Intraday Price Behavior of the Nikkei Stock Average and the Nikkei 225 Futures

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要旨（Abstract）

アメリカの株式や株価指数先物を対象とした日中の取引状況に関する分析ではボラティリティと取引回数に関してU字型パターンが観察されているのに対して，わが国ではW字型パターンが観察されている。Chang, Fukuda, Rhee, and Takano (1993) はTOPIXの日中のリターンとボラティリティについてW字型パターンを報告しており，川原・村瀬 (1993) や宇野・山田 (1993) は東証1部上場株式に関して日中のボラティリティ，取引回数，取引量にW字型パターンを報告している。本稿ではTOPIXを対象としたChang et al. (1993) の分析手法とS&P500指数先物を対象としたEkman (1992) の分析手法を日経平均株価と日経平均先物に対して適用した。さらに，日経平均株価と日経平均先物価格の日中における先行／遅行関係を分刻みデータを用いて分析した。なお，日経平均先物に対する規制が厳しかった期間と厳しくなかった期間，および曜日ごとに標本を分類して分析を行った。

U-shaped intraday patterns have been documented for the return volatility and trade of the U.S. stocks and stock index futures, while W-shaped intraday patterns have been reported for those of the Japanese stocks. Chang, Fukuda, Rhee, and Takano (1993) document W-shaped intraday patterns for the return and volatility of the TOPIX. Similar results are reported by Kawahara and Murase (1993) and by Uno and Yamada (1993) for the volatility, number of transactions, and trading volume of the stocks listed in the first section of the Tokyo Stock Exchange. This paper attempts to extend the analysis of Chang et al. (1993) for the TOPIX and Ekman (1992)'s method for the S&P 500 futures to the Nikkei Stock Average and the Nikkei 225 futures. In addition, the lead-lag relations between the Nikkei Stock Average and the Nikkei 225 futures are also investigated. Furthermore, this paper analyzes the intraday return characteristics and the lead-lag relations of the Nikkei Stock Average and the Nikkei 225 futures for two subperiods (the non-regulated period and the regulated period) as well as weekly pattern subsamples.

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Contents

Ⅰ. Introduction

The study of market microstructure has become one of the most active fields in the analysis of capital markets. This literature originated in the United State and the U.S. market has been the main focus of the analysis. Wood, McInish, and Ord (1985), using transactions data, document a U-shaped intraday pattern in returns and standard deviations for the U.S. stocks. Similar results are reported by Jain and Joh (1988) in hourly returns and volatility of the S&P 500 and by Lockwood and Linn (1990) in hourly volatility of the Dow Jones Industrial Average. In addition, Ekman (1992) shows the U-shaped pattern in returns and volatility for the S&P 500 index futures.

The analysis of market microstructure has also been applied to the Japanese capital market. Kato (1990) uses hourly Tokyo Stock Price Index (TOPIX) to identify weekly patterns of returns and Amihud and Mendelson (1991) examine opening and closing return volatility of 50 stock prices. Chang, Fukuda, Rhee, and Takano (1993) document a W-shaped intraday pattern in returns and standard deviations of the TOPIX by using minute-by-minute data. Similar results are reported by Kawahara and Murase (1993) and by Uno and Yamada (1993) for intraday return volatility, numbers of transaction and volume of the stocks listed in the first section of the Tokyo Stock Exchange. As for the stock index futures, Uno (1994) analyzes tick-by-tick transactions of the Nikkei 225 futures, SIMEX Nikkei futures, and TOPIX futures and then Yoshikawa (1994) shows a W-shaped pattern for intraday return volatility and trading volume by using the minute-by-minute data of the Nikkei 225 futures, SIMEX Nikkei futures, TOPIX futures, and the newly introduced Nikkei 300 futures.

This paper applies the methods of Chang et al. (1993) and Ekman (1992) to analyze intraday price behaviors of the Nikkei Stock Average (NSA), the most popular Japanese stock index, and the Nikkei 225 futures, which is the most active stock index futures in the Japanese stock index futures market. In addition, the lead-lag relations between the NSA and the Nikkei 225 futures are also investigated by the vector autoregressive model which is similar to Kawaller, Koch, and Koch (1987) who analyze the relationship between the S&P 500 stock and the S&P 500 stock index futures.

This paper is organized as follows. Section II describes the data. Intraday returns are analyzed in section III and the return volatility, skewness, and kurtosis of intraday returns are analyzed in section IV. Section V investigates return reversals and section VI examines the lead-lag relations. Final section provides summary and conclusions.

II. Data

This study uses the minute-by-minute values of the NSA and the Nikkei 225 futures prices during the period between October 3, 1988 and September 8, 1994. The Osaka Securities Exchange (OSE) introduced the Nikkei 225 futures on September 3, 1988 which is the same day when the Tokyo Stock Exchange (TSE) started the trading of the TOPIX futures. While the TSE adopted a computer-based trading system for the TOPIX futures from the start, the OSE began the Nikkei 225 futures trading by a floor trading system due to a delay of its preparation. The data for this study starts on October 3, 1988 when the OSE adopted the computer-based trading system.

The NSA is a Dow-Jones-type stock price average which is composed of 225 stocks listed in the first section of the TSE and it was the official stock index of the TSE until the TOPIX adopted in 1969. The Nihon Keizai Shinbun Co. reports the NSA in each minute except the opening minute. Therefore, intraday NSA data for this study is comprised of 240 values for 9:01-11:00 and 13:01-15:00 before April 22, 1991 and after then 270 values for 9:01-11:00 and 12:31-15:00. There is only morning session trading for the first and last business day of each year. Until January 28, 1989 there was morning session trading on the first, fourth and fifth Saturdays of each month. Although the NSA is calculated to two decimals, the data for this study consists of only integral numbers which are not rounded. However, this is not a serious problem because the NSA is a number of five figures and the quote for the Nikkei 225 futures is 10 points.

Concerning to the data for the Nikkei 225 futures, the transaction price of the last trade for each minute is adopted. If there is no trading within the minute, the last bid or ask quote which is nearer to the previous minute price is used. In the case of equal distance, the average value of the last bid and ask quote is adopted. The trading time of the Nikkei 225 futures has changed several times because of the regulations for the stock index futures[1]. At the beginning of the trade, the intraday data was comprised of 272 values (9:00-11:15 and 13:00-15:15). On October 2, 1990, the number was reduced to 252 values (9:00-11:00 and 13:00-15:10). On April 22, 1991, it was increased to 282 values (9:00-11:00 and 12:30-15:10). From February 6, 1992, it was reduced again to 272 values (9:00-11:00 and 12:30-15:00).

Before proceeding to the microstructure analysis, Japanese institutionally unique features should be noted. Contrary to the open-outcry system which is popular in the U.S. futures market, the Japanese computer-based trading system requires the clearance of all market orders so as to match orders.

Therefore, if there is an imbalance in orders, the bid or ask quote (which is called a 'special quote') is changed to use limit orders or to invite new orders. This modification of the special quote is executed not by the computer, but by a special member house (Saitori in the TSE and Nakadachi in the OSE) and the modification is regulated by a rule. At the beginning of the Nikkei 225 futures, the special quote could move 90 points of the previous value for 3 minutes. The maximum range for the special quote was also changed several times due to the regulations for the stock index futures. On August 24, 1990, the range was reduced to 50 points for 6 minutes. On June 27, 1991, it was reduced again to 30 points for 5 minutes and it was further reduced to 20 points for 5 minutes after 15:00 on December 17, 1991. As a result, the maximum range of the Nikkei 225 futures price movement had been reduced from 900 points for 30 minutes to 180 points for 30 minutes, 1/5 of the original limit (to 100 points for 30 minutes after 15:00, which is 1/9). Nevertheless, the regulation for the special quote of stock index futures was restored to the original 90 points for 3 minutes on February 14, 1994 in conjunction with the introduction of the Nikkei 300 futures to the OSE. This special quote regulation for the futures must be remembered because these regulations must have a strong influence on the intraday price movement.

In addition, the regulation of margins for stock index futures was reinforced four times and relaxed three times. At the beginning of the trade, 9% of gross contract value (which includes a cash margin of at least 3%) was required for investors and 6% of net contract value was required for member houses. On August 24, 1990, these rates were raised to 15% (5% cash) for investors and 10% for member houses. On January 31, 1991, they were raised again to 20% (7% cash) for investors and 15% (2% cash) for member houses. On June 27, 1991, they were raised further to 25% (8% cash) for investors and 20% (5% cash) for member houses. Finally, they were raised again to 30% (13% cash) for investors and 25% (10% cash) for member houses on December 18, 1991. As a result, these margin rates had become more than three times of the original rates. However, the margin regulation has been relaxed gradually in conjunction with the listing of the Nikkei 300 futures. On February 14, 1994, the margin rates for the Nikkei 225 futures and TOPIX futures were reduced to 25% (8% cash) for investors and 20% (5% cash) for member houses; those for the Nikkei 300 futures were 20% (3% cash) for investors and 15% for member houses. On August 15, 1994, the margin rates for the Nikkei 225 futures and TOPIX futures were reduced again to 20% (5% cash) for investors and 15% (2% cash) for member houses; those for the Nikkei 300 futures were also reduced to 15% (3% cash) for investors and 10% for member houses. On February 13, 1995, the margin rates for the Nikkei 225 futures and TOPIX futures were further reduced to the same level as those for the Nikkei 300 futures.

The margin regulation was implemented to restrict the trading of stock index futures, especially the Nikkei 225 futures, by raising the trading cost. Two other instruments were also implemented. One is the introduction of the exchange tax on October 2, 1990, which is an exceptional tax for stock index futures. The other is the doubling of commission rate for stock index futures on March 23, 1992.

Although these regulations were not so important for intraday price movement, these facts should be remembered to evaluate the situation correctly.

Ⅲ. Intraday Returns

The rate of the return is usually used in order to analyze price movements. In the market microstructure analysis, intraday returns, r_t, are commonly defined as the following natural logarithm of the two values:

$$r_t = \ln (P_t/P_{t-1})$$

where P_t represents the value observed at time t and P_{t-1} is the value observed at the previous time t-1. For example, f_{901} is a one-minute Nikkei 225 futures return between 9:00 and 9:01 (i_{902} is a one-minute NSA return between 9:01 and 9:02) while f_{900} represents an overnight futures return between the closing price of the previous day and the opening price (i_{901} is an overnight NSA return between the closing price of the previous day and the opening price).

