	206	5%	676,088	2%	343,740	1%	398,531	5%
C3	H4	23	1%	35,019	0%	14,971	0%	34,486	0%
C4	H1	195	4%	2,331,722	7%	1,754,429	7%	477,943	6%
C4	H2	467	10%	3,811,269	11%	2,755,218	12%	1,353,687	16%
C4	H3	61	1%	326,843	1%	210,407	1%	177,588	2%
C4	H4	5	0%	6,599	0%	4,458	0%	5,323	0%
C5	H1	894	20%	15,773,284	46%	14,943,880	64%	1,034,581	12%
C5	H2	115	3%	556,794	2%	488,690	2%	172,628	2%
C5	H3	5	0%	12,355	0%	14,442	0%	8,233	0%
C5	H4	0	0%	0	0%	0	0%	0	0%
	Total	4,448	100%	34,075,892	100%	23,447,976	100%	8,408,934	100%

Table 1: Distribution of the new, cancellation and executed orders for all listed stocks as of 8th July 2015 by server type.

We observe that in total, 69% of the new orders are canceled and 25% of them are executed. The rest are orders expired either as the special orders such as the immediate or cancel orders or at the end of the trading session of the day. Particularly, C5H1, the category with the highest cancellation and the lowest executed ratios which accounts for 20% of the servers in number, has 46% share of the new orders and 64% share of the cancellation orders. It is notable that although only 7% of the new orders submitted by C5H1 are executed, they still consist of 10% of all the executed orders.

2.3 Classification of server types

Next, we categorize the servers, which have more than 100 new order submissions in the day, into four types. Firstly, following Hosaka [9] for the definition of HFTs, we categorize the server IDs labeled C5H1, C4H1, C3H1 and C2H1 as Server type B. Then, for the other server IDs, if a server does not have any sell orders executed in the one second after the opening of the afternoon session, when the most of the executed orders are as a result of participating in Itayose in the lunch break, then we regard it as the server in Server type A. Here, Itayose is a method of matching orders submitted in the lunch break or the pre-opening of the market, which is adopted in TSE. In the method, only the price level of orders matters for the order matching, and the price-time priority principle does not apply.

Since it is expected that servers dealing with customer order flows place at least one sell order at a low price when there is a negative market surprise in the lunch break, we presume that Server type A includes servers of proprietary traders with non-market making and high-speed algorithmic trading strategies. Moreover, for the servers in neither Server type A nor Server type B, if the average volume in JPY per order is less than JPY 3 million, we label them as Server type C, otherwise Server type D. Here, we define the average volume per order as follows. For each new order of server IDs, we multiply the

order volume by the order price. We take the average over the new orders submitted by the server ID.

Server type B is expected to include traders who take a market making strategy actively placing orders at the best bid or offer. Server type C is supposed to include securities companies who mainly deal with orders from retail customers. Server type D is assumed to include the servers of securities companies which primarily deal with large orders from their customers. We note that traders, who execute large orders from institutional investors such as insurance companies and pensions with algorithmic strategies, are assumed to belong to Server type C or D, since they also make use of Itayose in the lunch break and the pre-opening period. Also, non-market-making proprietary traders with algorithmic strategies using Itayose are expected to belong to Server type C or D.

	# of servers	Share	# of new orders	Share	# of cancellation orders	Cancellation ratio	Share
Server type A	1,633	37%	2,585,173	8%	943,715	37%	4%
Server type B	1,125	25%	18,204,160	53%	16,734,145	92%	71%
Server type C	1,115	25%	11,300,943	33%	4,921,759	44%	21%
Server type D	273	6%	1,976,217	6%	823,922	42%	4%

Table 2: Number of servers, new orders, and cancellation orders by server type

	# of executed orders	Execution ratio	Share	Average volume per order in JPY
Server type A	1,014,443	39%	12%	3,784,789
Server type B	1,529,295	8%	18%	2,581,234
Server type C	4,825,364	43%	57%	1,024,046
Server type D	1,032,812	52%	12%	8,315,842

Table 3: Number of executed orders by server type

Tables 2 and 3 show numbers of servers, new orders, cancellation orders, and executed orders, those ratios against the new orders, and average volumes in JPY per order by server type. We observe that Server type A has the largest number of server IDs, 37% of the total numbers, though the shares of the new, executed, and cancellation orders are low. Server type B has the largest shares of the new orders and the cancellation orders, which are 53% and 71%, respectively, and 18% share of the executed orders, which is the second largest after that of Server type C. Server type C has the largest share of the executed orders, 57%, and the second largest shares of the new and cancellation orders and the number of server IDs. Server type D has the highest execution ratio, 52%, and the highest order volume per order, which is around JPY 8 million, although the shares of the server numbers and the new, cancellation, executed orders are the lowest among the four categories.

	H1	H2	H3	H4
C1	128	121	380	186
C2	0	18	30	246
C3	0	357	59	5
C4	0	70	12	3
C5	0	17	1	0

Table 4: Server distribution, Server type A

	H1	H2	H3	H4
C1	0	0	0	0
C2	13	0	0	0
C3	23	0	0	0
C4	195	0	0	0
C5	894	0	0	0

Table 5: Server distribution, Server type B

	H1	H2	H3	H4
C1	5	14	64	110
C2	0	9	151	59
C3	0	129	126	9
C4	0	345	40	2
C5	0	48	4	0

Table 6: Server distribution, Server type C

	H1	H2	H3	H4
C1	10	0	12	20
C2	0	5	33	49
C3	0	3	21	9
C4	0	52	9	0
C5	0	50	0	0

Table 7: Server distribution, Server type D

Tables 4-7 show numbers of servers by the cancellation and hit ratios. We observe that Server type A, which has 37% and 39% of the cancellation and execution ratios, have its servers mostly in C1H3, the categories with low cancellation and high execution ratios. Server type B, which has the high cancellation ratio 92% and the low execution ratio 8%, are mainly distributed in C5H1. Server type C, which has the relatively high cancellation ratio 44% and the execution ratio 43%, exist most heavily on C4H2. Server type D, which has high cancellation ratio 42% and execution ratios 52%, are distributed mainly in C4H2.

3 *Analysis of trading and ordering patterns by server type*

In this section, we analyze the shares of the volumes of the executed orders and the changes in volumes of the submitted orders by server type, during the 10 second intervals of the top 10 trading volume stocks for the four different market situations.

Tables 8 and 9 illustrate an example of order books, which are for Mitsubishi UFJ Financial Group, at 9:10:00 a.m. and 9:10:10 a.m. on 8th July 2015. These tables indicate that the stocks were sold off in the short interval, and as a result, the buying orders in the price range from 875.2 to 875.5 were taken and the selling orders in the range from 875.3 to 875.7 were placed instead.

These changes in the order book are due to different types of orders submitted during the period. The originally placed limit buy orders are either canceled, modified to different

price levels, or taken by market sell orders, while new limit buy orders are placed at the same time. In contrast, there is no limit sell order in the price range at first. As new market sell orders are executed against the existing limit buy orders, new limit sell orders are placed and the limit sell prices are changed to lower levels.

877.0	37,600	0
876.9	20,300	0
876.8	6,900	0
876.7	2,200	0
876.6	5,400	0
876.5	18,700	0
876.4	7,500	0
876.3	6,100	0
876.2	7,000	0
876.1	6,000	0
876.0	3,300	0
875.9	4,500	0
875.8	600	0
875.7	0	0
875.6	0	0
875.5	0	4,300
875.4	0	8,400
875.3	0	3,500
875.2	0	3,900
875.1	0	3,300
875.0	0	20,900
874.9	0	32,000
874.8	0	1,900
874.7	0	5,100
874.6	0	42,900
874.5	0	6,500
874.4	0	9,200
874.3	0	21,800
874.2	0	12,200
874.1	0	400
874.0	0	34,100

Table 8: Order book at the beginning of the period.

877.0	35,400	0
876.9	20,300	0
876.8	5,600	0
876.7	600	0
876.6	2,500	0
876.5	13,700	0
876.4	6,900	0
876.3	2,600	0
876.2	9,900	0
876.1	6,600	0
876.0	16,000	0
875.9	5,800	0
875.8	2,200	0
875.7	7,000	0
875.6	4,500	0
875.5	3,100	0
875.4	1,600	0
875.3	700	0
875.2	0	0
875.1	0	600
875.0	0	23,200
874.9	0	13,500
874.8	0	2,900
874.7	0	2,800
874.6	0	5,500
874.5	0	7,000
874.4	0	5,100
874.3	0	43,600
874.2	0	8,000
874.1	0	6,900
874.0	0	35,200

Table 9: Order book at the end of the period.

3.1 Execution share and change in order volume

In this subsection, we examine trading and ordering patterns in different degrees of price movements by server type. First, we observe the case of 1st September 2015 when the index declined most in the year by 3.19%. Tables 10-17 show the shares of the executed volume, changes in order volume, and average numbers of price renewal trades for the four server types. These numbers are calculated as follows. Let $w_{\alpha,\beta,\gamma}$, $v_{\alpha,\beta,\gamma}$, and $u_{\alpha,\beta,\gamma}$ be the share of executed orders, the change in order volume and the number of price renewal, respectively for the server type β in the 10 second periods for the market situation α and the order type γ. Here, $\alpha \in \{$ negative return greater than 10 bps, negative return less than 10 bps, positive return less than 10 bps, positive return greater than 10 bps$\}$. Since we are interested in the execution and ordering patterns of servers in market moves, we exclude the ten second intervals with zero return, where the start price and the end price are the same, from our analysis. $\beta \in \{$A, B, C, D$\}$. $\gamma \in \{$buy, sell$\}$. Let A_i be the i-th 10 second interval of $[0, T]$. Then, the trading period $[0, T]$ is divided into 1,800 disjoint 10 second intervals as follows.

$$[0, T] = \coprod_{l=1}^{1800} A_l \tag{3}$$

We note that $\coprod_{l=901}^{1260} A_l$ corresponds to the lunch break of the market, which is from 11:30 a.m. to 0:30 p.m. JST. We denote by $L_\alpha^{(k)}$ the set of $l \in \{1, \ldots, 1800\}$ where the return

of stock k in A_l is α. Here, $k = 1, \ldots, 10$ represent the top 10 trading volume stocks as of 30th March 2015: 7203 Toyota, 8306 Mitsubishi UFJ Financial Group, 8411 Mizuho Financial Group, 9984 Softbank, 8316 Mitsui Sumitomo Financial Group, 6758 Sony, 2802 Ajinomoto, 6762 TDK, 7267 Honda, and 7270 Subaru. Here, the four digit numbers represent the ticker codes of the stocks.