Table 1 shows the summary statistics for the intraday returns averaged for each 15- minute interval across the whole period (the 1472 business days from October 3, 1988 to September 8, 1994) and the two subperiods; the non-regulated period (391 business days from January 30, 1989 to August 23, 1990) and the regulated period (469 business days from March 23, 1992 to February 10, 1994). First, positive and the largest absolute values are recorded for both the NSA and the futures during the morning opening interval which includes overnight returns. Although other observers report similar results, this study found that the overnight index returns exceed the overnight futures returns by absolute value. This can be explained partly by the difference of their closing times and partly by the difference of their speed of price change at the closing and opening time. Nevertheless, this gap is at its largest during the regulated period when their closing times were just the same and the changes in futures prices were limited severely. One possible explanation for this is the fact that some stock prices change after the closing time at 15:00 as Chang et al. (1993) suggested. Since the final data for this study is the index value at 15:00, not the last value of the day, the index values might have changed after 15:00.

Second, in contrast to the morning opening interval, average returns for the afternoon opening interval which include lunch break returns are negative and are also the second largest absolute values for both the NSA and the futures. Based on the result of the overnight returns, the returns for the afternoon opening interval should be positive and the second largest absolute values. However, the result of this study is similar to the result reported by Chang et al. (1993) who employ the TOPIX during the period between August 12, 1987 and April 26, 1991 with the exception that their subperiod (the bull market period between August 12, 1987 and December 28, 1989) shows positive and the second largest absolute value. It is difficult to determine the reason, but market sentiment might have an

Table 1

NSA: Whole Period

	Average(%)	St.Dev.(%)	Skewness	Kurtosis	Num.Obs
9:01	0.0486	0.2046	-0.1315	0.5057	1,472
9:01-9:15	0.0047	0.0697	-0.0469	5.2437	22,094
9:16-9:30	-0.0020	0.0403	0.3510	13.4906	22,095
9:31-9:45	-0.0017	0.0390	0.5470	20.1591	22,095
9:46-10:00	-0.0011	0.0388	1.1880	21.8628	22,095
10:01-10:15	0.0004	0.0399	0.8181	16.8377	22,095
10:16-10:30	0.0009	0.0391	1.1547	19.0273	22,095
10:31-10:45	0.0007	0.0392	0.8943	20.0065	22,095
10:46-11:00	-0.0005	0.0419	0.6684	19.8132	22,095
11:01-11:15					
12:31	-0.0103	0.1407	0.2039	0.6977	827
12:31-12:45	-0.0032	0.0490	0.1277	12.6141	12,405
12:46-13:00	-0.0013	0.0395	0.4661	17.7432	12,405
13:01-13:15	-0.0010	0.0404	0.6324	19.5439	21,795
13:16-13:30	0.0000	0.0376	0.3053	24.9994	21,795
13:31-13:45	0.0003	0.0368	0.8867	19.0996	21,795
13:46-14:00	0.0002	0.0414	1.0045	24.1354	21,795
14:01-14:15	-0.0004	0.0419	0.0923	21.7173	21,795
14:16-14:30	0.0000	0.0454	0.4880	16.5317	21,795
14:31-14:45	0.0004	0.0494	0.1816	11.2167	21,795
14:46-15:00	0.0001	0.0610	0.2038	9.1638	21,795
15:01-15:15					
Total Time	-0.0002	0.0439	0.5535	17.4003	375,929
Mor.Session	0.0002	0.0435	0.6968	17.0551	176,759
Aft.Session	-0.0005	0.0442	0.4388	17.6765	199,170
Mor.Opening	0.0486	0.2046	-0.1315	0.5057	1,472
Mor.Closing	-0.0017	0.0478	-0.1182	15.6223	1,473
Aft.Opening	-0.0180	0.1318	0.2813	0.9142	1,453
Aft.Closing	0.0030	0.0899	0.0025	5.2880	1,453

Futures: Whole Period

	Average(%)	St.Dev.(%)	Skewness	Kurtosis	Num.Obs
9:00	0.0446	0.3083	4.0253	36.5148	1,472
9:00-9:15	0.0021	0.0777	0.0669	10.6166	23,567
9:16-9:30	-0.0009	0.0564	-0.2097	7.0851	22,095
9:31-9:45	-0.0004	0.0530	-0.3443	8.3486	22,095
9:46-10:00	0.0000	0.0508	-0.1132	6.0502	22,095
10:01-10:15	0.0004	0.0516	-0.2944	7.6481	22,095
10:16-10:30	0.0014	0.0520	-0.0964	6.0645	22,095
10:31-10:45	0.0003	0.0524	0.0428	5.0027	22,095
10:46-11:00	-0.0012	0.0532	0.0170	5.1336	22,095
11:01-11:15	-0.0009	0.0325	-0.1125	24.5024	7,530
12:30	-0.0135	0.1209	0.2987	-0.0476	827
12:30-12:45	-0.0026	0.0557	0.0600	3.6067	13,232
12:46-13:00	0.0001	0.0533	-0.0047	2.6436	13,032
13:01-13:15	0.0001	0.0456	-0.1161	5.9165	21,810
13:16-13:30	0.0001	0.0466	-0.0625	6.0469	21,810
13:31-13:45	0.0007	0.0473	0.1960	5.8618	21,810
13:46-14:00	0.0004	0.0478	0.1058	5.3777	21,810
14:01-14:15	-0.0007	0.0491	-0.1083	4.3998	21,810
14:16-14:30	-0.0010	0.0524	-0.1606	4.0135	21,810
14:31-14:45	-0.0006	0.0553	-0.0498	4.1750	21,810
14:46-15:00	-0.0007	0.0566	0.0424	3.8745	21,810
15:01-15:15	0.0008	0.0446	0.0800	10.3377	10,605
Total Time	-0.0001	0.0518	-0.0523	6.8371	397,111
Mor.Session	0.0001	0.0535	-0.1146	8.9514	185,762
Aft.Session	-0.0003	0.0504	-0.0013	5.1049	211,349
Mor.Opening	0.0446	0.3083	4.0253	36.5148	1,472
Mor.Closing	-0.0008	0.0461	-0.1219	2.1081	1,473
Aft.Opening	-0.0156	0.1251	0.0840	0.6479	1,453
Aft.Closing	-0.0024	0.0612	-0.1353	1.7328	1,453

NSA: Non-Regulated Period

	Average(%)	St.Dev.(%)	Skewness	Kurtosis	Num.Obs
9:01	0.0778	0.1448	-0.3081	0.2768	390
9:01-9:15	0.0095	0.0543	-0.3470	2.4290	5,864
9:16-9:30	-0.0028	0.0302	0.0699	7.8101	5,865
9:31-9:45	-0.0034	0.0263	-0.0048	6.3055	5,865
9:46-10:00	-0.0027	0.0259	0.0552	10.4217	5,865
10:01-10:15	-0.0011	0.0268	0.7264	10.8796	5,865
10:16-10:30	-0.0004	0.0270	0.4254	13.1738	5,865
10:31-10:45	0.0000	0.0256	0.8394	10.9056	5,865
10:46-11:00	-0.0004	0.0242	0.3498	8.3630	5,865
11:01-11:15					
12:31					
12:31-12:45					
12:46-13:00	-0.0216	0.1051	0.5339	0.9137	389
13:01-13:15	-0.0030	0.0341	-0.0863	8.5574	5,835
13:16-13:30	-0.0011	0.0251	0.6442	10.1183	5,835
13:31-13:45	-0.0004	0.0268	1.3628	11.2930	5,835
13:46-14:00	-0.0008	0.0273	0.9471	14.7605	5,835
14:01-14:15	0.0004	0.0267	0.9189	8.4519	5,835
14:16-14:30	-0.0001	0.0294	0.8082	9.2402	5,835
14:31-14:45	0.0003	0.0312	0.6715	7.1248	5,835
14:46-15:00	0.0011	0.0355	0.6664	6.7166	5,835
15:01-15:15					
Total Time	-0.0003	0.0298	0.5029	9.1594	93,599
Mor.Session	-0.0002	0.0300	0.2643	8.7860	46,919
Aft.Session	-0.0004	0.0295	0.7416	9.5328	46,680
Mor.Opening	0.0778	0.1448	-0.3081	0.2768	390
Mor.Closing	0.0003	0.0260	0.2694	5.9096	391
Aft.Opening	-0.0216	0.1051	0.5339	0.9137	389
Aft.Closing	0.0156	0.0386	0.5604	5.9198	389

Futures: Non-Regulated Period

	Average(%)	St.Dev.(%)	Skewness	Kurtosis	Num.Obs
9:00	0.0673	0.3502	2.8162	18.4706	390
9:00-9:15	0.0025	0.0775	-0.1629	16.9452	6,255
9:16-9:30	-0.0018	0.0479	-0.8604	23.7803	5,865
9:31-9:45	-0.0011	0.0426	-2.0818	29.1262	5,865
9:46-10:00	-0.0005	0.0384	-0.5085	21.6759	5,865
10:01-10:15	-0.0002	0.0395	-0.9865	21.1367	5,865
10:16-10:30	0.0011	0.0404	-0.7717	23.8877	5,865
10:31-10:45	-0.0002	0.0381	-0.1802	23.0442	5,865
10:46-11:00	-0.0006	0.0379	0.5587	20.7670	5,865
11:01-11:15	-0.0010	0.0319	0.1049	23.4871	5,865
12:30					
12:30-12:45					
12:46-13:00	-0.0260	0.1294	-0.2480	2.5490	389
13:01-13:15	-0.0022	0.0416	-0.6678	16.5046	5,835
13:16-13:30	-0.0003	0.0345	0.3917	17.4841	5,835
13:31-13:45	0.0003	0.0362	1.2046	24.7796	5,835
13:46-14:00	0.0003	0.0350	0.2550	20.4771	5,835
14:01-14:15	0.0006	0.0348	0.2903	14.7039	5,835
14:16-14:30	-0.0005	0.0353	-0.2209	15.0312	5,835
14:31-14:45	-0.0007	0.0385	-0.3744	18.5599	5,835
14:46-15:00	-0.0009	0.0376	-0.1165	15.1437	5,835
15:01-15:15	0.0006	0.0408	-0.1014	17.1885	5,835
Total Time	-0.0003	0.0406	-0.2362	20.1812	106,079
Mor.Session	-0.0002	0.0440	-0.5404	22.6081	53,175
Aft.Session	-0.0003	0.0372	0.0680	17.7544	52,904
Mor.Opening	0.0673	0.3502	2.8162	18.4706	390
Mor.Closing	-0.0005	0.0373	-0.8313	5.0352	391
Aft.Opening	-0.0260	0.1294	-0.2480	2.5490	389
Aft.Closing	-0.0007	0.0597	-0.7362	4.4713	389

NSA: Regulated Period

	Average(%)	St.Dev.(%)	Skewness	Kurtosis	Num.Obs
9:01	0.0561	0.2333	0.0898	0.4553	468
9:01-9:15	0.0017	0.0784	-0.1439	4.8355	7,034
9:16-9:30	-0.0041	0.0483	-0.0822	10.6783	7,035
9:31-9:45	0.0007	0.0487	0.7288	15.0992	7,035
9:46-10:00	0.0010	0.0495	0.7031	15.6700	7,035
10:01-10:15	0.0024	0.0506	0.5433	13.3520	7,035
10:16-10:30	0.0026	0.0493	0.7955	14.4889	7,035
10:31-10:45	0.0011	0.0499	0.6208	16.3695	7,035
10:46-11:00	-0.0001	0.0547	0.3779	13.8836	7,035
11:01-11:15					
12:31	-0.0066	0.1531	0.2177	0.4195	465
12:31-12:45	-0.0036	0.0534	0.0141	10.7986	6,975
12:46-13:00	-0.0015	0.0429	0.2213	15.9899	6,975
13:01-13:15	0.0007	0.0439	0.6090	19.6894	6,975
13:16-13:30	0.0004	0.0448	0.0545	20.7386	6,975
13:31-13:45	0.0001	0.0440	0.5119	16.6134	6,975
13:46-14:00	-0.0003	0.0519	0.6968	18.7082	6,975
14:01-14:15	-0.0006	0.0539	-0.3801	16.6817	6,975
14:16-14:30	0.0002	0.0589	0.1746	11.5265	6,975
14:31-14:45	-0.0017	0.0635	-0.2006	7.5411	6,975
14:46-15:00	0.0008	0.0788	0.0035	6.3296	6,975
15:01-15:15					
Total Time	0.0000	0.0536	0.2916	13.8330	126,029
Mor.Session	0.0007	0.0537	0.4429	13.0471	56,279
Aft.Session	-0.0006	0.0536	0.1705	14.4617	69,750
Mor.Opening	0.0561	0.2333	0.0898	0.4553	468
Mor.Closing	0.0002	0.0612	0.1509	11.4787	469
Aft.Opening	-0.0066	0.1531	0.2177	0.4195	465
Aft.Closing	0.0009	0.0056	0.1847	2.2691	465

Futures: Regulated Period

	Average(%)	St.Dev.(%)	Skewness	Kurtosis	Num.Obs
9:00	0.0322	0.2039	1.9472	11.0354	468
9:00-9:15	0.0020	0.0704	-0.1476	4.6138	7,503
9:16-9:30	-0.0006	0.0659	-0.1464	2.2936	7,035
9:31-9:45	0.0015	0.0639	0.1153	3.9233	7,035
9:46-10:00	0.0013	0.0614	-0.0169	2.4196	7,035
10:01-10:15	0.0009	0.0626	-0.2020	4.0535	7,035
10:16-10:30	0.0025	0.0642	0.0208	2.1252	7,035
10:31-10:45	0.0004	0.0651	0.0629	1.5281	7,035
10:46-11:00	-0.0017	0.0661	-0.0223	1.8083	7,035
11:01-11:15					
12:30	-0.0159	0.1239	0.1847	-1.1747	465
12:30-12:45	-0.0035	0.0590	-0.1301	2.9700	7,440
12:46-13:00	0.0011	0.0554	-0.0171	2.3515	6,975
13:01-13:15	0.0003	0.0540	-0.1011	2.2456	6,975
13:16-13:30	0.0000	0.0560	-0.0522	2.3361	6,975
13:31-13:45	0.0006	0.0564	0.0602	2.1959	6,975
13:46-14:00	0.0000	0.0585	0.0001	2.0767	6,975
14:01-14:15	-0.0020	0.0602	-0.1784	1.8295	6,975
14:16-14:30	-0.0012	0.0659	-0.1666	1.8269	6,975
14:31-14:45	-0.0015	0.0693	-0.0437	1.4009	6,975
14:46-15:00	-0.0004	0.0717	0.0157	1.5067	6,975
15:01-15:15					
Total Time	0.0000	0.0626	-0.0534	2.4271	126,963
Mor.Session	0.0008	0.0650	-0.0429	2.8603	56,748
Aft.Session	-0.0007	0.0606	-0.0618	2.0799	70,215
Mor.Opening	0.0322	0.2039	1.9472	11.0354	468
Mor.Closing	-0.0031	0.0517	-0.1792	0.5196	469
Aft.Opening	-0.0159	0.1239	0.1847	-1.1747	465
Aft.Closing	-0.0021	0.0584	0.1826	0.4932	465

Figure 1

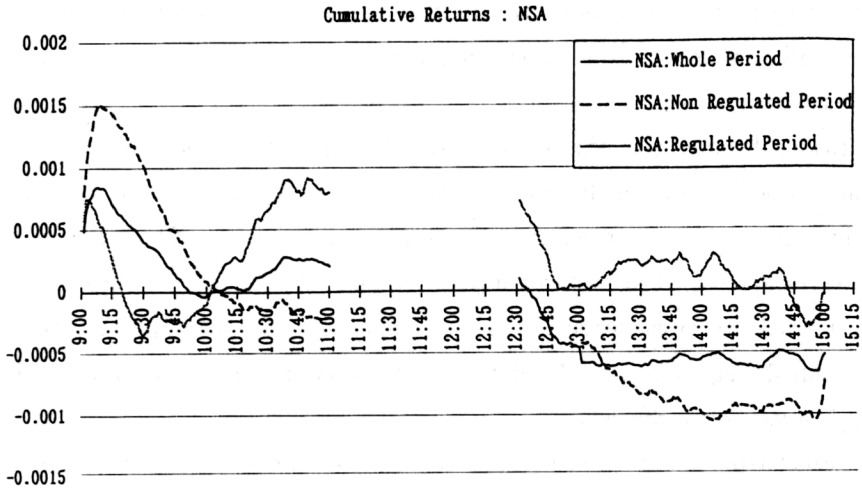
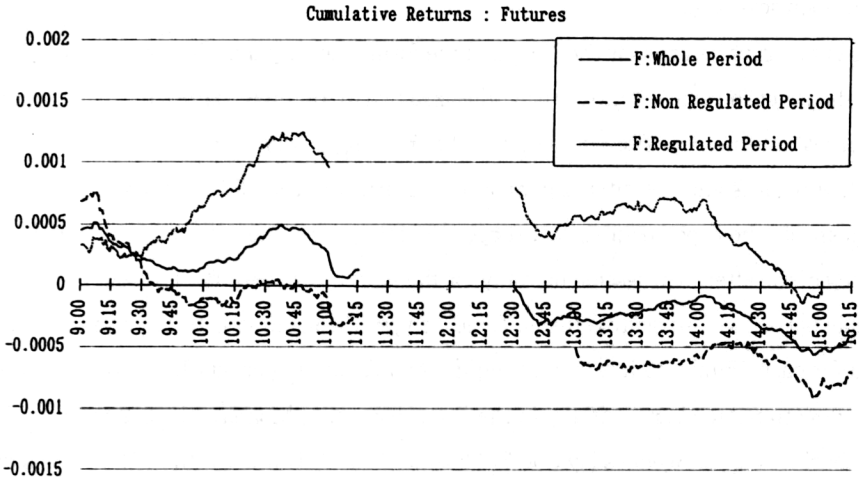


Figure 2



influence on making these values positive or negative as Chang et al. (1993) explain. In addition, although the NSA return indicates larger absolute value than the futures return during the whole period, the NSA returns are smaller in absolute value than the futures returns for both the non-regulated period and the regulated period.

Third, the returns for the afternoon closing interval tend to be positive, though the futures return during the regulated period is negative. However, the values of the futures returns at the afternoon closing are negative. Harris (1986) examined the NYSE listed stocks and showed high returns at the closing. Ekman (1992) also reported high returns at the closing for S&P 500 futures. The result of this study shows that the NSA has a weak tendency to rise at closing, but there is no apparent movement of the futures not only during the non-regulated period but also during the regulated period during which the closing time was exactly the same.

Fourth, the returns for the morning closing interval are negative, but not large absolute values. These results are also similar to the results of Chang et al. (1993). If there is rising tendency in returns at the afternoon closing, it should be similarly applicable for the closing of morning session. Therefore, this tendency seems to be very weak even if these findings are correct. Otherwise, there must be other reasons for the rise of the closing returns of the afternoon session; for example, the closing price of the day is used to evaluate the portfolios on that day, or liquidity traders prefer to buy or not to sell at the closing of the afternoon session etc.

Figure 1 shows cumulative returns for the NSA and the futures during the whole period and the two subperiods. The shapes of the whole period are synthesized by two different curves of their subperiods and these two curves indicate opposite directions in the morning session. In addition, the shapes of the NSA cumulative returns and the futures cumulative returns are also different for some intervals. They are not necessarily the expected identical shapes. Furthermore, there seems to be a rising tendency in the closing of the afternoon session not only for the NSA but also for the futures.

As for the weekly patterns of intraday returns, Table 2 shows the summary statistics of the intraday returns averaged for each 15-minute interval during the non-Saturday period (the 1388 business days from January 30, 1989 to September 8, 1994) and the five subsamples; Monday (the 272 business days), Tuesday (the 280 business days), Wednesday (the 278 business days), Thursday (the 281 business days), and Friday (the 277 business days). First, positive and the largest absolute values are recorded for the morning opening interval with the exception of the NSA return on Monday and the futures returns on Monday, Tuesday and Wednesday. The same method is applied to U.S. stocks by Harris (1986) and to S&P 500 futures by Ekman (1992). Harris (1986) documents that average returns for overnight returns and the first intervals are positive except on Monday. Ekman (1992) also reports a similar result for S&P 500 futures, but not as distinct as Harris (1986). This study shows different results for the futures returns on the Tuesday and Wednesday opening intervals. However, this result is partly consistent

Table 2 (A)

NSA: Non-Saturday Period

	Average(%)	St.Dev.(%)	Skewness	Kurtosis	Num.Obs
9:01	0.0476	0.2095	-0.1204	0.3753	1,387
9:01-9:15	0.0043	0.0713	-0.0336	5.0120	20,820
9:16-9:30	-0.0022	0.0411	0.3586	13.0549	20,820
9:31-9:45	-0.0017	0.0398	0.5356	19.5490	20,820
9:46-10:00	-0.0011	0.0397	1.1723	21.0267	20,820
10:01-10:15	0.0005	0.0408	0.8022	16.2039	20,820
10:16-10:30	0.0010	0.0399	1.1358	18.3512	20,820
10:31-10:45	0.0007	0.0401	0.8785	19.3089	20,820
10:46-11:00	-0.0005	0.0429	0.6684	19.1170	20,820
11:01-11:15					
12:31	-0.0103	0.1407	0.2039	0.6977	827
12:31-12:45	-0.0032	0.0490	0.1277	12.6141	12,405
12:46-13:00	-0.0013	0.0395	0.4661	17.7432	12,405
13:01-13:15	-0.0011	0.0410	0.6274	19.0608	20,670
13:16-13:30	0.0000	0.0384	0.2983	24.2381	20,670
13:31-13:45	0.0004	0.0376	0.8688	18.5272	20,670
13:46-14:00	0.0002	0.0423	0.9868	23.2592	20,670
14:01-14:15	-0.0003	0.0428	0.0885	20.8982	20,670
14:16-14:30	0.0000	0.0464	0.4754	15.8886	20,670
14:31-14:45	0.0003	0.0504	0.1718	10.7677	20,670
14:46-15:00	0.0000	0.0624	0.2032	8.7593	20,670
15:01-15:15					
Total Time	-0.0002	0.0447	0.5462	16.8544	356,730
Mor.Session	0.0001	0.0445	0.6897	16.4530	166,560
Aft.Session	-0.0005	0.0450	0.4314	17.1756	190,170
Mor.Opening	0.0476	0.2095	-0.1204	0.3753	1,387
Mor.Closing	-0.0018	0.0488	-0.0952	15.0937	1,388
Aft.Opening	-0.0185	0.1338	0.2898	0.8618	1,378
Aft.Closing	0.0020	0.0918	0.0187	5.0022	1,378