Let $l_\alpha^{(k)}(j),\ j = 1, \ldots, \#L_\alpha^{(k)}$ be elements of $L_\alpha^{(k)}$. We define $w_{\alpha,\beta,\gamma}$, $v_{\alpha,\beta,\gamma}$ and $u_{\alpha,\beta,\gamma}$ as follows.

$$w_{\alpha,\beta,\gamma} = \frac{1}{\sum_{k=1}^{10} \#L_\alpha^{(k)}} \sum_{k=1}^{10} \sum_{j=1}^{\#L_\alpha^{(k)}} \frac{\sum_{i=1}^{\mathcal{N}^{(k)}} x_{i,2}^{(k)} 1_{\{x_{i,1}^{(k)}=2, x_{i,3}^{(k)}=1_{\{\gamma=\text{sell}\}}, x_{i,7}^{(k)} \in \mathcal{S}_\beta, x_{i,5}^{(k)} \in A_{l_\alpha^{(k)}(j)}\}}}{\sum_{i=1}^{\mathcal{N}^{(k)}} x_{i,2}^{(k)} 1_{\{x_{i,1}^{(k)}=2, x_{i,3}^{(k)}=1_{\{\gamma=\text{sell}\}}, x_{i,5}^{(k)} \in A_{l_\alpha^{(k)}(j)}\}}}. \tag{4}$$

$$v_{\alpha,\beta,\gamma} = \frac{1}{\sum_{k=1}^{10} \#L_\alpha^{(k)}} \sum_{k=1}^{10} \sum_{j=1}^{\#L_\alpha^{(k)}} \frac{\sum_{s \in \mathcal{S}_\beta} c_{s, A_{l_\alpha^{(k)}(j)}}^{(k),\gamma}}{\sum_{i=1}^{\mathcal{N}^{(k)}} x_{i,2}^{(k)} 1_{\{x_{i,1}^{(k)}=2, x_{i,3}^{(k)}=1_{\{\gamma=\text{sell}\}}, x_{i,5}^{(k)} \in A_{l_\alpha^{(k)}(j)}\}}} \tag{5}$$

$$u_{\alpha,\beta,\gamma} = \frac{1}{\sum_{k=1}^{10} \#L_\alpha^{(k)}} \sum_{k=1}^{10} \sum_{j=1}^{\#L_\alpha^{(k)}} \sum_{i=1}^{\mathcal{N}^{(k)}} 1_{\{x_{i,1}^{(k)}=2, x_{i,3}^{(k)}=1_{\{\gamma=\text{sell}\}}, x_{i,7}^{(k)} \in \mathcal{S}_\beta, x_{i,5}^{(k)} \in A_{l_\alpha^{(k)}(j)}, x_{i,4} \neq x_{i,8}\}}, \tag{6}$$

where $\mathcal{S}_\beta$ is the set of servers with β for the server type.

Here, $c_{s,A}^{(k),buy}$ and $c_{s,A}^{(k),sell}$ are the changes in the buying and the selling order volume for the time interval A in $\mathcal{B} \subset (0, \infty)$, the price range between the last traded prices at the beginning of A and at the end of A, for the server s, respectively. They are defined as follows.

$$\begin{aligned} c_{s,A}^{(k),buy} &= \sum_{i=1}^{\mathcal{N}^{(k)}} x_{i2}^{(k)} 1_{\{x_{i1}^{(k)}=1,3,4,5, x_{i2}^{(k)} \in B, x_{i3}^{(k)}=0, x_{i5}^{(k)} \in A, x_{i7}^{(k)}=s\}}, \\ c_{s,A}^{(k),sell} &= \sum_{i=1}^{\mathcal{N}^{(k)}} x_{i2}^{(k)} 1_{\{x_{i1}^{(k)}=1,3,4,5, x_{i2}^{(k)} \in B, x_{i3}^{(k)}=1, x_{i5}^{(k)} \in A, x_{i7}^{(k)}=s\}}. \end{aligned} \tag{7}$$

We observe that Server type A has a large share of trading volume in the rapid market movements. In the 10 second intervals where the stock price declines more than 0.10% in Tables 10 and 11, the share of selling volume is 35%, while the share of buying volume is 14%. When the stock price rises more than 0.10% in Tables 16 and 17, the buying share is 36%, while the selling share is only 13%. Thus, they take the trading strategy where they follow the short-term trend of the stock price movements. Moreover, we find that they place a large amount of selling orders, 118% of the executed selling orders, when the stock price falls more than 0.10% in Table 11, and they place buying orders, which amount to 147% of the executed orders, when the stock price rises more than 0.10% in Table 16.

Server type B has a certain level of shares of executed volumes for both buying and selling sides in all the situations. In cases where the stock price moves more than 0.10%, we observe that the buying share is 21% when the price falls in Table 10, while it is 13%

when the price rises in Table 16. Similarly, the selling share is 26% when the price rises in Table 17, while it is 17% when the price falls in Table 11. This implies that Server type B trades against the market moves. Next, for the order placement, they submit large selling orders while canceling the buying orders in the falling markets. This indicates that Server type B takes market-making strategies, where they shift the price levels along with the sharp price falls.

Server type C has considerable shares of trading volumes for both buying and selling sides in all the market situations. They buy 50% of the executed volume, while selling 37% of it in the sharp price falls in Tables 10 and 11. They also have 50% share of the selling executed orders while having 40% share of the buying orders in the rapid price rises in Tables 16 and 17. They submit large selling orders in the price falls, while placing a large volume of buying orders in the price rises.

Server type D constantly has around 10%-14% shares of the executed volumes in Tables 10-17. The same things hold true for the other dates in our analysis, 4th and 8th of September, 24th and 26th of August, and 8th and 9th of July in Tables 165-220.

	Executed order volume	Change in order volume	Price renewal
Server type A	14%	21%	0.87
Server type B	21%	-50%	0.44
Server type C	50%	22%	1.57
Server type D	14%	10%	0.31

Table 10: Intervals with a negative return greater than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	35%	118%	2.06
Server type B	17%	124%	1.03
Server type C	37%	90%	3.04
Server type D	11%	15%	0.96

Table 11: Intervals with a negative return greater than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	17%	13%	0.64
Server type B	15%	-14%	0.27
Server type C	54%	51%	1.55
Server type D	14%	9%	0.39

Table 12: Intervals with a negative return less than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	32%	109%	1.25
Server type B	18%	67%	0.66
Server type C	40%	82%	2.12
Server type D	11%	20%	0.61

Table 13: Intervals with a negative return less than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	34%	116%	1.30
Server type B	13%	50%	0.49
Server type C	40%	92%	1.90
Server type D	12%	16%	0.52

Table 14: Intervals with a positive return less than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	17%	15%	0.55
Server type B	19%	-12%	0.29
Server type C	54%	42%	1.36
Server type D	11%	5%	0.34

Table 15: Intervals with a positive return less than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	36%	147%	2.37
Server type B	13%	105%	1.02
Server type C	40%	74%	2.61
Server type D	10%	37%	0.77

Table 16: Intervals with a positive return greater than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	13%	19%	0.81
Server type B	26%	-72%	0.43
Server type C	50%	33%	1.54
Server type D	12%	4%	0.35

Table 17: Intervals with a positive return greater than 0.10%, sell orders

Remark 1. *If we change the definition of Server type A in Section 2.3 as the servers which are not included in Server type B and do not have any buy/sell executed orders in any one second after the opening of the afternoon sessions of 6th, 7th and 8th of July, the summary of the server types is as in Tables 18 & 19. Note that the servers in Server type A of this classification are more likely to be the proprietary trading servers dealing only in the opening hours. The proprietary trading servers which sometimes use Itayose are excluded from Server type A in this definition. Tables 20-27 show the execution shares and ordering patterns of the four server types on 8th July 2015 with this classification. We still observe that Server type A has a larger share of selling orders in the price falls and buying orders in the price rises.*

	# of servers	Share	# of new orders	Share	# of cancellation orders	Cancellation ratio	Share
Server type A	1,234	28%	2,007,917	6%	682,501	34%	3%
Server type B	1,125	25%	18,204,160	53%	16,734,145	92%	71%
Server type C	1,331	30%	11,705,850	34%	5,130,087	44%	22%
Server type D	456	10%	2,148,566	6%	876,808	41%	4%

Table 18: Number of servers, new orders, and cancellation orders by server type

	# of executed orders	Execution ratio	Share	Average volume per order in JPY
Server type A	741,412	37%	9%	3,559,876
Server type B	1,529,295	8%	18%	2,581,234
Server type C	5,002,736	43%	59%	1,011,827
Server type D	1,128,471	53%	13%	8,449,489

Table 19: Number of executed orders by server type

	Executed order volume	Change in order volume	Price renewal
Server type A	11%	22%	0.74
Server type B	21%	-50%	0.44
Server type C	52%	21%	1.67
Server type D	16%	10%	0.34

Table 20: Intervals with a negative return greater than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	27%	103%	1.60
Server type B	17%	124%	1.03
Server type C	41%	97%	3.29
Server type D	14%	23%	1.17

Table 21: Intervals with a negative return greater than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	15%	17%	0.54
Server type B	15%	-14%	0.27
Server type C	56%	46%	1.63
Server type D	15%	10%	0.42

Table 22: Intervals with a negative return less than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	28%	102%	1.05
Server type B	18%	67%	0.66
Server type C	42%	87%	2.24
Server type D	12%	22%	0.68

Table 23: Intervals with a negative return less than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	30%	108%	1.11
Server type B	13%	50%	0.49
Server type C	43%	97%	2.04
Server type D	14%	18%	0.58

Table 24: Intervals with a positive return less than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	15%	14%	0.47
Server type B	19%	-12%	0.29
Server type C	55%	43%	1.42
Server type D	11%	5%	0.35

Table 25: Intervals with a positive return less than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	29%	129%	1.90
Server type B	13%	105%	1.02
Server type C	43%	83%	2.91
Server type D	14%	47%	0.95

Table 26: Intervals with a positive return greater than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	11%	18%	0.67
Server type B	26%	-72%	0.43
Server type C	51%	34%	1.65
Server type D	12%	4%	0.39

Table 27: Intervals with a positive return greater than 0.10%, sell orders

3.2 Shares of executed orders in the swings and roundabouts

Next, we investigate the shares of execution volumes in the 10 second intervals in different market thinnesses and returns for the four server types. Specifically, we analyze the dates when a large index decrease or increase was observed in the swings and roundabouts of the Nikkei 225 index in July, August, and September in 2015.

3.2.1 1st - 9th September

The Nikkei 225 index dropped by 7.50% in total in the daytime trading hours of 1st to 8th of September and increased by 5.70% on 9th. Among the first six trading dates in the trend of index fall, we choose 1st, 4th, and 8th of September where the index largely dropped by 3.19%, 2.84% and 2.87% respectively for the analysis. We note that the averages of the daily returns of the 10 representative stocks are as follows:

Trading date	Nikkei 225 index return	10 stock average return
1st September	-3.19%	-2.90%
2nd September	1.31%	1.66%
3rd September	-0.96%	-1.31%
4th September	-2.84%	-3.09%
7th September	1.05%	1.30%
8th September	-2.87%	-1.92%
9th September	5.70%	3.56%

Table 28: The Nikkei 225 index and 10 representative stock return

First, we classify the 10 second intervals of the 10 representative stocks by return and market thinness. We label the intervals with a pair of numbers by the level of return and the market thinness as follows.

Return:

1. negative return greater than 0.20% in 10 seconds,
2. negative return less than 0.20% in 10 seconds,
3. positive return less than 0.20% in 10 seconds,
4. positive return greater than 0.20% in 10 seconds.

Market thinness: the 10 second price change in basis points divided by the executed volume in JPY multiplied by 10 million is

1. less than 1,
2. between 1 and 5,
3. greater than 5.

In other words, 1, 2 and 3 for the market thinness imply that the stock price moves less than 1 bp, 1-5 bps, and more than 5 bps, respectively, with JPY 10 million in the interval. Table 29 is a histogram which shows the number of the 10 second intervals for the 10 representative stocks in the date by the return and the market thinness. We observe that for all the dates with the price change 1 and 4, the numbers of times with the thinness 3 are large compared to these with the thinnesses 1 and 2. This means that the sharp price movements are caused by small volumes of trades.

Tables 30-33, 35-38, 40-43, and 45-48 show the shares of the executed orders and the price renewal orders for the four server types by the return and the market thinness. It is observed that on 1st and 8th, the shares of selling volume for Server type A are biased toward the situations with the returns 1 and 2, which indicates that Server type A sells larger volumes in the price falls than in the price rises.

Figures 1-8 are the scattered diagrams displaying the relation between the executed volume in JPY (the horizontal axis) and the return in bps for the 10 second intervals (the vertical axis). The dots and the cross marks correspond to the intervals when the market is opened and at the beginning of the afternoon session, respectively.

On 9th, when the index rebounded significantly, as the high numbers of times for the thinness 2 compared to the thinness 3 and the horizontally long scatter diagram show, the prices did not move much by small volumes of trades. The shares of Server type A are around 20-30 % in all the situations, and Server type C has constantly large shares higher than 40% on the date.