Futures: Non-Saturday Period

	Average(%)	St.Dev.(%)	Skewness	Kurtosis	Num.Obs
9:00	0.0419	0.3141	4.0520	36.0462	1,387
9:00-9:15	0.0018	0.0790	0.0038	10.1540	22,207
9:16-9:30	-0.0010	0.0578	-0.1981	6.7054	20,820
9:31-9:45	-0.0003	0.0543	-0.3378	7.8831	20,820
9:46-10:00	0.0000	0.0521	-0.1093	5.6533	20,820
10:01-10:15	0.0005	0.0529	-0.2783	7.1526	20,820
10:16-10:30	0.0014	0.0534	-0.0981	5.6811	20,820
10:31-10:45	0.0003	0.0537	0.0447	4.6763	20,820
10:46-11:00	-0.0013	0.0545	0.0218	4.8111	20,820
11:01-11:15	-0.0011	0.0345	-0.1721	22.8494	6,255
12:30	-0.0135	0.1209	0.2987	-0.0476	827
12:30-12:45	-0.0026	0.0557	0.0600	3.6067	13,232
12:46-13:00	0.0001	0.0534	-0.0039	2.6303	12,956
13:01-13:15	0.0000	0.0464	-0.1473	5.4088	20,670
13:16-13:30	0.0002	0.0476	-0.0629	5.7288	20,670
13:31-13:45	0.0007	0.0484	0.1938	5.5417	20,670
13:46-14:00	0.0004	0.0489	0.1049	5.0551	20,670
14:01-14:15	-0.0008	0.0503	-0.1024	4.1051	20,670
14:16-14:30	-0.0011	0.0537	-0.1531	3.7440	20,670
14:31-14:45	-0.0006	0.0566	-0.0492	3.8859	20,670
14:46-15:00	-0.0007	0.0579	0.0432	3.6169	20,670
15:01-15:15	0.0008	0.0466	0.0628	9.4419	9,465
Total Time	-0.0002	0.0530	-0.0583	6.4196	375,215
Mor.Session	0.0000	0.0549	-0.1239	8.4092	174,202
Aft.Session	-0.0004	0.0514	-0.0045	4.7897	201,013
Mor.Opening	0.0419	0.3141	4.0520	36.0462	1,387
Mor.Closing	-0.0017	0.0468	-0.1190	2.0325	1,388
Aft.Opening	-0.0163	0.1280	0.0986	0.5142	1,378
Aft.Closing	-0.0026	0.0619	-0.1435	1.7102	1,378

NSA: Monday

	Average(%)	St.Dev.(%)	Skewness	Kurtosis	Num.Obs
9:01	0.0311	0.1973	-0.2725	0.1218	271
9:01-9:15	-0.0009	0.0705	-0.3163	4.1260	4,079
9:16-9:30	-0.0040	0.0397	-0.0266	10.6068	4,080
9:31-9:45	-0.0010	0.0406	0.8204	18.6146	4,080
9:46-10:00	-0.0019	0.0393	1.0410	18.0655	4,080
10:01-10:15	0.0008	0.0385	0.7256	18.2748	4,080
10:16-10:30	-0.0003	0.0355	1.1373	16.1269	4,080
10:31-10:45	-0.0004	0.0364	1.0700	17.5834	4,080
10:46-11:00	-0.0003	0.0381	0.9369	17.1213	4,080
11:01-11:15					
12:31	-0.0137	0.1284	0.0230	0.0274	161
12:31-12:45	-0.0056	0.0442	-0.2302	11.8793	2,415
12:46-13:00	-0.0037	0.0381	-0.2387	17.8399	2,415
13:01-13:15	-0.0021	0.0374	0.3773	19.4714	4,035
13:16-13:30	-0.0005	0.0366	0.9250	19.8013	4,035
13:31-13:45	0.0002	0.0326	1.2997	15.9562	4,035
13:46-14:00	-0.0003	0.0403	0.8708	21.4483	4,035
14:01-14:15	-0.0004	0.0421	-0.6282	20.5575	4,035
14:16-14:30	-0.0005	0.0464	0.1176	16.1417	4,035
14:31-14:45	-0.0016	0.0460	-0.3819	11.0470	4,035
14:46-15:00	0.0005	0.0584	0.0761	8.6359	4,035
15:01-15:15					
Total Time	-0.0012	0.0424	0.4195	15.6860	69,749
Mor.Session	-0.0010	0.0423	0.6735	15.0649	32,639
Aft.Session	-0.0014	0.0425	0.2163	16.1828	37,110
Mor.Opening	0.0311	0.1973	-0.2725	0.1218	271
Mor.Closing	-0.0046	0.0437	-0.3586	9.2525	272
Aft.Opening	-0.0137	0.1262	0.1094	0.3577	269
Aft.Closing	-0.0043	0.0944	-0.1928	5.2028	269

Futures: Monday

	Average(%)	St.Dev.(%)	Skewness	Kurtosis	Num.Obs
9:00	0.0008	0.2412	0.0951	0.4272	271
9:00-9:15	-0.0039	0.0748	-0.3970	8.8142	4,351
9:16-9:30	-0.0021	0.0571	-0.3991	7.6214	4,080
9:31-9:45	-0.0006	0.0539	-0.1447	12.0219	4,080
9:46-10:00	-0.0006	0.0510	-0.2179	5.3465	4,080
10:01-10:15	0.0013	0.0531	-0.3372	9.4299	4,080
10:16-10:30	0.0002	0.0528	-0.1412	5.6827	4,080
10:31-10:45	0.0000	0.0514	-0.0985	3.9129	4,080
10:46-11:00	-0.0017	0.0517	-0.2435	4.2036	4,080
11:01-11:15	-0.0013	0.0318	-0.7302	11.6543	1,245
12:30	-0.0165	0.1151	-0.2303	0.3426	176
12:30-12:45	-0.0034	0.0540	0.0610	2.8743	2,816
12:46-13:00	-0.0021	0.0523	-0.0825	2.6724	2,733
13:01-13:15	-0.0008	0.0445	-0.5535	5.9631	4,035
13:16-13:30	-0.0006	0.0437	-0.2378	5.4374	4,035
13:31-13:45	0.0002	0.0437	-0.2240	4.2046	4,035
13:46-14:00	-0.0001	0.0456	0.1083	4.5392	4,035
14:01-14:15	-0.0015	0.0471	-0.2346	3.1117	4,035
14:16-14:30	-0.0009	0.0495	-0.1960	4.2910	4,035
14:31-14:45	-0.0021	0.0539	-0.1713	3.3230	3,820
14:46-15:00	0.0000	0.0544	-0.0757	3.3199	4,035
15:01-15:15	0.0016	0.0400	0.3345	8.0968	1,825
Total Time	-0.0009	0.0504	-0.1981	5.8167	73,595
Mor.Session	-0.0010	0.0532	-0.3017	7.6406	34,156
Aft.Session	-0.0009	0.0481	-0.1131	4.3223	39,439
Mor.Opening	0.0008	0.2412	0.0951	0.4272	271
Mor.Closing	-0.0051	0.0468	0.0728	2.0772	272
Aft.Opening	-0.0252	0.1224	-0.3750	0.5840	269
Aft.Closing	-0.0046	0.0596	0.0189	0.7427	269

NSA: Tuesday

	Average(%)	St.Dev.(%)	Skewness	Kurtosis	Num.Obs
9:01	0.0429	0.2176	0.1002	1.6907	280
9:01-9:15	0.0041	0.0736	0.1356	4.5244	4,200
9:16-9:30	-0.0005	0.0407	0.4355	11.1993	4,200
9:31-9:45	-0.0014	0.0396	0.4779	19.2662	4,200
9:46-10:00	0.0009	0.0429	1.6875	17.9116	4,200
10:01-10:15	-0.0013	0.0405	0.6123	13.8988	4,200
10:16-10:30	0.0035	0.0402	1.6794	20.0563	4,200
10:31-10:45	0.0029	0.0414	1.2610	20.2907	4,200
10:46-11:00	0.0003	0.0417	0.6309	17.0737	4,200
11:01-11:15					
12:31	-0.0082	0.1439	-0.2915	0.3839	167
12:31-12:45	-0.0028	0.0456	-0.0979	13.2838	2,505
12:46-13:00	-0.0027	0.0378	1.3517	19.7725	2,505
13:01-13:15	0.0009	0.0368	1.0186	15.1217	4,185
13:16-13:30	-0.0007	0.0353	0.3252	18.9788	4,185
13:31-13:45	0.0003	0.0361	1.2303	19.1094	4,185
13:46-14:00	-0.0006	0.0436	0.8713	16.2963	4,185
14:01-14:15	-0.0008	0.0391	0.7365	15.3566	4,185
14:16-14:30	-0.0009	0.0441	0.5602	12.3747	4,185
14:31-14:45	-0.0002	0.0476	-0.0835	9.7166	4,185
14:46-15:00	-0.0017	0.0576	0.2567	10.0140	4,185
15:01-15:15					
Total Time	-0.0001	0.0437	0.7232	15.1947	72,090
Mor.Session	0.0011	0.0451	0.8650	15.5276	33,600
Aft.Session	-0.0010	0.0427	0.6097	14.9284	38,490
Mor.Opening	0.0429	0.2176	0.1002	1.6907	280
Mor.Closing	0.0004	0.0436	0.1569	17.3169	280
Aft.Opening	-0.0153	0.1344	-0.1104	0.4796	279
Aft.Closing	0.0003	0.0761	-0.1364	5.8109	279