- ***Tables and figure of 1st September 2015 - Down 3.19%***

Return	Thinness	# of times
1	1	2
1	2	19
1	3	53
2	1	1272
2	2	3009
2	3	2144
3	1	1101
3	2	2638
3	3	2146
4	1	1
4	2	19
4	3	43

Table 29: Number of times for intervals with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	6%	4%	17%	72%
1	2	37%	18%	38%	7%
1	3	34%	17%	45%	5%
2	1	32%	19%	35%	14%
2	2	35%	18%	38%	10%
2	3	29%	16%	44%	10%
3	1	20%	17%	49%	14%
3	2	17%	18%	54%	11%
3	3	14%	23%	55%	8%
4	1	47%	6%	42%	6%
4	2	6%	20%	58%	16%
4	3	9%	39%	43%	9%

Table 30: Shares of selling orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	12%	12%	54%	23%
1	2	12%	22%	50%	16%
1	3	10%	31%	43%	16%
2	1	20%	12%	48%	20%
2	2	16%	14%	54%	15%
2	3	16%	19%	56%	9%
3	1	32%	13%	39%	15%
3	2	37%	14%	38%	12%
3	3	33%	12%	44%	11%
4	1	9%	16%	6%	69%
4	2	39%	15%	38%	7%
4	3	36%	14%	44%	7%

Table 31: Shares of buying orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	4%	2%	16%	77%
1	2	25%	19%	44%	12%
1	3	30%	12%	52%	6%
2	1	28%	17%	38%	17%
2	2	31%	15%	41%	12%
2	3	27%	12%	46%	11%
3	1	23%	11%	48%	15%
3	2	17%	9%	46%	11%
3	3	10%	5%	29%	5%
4	1	88%	1%	12%	0%
4	2	15%	16%	48%	11%
4	3	19%	9%	33%	2%

Table 32: Shares of price renewal selling orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	68%	11%	13%	9%
1	2	34%	9%	43%	4%
1	3	17%	9%	21%	6%
2	1	25%	8%	49%	14%
2	2	20%	7%	45%	12%
2	3	10%	3%	24%	6%
3	1	31%	10%	43%	15%
3	2	35%	11%	40%	13%
3	3	32%	8%	44%	12%
4	1	14%	5%	11%	71%
4	2	32%	13%	46%	9%
4	3	35%	10%	43%	11%

Table 33: Shares of price renewal buying orders with different levels of market returns and thinnesses

Figure 1: Executed volumes vs price changes, 1st September

- ***Tables and figure of 4th September 2015 - Down 2.84%***

Figure 2: Executed volumes vs price changes, 4th September

Return	Thinness	# of times
1	1	1
1	2	17
1	3	38
2	1	828
2	2	2397
2	3	2279
3	1	815
3	2	2303
3	3	2220
4	1	2
4	2	12
4	3	35

Table 34: Number of times for intervals with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	60%	8%	28%	5%
1	2	17%	12%	55%	14%
1	3	25%	31%	40%	4%
2	1	24%	18%	47%	11%
2	2	25%	20%	46%	10%
2	3	27%	20%	44%	9%
3	1	24%	18%	46%	11%
3	2	24%	18%	47%	10%
3	3	26%	21%	44%	9%
4	1	3%	26%	17%	53%
4	2	12%	17%	50%	21%
4	3	21%	21%	44%	14%

Table 35: Shares of selling orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	27%	72%	1%	0%
1	2	29%	12%	38%	21%
1	3	20%	19%	55%	7%
2	1	25%	14%	49%	12%
2	2	26%	15%	47%	12%
2	3	26%	17%	46%	10%
3	1	25%	12%	50%	12%
3	2	25%	15%	48%	12%
3	3	28%	16%	45%	11%
4	1	1%	3%	45%	51%
4	2	22%	14%	51%	12%
4	3	29%	20%	41%	10%

Table 36: Shares of buying orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	50%	0%	25%	25%
1	2	27%	7%	46%	15%
1	3	10%	7%	34%	1%
2	1	23%	12%	49%	11%
2	2	25%	12%	45%	9%
2	3	26%	9%	41%	9%
3	1	23%	12%	47%	11%
3	2	25%	12%	45%	11%
3	3	25%	11%	40%	8%
4	1	1%	0%	10%	89%
4	2	9%	9%	61%	20%
4	3	20%	8%	32%	12%

Table 37: Shares of price renewal selling orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	23%	77%	0%	0%
1	2	34%	13%	39%	15%
1	3	14%	5%	30%	7%
2	1	26%	7%	47%	11%
2	2	26%	6%	47%	12%
2	3	27%	6%	39%	9%
3	1	25%	6%	49%	12%
3	2	26%	6%	46%	12%
3	3	28%	6%	38%	10%
4	1	0%	0%	33%	67%
4	2	21%	4%	53%	14%
4	3	19%	7%	28%	5%

Table 38: Shares of price renewal buying orders with different levels of market returns and thinnesses

- ***Tables and figure of 8th September 2015 - Down 2.87%***

Figure 3: Executed volumes vs price changes, 8th September

Return	Thinness	# of times
1	1	1
1	2	20
1	3	59
2	1	835
2	2	2499
2	3	2652
3	1	826
3	2	2402
3	3	2575
4	1	2
4	2	13
4	3	59

Table 39: Number of times for intervals with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	58%	32%	0%	10%
1	2	38%	19%	36%	8%
1	3	35%	16%	39%	9%
2	1	37%	16%	34%	14%
2	2	38%	16%	36%	10%
2	3	33%	14%	45%	8%
3	1	22%	13%	47%	18%
3	2	19%	17%	51%	13%
3	3	15%	22%	55%	8%
4	1	6%	44%	25%	25%
4	2	12%	22%	46%	19%
4	3	13%	37%	42%	8%

Table 40: Shares of selling orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	28%	25%	41%	7%
1	2	10%	21%	47%	22%
1	3	12%	32%	47%	9%
2	1	20%	12%	52%	15%
2	2	18%	16%	52%	13%
2	3	18%	23%	50%	8%
3	1	33%	13%	44%	11%
3	2	39%	14%	38%	9%
3	3	39%	13%	41%	8%
4	1	27%	4%	20%	49%
4	2	36%	21%	32%	10%
4	3	39%	18%	36%	6%

Table 41: Shares of buying orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	83%	17%	0%	0%
1	2	39%	16%	35%	9%
1	3	33%	9%	49%	10%
2	1	32%	11%	43%	14%
2	2	34%	11%	42%	12%
2	3	30%	9%	48%	9%
3	1	23%	8%	49%	13%
3	2	19%	7%	47%	11%
3	3	10%	5%	29%	5%
4	1	2%	38%	32%	28%
4	2	28%	16%	42%	14%
4	3	6%	6%	38%	0%

Table 42: Shares of price renewal selling orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	27%	0%	73%	0%
1	2	28%	17%	45%	5%
1	3	12%	4%	23%	0%
2	1	25%	7%	52%	11%
2	2	21%	6%	46%	9%
2	3	12%	3%	25%	4%
3	1	34%	10%	42%	13%
3	2	38%	9%	42%	10%
3	3	37%	7%	43%	8%
4	1	2%	1%	48%	49%
4	2	33%	12%	45%	10%
4	3	33%	15%	41%	11%

Table 43: Shares of price renewal buying orders with different levels of market returns and thinnesses

- ***Tables and figure of 9th September 2015 - Up 5.70%***

Figure 4: Executed volumes vs price changes, 9th September

Return	Thinness	# of times
1	1	3
1	2	18
1	3	30
2	1	1272
2	2	2550
2	3	1630
3	1	1625
3	2	2627
3	3	1675
4	1	4
4	2	27
4	3	27

Table 44: Number of times for intervals with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	28%	31%	40%	1%
1	2	20%	16%	52%	11%
1	3	16%	19%	51%	14%
2	1	22%	12%	53%	12%
2	2	22%	13%	53%	12%
2	3	22%	15%	52%	11%
3	1	20%	12%	54%	14%
3	2	20%	14%	53%	12%
3	3	24%	16%	50%	11%
4	1	2%	6%	68%	24%
4	2	20%	21%	49%	11%
4	3	18%	29%	41%	12%

Table 45: Shares of selling orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	26%	18%	54%	1%
1	2	27%	13%	50%	10%
1	3	18%	24%	40%	18%
2	1	24%	12%	50%	14%
2	2	25%	13%	48%	13%
2	3	29%	13%	47%	11%
3	1	28%	12%	48%	13%
3	2	27%	13%	47%	13%
3	3	28%	13%	48%	11%
4	1	32%	13%	46%	9%
4	2	20%	19%	47%	14%
4	3	29%	18%	47%	6%

Table 46: Shares of buying orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	33%	27%	38%	2%
1	2	22%	9%	44%	20%
1	3	14%	3%	27%	13%
2	1	19%	6%	55%	16%
2	2	19%	6%	52%	13%
2	3	21%	6%	46%	8%
3	1	17%	7%	55%	15%
3	2	18%	6%	53%	12%
3	3	21%	6%	44%	10%
4	1	7%	20%	20%	28%
4	2	21%	7%	51%	18%
4	3	16%	1%	48%	6%

Table 47: Shares of price renewal selling orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	22%	4%	66%	8%
1	2	32%	6%	50%	6%
1	3	21%	4%	33%	10%
2	1	26%	6%	47%	13%
2	2	27%	6%	43%	11%
2	3	30%	6%	35%	9%
3	1	30%	6%	44%	12%
3	2	28%	6%	43%	10%
3	3	30%	6%	36%	9%
4	1	20%	15%	56%	8%
4	2	25%	11%	51%	13%
4	3	21%	3%	45%	2%

Table 48: Shares of price renewal buying orders with different levels of market returns and thinnesses

3.2.2 24th - 26th of August

The Nikkei 225 index fell by 4.81% in total in the daytime trading hours of 24th and 25th. The index increased by 2.70% on 26th. The returns of the 10 representative stocks are as follows:

Trading date	Nikkei 225 index return	10 stock average return
24th August	-2.80%	-3.34%
25th August	-2.01%	0.83%
26th August	2.70%	2.16%

Table 49: The Nikkei 225 index and 10 representative stock return

Among the three dates, we focus on the analysis of 24th when the index dropped by 2.80%, and 26th when the index increased by 2.70%. We observe that on 24th, the shares of selling orders for Server type A are skewed to the situations with the price falls. It is notable that on 26th, the numbers of the situations with the return 1 and 4 are particularly high and skewed to the market thinness 3. Moreover, Server type A has large shares of buying orders 45% in the situation with Return 4 & Thinness 3 and selling orders 51% in the situations with Return 1 & Thinness 3. This implies that there were large price fluctuations mainly caused by small volumes of trades of Server type A on this date.

- ***Tables and figure of 24th August 2015 - Down 2.80%***

Figure 5: Executed volumes vs price changes, 24th August

Return	Thinness	# of times
1	1	14
1	2	25
1	3	73
2	1	2225
2	2	2894
2	3	1659
3	1	1897
3	2	2684
3	3	1553
4	1	5
4	2	39
4	3	73

Table 50: Number of times for intervals with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	13%	30%	34%	16%
1	2	27%	12%	45%	16%
1	3	45%	10%	39%	6%
2	1	29%	13%	43%	15%
2	2	32%	13%	45%	10%
2	3	34%	12%	46%	9%
3	1	17%	14%	51%	17%
3	2	13%	17%	58%	12%
3	3	11%	21%	61%	8%
4	1	8%	31%	49%	11%
4	2	10%	23%	55%	13%
4	3	8%	28%	52%	12%

Table 51: Shares of selling orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	14%	14%	51%	21%
1	2	12%	19%	48%	21%
1	3	11%	43%	34%	11%
2	1	18%	11%	52%	18%
2	2	16%	16%	54%	15%
2	3	13%	24%	53%	10%
3	1	32%	11%	41%	16%
3	2	37%	11%	40%	12%
3	3	36%	13%	41%	10%
4	1	13%	7%	34%	46%
4	2	34%	12%	40%	15%
4	3	49%	13%	31%	8%

Table 52: Shares of buying orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	10%	15%	44%	24%
1	2	18%	11%	53%	18%
1	3	47%	7%	40%	5%
2	1	27%	9%	48%	16%
2	2	31%	8%	48%	12%
2	3	33%	9%	45%	10%
3	1	21%	7%	55%	15%
3	2	18%	6%	55%	11%
3	3	10%	4%	34%	5%
4	1	12%	27%	48%	14%
4	2	14%	12%	57%	7%
4	3	10%	7%	29%	4%

Table 53: Shares of price renewal selling orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	22%	9%	48%	21%
1	2	22%	11%	48%	12%
1	3	14%	5%	18%	4%
2	1	24%	5%	52%	16%
2	2	21%	5%	52%	12%
2	3	10%	3%	30%	6%
3	1	31%	6%	45%	17%
3	2	36%	5%	45%	13%
3	3	36%	7%	43%	10%
4	1	4%	5%	31%	60%
4	2	33%	7%	42%	18%
4	3	48%	10%	34%	7%

Table 54: Shares of price renewal buying orders with different levels of market returns and thinnesses

- ***Tables and figure of 26th August 2015 - Up 2.70%***

Figure 6: Executed volumes vs price changes, 26th August

Return	Thinness	# of times
1	1	12
1	2	131
1	3	212
2	1	1488
2	2	3018
2	3	1858
3	1	1445
3	2	2928
3	3	2303
4	1	11
4	2	144
4	3	241

Table 55: Number of times for intervals with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	26%	28%	28%	17%
1	2	45%	22%	22%	10%
1	3	51%	19%	24%	6%
2	1	35%	16%	39%	11%
2	2	39%	17%	35%	9%
2	3	40%	16%	37%	7%
3	1	24%	15%	47%	14%
3	2	23%	17%	47%	13%
3	3	19%	21%	50%	10%
4	1	11%	27%	43%	20%
4	2	21%	22%	43%	14%
4	3	16%	30%	42%	12%

Table 56: Shares of selling orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	12%	15%	52%	20%
1	2	20%	18%	48%	14%
1	3	15%	28%	45%	13%
2	1	23%	13%	47%	17%
2	2	20%	15%	50%	14%
2	3	15%	20%	53%	12%
3	1	31%	14%	39%	16%
3	2	35%	15%	39%	11%
3	3	37%	12%	41%	10%
4	1	27%	18%	25%	31%
4	2	38%	17%	31%	15%
4	3	45%	14%	29%	11%

Table 57: Shares of buying orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	22%	17%	37%	25%
1	2	46%	15%	25%	14%
1	3	54%	13%	25%	7%
2	1	38%	11%	39%	11%
2	2	41%	11%	38%	9%
2	3	40%	13%	38%	7%
3	1	34%	11%	43%	11%
3	2	32%	9%	43%	8%
3	3	20%	7%	30%	5%
4	1	35%	9%	48%	8%
4	2	43%	10%	35%	9%
4	3	23%	9%	28%	5%

Table 58: Shares of price renewal selling orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	37%	19%	33%	12%
1	2	33%	8%	44%	12%
1	3	25%	8%	35%	7%
2	1	28%	8%	47%	17%
2	2	27%	7%	46%	14%
2	3	18%	5%	33%	7%
3	1	32%	8%	42%	18%
3	2	36%	8%	43%	13%
3	3	38%	7%	41%	11%
4	1	22%	8%	35%	35%
4	2	38%	10%	34%	18%
4	3	46%	8%	32%	13%

Table 59: Shares of price renewal buying orders with different levels of market returns and thinnesses

3.2.3 8th and 9th July

- ***Tables and figure of 8th July 2015 - Down 2.69%***

Figure 7: Executed volumes vs price changes, 8th July

The Nikkei 225 index dropped by 2.69% on 8th and increased by 2.23% on 9th July. The returns of the 10 representative stocks are as follows:

Trading date	Nikkei 225 index return	10 stock average return
8th July	-2.69%	-2.88%
9th July	2.23%	2.73%

Table 60: The Nikkei 225 index and 10 representative stock return

We observe that on 8th, the shares of the selling volumes for Server type A are skewed to the situations of the price falls and on 9th, the shares of the buying volumes for Server type A are biased toward the situations with the price rises.

Return	Thinness	# of times
1	1	6
1	2	6
1	3	24
2	1	1783
2	2	2594
2	3	1696
3	1	1511
3	2	2525
3	3	1632
4	1	1
4	2	13
4	3	20

Table 61: Number of times for intervals with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	13%	26%	41%	21%
1	2	24%	23%	30%	22%
1	3	43%	9%	32%	16%
2	1	30%	15%	39%	16%
2	2	33%	13%	40%	13%
2	3	27%	11%	50%	12%
3	1	14%	17%	53%	17%
3	2	12%	18%	57%	13%
3	3	13%	24%	53%	10%
4	1	9%	27%	56%	8%
4	2	15%	27%	49%	9%
4	3	9%	32%	43%	16%

Table 62: Shares of selling orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	8%	7%	61%	22%
1	2	4%	11%	58%	26%
1	3	5%	19%	68%	8%
2	1	17%	12%	51%	20%
2	2	14%	15%	54%	16%
2	3	15%	18%	56%	12%
3	1	36%	11%	37%	16%
3	2	39%	10%	37%	14%
3	3	31%	8%	49%	12%
4	1	17%	10%	55%	18%
4	2	33%	3%	41%	22%
4	3	44%	8%	42%	6%

Table 63: Shares of buying orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	5%	11%	54%	30%
1	2	21%	19%	35%	25%
1	3	30%	5%	40%	25%
2	1	27%	10%	45%	18%
2	2	30%	9%	45%	14%
2	3	25%	7%	53%	11%
3	1	16%	7%	55%	16%
3	2	12%	6%	47%	14%
3	3	7%	3%	26%	5%
4	1	12%	7%	61%	20%
4	2	7%	2%	48%	5%
4	3	6%	0%	19%	0%

Table 64: Shares of price renewal selling orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	15%	19%	42%	25%
1	2	19%	1%	67%	13%
1	3	4%	0%	21%	0%
2	1	19%	6%	52%	18%
2	2	14%	4%	48%	14%
2	3	8%	2%	26%	6%
3	1	34%	8%	40%	18%
3	2	35%	6%	42%	16%
3	3	29%	4%	52%	12%
4	1	14%	1%	79%	6%
4	2	26%	1%	45%	27%
4	3	41%	6%	46%	7%

Table 65: Shares of price renewal buying orders with different levels of market returns and thinnesses

- ***Tables and figure of 9th July 2015 - Up 2.23%***

Figure 8: Executed volumes vs price changes, 9th July

Return	Thinness	# of times
1	1	10
1	2	36
1	3	57
2	1	1526
2	2	2962
2	3	1716
3	1	1620
3	2	3105
3	3	2011
4	1	9
4	2	68
4	3	59

Table 66: Number of times for intervals with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	19%	12%	43%	26%
1	2	36%	15%	30%	19%
1	3	40%	12%	30%	18%
2	1	33%	15%	37%	16%
2	2	39%	13%	35%	14%
2	3	36%	10%	43%	11%
3	1	18%	15%	48%	19%
3	2	14%	17%	53%	16%
3	3	13%	21%	56%	10%
4	1	16%	29%	44%	11%
4	2	12%	23%	42%	22%
4	3	11%	28%	51%	10%

Table 67: Shares of selling orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	24%	20%	43%	14%
1	2	17%	22%	36%	25%
1	3	10%	38%	39%	13%
2	1	19%	13%	46%	22%
2	2	15%	16%	51%	18%
2	3	14%	20%	53%	13%
3	1	32%	12%	36%	20%
3	2	39%	11%	35%	14%
3	3	34%	10%	43%	13%
4	1	21%	12%	40%	27%
4	2	38%	12%	30%	20%
4	3	58%	9%	25%	7%

Table 68: Shares of buying orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	9%	4%	47%	29%
1	2	32%	6%	38%	24%
1	3	37%	6%	37%	18%
2	1	30%	9%	42%	18%
2	2	36%	7%	40%	16%
2	3	35%	6%	45%	11%
3	1	20%	8%	49%	18%
3	2	15%	7%	47%	15%
3	3	8%	3%	28%	5%
4	1	25%	9%	50%	16%
4	2	15%	7%	46%	26%
4	3	12%	1%	23%	2%

Table 69: Shares of price renewal selling orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	36%	13%	36%	15%
1	2	18%	7%	46%	22%
1	3	15%	2%	20%	8%
2	1	20%	5%	51%	22%
2	2	16%	5%	51%	17%
2	3	9%	2%	34%	7%
3	1	29%	7%	42%	22%
3	2	36%	5%	42%	16%
3	3	32%	6%	46%	13%
4	1	17%	3%	48%	32%
4	2	30%	8%	40%	22%
4	3	55%	11%	27%	7%

Table 70: Shares of price renewal buying orders with different levels of market returns and thinnesses

3.3 Shares of executed orders on a quiet day: Tables and figure of 17th July 2015 - Up 0.02%

In this subsection, we present shares of buying/selling for the four server types on 17th July 2015 as an example of a low volatility day as opposed to the days in the swings and roundabouts in Section 3.2.

Figure 9: Executed volumes vs price changes, 17th July

The horizontally long scattered diagram indicates that the market was thick. The Nikkei 225 index is almost unchanged on 17th; it increased only by 0.02%. The returns of the 10 representative stocks are as follows:

Trading date	Nikkei 225 index return	10 stock average return
8th July	+0.02%	+0.22%

Table 71: The Nikkei 225 index and 10 representative stock return

Although most of the price movements are small in the day, we observe similar trading patterns to the days in the swings and roundabouts for each server type. Server type A takes a trend following strategy; we observe that the shares of the selling/buying volumes for Server type A are skewed to the situations of the price falls/increases. Server types B & D have constant shares in both buying and selling, and Server type C has large shares.

Return	Thinness	# of times
1	1	0
1	2	3
1	3	7
2	1	1041
2	2	1411
2	3	1196
3	1	1031
3	2	1414
3	3	1236
4	1	0
4	2	0
4	3	7

Table 72: Number of times for intervals with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	N/A	N/A	N/A	N/A
1	2	30%	14%	25%	9%
1	3	25%	10%	48%	14%
2	1	21%	12%	48%	19%
2	2	21%	10%	52%	17%
2	3	15%	9%	59%	18%
3	1	8%	11%	61%	19%
3	2	10%	13%	60%	17%
3	3	14%	16%	54%	16%
4	1	N/A	N/A	N/A	N/A
4	2	N/A	N/A	N/A	N/A
4	3	13%	16%	67%	5%

Table 73: Shares of selling orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	N/A	N/A	N/A	N/A
1	2	47%	12%	26%	14%
1	3	8%	21%	65%	6%
2	1	9%	14%	57%	19%
2	2	10%	14%	61%	14%
2	3	13%	15%	61%	11%
3	1	24%	15%	43%	19%
3	2	24%	12%	49%	15%
3	3	17%	10%	60%	12%
4	1	N/A	N/A	N/A	N/A
4	2	N/A	N/A	N/A	N/A
4	3	39%	14%	36%	11%

Table 74: Shares of buying orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	N/A	N/A	N/A	N/A
1	2	53%	4%	38%	1%
1	3	10%	2%	55%	22%
2	1	15%	10%	54%	21%
2	2	15%	7%	58%	18%
2	3	12%	6%	60%	16%
3	1	7%	6%	56%	14%
3	2	6%	3%	45%	9%
3	3	3%	2%	21%	5%
4	1	N/A	N/A	N/A	N/A
4	2	N/A	N/A	N/A	N/A
4	3	0%	0%	0%	0%

Table 75: Shares of price renewal selling orders with different levels of market returns and thinnesses

Return	Thinness	Server type A	Server type B	Server type C	Server type D
1	1	N/A	N/A	N/A	N/A
1	2	31%	9%	26%	0%
1	3	14%	14%	43%	0%
2	1	8%	7%	57%	14%
2	2	7%	4%	40%	9%
2	3	4%	2%	18%	3%
3	1	18%	10%	51%	21%
3	2	20%	10%	53%	15%
3	3	15%	8%	61%	11%
4	1	N/A	N/A	N/A	N/A
4	2	N/A	N/A	N/A	N/A
4	3	34%	25%	25%	16%

Table 76: Shares of price renewal buying orders with different levels of market returns and thinnesses

4 Buying levels in the price falls and P&L of Server type B

As we have observed in Section 3.1, Server type B has certain shares of buying orders in the price falling situations. In order to examine trading patterns of the server type in the situations in more detail, this section investigates the price levels where Server type B buys in the price falls. Particularly, we further classify the servers in Server type B by aggressiveness and observe their shares and execution levels in the price falls. In addition, we observe P&L of Server type B on trading of the 10 stocks on two price falling days, 8th July and 1st September 2015.