Futures: Tuesday

	Average(%)	St.Dev.(%)	Skewness	Kurtosis	Num.Obs
9:00	0.0027	0.2160	-0.0016	-0.8843	280
9:00-9:15	0.0005	0.0742	-0.2513	6.4885	4,480
9:16-9:30	0.0001	0.0584	0.1439	7.4116	4,200
9:31-9:45	0.0004	0.0547	-0.4548	7.6597	4,200
9:46-10:00	0.0012	0.0519	-0.1463	5.4231	4,200
10:01-10:15	0.0000	0.0550	-0.3865	7.8281	4,200
10:16-10:30	0.0031	0.0527	0.2900	5.7798	4,200
10:31-10:45	0.0023	0.0525	0.2226	5.2196	4,200
10:46-11:00	-0.0016	0.0548	0.2066	5.8896	4,200
11:01-11:15	-0.0001	0.0288	0.4144	11.5923	1,260
12:30	-0.0003	0.1170	0.4059	-0.5707	182
12:30-12:45	-0.0011	0.0551	0.1482	3.4218	2,912
12:46-13:00	-0.0001	0.0545	-0.1268	3.2397	2,827
13:01-13:15	-0.0005	0.0461	-0.0147	6.2047	4,185
13:16-13:30	-0.0005	0.0476	0.1287	6.6979	4,185
13:31-13:45	-0.0003	0.0488	0.5148	6.6829	4,185
13:46-14:00	-0.0003	0.0501	-0.0234	5.9137	4,185
14:01-14:15	-0.0014	0.0508	-0.0749	3.9959	4,185
14:16-14:30	-0.0025	0.0546	-0.2091	3.9258	4,185
14:31-14:45	-0.0003	0.0577	0.0771	4.3185	3,935
14:46-15:00	-0.0009	0.0592	-0.0898	3.9593	4,185
15:01-15:15	0.0005	0.0496	0.2206	9.2665	1,940
Total Time	-0.0001	0.0529	0.0296	6.0229	76,049
Mor.Session	0.0006	0.0538	0.0024	7.0285	35,140
Aft.Session	-0.0007	0.0522	0.0518	5.1990	40,909
Mor.Opening	0.0027	0.2160	-0.0016	-0.8843	280
Mor.Closing	-0.0012	0.0463	-0.1518	2.9042	280
Aft.Opening	0.0013	0.1242	0.4005	0.4200	279
Aft.Closing	-0.0022	0.0637	0.1842	1.0176	279

Table 2 (B)

NSA: Wednesday

	Average(%)	St.Dev.(%)	Skewness	Kurtosis	Num.Obs
9:01	0.0461	0.2119	-0.1153	-0.4331	278
9:01-9:15	0.0041	0.0694	0.0654	4.3666	4,170
9:16-9:30	-0.0003	0.0394	-0.0845	11.2766	4,170
9:31-9:45	-0.0017	0.0387	0.8688	15.3352	4,170
9:46-10:00	-0.0016	0.0373	0.7716	18.4260	4,170
10:01-10:15	0.0009	0.0408	0.5980	13.4090	4,170
10:16-10:30	0.0004	0.0408	0.9206	17.4202	4,170
10:31-10:45	0.0007	0.0412	0.5495	11.3689	4,170
10:46-11:00	-0.0024	0.0458	0.6179	15.9743	4,170
11:01-11:15					
12:31	-0.0119	0.1352	0.4339	0.8465	165
12:31-12:45	-0.0039	0.0468	0.4114	9.8348	2,475
12:46-13:00	-0.0005	0.0370	0.0835	15.7377	2,475
13:01-13:15	0.0004	0.0379	0.9058	14.7367	4,155
13:16-13:30	0.0002	0.0397	0.5316	17.1101	4,155
13:31-13:45	-0.0016	0.0389	0.0646	15.9074	4,155
13:46-14:00	0.0005	0.0450	0.5644	20.4967	4,155
14:01-14:15	-0.0001	0.0453	0.0308	14.5454	4,155
14:16-14:30	0.0010	0.0452	1.1713	17.7361	4,155
14:31-14:45	0.0009	0.0503	-0.0508	9.0368	4,155
14:46-15:00	0.0010	0.0640	0.3767	8.0401	4,155
15:01-15:15					
Total Time	-0.0002	0.0448	0.4587	13.8907	71,550
Mor.Session	0.0000	0.0442	0.5384	13.4471	33,360
Aft.Session	-0.0004	0.0453	0.3950	14.2456	38,190
Mor.Opening	0.0461	0.2119	-0.1153	0.4331	278
Mor.Closing	-0.0056	0.0436	-1.4764	13.4334	278
Aft.Opening	-0.0319	0.1319	0.2687	0.9032	277
Aft.Closing	0.0090	0.0982	0.4999	5.3024	277

Futures: Wednesday

	Average(%)	St.Dev.(%)	Skewness	Kurtosis	Num.Obs
9:00	0.0414	0.2476	1.3221	7.2465	278
9:00-9:15	0.0009	0.0743	0.0222	8.9481	4,448
9:16-9:30	-0.0011	0.0571	-0.0476	5.9629	4,170
9:31-9:45	0.0002	0.0526	-0.1676	4.4669	4,170
9:46-10:00	-0.0009	0.0533	0.0098	5.8830	4,170
10:01-10:15	0.0004	0.0518	-0.0928	4.1653	4,170
10:16-10:30	0.0018	0.0530	0.0052	4.2013	4,170
10:31-10:45	-0.0006	0.0543	-0.0005	3.9824	4,170
10:46-11:00	-0.0025	0.0549	-0.2848	3.9065	4,170
11:01-11:15	-0.0021	0.0328	-0.7908	8.2872	1,260
12:30	-0.0086	0.1269	0.3126	0.4799	181
12:30-12:45	-0.0030	0.0568	-0.2433	3.6727	2,896
12:46-13:00	-0.0006	0.0537	-0.0293	2.2516	2,811
13:01-13:15	0.0008	0.0486	-0.0610	4.4044	4,155
13:16-13:30	-0.0007	0.0481	-0.0504	3.6869	4,155
13:31-13:45	0.0007	0.0497	0.1137	4.2468	4,155
13:46-14:00	0.0006	0.0494	0.0599	3.1673	4,155
14:01-14:15	-0.0008	0.0517	-0.2587	3.7005	4,155
14:16-14:30	-0.0006	0.0553	-0.0838	3.6843	4,155
14:31-14:45	-0.0004	0.0558	-0.0712	3.9334	3,900
14:46-15:00	0.0000	0.0577	0.0393	3.0292	4,155
15:01-15:15	0.0002	0.0457	-0.4367	4.9792	1,930
Total Time	-0.0004	0.0529	-0.1191	4.5318	75,520
Mor.Session	-0.0004	0.0539	-0.1484	5.5588	34,898
Aft.Session	-0.0004	0.0520	-0.0952	3.6904	40,622
Mor.Opening	0.0414	0.2476	1.3221	7.2465	278
Mor.Closing	-0.0002	0.0436	0.0939	2.2960	278
Aft.Opening	-0.0211	0.1349	0.2687	0.7145	277
Aft.Closing	-0.0011	0.0659	-0.5352	4.2003	277

NSA: Thursday

	Average(%)	St.Dev.(%)	Skewness	Kurtosis	Num.Obs
9:01	0.0645	0.2066	-0.0455	0.3699	281
9:01-9:15	0.0093	0.0663	-0.3007	5.0143	4,215
9:16-9:30	-0.0035	0.0412	0.7775	14.0183	4,215
9:31-9:45	-0.0020	0.0386	0.7291	13.3044	4,215
9:46-10:00	-0.0003	0.0406	1.0450	17.3544	4,215
10:01-10:15	0.0026	0.0416	1.1146	13.1803	4,215
10:16-10:30	0.0015	0.0408	1.0715	13.2174	4,215
10:31-10:45	0.0005	0.0415	1.2920	17.8664	4,215
10:46-11:00	-0.0004	0.0432	0.3713	16.6914	4,215
11:01-11:15					
12:31	-0.0093	0.1575	0.2749	0.7404	167
12:31-12:45	-0.0028	0.0529	-0.2914	12.5864	2,505
12:46-13:00	-0.0001	0.0430	0.7162	12.9196	2,505
13:01-13:15	-0.0001	0.0409	0.7504	19.5534	4,185
13:16-13:30	0.0014	0.0370	0.9884	18.6133	4,185
13:31-13:45	0.0010	0.0397	1.5194	16.5079	4,185
13:46-14:00	0.0008	0.0403	1.0063	20.6034	4,185
14:01-14:15	0.0010	0.0416	0.9859	13.4791	4,185
14:16-14:30	0.0005	0.0494	0.8389	12.7673	4,185
14:31-14:45	0.0013	0.0566	0.4885	10.3596	4,185
14:46-15:00	-0.0012	0.0685	0.2455	6.2958	4,185
15:01-15:15					
Total Time	0.0005	0.0459	0.7407	14.0733	72,210
Mor.Session	0.0010	0.0442	0.7625	13.8309	33,720
Aft.Session	0.0001	0.0472	0.7233	14.2673	38,490
Mor.Opening	0.0645	0.2066	-0.0455	0.3699	281
Mor.Closing	-0.0002	0.0469	0.5673	11.7005	281
Aft.Opening	-0.0179	0.1406	0.4711	1.1905	279
Aft.Closing	0.0027	0.0976	-0.2302	3.2952	279

Futures: Thursday

	Average(%)	St.Dev.(%)	Skewness	Kurtosis	Num.Obs
9:00	0.0507	0.2276	1.9769	18.0228	281
9:00-9:15	0.0055	0.0702	-0.1355	7.8571	4,496
9:16-9:30	-0.0006	0.0585	-0.3401	5.4587	4,215
9:31-9:45	-0.0010	0.0555	-0.3361	6.4573	4,215
9:46-10:00	0.0012	0.0514	-0.0189	5.9696	4,215
10:01-10:15	0.0022	0.0517	-0.0422	3.8774	4,215
10:16-10:30	0.0019	0.0531	0.0420	4.6415	4,215
10:31-10:45	-0.0003	0.0556	0.0551	5.5303	4,215
10:46-11:00	0.0005	0.0556	0.1741	4.3575	4,215
11:01-11:15	-0.0007	0.0389	0.8834	15.7476	1,260
12:30	-0.0251	0.1231	0.5235	-0.1609	183
12:30-12:45	-0.0039	0.0560	0.2446	3.9651	2,928
12:46-13:00	0.0018	0.0528	0.2488	2.5815	2,841
13:01-13:15	0.0008	0.0463	-0.0023	6.0121	4,185
13:16-13:30	0.0018	0.0477	0.0863	4.6385	4,185
13:31-13:45	0.0013	0.0495	0.4199	5.0917	4,185
13:46-14:00	0.0009	0.0492	0.1270	5.0736	4,185
14:01-14:15	0.0004	0.0510	0.2330	4.6058	4,185
14:16-14:30	-0.0011	0.0533	-0.0873	3.0154	4,185
14:31-14:45	-0.0006	0.0585	-0.0576	3.6188	3,935
14:46-15:00	-0.0024	0.0579	0.0910	3.4903	4,185
15:01-15:15	0.0024	0.0474	0.4702	6.6304	1,914
Total Time	0.0005	0.0531	0.1035	5.4233	76,174
Mor.Session	0.0010	0.0546	0.0301	6.6641	35,261
Aft.Session	0.0001	0.0518	0.1636	4.4068	40,913
Mor.Opening	0.0507	0.2276	1.9769	18.0228	281
Mor.Closing	0.0033	0.0467	-0.4069	2.1252	281
Aft.Opening	-0.0141	0.1293	0.0462	0.2603	279
Aft.Closing	-0.0012	0.0574	-0.0884	0.8454	279