4.1 Buying levels of Server type B in the price falls

Firstly, we investigate at which levels the servers bought the stocks in the price falling intervals with a negative return more than 10 bps or 20 bps on 8th July and 1st September 2015. For each server type, we take the volume weighted average of the buying levels over the price falling intervals. The levels are expressed in percentage where 100% is the high price and 0% is the low price in the 10 seconds. The servers are classified based on the trading data of all the listed stocks in TSE of the corresponding date. Aggressiveness of a server is defined as the ratio of aggressively executed orders to all orders executed by the server. We say that an order is aggressively executed when the server buys or sells the stock by taking orders placed in the opposite side of the order book, which is identified in our data set.

Tables 77 & 78 show the buying levels of Server type B and the other server types on 8th July 2015 in the intervals with negative returns more than 10 bps and 20 bps, respectively. Tables 79 & 80 illustrate the buying levels of servers in Server type B further classified by the aggressiveness. In these tables, the shares are calculated as the ratio of the executed volume of the server type to that of the total servers.

We observe that in these price falling situations, Server type B buys at lower levels than the other server types. Moreover, the servers with aggressiveness 0-20% in Server type B has the largest share. The same observation holds for 1st September 2015 as in Tables 81 - 84.

	Share	Buying level
Server type B	21%	20%
others	79%	33%

Table 77: Server type B's buying level in the intervals with negative return greater than 10 bps, 8th July 2015

	Share	Buying level
Server type B	16%	21%
others	84%	38%

Table 78: Server type B's buying level in the intervals with negative return greater than 20 bps, 8th July 2015

Server type B	Share	Buying level
Aggressiveness 0.8-1.0	0%	N/A
Aggressiveness 0.6-0.8	0%	26%
Aggressiveness 0.4-0.6	2%	21%
Aggressiveness 0.2-0.4	3%	28%
Aggressiveness 0.0-0.2	16%	18%

Table 79: Server type B's buying level by aggressiveness in the intervals with negative return greater than 10 bps, 8th July 2015

Server type B	Share	Buying level
Aggressiveness 0.8-1.0	0%	N/A
Aggressiveness 0.6-0.8	0%	56%
Aggressiveness 0.4-0.6	1%	34%
Aggressiveness 0.2-0.4	2%	41%
Aggressiveness 0.0-0.2	13%	17%

Table 80: Server type B's buying level by aggressiveness in the intervals with negative return greater than 20 bps, 8th July 2015

	Share	Buying level
Server type B	24%	28%
others	76%	36%

Table 81: Server type B's buying level in the intervals with negative return greater than 10 bps, 1st September 2015

	Share	Buying level
Server type B	31%	35%
Others	69%	42%

Table 82: Server type B's buying level in the intervals with negative return greater than 20 bps, 1st September 2015

Server type B	Share	Buying level
Aggressiveness 0.8-1.0	0%	51%
Aggressiveness 0.6-0.8	0%	51%
Aggressiveness 0.4-0.6	1%	41%
Aggressiveness 0.2-0.4	5%	37%
Aggressiveness 0.0-0.2	16%	24%

Table 83: Server type B's buying level by aggressiveness in the intervals with negative return greater than 10 bps, 1st September 2015

Server type B	Share	Buying level
Aggressiveness 0.8-1.0	0%	42%
Aggressiveness 0.6-0.8	0%	37%
Aggressiveness 0.4-0.6	1%	49%
Aggressiveness 0.2-0.4	7%	47%
Aggressiveness 0.0-0.2	22%	30%

Table 84: Server type B's buying level by aggressiveness in the intervals with negative return greater than 20 bps, 1st September 2015

4.2 Execution share and change in order volume of Server type B by aggressiveness

Tables 85-92 show the execution shares and changes in order volume of Server type B by aggressiveness on 1st September 2015. This corresponds to Server type B in Tables 10-17 in Section 3.1. Here, the classification is based on the order data on 8th July 2015 as in Section 3.1. We observe that cancellation of buying orders in the price falls is done by passive servers with aggressiveness 0.0-0.2, and the addition of the selling orders in the price falls are done by the servers with aggressiveness 0.2-0.4. We also observe that the selling/buying execution shares in the price falls/rises are mostly had by passive servers with aggressiveness 0.0-0.2.

	Executed order volume	Change in order volume	Price renewal
Aggressiveness 0.8-1.0	0%	0%	0.00
Aggressiveness 0.6-0.8	0%	-4%	0.02
Aggressiveness 0.4-0.6	1%	11%	0.08
Aggressiveness 0.2-0.4	2%	37%	0.13
Aggressiveness 0.0-0.2	18%	-88%	0.21

Table 85: Intervals with a negative return greater than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Aggressiveness 0.8-1.0	0%	0%	0.00
Aggressiveness 0.6-0.8	1%	-1%	0.09
Aggressiveness 0.4-0.6	5%	24%	0.36
Aggressiveness 0.2-0.4	4%	114%	0.22
Aggressiveness 0.0-0.2	7%	-25%	0.36

Table 86: Intervals with a negative return greater than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Aggressiveness 0.8-1.0	0%	0%	0.00
Aggressiveness 0.6-0.8	0%	0%	0.03
Aggressiveness 0.4-0.6	1%	12%	0.06
Aggressiveness 0.2-0.4	2%	54%	0.08
Aggressiveness 0.0-0.2	10%	-51%	0.10

Table 87: Intervals with a negative return less than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Aggressiveness 0.8-1.0	0%	0%	0.00
Aggressiveness 0.6-0.8	1%	0%	0.03
Aggressiveness 0.4-0.6	6%	21%	0.28
Aggressiveness 0.2-0.4	4%	90%	0.16
Aggressiveness 0.0-0.2	7%	-22%	0.19

Table 88: Intervals with a negative return less than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Aggressiveness 0.8-1.0	0%	0%	0.00
Aggressiveness 0.6-0.8	1%	0%	0.04
Aggressiveness 0.4-0.6	3%	36%	0.15
Aggressiveness 0.2-0.4	3%	102%	0.12
Aggressiveness 0.0-0.2	6%	-26%	0.18

Table 89: Intervals with a positive return less than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Aggressiveness 0.8-1.0	0%	0%	0.00
Aggressiveness 0.6-0.8	1%	0%	0.02
Aggressiveness 0.4-0.6	3%	-1%	0.10
Aggressiveness 0.2-0.4	3%	52%	0.06
Aggressiveness 0.0-0.2	13%	-50%	0.10

Table 90: Intervals with a positive return less than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Aggressiveness 0.8-1.0	0%	0%	0.00
Aggressiveness 0.6-0.8	1%	0%	0.06
Aggressiveness 0.4-0.6	2%	52%	0.16
Aggressiveness 0.2-0.4	3%	102%	0.33
Aggressiveness 0.0-0.2	8%	-34%	0.49

Table 91: Intervals with a positive return greater than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Aggressiveness 0.8-1.0	0%	0%	0.00
Aggressiveness 0.6-0.8	0%	-5%	0.04
Aggressiveness 0.4-0.6	1%	2%	0.12
Aggressiveness 0.2-0.4	3%	28%	0.09
Aggressiveness 0.0-0.2	21%	-92%	0.18

Table 92: Intervals with a positive return greater than 0.10%, sell orders

4.3 P&L of Server type B

Next, we investigate P&L that Server type B made on 8th July and 1st of September 2015 in trading of the 10 stocks. Table 93 shows P&L of Server type B and the other server types together with their returns on trading volume for the 10 stocks on 8th July 2015. The trading volume is calculated as the net cash amount paid/received on buying/selling the stocks. Table 94 presents those of servers in Server type B further classified by the aggressiveness. P&L of a server is defined as the mark-to-market of its position at the end of the day. Tables 95 & 96 are the same analysis for 1st September 2015. Sections 4.2.1 and 4.2.2 present the corresponding results by ticker.

We observe that on both 8th July and 1st September 2015 when the stock prices fell largely, Server type B made a profit on trading of the stocks from the other server types. In detail, Server type B earned a profit on 10 out of 10 stocks on 8th July and 9 out of 10 stocks on 1st September 2015. Particularly, Server type B with aggressiveness 40 - 60% made a large portion of Server type B' profit with high returns on trading volume. Server type B with aggressiveness 0-20% has the largest share in trading volume and shows a constant profit.

	Share	P&L	Total volume in cash	P&L vs Total volume
Server type B	14%	336,540,010	134,772,260,696	0.25%
Others	86%	-335,466,010	827,602,148,834	-0.04%

Table 93: P&L of Server type B and the others, 8th July 2015

Server type B	Share	P&L	Total volume in cash	P&L vs Total volume
Aggressiveness 0.8-1.0	0%	0	0	N/A
Aggressiveness 0.6-0.8	1%	18,746,210	4,880,967,365	0.38%
Aggressiveness 0.4-0.6	3%	196,431,190	24,746,065,522	0.79%
Aggressiveness 0.2-0.4	3%	38,632,820	31,944,427,532	0.12%
Aggressiveness 0.0-0.2	8%	82,734,430	75,683,095,172	0.11%

Table 94: P&L of Server type B by aggressiveness, 8th July 2015

	Share	P&L	Total volume in cash	P&L vs total volume
Server type B	22%	207,084,590	164,108,079,984	0.13%
others	78%	-207,084,590	588,853,030,054	-0.04%

Table 95: P&L of Server type B and the others, 1st September 2015

Server type B	Share	P&L	Total volume in cash	P&L vs total volume
Aggressiveness 0.8-1.0	1%	9,553,330	11,194,668,720	0.09%
Aggressiveness 0.6-0.8	2%	27,046,050	11,595,633,917	0.23%
Aggressiveness 0.4-0.6	4%	94,644,080	28,753,740,717	0.33%
Aggressiveness 0.2-0.4	6%	-18,010,500	43,568,305,655	-0.04%
Aggressiveness 0.0-0.2	9%	93,940,410	68,479,613,585	0.14%

Table 96: P&L of Server type B by aggressiveness, 1st September 2015

4.3.1 P&L of Server type B by ticker, 8th July 2015

Table 97 shows daily returns of the 10 stocks on 8th July 2015.

Ticker	Start price	End price	Daily return
8316	5461	5230	-4.23%
8411	264	253.3	-4.05%
8306	875	840.5	-3.94%
6758	3445	3322	-3.57%
6762	8990	8720	-3.00%
7270	4428.5	4318.5	-2.48%
7267	3930	3835	-2.42%
9984	7084	6934	-2.12%
7203	8092	7931	-1.99%
2802	2628.5	2602	-1.01%

Table 97: 8th July 2015 Daily return by ticker

Tables 98-117 show P&L of Server type B corresponding to Tables 93 & 94 for each individual stock.