NSA: Friday

	Average(%)	St.Dev.(%)	Skewness	Kurtosis	Num.Obs
9:01	0.0528	0.2134	-0.3328	-0.0493	277
9:01-9:15	0.0046	0.0753	0.0011	4.3557	4,155
9:16-9:30	-0.0030	0.0435	0.6869	12.0323	4,155
9:31-9:45	-0.0023	0.0400	0.3196	10.8896	4,155
9:46-10:00	-0.0025	0.0366	0.2104	17.3452	4,155
10:01-10:15	-0.0004	0.0415	1.0104	15.6567	4,155
10:16-10:30	-0.0002	0.0407	0.2018	14.5170	4,155
10:31-10:45	0.0000	0.0381	0.4732	19.3113	4,155
10:46-11:00	0.0002	0.0436	1.0115	17.5851	4,155
11:01-11:15					
12:31	-0.0085	0.1379	0.5659	1.1925	167
12:31-12:45	-0.0011	0.0530	0.7077	9.9399	2,505
12:46-13:00	0.0006	0.0390	0.1018	16.6896	2,505
13:01-13:15	-0.0007	0.0354	-0.0715	21.9524	4,110
13:16-13:30	-0.0005	0.0411	-0.3141	22.0630	4,110
13:31-13:45	0.0020	0.0387	0.7136	14.7029	4,110
13:46-14:00	0.0007	0.0400	1.0788	16.5115	4,110
14:01-14:15	-0.0014	0.0443	-0.1955	17.6495	4,110
14:16-14:30	-0.0001	0.0454	-0.1933	12.3961	4,110
14:31-14:45	0.0011	0.0496	0.5437	9.1737	4,110
14:46-15:00	0.0013	0.0616	0.0243	8.9930	4,110
15:01-15:15					
Total Time	-0.0001	0.0451	0.3532	14.4782	71,130
Mor.Session	-0.0005	0.0449	0.4894	13.9616	33,240
Aft.Session	0.0002	0.0452	0.2442	14.8915	37,890
Mor.Opening	0.0528	0.2134	-0.3328	-0.0493	277
Mor.Closing	0.0008	0.0584	0.4004	16.5210	277
Aft.Opening	-0.0138	0.1352	0.6563	1.2633	274
Aft.Closing	0.0019	0.0910	-0.0019	5.4025	274

Futurs: Friday

	Average(%)	St.Dev.(%)	Skewness	Kurtosis	Num.Obs
9:00	0.1133	0.5185	3.8890	19.9669	277
9:00-9:15	0.0061	0.0924	-0.0487	7.8518	4,432
9:16-9:30	-0.0011	0.0569	-0.3225	4.8895	4,155
9:31-9:45	-0.0006	0.0539	-0.2513	4.6052	4,155
9:46-10:00	-0.0011	0.0522	-0.1488	4.0112	4,155
10:01-10:15	-0.0015	0.0518	-0.2632	3.8338	4,155
10:16-10:30	0.0000	0.0544	-0.5770	5.7654	4,155
10:31-10:45	-0.0002	0.0541	0.0307	3.6598	4,155
10:46-11:00	-0.0014	0.0551	0.1379	4.6238	4,155
11:01-11:15	-0.0010	0.0351	-0.7240	11.9999	1,230
12:30	-0.0172	0.1216	0.4180	-0.3101	182
12:30-12:45	-0.0017	0.0562	-0.0697	2.2337	2,912
12:46-13:00	0.0013	0.0529	0.0316	2.0665	2,822
13:01-13:15	-0.0003	0.0468	-0.0860	4.2988	4,110
13:16-13:30	0.0007	0.0501	-0.1603	5.8941	4,110
13:31-13:45	0.0019	0.0493	-0.0372	4.8046	4,110
13:46-14:00	0.0006	0.0492	0.0760	4.3474	4,110
14:01-14:15	-0.0008	0.0500	-0.1799	3.4154	4,110
14:16-14:30	-0.0007	0.0549	-0.1498	3.0470	4,110
14:31-14:45	0.0002	0.0564	-0.1512	3.2379	3,870
14:46-15:00	-0.0001	0.0598	0.1750	3.1885	4,110
15:01-15:15	-0.0005	0.0469	-0.1909	6.3707	1,855
Total Time	0.0000	0.0540	-0.1439	4.7007	74,976
Mor.Session	-0.0001	0.0565	-0.2394	5.7092	34,747
Aft.Session	0.0000	0.0520	-0.0657	3.8745	40,229
Mor.Opening	0.1133	0.5185	3.8890	19.9669	277
Mor.Closing	-0.0015	0.0478	-0.1930	1.3013	277
Aft.Opening	-0.0230	0.1277	0.1003	0.4093	274
Aft.Closing	-0.0041	0.0630	-0.2184	0.8445	274

Figure 3

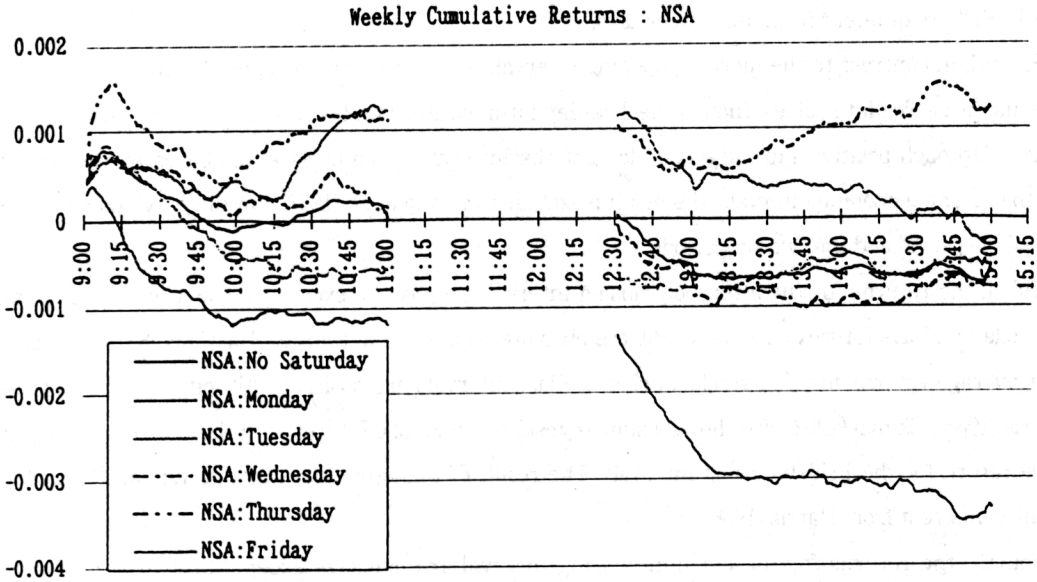
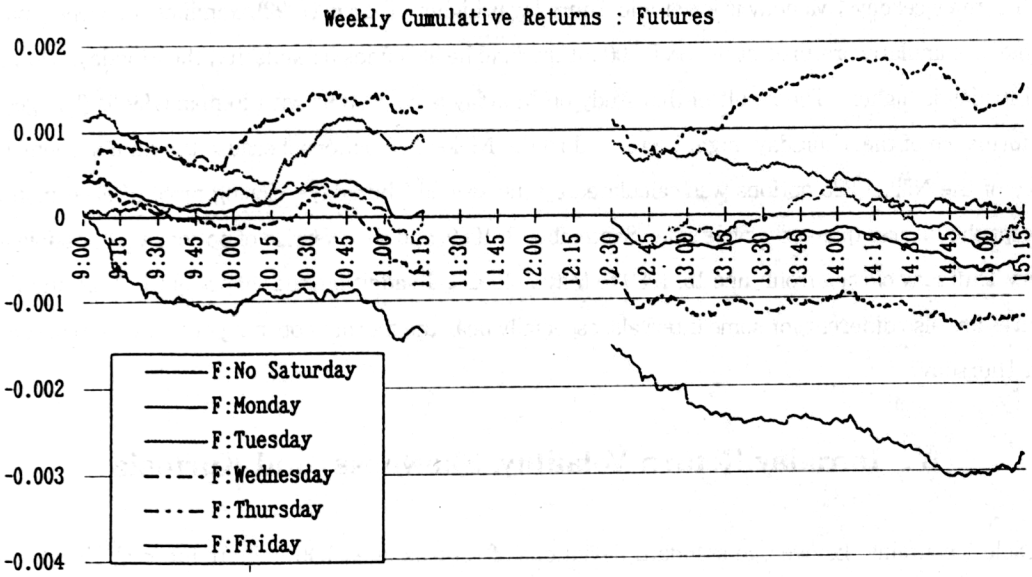


Figure 4



with the result reported by Kato (1990) who indicates that Monday and Tuesday intraday returns of the TOPIX are different from other weekdays.

Second, in contrast to the morning opening interval, the returns for the opening interval are negative and large absolute values, though the Tuesday futures return and both Friday returns are not that large. Although positive and the second largest absolute values can be expected based on the results for the morning opening intervals, the result is similar to Chang et al. (1993) and the previous result for the whole period and the two subperiods.

Third, the returns for the afternoon closing interval are positive except the NSA on Tuesday and Thursday and the futures on Friday, but the absolute values are not large. Harris (1986) documents that average returns for U.S. stocks during the last intervals are positive. Although not as clear as Harris (1986), Ekman (1992) also shows a similar result for S&P 500 futures with the exception of a negative return for the Friday closing interval. The result of this study is similar to Ekman (1992), but slightly different from Harris (1986).

Fourth, the returns for the morning closing interval are negative except the NSA returns on Tuesday and Friday, but not large absolute values. This result is contrary to Harris (1986) and Ekman (1992), but similar to Chang et al. (1993) and the previous result for the whole period and the two subperiods.