- 8316

	Share	P&L	Total volume in cash	P&L vs total volume
Server type B	16%	41,105,300	20,579,500,040	0.20%
others	84%	-41,105,300	107,999,925,528	-0.04%

Table 98: 8th July 2015 P&L, 8316

Server type B	Share	P&L	Total volume in cash	P&L vs total volume
Aggressiveness 0.8-1.0	0%	0	0	N/A
Aggressiveness 0.6-0.8	1%	3,492,200	767,003,600	0.46%
Aggressiveness 0.4-0.6	3%	20,207,700	3,255,798,040	0.62%
Aggressiveness 0.2-0.4	4%	-274,200	4,867,563,536	-0.01%
Aggressiveness 0.0-0.2	9%	17,755,200	11,681,200,344	0.15%

Table 99: 8th July 2015 P&L, 8316

- 8411

	Share	P&L	Total volume in cash	P&L vs total volume
Server type B	15%	39,453,340	24,121,638,711	0.16%
others	85%	-39,453,340	135,323,174,681	-0.03%

Table 100: 8th July 2015 P&L, 8411

Server type B	Share	P&L	Total volume in cash	P&L vs total volume
Aggressiveness 0.8-1.0	0%	0	0	N/A
Aggressiveness 0.6-0.8	0%	3,157,530	761,826,127	0.41%
Aggressiveness 0.4-0.6	3%	31,082,340	4,745,423,124	0.65%
Aggressiveness 0.2-0.4	3%	5,109,730	4,117,529,988	0.12%
Aggressiveness 0.0-0.2	9%	119,680	14,489,841,600	0.00%

Table 101: 8th July 2015 P&L, 8411

- 8306

	Share	P&L	Total volume in cash	P&L vs total volume
Server type B	16%	148,911,620	27,365,561,740	0.54%
others	84%	-148,911,620	147,907,571,900	-0.10%

Table 102: 8th July 2015 P&L, 8306

Server type B	Share	P&L	Total volume in cash	P&L vs total volume
Aggressiveness 0.8-1.0	0%	0	0	N/A
Aggressiveness 0.6-0.8	1%	8,127,530	1,598,529,416	0.51%
Aggressiveness 0.4-0.6	4%	84,078,450	6,408,822,288	1.31%
Aggressiveness 0.2-0.4	4%	34,527,440	6,543,215,712	0.53%
Aggressiveness 0.0-0.2	7%	22,178,200	12,814,994,324	0.17%

Table 103: 8th July 2015 P&L, 8306

- 6758

	Share	P&L	Total volume in cash	P&L vs total volume
Server type B	12%	26,040,250	6,968,998,680	0.37%
others	88%	-26,040,250	50,760,615,640	-0.05%

Table 104: 8th July 2015 P&L, 6758

Server type B	Share	P&L	Total volume in cash	P&L vs total volume
Aggressiveness 0.8-1.0	0%	0	0	N/A
Aggressiveness 0.6-0.8	0%	175,750	76,374,440	0.23%
Aggressiveness 0.4-0.6	1%	6,001,800	638,706,600	0.94%
Aggressiveness 0.2-0.4	2%	1,315,000	1,298,365,480	0.10%
Aggressiveness 0.0-0.2	9%	18,511,000	4,932,572,240	0.38%

Table 105: 8th July 2015 P&L, 6758

- 6762

	Share	P&L	Total volume in cash	P&L vs total volume
Server type B	18%	4,487,000	4,376,135,160	0.10%
others	82%	-4,487,000	20,479,961,052	-0.02%

Table 106: 8th July 2015 P&L, 6762

Server type B	Share	P&L	Total volume in cash	P&L vs total volume
Aggressiveness 0.8-1.0	0%	0	0	N/A
Aggressiveness 0.6-0.8	0%	-120,000	101,055,330	-0.12%
Aggressiveness 0.4-0.6	2%	1,181,000	459,582,066	0.26%
Aggressiveness 0.2-0.4	5%	1,939,000	1,275,933,384	0.15%
Aggressiveness 0.0-0.2	10%	1,497,000	2,532,534,444	0.06%

Table 107: 8th July 2015 P&L, 6762

- 7270

	Share	P&L	Total volume in cash	P&L vs total volume
Server type B	14%	19,083,450	4,876,461,656	0.39%
others	86%	-19,083,450	29,405,957,424	-0.06%

Table 108: 8th July 2015 P&L, 7270

Server type B	Share	P&L	Total volume in cash	P&L vs total volume
Aggressiveness 0.8-1.0	0%	0	0	N/A
Aggressiveness 0.6-0.8	1%	1,755,500	198,440,274	0.88%
Aggressiveness 0.4-0.6	2%	5,836,550	628,175,172	0.93%
Aggressiveness 0.2-0.4	3%	2,960,600	961,975,368	0.31%
Aggressiveness 0.0-0.2	9%	8,529,900	3,086,556,668	0.28%

Table 109: 8th July 2015 P&L, 7270

- 7267

	Share	P&L	Total volume in cash	P&L vs total volume
Server type B	16%	11,231,650	6,574,658,238	0.17%
others	84%	-11,231,650	34,158,475,356	-0.03%

Table 110: 8th July 2015 P&L, 7267

Server type B	Share	P&L	Total volume in cash	P&L vs total volume
Aggressiveness 0.8-1.0	0%	0	0	N/A
Aggressiveness 0.6-0.8	1%	735,600	215,746,709	0.34%
Aggressiveness 0.4-0.6	2%	6,433,650	842,070,638	0.76%
Aggressiveness 0.2-0.4	4%	1,512,850	1,705,444,811	0.09%
Aggressiveness 0.0-0.2	9%	2,525,650	3,804,811,351	0.07%

Table 111: 8th July 2015 P&L, 7267

- 9984

	Share	P&L	Total volume in cash	P&L vs total volume
Server type B	12%	7,311,900	21,997,144,080	0.03%
others	88%	-7,311,900	160,852,988,400	0.00%

Table 112: 8th July 2015 P&L, 9984

Server type B	Share	P&L	Total volume in cash	P&L vs total volume
Aggressiveness 0.8-1.0	0%	0	0	N/A
Aggressiveness 0.6-0.8	1%	1,716,000	1,031,224,560	0.17%
Aggressiveness 0.4-0.6	2%	9,589,500	3,921,567,960	0.24%
Aggressiveness 0.2-0.4	3%	-8,188,300	6,004,141,920	-0.14%
Aggressiveness 0.0-0.2	6%	4,170,300	11,033,964,000	0.04%

Table 113: 8th July 2015 P&L, 9984

- 7203

	Share	P&L	Total volume in cash	P&L vs total volume
Server type B	11%	38,378,500	17,911,625,391	0.21%
others	89%	-38,378,500	140,712,941,853	-0.03%

Table 114: 8th July 2015 P&L, 7203

Server type B	Share	P&L	Total volume in cash	P&L vs total volume
Aggressiveness 0.8-1.0	0%	0	0	N/A
Aggressiveness 0.6-0.8	0%	-37,400	88,802,109	-0.04%
Aggressiveness 0.4-0.6	2%	31,884,200	3,588,885,234	0.89%
Aggressiveness 0.2-0.4	3%	-1,716,800	4,485,706,533	-0.04%
Aggressiveness 0.0-0.2	6%	8,237,500	9,743,431,401	0.08%

Table 115: 8th July 2015 P&L, 7203

- 2802

	Share	P&L	Total volume in cash	P&L vs total volume
Server type B	18%	537,000	2,546,738,800	0.02%
others	82%	-537,000	11,485,241,200	0.00%

Table 116: 8th July 2015 P&L, 2802

Server type B	Share	P&L	Total volume in cash	P&L vs total volume
Aggressiveness 0.8-1.0	0%	0	0	N/A
Aggressiveness 0.6-0.8	0%	-256,500	41,964,800	-0.61%
Aggressiveness 0.4-0.6	2%	136,000	257,034,400	0.05%
Aggressiveness 0.2-0.4	5%	1,447,500	684,550,800	0.21%
Aggressiveness 0.0-0.2	11%	-790,000	1,563,188,800	-0.05%

Table 117: 8th July 2015 P&L, 2802

4.3.2 P&L of Server type B by ticker, 1st September 2015

ticker	start	end	daily return
6762	7360	7030	-4.48%
2802	2656	2550.5	-3.97%
7270	4230	4081	-3.52%
7267	3800	3679.5	-3.17%
8411	247	240	-2.83%
8306	797.1	777	-2.52%
9984	7030	6853	-2.52%
6758	3123.5	3051	-2.32%
8316	4913.5	4818	-1.94%
7203	7124	7000	-1.74%

Table 118: 1st September 2015 Daily return by ticker

- 6762

	Share	P&L	Total volume in cash	P&L vs total volume
Server type B	22%	-9,198,000	6,322,563,792	-0.15%
others	78%	9,198,000	23,018,195,584	0.04%

Table 119: 1st September 2015 P&L, 6762

Server type B	Share	P&L	Total volume in cash	P&L vs total volume
Aggressiveness 0.8-1.0	0%	-1,113,000	120,184,512	-0.93%
Aggressiveness 0.6-0.8	2%	-4,404,000	646,707,136	-0.68%
Aggressiveness 0.4-0.6	1%	-452,000	367,707,376	-0.12%
Aggressiveness 0.2-0.4	4%	-1,540,000	1,302,714,264	-0.12%
Aggressiveness 0.0-0.2	13%	-1,677,000	3,882,388,968	-0.04%

Table 120: 1st September 2015 P&L, 6762

- 2802

	Share	P&L	Total volume in cash	P&L vs total volume
Server type B	24%	17,019,500	3,706,461,640	0.46%
others	76%	-17,019,500	11,622,666,840	-0.15%

Table 121: 1st September 2015 P&L, 2802

Server type B	Share	P&L	Total volume in cash	P&L vs total volume
Aggressiveness 0.8-1.0	0%	271,000	41,940,160	0.65%
Aggressiveness 0.6-0.8	2%	651,000	243,777,180	0.27%
Aggressiveness 0.4-0.6	3%	3,927,500	495,418,140	0.79%
Aggressiveness 0.2-0.4	8%	10,179,000	1,226,749,680	0.83%
Aggressiveness 0.0-0.2	11%	2,007,000	1,640,908,760	0.12%

Table 122: 1st September 2015 P&L, 2802

- 7270

	Share	P&L	Total volume in cash	P&L vs total volume
Server type B	24%	6,811,350	9,242,261,532	0.07%
others	76%	-6,811,350	28,493,960,044	-0.02%

Table 123: 1st September 2015 P&L, 7270

Server type B	Share	P&L	Total volume in cash	P&L vs total volume
Aggressiveness 0.8-1.0	1%	757,650	291,742,776	0.26%
Aggressiveness 0.6-0.8	2%	2,446,500	809,149,836	0.30%
Aggressiveness 0.4-0.6	3%	7,286,150	1,099,645,848	0.66%
Aggressiveness 0.2-0.4	6%	276,500	2,446,566,556	0.01%
Aggressiveness 0.0-0.2	12%	-4,085,150	4,577,701,820	-0.09%

Table 124: 1st September 2015 P&L, 7270

- 7267

	Share	P&L	Total volume in cash	P&L vs total volume
Server type B	24%	7,575,150	8,851,859,280	0.09%
others	76%	-7,575,150	27,814,061,874	-0.03%

Table 125: 1st September 2015 P&L, 7267

Server type B	Share	P&L	Total volume in cash	P&L vs total volume
Aggressiveness 0.8-1.0	1%	539,450	240,669,238	0.22%
Aggressiveness 0.6-0.8	2%	541,250	744,360,894	0.07%
Aggressiveness 0.4-0.6	7%	3,620,900	2,613,831,848	0.14%
Aggressiveness 0.2-0.4	4%	-4,688,500	1,289,405,933	-0.36%
Aggressiveness 0.0-0.2	11%	7,652,750	3,930,061,597	0.19%

Table 126: 1st September 2015 P&L, 7267

- 8411

	Share	P&L	Total volume in cash	P&L vs total volume
Server type B	19%	44,960,260	22,059,147,366	0.20%
others	81%	-44,960,260	94,046,785,812	-0.05%