Figure 2 presents weekly cumulative returns for the NSA and the futures. The shapes of the non-Saturday period are composed of five different curves and these curves indicate the distinct shapes for each of the weekdays; Monday is lower and Thursday is higher. Ekman (1992) examines the weekly patterns for cumulative returns of the S&P 500 futures and he also finds irregularity; the Monday is lower and Friday is higher. The result of this study on Monday is consistent with Ekman (1992). The good performance of the Thursday might be related to the Nikkei 225 options, because the final settlement price of the Nikkei 225 options was calculated by the second Thursday's closing price of each month (except the futures quarterly cycle since September 8, 1989) and the exercise of options was possible at every Thursday closing from June 15, 1989 to May 7, 1992[2]. In addition, the shapes of the NSA and the futures are also different for some intervals, especially near the morning opening on Monday, Tuesday, and Thursday.

Ⅳ. Intraday Return Volatility, Skewness, and Kurtosis

Table 1 contains the average standard deviations of returns in each 15-minute interval. First, the largest values are recorded during the morning opening interval for both the NSA and the futures except during the regulated period. Although this result is similar to those of other observers, the new result is that the standard deviations of the NSA are less than those of the futures except during the

regulated period. The reason can probably be explained by differences in speed of change, because the relation is reversed during the regulated period when both closing times were the same and the futures price movement was limited severely.

Second, the standard deviations of returns in the afternoon opening interval for both the NSA and the futures are not the second largest values, but those of the afternoon opening are the second largest next to those of the morning opening. This result is the same as that of Chang et al. (1993) for the TOPIX. One reason is the diffusion of private information which is the hypothesis of Kyle (1985) and Admati and Pfleiderer (1988). Another reason is the difference in trading methods between opening of sessions and following sessions[3].

Third, the standard deviations of returns in the afternoon closing interval are large with the exception of the futures closing interval during the whole period and the non-regulated period. The reason for this difference is not clear, but one possible explanation is the decline of the futures return volatility after the closing of the stock market, as Ekman (1992) explains for S&P 500 futures.

Fourth, the standard deviations of returns in the morning closing interval are small except during the regulated period. Those of the morning closing are also relatively low except for those of the NSA during the whole period and the regulated period. These results are contrary to the results of Chang et al. (1993) who report increases in the standard deviations at the morning closing.

As for the weekly patterns of return volatility, Table 2 represents the standard deviations of the intraday returns averaged for each interval during the non-Saturday period and the five weekday subsamples. First, the largest values are recorded during the morning opening interval except for the NSA on Thursday. Similar results are reported by Ekman (1992) who used the average absolute values. In addition, the standard deviations of the NSA are less than those of the futures for each weekday, which is similar to the result for the whole period and the two subperiods.

Second, the standard deviations of returns in the afternoon opening interval are relatively large, but are not the second largest values. Similar to the above result, the standard deviations of the NSA are less than those of the futures.

Third, the standard deviations of returns in the afternoon closing interval are large for the NSA, but are not large for the futures so that the NSA exceeds the futures. In addition, the standard deviations of returns in the afternoon closing interval are smaller than those of the previous interval for the futures. Ekman (1992) documents a similar result for S&P 500 futures.

Fourth, contrary to these, the standard deviations of returns in the morning closing interval are small. However, the standard deviations of the NSA are larger than those of the futures and the values of the futures morning closing interval are also smaller than the previous interval.

Table 1 also shows skewness of average returns for each 15-minute interval during the whole period and the two subperiods. Positive and the largest values are recorded for the overnight futures returns

during the whole period and the regulated period. There is no tendency for the other returns. Although Chang et al. (1993) show positive and the largest skewness for overnight TOPIX returns during the whole period and the bull market period, the overnight NSA returns does not exhibit a similar result. The new findings are that skewness of the overnight futures returns exceed those of the overnight NSA returns and that skewness of the NSA returns become large during the middle of sessions. The first phenomenon can be explained by the difference in the speed of price change, but there is no explanation for the second phenomenon. Furthermore, skewness of the futures returns decreased drastically during the regulated period compared to the non-regulated period.

Table 2 represents skewness of the intraday returns averaged for each interval during the non-Saturday period and the five subsamples from Monday to Friday. The largest values are recorded for the overnight futures returns during the non-Saturday period and Friday. It is also observed in all weekdays that skewness of the NSA returns is larger during the middle of sessions than that of the opening and closing.

As for the kurtosis of the intraday returns, Table 1 shows kurtosis of average returns for each interval during the whole period and the two subperiods. The largest values are recorded for the futures returns of the first interval during the whole period and the non-regulated period. There is also a tendency for the NSA returns to be large during the middle of sessions. However, this contradicts the result of Chang et al. (1993) which reports positive and the largest kurtosis for overnight TOPIX returns during the whole period and the bull market period. One alternative interpretation for these phenomena is that there is a trade-off relation between the volatility and the kurtosis of the returns, since large kurtosis arise during the non-volatile intervals. Therefore, the large kurtosis and the high volatility seem to be a exceptional case. Furthermore, kurtosis of the futures returns also decreased extremely during the regulated period compared to the non-regulated period.

Table 2 also shows kurtosis of the intraday returns averaged for each interval during the non-Saturday period and the five weekdays subsamples. As for the weekday patterns, there is no particular feature which is different from the whole period and the two subperiods.

V. Return Reversals

The return reversals are verified by Ekman (1992) for S&P 500 futures using the autocorrelation of one-minute returns in each 15-minute interval on the one hand, the percentage of transaction price reversals in each 15-minute interval on the other hand. They are also documented for the TOPIX by Chang et al. (1993) who used the correlation's of adjacent minute-by-minute return series for each 30-minute interval on the one hand, the autocorrelation coefficients of 12 one-minute lags for each 60-minute interval on the other hand. The correlations of adjacent minute-by-minute return series are

Table 3

NSA: Whole Period

	Average	St.Dev.	Minimum	Maximum	Num.Obs
9:01	-0.0187	-	-	-	1
9:01-9:15	0.4904	0.1927	-0.0187	0.7152	15
9:16-9:30	0.3377	0.0316	0.2828	0.3875	15
9:31-9:45	0.3011	0.0592	0.1711	0.3828	15
9:46-10:00	0.3107	0.0392	0.2650	0.4062	15
10:01-10:15	0.3090	0.0419	0.2400	0.3864	15
10:16-10:30	0.3131	0.0452	0.2429	0.4104	15
10:31-10:45	0.3052	0.0486	0.2010	0.3699	15
10:46-11:00	0.3270	0.0258	0.2789	0.3708	15
11:01-11:15					
Aft.Opening	0.0865	-	-	-	1
12:31-12:45	0.3621	0.1062	0.0865	0.5214	15
12:46-13:00	0.3617	0.0483	0.2556	0.4555	15
13:01-13:15	0.3579	0.0902	0.2140	0.5188	15
13:16-13:30	0.3318	0.0627	0.2441	0.4902	15
13:31-13:45	0.3318	0.0627	0.2441	0.4902	15
13:46-14:00	0.3181	0.0340	0.2572	0.3740	15
14:01-14:15	0.3056	0.0708	0.1193	0.3977	15
14:16-14:30	0.3194	0.0374	0.2461	0.3744	15
14:31-14:45	0.3230	0.0268	0.2746	0.3724	15
14:46-15:00	0.2184	0.0655	0.1126	0.3233	15
15:01-15:15					
Total Time	0.3276	0.0852	-0.0187	0.7152	270
Mor.Session	0.3368	0.0970	-0.0187	0.7152	120
Aft.Session	0.3203	0.0740	0.0865	0.5214	150

Futures: Whole Period

	Average	St.Dev.	Minimum	Maximum	Num.Obs
9:00	-0.0350	-	-	-	1
9:00-9:15	0.0202	0.0263	-0.0350	0.0762	16
9:16-9:30	0.0138	0.0323	-0.0241	0.0840	15
9:31-9:45	0.0015	0.0398	-0.1048	0.0707	15
9:46-10:00	0.0165	0.0194	-0.0161	0.0410	15
10:01-10:15	0.0300	0.0373	-0.0274	0.0983	15
10:16-10:30	0.0326	0.0306	-0.0168	0.0848	15
10:31-10:45	0.0457	0.0422	-0.0380	0.1296	15
10:46-11:00	0.0538	0.0428	-0.0491	0.1164	15
11:01-11:15	0.0113	0.1135	-0.1756	0.3089	15
Aft.Opening	-0.0416	-	-	-	1
12:30-12:45	-0.0008	0.0534	-0.1133	0.0936	16
12:46-13:00	-0.0242	0.0376	-0.0900	0.0553	15
13:01-13:15	-0.0036	0.0209	-0.0444	0.0319	15
13:16-13:30	0.0047	0.0317	-0.0410	0.0612	15
13:31-13:45	0.0046	0.0238	-0.0324	0.0350	15
13:46-14:00	0.0171	0.0359	-0.0307	0.1151	15
14:01-14:15	0.0235	0.0304	-0.0251	0.0726	15
14:16-14:30	0.0519	0.0324	-0.0016	0.1304	15
14:31-14:45	0.0618	0.0322	0.0012	0.1222	15
14:46-15:00	0.0595	0.0272	0.0154	0.1109	15
15:01-15:15	-0.0207	0.0683	-0.1065	0.1312	15
Total Time	0.0199	0.0490	-0.1756	0.3089	302
Mor.Session	0.0250	0.0510	-0.1756	0.3089	136
Aft.Session	0.0157	0.0470	-0.1133	0.1312	166

NSA: Non-Regulated Period

	Average	St.Dev.	Minimum	Maximum	Num.Obs
9:01	0.0666	-	-	-	1
9:01-9:15	0.5740	0.2186	0.0666	0.7947	15
9:16-9:30	0.3363	0.0618	0.2238	0.4299	15
9:31-9:45	0.2556	0.0674	0.1191	0.3580	15
9:46-10:00	0.2784	0.1062	0.0937	0.4591	15
10:01-10:15	0.2539	0.0706	0.1336	0.3672	15
10:16-10:30	0.3388	0.0741	0.2581	0.5038	15
10:31-10:45	0.2995	0.0497	0.2228	0.3962	15
10:46-11:00	0.3007	0.0674	0.1642	0.3782	15
11:01-11:15					
13:01	0.1058	-	-	-	1
13:01-13:15	0.4092	0.1228	0.2203	0.6482	15
13:16-13:30	0.3233	0.0766	0.2000	0.4460	15
13:31-13:45	0.3407	0.0807	0.1903	0.4587	15
13:46-14:00	0.3583	0.0817	0.1988	0.4892	15
14:01-14:15	0.2727	0.0848	0.1038	0.4044	15
14:16-14:30	0.2832	0.0702	0.1543	0.4108	15
14:31-14:45	0.3154	0.0950	0.1679	0.4685	15
14:46-15:00	0.2315	0.0880	0.1203	0.4015	15
15:01-15:15					
Total Time	0.3220	0.1219	0.0666	0.7947	240
Mor.Session	0.3296	0.1397	0.0666	0.7947	120
Aft.Session	0.3143	0.1012	0.1038	0.6482	120