Table 127: 1st September 2015 P&L, 8411

Server type B	Share	P&L	Total volume in cash	P&L vs total volume
Aggressiveness 0.8-1.0	1%	2,253,690	1,038,211,651	0.22%
Aggressiveness 0.6-0.8	1%	9,616,690	792,372,741	1.21%
Aggressiveness 0.4-0.6	3%	20,764,210	3,784,454,434	0.55%
Aggressiveness 0.2-0.4	7%	3,221,730	8,640,468,677	0.04%
Aggressiveness 0.0-0.2	7%	9,051,320	7,784,890,679	0.12%

Table 128: 1st September 2015 P&L, 8411

- 8306

	Share	P&L	Total volume in cash	P&L vs total volume
Server type B	19%	20,878,480	22,629,179,246	0.09%
others	81%	-20,878,480	97,354,890,922	-0.02%

Table 129: 1st September 2015 P&L, 8306

Server type B	Share	P&L	Total volume in cash	P&L vs total volume
Aggressiveness 0.8-1.0	3%	3,353,390	3,285,602,956	0.10%
Aggressiveness 0.6-0.8	1%	8,258,060	1,234,048,488	0.67%
Aggressiveness 0.4-0.6	4%	23,592,220	5,314,497,008	0.44%
Aggressiveness 0.2-0.4	4%	-18,892,980	5,393,336,372	-0.35%
Aggressiveness 0.0-0.2	6%	4,567,790	7,401,694,422	0.06%

Table 130: 1st September 2015 P&L, 8306

- 9984

	Share	P&L	Total volume in cash	P&L vs total volume
Server type B	22%	18,751,000	22,673,152,892	0.08%
others	78%	-18,751,000	78,836,135,872	-0.02%

Table 131: 1st September 2015 P&L, 9984

Server type B	Share	P&L	Total volume in cash	P&L vs total volume
Aggressiveness 0.8-1.0	1%	-236,300	1,218,643,842	-0.02%
Aggressiveness 0.6-0.8	3%	1,370,900	3,259,421,698	0.04%
Aggressiveness 0.4-0.6	3%	5,252,100	3,280,910,867	0.16%
Aggressiveness 0.2-0.4	6%	-6,866,500	6,539,639,366	-0.10%
Aggressiveness 0.0-0.2	8%	19,364,700	8,274,716,463	0.23%

Table 132: 1st September 2015 P&L, 9984

- 6758

	Share	P&L	Total volume in cash	P&L vs total volume
Server type B	21%	24,449,750	13,555,727,319	0.18%
others	79%	-24,449,750	49,696,660,665	-0.05%

Table 133: 1st September 2015 P&L, 6758

Server type B	Share	P&L	Total volume in cash	P&L vs total volume
Aggressiveness 0.8-1.0	2%	2,319,550	1,533,530,730	0.15%
Aggressiveness 0.6-0.8	1%	-1,511,950	674,691,309	-0.22%
Aggressiveness 0.4-0.6	3%	468,600	2,209,777,344	0.02%
Aggressiveness 0.2-0.4	6%	11,777,100	3,621,994,284	0.33%
Aggressiveness 0.0-0.2	9%	11,442,350	5,452,277,208	0.21%

Table 134: 1st September 2015 P&L, 6758

- 8316

	Share	P&L	Total volume in cash	P&L vs total volume
Server type B	24%	14,032,600	22,308,564,957	0.06%
others	76%	-14,032,600	70,770,301,249	-0.02%

Table 135: 1st September 2015 P&L, 8316

Server type B	Share	P&L	Total volume in cash	P&L vs total volume
Aggressiveness 0.8-1.0	3%	420,400	2,787,168,991	0.02%
Aggressiveness 0.6-0.8	1%	3,917,000	1,377,252,475	0.28%
Aggressiveness 0.4-0.6	2%	5,455,900	2,279,657,548	0.24%
Aggressiveness 0.2-0.4	5%	-15,140,350	4,805,514,211	-0.32%
Aggressiveness 0.0-0.2	12%	19,394,250	10,941,966,212	0.18%

Table 136: 1st September 2015 P&L, 8316

- 7203

	Share	P&L	Total volume in cash	P&L vs total volume
Server type B	23%	61,804,500	32,759,161,960	0.19%
others	77%	-61,804,500	107,199,371,192	-0.06%

Table 137: 1st September 2015 P&L, 7203

Server type B	Share	P&L	Total volume in cash	P&L vs total volume
Aggressiveness 0.8-1.0	0%	987,500	636,973,864	0.16%
Aggressiveness 0.6-0.8	1%	6,160,600	1,813,852,160	0.34%
Aggressiveness 0.4-0.6	5%	24,728,500	7,307,840,304	0.34%
Aggressiveness 0.2-0.4	6%	3,663,500	8,301,916,312	0.04%
Aggressiveness 0.0-0.2	10%	26,222,400	14,593,007,456	0.18%

Table 138: 1st September 2015 P&L, 7203

4.4 P&L of Server type A

Tables 141-151 & 154-164 show the P&L of Server type A made in trading of the 10 representative stocks on 8th July and 1st September 2015, which correspond to the P&L of Server type B in Tables 93-138 in Section 4.3. We observe that Server type A also makes profits constantly for 8 out of 10 stocks on 8th July 2015 and 10 out of 10 stocks on 1st September 2015.

In addition, we calculate selling/buying execution shares of Server type A in price falls/rises from local high/low prices, which corresponds to the analysis in Section 3.1 and Appendix A. Tables 139, 140, 152 & 153 show selling/buying shares of Server type A in the 10 second intervals with price falls/rises from a local high/low price, which is the high/low price in 5 minutes before and after the interval for 8th July and 1st September 2015. These tables also show the shares in the price falls/rises from the other prices.

We observe that the selling/buying shares of Server type A in the small price falls/rises from the local high/low prices are high compared to those in the small price falls/rises from the other prices for both 8th July and 1st September 2015, while it is not the case with the 10 second intervals with price falls greater than 10 bps on 8th July 2015. This implies that Server type A captures the tops and bottoms particularly in the small price moves in making the profits, which may not be done by the other server types.

4.4.1 P&L of Server type A by ticker, 8th July 2015

	Selling share (fall from a local high price)	# of times	Selling share (other fall cases)	# of times
Negative return greater than 0.10%	25%	67	32%	423
Negative return less than 0.10%	37%	147	31%	5474

Table 139: Execution shares of Server type A in price falls, falls from a local high price vs other cases, 8th July 2015

	Buying share (rise from a local low price)	# of times	Buying share (other rise cases)	# of times
Positive return greater than 0.10%	52%	48	37%	365
Positive return less than 0.10%	46%	158	36%	5138

Table 140: Execution shares of Server type A in price rises, rises from a local low price vs other cases, 8th July 2015

	Share	P&L	Total volume in cash	P&L vs total volume
Server type A	23%	66,698,980	221,161,827,600	0.03%

Table 141: 8th July 2015 P&L

	Share	P&L	Total volume in cash	P&L vs total volume
Server type A	27%	1,573,500	3,850,166,500	0.04%

Table 142: 8th July 2015 P&L, 2802

	Share	P&L	Total volume in cash	P&L vs total volume
Server type A	21%	12,837,300	38,505,061,500	0.03%

Table 143: 8th July 2015 P&L, 9984

	Share	P&L	Total volume in cash	P&L vs total volume
Server type A	29%	4,974,800	11,857,364,400	0.04%

Table 144: 8th July 2015 P&L, 7267

	Share	P&L	Total volume in cash	P&L vs total volume
Server type A	27%	1,225,100	9,367,624,300	0.01%

Table 145: 8th July 2015 P&L, 7270

	Share	P&L	Total volume in cash	P&L vs total volume
Server type A	26%	-5,698,000	6,414,408,000	-0.09%

Table 146: 8th July 2015 P&L, 6762

	Share	P&L	Total volume in cash	P&L vs total volume
Server type A	24%	9,560,400	14,044,861,500	0.07%

Table 147: 8th July 2015 P&L, 6758

	Share	P&L	Total volume in cash	P&L vs total volume
Server type A	19%	8,952,220	33,853,746,090	0.03%

Table 148: 8th July 2015 P&L, 8306

	Share	P&L	Total volume in cash	P&L vs total volume
Server type A	19%	17,096,260	30,059,611,910	0.06%

Table 149: 8th July 2015 P&L, 8411

	Share	P&L	Total volume in cash	P&L vs total volume
Server type A	24%	-3,859,700	31,361,003,100	-0.01%

Table 150: 8th July 2015 P&L, 8316

	Share	P&L	Total volume in cash	P&L vs total volume
Server type A	26%	20,037,100	41,847,980,300	0.05%

Table 151: 8th July 2015 P&L, 7203

4.4.2 P&L of Server type A by ticker, 1st September 2015

	Selling share (fall from a local high price)	# of times	Selling share (other fall cases)	# of times
Negative return greater than 0.10%	35%	58	32%	654
Negative return less than 0.10%	37%	118	31%	5676

Table 152: Execution shares of Server type A in price falls, falls from a local high price vs other cases, 1st September 2015

	Buying share (rise from a local low price)	# of times	Buying share (other rise cases)	# of times
Positive return greater than 0.10%	40%	60	35%	594
Positive return less than 0.10%	41%	122	33%	5174

Table 153: Execution shares of Server type A in price rises, rises from a local low price vs other cases, 1st September 2015

	Share	P&L	Total volume in cash	P&L vs total volume
Server type A	22%	117,688,090	164,490,496,170	0.07%

Table 154: 1st September 2015 P&L

	Share	P&L	Total volume in cash	P&L vs total volume
Server type A	23%	9,449,900	23,379,046,900	0.04%

Table 155: 1st September 2015 P&L, 9984

	Share	P&L	Total volume in cash	P&L vs total volume
Server type A	27%	10,954,690	31,876,490,170	0.03%

Table 156: 1st September 2015 P&L, 8411

	Share	P&L	Total volume in cash	P&L vs total volume
Server type A	22%	15,518,250	20,205,512,350	0.08%

Table 157: 1st September 2015 P&L, 8316

	Share	P&L	Total volume in cash	P&L vs total volume
Server type A	19%	26,537,150	22,322,593,550	0.12%

Table 158: 1st September 2015 P&L, 8306

	Share	P&L	Total volume in cash	P&L vs total volume
Server type A	23%	4,007,900	8,577,699,100	0.05%

Table 159: 1st September 2015 P&L, 7270

	Share	P&L	Total volume in cash	P&L vs total volume
Server type A	25%	9,991,800	9,194,772,700	0.11%

Table 160: 1st September 2015 P&L, 7267

	Share	P&L	Total volume in cash	P&L vs total volume
Server type A	19%	25,138,600	26,373,838,800	0.10%

Table 161: 1st September 2015 P&L, 7203

	Share	P&L	Total volume in cash	P&L vs total volume
Server type A	21%	528,000	6,273,430,000	0.01%

Table 162: 1st September 2015 P&L, 6762

	Share	P&L	Total volume in cash	P&L vs total volume
Server type A	19%	5,021,800	12,246,886,600	0.04%

Table 163: 1st September 2015 P&L, 6758

	Share	P&L	Total volume in cash	P&L vs total volume
Server type A	26%	10,540,000	4,040,226,000	0.26%

Table 164: 1st September 2015 P&L, 2802

5 Conclusion

We have observed that various sorts of servers trade and place orders differently in the market movements. Particularly, Server type A follows the short-term market trend, selling in the price falls and buying in the price rises, which accelerates the market movements. Moreover, Server type A places large orders along with the price movements, which opposes to rebound of the stock price. We have also found that while Server type B cancels its buying/selling orders in the rapid price falls/rises, it has a constant share of buying/selling orders in such a situation. The other types, Server types C & D consistently buy/sell and place orders regardless of the market situation. Furthermore, we have investigated shares of the executed orders by the server type in the large swings and roundabout of the Nikkei 225 index, which occurred in July, August, and September 2015, and the two patterns have been observed. The first one is that the market is highly liquid and Server type C has the largest share of buying volume in the price rebound. The second one is that the market is thin and the stock prices rebound accompanying the large price fluctuations due to the trading of Server type A. In both cases, in the price falls of the swing and the roundabouts, Server type A has the largest share of selling volume. Also, we have investigated at which level Server type B buys the stocks in the price falls. We have observed that passive servers are the main buyers and they trade at low levels. Moreover, in the price falling days, Server types B&A make profits from the other server types. In particular, the aggressive servers earn most of the profit of Server type B.

Acknowledgment

We would like to express our gratitude to JPX for supplying the order data in TSE.

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A Changes in order volume for the other trading dates

This section provides the results of the same analysis as Section 3 for the other dates which are also investigated in Section 4.

A.0.1 4th September

	Executed order volume	Change in order volume	Price renewal
Server type A	13%	26%	1.06
Server type B	25%	-56%	0.47
Server type C	49%	32%	2.41
Server type D	13%	1%	0.54

Table 165: Intervals with a negative return greater than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	39%	156%	2.76
Server type B	18%	154%	1.09
Server type C	33%	74%	4.38
Server type D	10%	22%	1.18

Table 166: Intervals with a negative return greater than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	18%	28%	0.76
Server type B	18%	-18%	0.28
Server type C	51%	33%	1.81
Server type D	13%	9%	0.44

Table 167: Intervals with a negative return less than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	33%	101%	1.46
Server type B	18%	63%	0.64
Server type C	40%	67%	2.44
Server type D	9%	14%	0.54

Table 168: Intervals with a negative return less than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	35%	127%	1.56
Server type B	13%	46%	0.41
Server type C	42%	63%	2.41
Server type D	10%	17%	0.60

Table 169: Intervals with a positive return less than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	18%	20%	0.81
Server type B	22%	-29%	0.35
Server type C	50%	38%	1.69
Server type D	10%	5%	0.35

Table 170: Intervals with a positive return less than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	42%	169%	2.92
Server type B	15%	105%	1.07
Server type C	36%	67%	3.31
Server type D	8%	17%	0.81

Table 171: Intervals with a positive return greater than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	15%	23%	1.09
Server type B	26%	-94%	0.50
Server type C	48%	24%	2.04
Server type D	11%	1%	0.47

Table 172: Intervals with a positive return greater than 0.10%, sell orders

A.0.2 8th September

	Executed order volume	Change in order volume	Price renewal
Server type A	14%	21%	0.79
Server type B	25%	-43%	0.35
Server type C	50%	38%	1.52
Server type D	11%	2%	0.24

Table 173: Intervals with a negative return greater than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	35%	124%	2.24
Server type B	15%	112%	0.87
Server type C	42%	76%	2.99
Server type D	8%	29%	0.69

Table 174: Intervals with a negative return greater than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	19%	29%	0.57
Server type B	18%	-28%	0.19
Server type C	52%	39%	1.30
Server type D	11%	10%	0.22

Table 175: Intervals with a negative return less than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	36%	114%	1.22
Server type B	15%	76%	0.49
Server type C	39%	74%	1.83
Server type D	10%	29%	0.43

Table 176: Intervals with a negative return less than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	38%	126%	1.38
Server type B	13%	66%	0.44
Server type C	40%	82%	1.83
Server type D	9%	24%	0.42

Table 177: Intervals with a positive return less than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	18%	25%	0.53
Server type B	18%	-22%	0.23
Server type C	53%	39%	1.24
Server type D	11%	9%	0.26

Table 178: Intervals with a positive return less than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	39%	146%	2.16
Server type B	16%	129%	0.78
Server type C	37%	74%	2.71
Server type D	8%	16%	0.69

Table 179: Intervals with a positive return greater than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	15%	19%	0.64
Server type B	31%	-74%	0.37
Server type C	45%	25%	1.37
Server type D	10%	2%	0.28

Table 180: Intervals with a positive return greater than 0.10%, sell orders

A.0.3 9th September

	Executed order volume	Change in order volume	Price renewal
Server type A	17%	23%	1.18
Server type B	25%	-41%	0.42
Server type C	45%	29%	1.84
Server type D	13%	8%	0.39

Table 181: Intervals with a positive return greater than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	28%	95%	2.02
Server type B	14%	97%	0.91
Server type C	45%	75%	3.83
Server type D	13%	24%	1.20

Table 182: Intervals with a negative return greater than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	17%	29%	0.73
Server type B	15%	-20%	0.24
Server type C	54%	43%	1.54
Server type D	14%	5%	0.34

Table 183: Intervals with a negative return less than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	30%	100%	1.12
Server type B	12%	45%	0.47
Server type C	47%	75%	2.67
Server type D	11%	16%	0.65

Table 184: Intervals with a negative return less than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	37%	94%	1.71
Server type B	11%	42%	0.44
Server type C	42%	71%	2.27
Server type D	11%	24%	0.53

Table 185: Intervals with a positive return less than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	15%	22%	0.61
Server type B	15%	-14%	0.27
Server type C	57%	33%	2.08
Server type D	13%	6%	0.49

Table 186: Intervals with a positive return less than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	40%	110%	2.63
Server type B	13%	79%	0.80
Server type C	36%	72%	3.22
Server type D	11%	31%	0.81

Table 187: Intervals with a positive return greater than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	11%	22%	0.83
Server type B	23%	-42%	0.46
Server type C	53%	24%	2.23
Server type D	13%	15%	0.42

Table 188: Intervals with a positive return greater than 0.10%, sell orders

A.0.4 24th August

	Executed order volume	Change in order volume	Price renewal
Server type A	13%	19%	1.16
Server type B	27%	-69%	0.46
Server type C	46%	19%	3.44
Server type D	14%	13%	0.72

Table 189: Intervals with a negative return greater than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	35%	97%	2.50
Server type B	14%	123%	0.85
Server type C	40%	76%	5.27
Server type D	11%	29%	1.29

Table 190: Intervals with a negative return greater than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	16%	23%	1.04
Server type B	15%	-12%	0.28
Server type C	54%	33%	3.35
Server type D	15%	7%	0.83

Table 191: Intervals with a negative return less than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	31%	66%	1.65
Server type B	12%	49%	0.51
Server type C	45%	61%	3.78
Server type D	11%	17%	0.85

Table 192: Intervals with a negative return less than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	34%	78%	1.94
Server type B	11%	32%	0.49
Server type C	42%	55%	3.99
Server type D	13%	16%	1.08

Table 193: Intervals with a positive return less than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	14%	18%	0.86
Server type B	16%	-17%	0.34
Server type C	57%	38%	3.01
Server type D	13%	6%	0.59

Table 194: Intervals with a positive return less than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	41%	118%	3.04
Server type B	13%	95%	0.88
Server type C	34%	55%	4.76
Server type D	11%	21%	1.18

Table 195: Intervals with a positive return greater than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	11%	18%	1.00
Server type B	25%	-73%	0.41
Server type C	52%	23%	3.06
Server type D	12%	-3%	0.56

Table 196: Intervals with a positive return greater than 0.10%, sell orders

A.0.5 26th August

	Executed order volume	Change in order volume	Price renewal
Server type A	16%	30%	2.65
Server type B	20%	-25%	0.82
Server type C	50%	28%	3.98
Server type D	14%	10%	1.04

Table 197: Intervals with a negative return greater than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	44%	127%	5.29
Server type B	18%	81%	1.73
Server type C	29%	53%	4.71
Server type D	8%	17%	1.15

Table 198: Intervals with a negative return greater than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	20%	21%	1.54
Server type B	16%	-4%	0.44
Server type C	50%	28%	2.89
Server type D	14%	6%	0.83

Table 199: Intervals with a negative return less than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	37%	77%	2.72
Server type B	16%	30%	0.85
Server type C	38%	43%	2.99
Server type D	9%	14%	0.62

Table 200: Intervals with a negative return less than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	34%	75%	2.19
Server type B	14%	38%	0.58
Server type C	41%	54%	3.14
Server type D	12%	15%	0.94

Table 201: Intervals with a positive return less than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	22%	21%	1.65
Server type B	17%	-10%	0.53
Server type C	49%	28%	2.17
Server type D	12%	6%	0.41

Table 202: Intervals with a positive return less than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	40%	119%	4.31
Server type B	14%	93%	1.29
Server type C	35%	68%	5.24
Server type D	11%	28%	1.67

Table 203: Intervals with a positive return greater than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	18%	31%	2.61
Server type B	24%	-50%	0.95
Server type C	45%	23%	3.19
Server type D	12%	3%	0.57

Table 204: Intervals with a positive return greater than 0.10%, sell orders

A.0.6 8th July

	Executed order volume	Change in order volume	Price renewal
Server type A	11%	17%	0.52
Server type B	21%	-52%	0.31
Server type C	50%	29%	2.52
Server type D	18%	24%	0.81

Table 205: Intervals with a negative return greater than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	31%	109%	1.91
Server type B	14%	270%	0.75
Server type C	39%	89%	4.26
Server type D	16%	31%	1.10

Table 206: Intervals with a negative return greater than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	15%	22%	0.51
Server type B	14%	-19%	0.19
Server type C	54%	34%	1.93
Server type D	16%	11%	0.51

Table 207: Intervals with a negative return less than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	31%	90%	1.17
Server type B	13%	89%	0.42
Server type C	43%	75%	2.44
Server type D	13%	27%	0.62

Table 208: Intervals with a negative return less than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	36%	109%	1.24
Server type B	10%	42%	0.30
Server type C	41%	60%	2.34
Server type D	14%	29%	0.69

Table 209: Intervals with a positive return less than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	13%	17%	0.43
Server type B	19%	104%	0.21
Server type C	55%	44%	1.64
Server type D	13%	5%	0.40

Table 210: Intervals with a positive return less than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	38%	149%	1.79
Server type B	11%	94%	0.55
Server type C	37%	66%	6.40
Server type D	14%	35%	1.79

Table 211: Intervals with a positive return greater than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	9%	13%	0.36
Server type B	29%	-63%	0.31
Server type C	49%	44%	1.54
Server type D	14%	1%	0.36

Table 212: Intervals with a positive return greater than 0.10%, sell orders

A.0.7 9th July

	Executed order volume	Change in order volume	Price renewal
Server type A	17%	23%	1.18
Server type B	25%	-41%	0.42
Server type C	45%	29%	1.84
Server type D	13%	8%	0.39

Table 213: Intervals with a negative return greater than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	28%	95%	2.02
Server type B	14%	97%	0.91
Server type C	45%	75%	3.83
Server type D	13%	24%	1.20

Table 214: Intervals with a negative return greater than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	17%	29%	0.73
Server type B	15%	-20%	0.24
Server type C	54%	43%	1.54
Server type D	14%	5%	0.34

Table 215: Intervals with a negative return less than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	30%	100%	1.12
Server type B	12%	45%	0.47
Server type C	47%	75%	2.67
Server type D	11%	16%	0.65

Table 216: Intervals with a negative return less than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	37%	94%	1.71
Server type B	11%	42%	0.44
Server type C	42%	71%	2.27
Server type D	11%	24%	0.53

Table 217: Intervals with a positive return less than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	15%	22%	0.61
Server type B	15%	-14%	0.27
Server type C	57%	33%	2.08
Server type D	13%	6%	0.49

Table 218: Intervals with a positive return less than 0.10%, sell orders

	Executed order volume	Change in order volume	Price renewal
Server type A	40%	110%	2.63
Server type B	13%	79%	0.80
Server type C	36%	72%	3.22
Server type D	11%	31%	0.81

Table 219: Intervals with a positive return greater than 0.10%, buy orders

	Executed order volume	Change in order volume	Price renewal
Server type A	11%	22%	0.83
Server type B	23%	-42%	0.46
Server type C	53%	24%	2.23
Server type D	13%	15%	0.42

Table 220: Intervals with a positive return greater than 0.10%, sell orders

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