Futures: Non-Regulated Period

	Average	St.Dev.	Minimum	Maximum	Num.Obs
9:00	-0.1401	-	-	-	1
9:00-9:15	0.0181	0.0607	-0.1401	0.1322	16
9:16-9:30	0.0257	0.0309	-0.0391	0.0735	15
9:31-9:45	0.0291	0.0632	-0.0702	0.1506	15
9:46-10:00	0.0632	0.0725	-0.0328	0.1605	15
10:01-10:15	0.0954	0.0764	-0.0020	0.2234	15
10:16-10:30	0.0428	0.0579	-0.0500	0.1696	15
10:31-10:45	0.0477	0.0751	-0.0428	0.2398	15
10:46-11:00	0.0434	0.0551	-0.0478	0.1313	15
11:01-11:15	0.0070	0.1307	-0.1959	0.3530	15
13:00	-0.0297	-	-	-	1
13:00-13:15	0.0544	0.0946	-0.1519	0.2017	16
13:16-13:30	0.0202	0.0572	-0.0876	0.0990	15
13:31-13:45	0.0501	0.0649	-0.0546	0.1964	15
13:46-14:00	0.0154	0.0642	-0.1068	0.1223	15
14:01-14:15	0.0292	0.0531	-0.0417	0.1388	15
14:16-14:30	0.0409	0.0495	-0.0347	0.1253	15
14:31-14:45	0.0520	0.0452	-0.0135	0.1543	15
14:46-15:00	0.0238	0.0607	-0.0691	0.1019	15
15:01-15:15	-0.0456	0.0787	-0.1435	0.1444	15
Total Time	0.0337	0.0728	-0.1959	0.3530	272
Mor.Session	0.0412	0.0756	-0.1959	0.3530	136
Aft.Session	0.0261	0.0693	-0.1519	0.2017	136

NSA: Regulated Period

	Average	St.Dev.	Minimum	Maximum	Num.Obs
9:01	0.0042	-	-	-	1
9:01-9:15	0.4436	0.1399	0.1563	0.7121	15
9:16-9:30	0.3439	0.0662	0.2203	0.4678	15
9:31-9:45	0.2949	0.0837	0.0992	0.4121	15
9:46-10:00	0.3226	0.0615	0.2269	0.4468	15
10:01-10:15	0.3077	0.0570	0.2160	0.4321	15
10:16-10:30	0.3129	0.0561	0.1948	0.3911	15
10:31-10:45	0.3163	0.0885	0.1645	0.4415	15
10:46-11:00	0.3355	0.0482	0.2527	0.4144	15
11:01-11:15					
12:31	0.1134	-	-	-	1
12:31-12:45	0.3948	0.0955	0.2724	0.5781	15
12:46-13:00	0.3610	0.0520	0.2505	0.4549	15
13:01-13:15	0.3165	0.1257	0.0382	0.5274	15
13:16-13:30	0.3057	0.0785	0.1749	0.4056	15
13:31-13:45	0.2950	0.0778	0.1507	0.4649	15
13:46-14:00	0.3027	0.0663	0.1619	0.4207	15
14:01-14:15	0.2974	0.1302	-0.0633	0.4236	15
14:16-14:30	0.3209	0.0643	0.2192	0.4190	15
14:31-14:45	0.3328	0.0559	0.2729	0.4495	15
14:46-15:00	0.2238	0.0853	0.0782	0.3729	15
15:01-15:15					
Total Time	0.3231	0.0919	-0.0633	0.7121	268
Mor.Session	0.3310	0.0927	0.0042	0.7121	120
Aft.Session	0.3131	0.0955	-0.0633	0.5781	150

Futures: Regulated Period

	Average	St.Dev.	Minimum	Maximum	Num.Obs
9:00	-0.1156	-	-	-	1
9:00-9:15	0.0524	0.0640	-0.1156	0.1754	16
9:16-9:30	0.0394	0.0583	-0.0420	0.1546	15
9:31-9:45	0.0008	0.0840	-0.2209	0.1063	15
9:46-10:00	0.0235	0.0363	-0.0490	0.0770	15
10:01-10:15	0.0421	0.0423	-0.0302	0.1158	15
10:16-10:30	0.0491	0.0527	-0.0201	0.1369	15
10:31-10:45	0.0676	0.0585	-0.0232	0.1703	15
10:46-11:00	0.0738	0.0763	-0.1054	0.1849	15
11:01-11:15					
12:30	-0.0564	-	-	-	1
12:30-12:45	0.0077	0.0731	-0.1983	0.0999	16
12:46-13:00	-0.0148	0.0413	-0.0810	0.0630	15
13:01-13:15	-0.0067	0.0321	-0.0507	0.0673	15
13:16-13:30	0.0174	0.0322	-0.0369	0.0656	15
13:31-13:45	0.0032	0.0562	-0.1141	0.0773	15
13:46-14:00	0.0314	0.0548	-0.0599	0.1518	15
14:01-14:15	0.0257	0.0565	-0.0570	0.1175	15
14:16-14:30	0.0771	0.0603	-0.0201	0.1995	15
14:31-14:45	0.1002	0.0471	0.0068	0.1606	15
14:46-15:00	0.0927	0.0537	-0.0090	0.1748	15
15:01-15:15					
Total Time	0.0385	0.0633	-0.2209	0.1995	270
Mor.Session	0.0437	0.0631	-0.2209	0.1849	121
Aft.Session	0.0330	0.0643	-0.1983	0.1995	151

Table 4 (A)

NSA: Non-Saturday Period

	Average	St.Dev.	Minimum	Maximum	Num.Obs
9:01	-0.0191	-	-	-	1
9:01-9:15	0.4935	0.1931	-0.0191	0.7169	15
9:16-9:30	0.3432	0.0323	0.2878	0.3935	15
9:31-9:45	0.3058	0.0591	0.1780	0.3864	15
9:46-10:00	0.3152	0.0393	0.2707	0.4111	15
10:01-10:15	0.3139	0.0421	0.2442	0.3906	15
10:16-10:30	0.3179	0.0463	0.2434	0.4177	15
10:31-10:45	0.3091	0.0498	0.2041	0.3788	15
10:46-11:00	0.3301	0.0257	0.2835	0.3733	15
11:01-11:15					
Aft.Opening	0.0865	-	-	-	1
12:31-12:45	0.3621	0.1062	0.0865	0.5214	15
12:46-13:00	0.3617	0.0483	0.2556	0.4555	15
13:01-13:15	0.3611	0.0903	0.2155	0.5213	15
13:16-13:30	0.3347	0.0637	0.2451	0.4953	15
13:31-13:45	0.3080	0.0558	0.2222	0.3827	15
13:46-14:00	0.3212	0.0347	0.2578	0.3770	15
14:01-14:15	0.3084	0.0716	0.1205	0.3998	15
14:16-14:30	0.3225	0.0375	0.2472	0.3773	15
14:31-14:45	0.3254	0.0269	0.2779	0.3734	15
14:46-15:00	0.2202	0.0656	0.1145	0.3247	15
15:01-15:15					
Total Time	0.3308	0.0854	-0.0191	0.7169	270
Mor.Session	0.3411	0.0970	-0.0191	0.7169	120
Aft.Session	0.3225	0.0741	0.0865	0.5214	150

Futures: Non-Saturday Period

	Average	St.Dev.	Minimum	Maximum	Num.Obs
9:00	-0.0394	-	-	-	1
9:00-9:15	0.0234	0.0281	-0.0394	0.0868	16
9:16-9:30	0.0147	0.0329	-0.0247	0.0853	15
9:31-9:45	0.0026	0.0403	-0.1074	0.0729	15
9:46-10:00	0.0167	0.0197	-0.0168	0.0422	15
10:01-10:15	0.0305	0.0372	-0.0267	0.0966	15
10:16-10:30	0.0341	0.0287	-0.0117	0.0891	15
10:31-10:45	0.0465	0.0430	-0.0399	0.1301	15
10:46-11:00	0.0548	0.0427	-0.0491	0.1171	15
11:01-11:15	0.0206	0.1189	-0.1752	0.3298	15
Aft.Opening	-0.0416	-	-	-	1
12:30-12:45	-0.0008	0.0534	-0.1133	0.0936	16
12:46-13:00	-0.0242	0.0376	-0.0900	0.0553	15
13:01-13:15	-0.0019	0.0212	-0.0439	0.0334	15
13:16-13:30	0.0049	0.0318	-0.0424	0.0603	15
13:31-13:45	0.0058	0.0247	-0.0317	0.0364	15
13:46-14:00	0.0180	0.0362	-0.0303	0.1164	15
14:01-14:15	0.0240	0.0306	-0.0252	0.0740	15
14:16-14:30	0.0525	0.0329	-0.0028	0.1306	15
14:31-14:45	0.0627	0.0321	0.0036	0.1224	15
14:46-15:00	0.0602	0.0276	0.0156	0.1122	15
15:01-15:15	-0.0189	0.0699	-0.1048	0.1427	15
Total Time	0.0212	0.0498	-0.1752	0.3298	302
Mor.Session	0.0271	0.0521	-0.1752	0.3298	136
Aft.Session	0.0165	0.0473	-0.1133	0.1427	166

NSA: Monday

	Average	St.Dev.	Minimum	Maximum	Num.Obs
9:01	0.0570	-	-	-	1
9:01-9:15	0.4935	0.1931	-0.0191	0.7169	15
9:16-9:30	0.3432	0.0323	0.2878	0.3935	15
9:31-9:45	0.3058	0.0591	0.1780	0.3864	15
9:46-10:00	0.3152	0.0393	0.2707	0.4111	15
10:01-10:15	0.3139	0.0421	0.2442	0.3906	15
10:16-10:30	0.3179	0.0463	0.2434	0.4177	15
10:31-10:45	0.3091	0.0498	0.2041	0.3788	15
10:46-11:00	0.3301	0.0257	0.2835	0.3733	15
11:01-11:15					
Aft.Opening	0.0135	-	-	-	1
12:31-12:45	0.3621	0.1062	0.0865	0.5214	15
12:46-13:00	0.3617	0.0483	0.2556	0.4555	15
13:01-13:15	0.3611	0.0903	0.2155	0.5213	15
13:16-13:30	0.3347	0.0637	0.2451	0.4953	15
13:31-13:45	0.3080	0.0558	0.2222	0.3827	15
13:46-14:00	0.3212	0.0347	0.2578	0.3770	15
14:01-14:15	0.3084	0.0716	0.1205	0.3998	15
14:16-14:30	0.3225	0.0375	0.2472	0.3773	15
14:31-14:45	0.3254	0.0269	0.2779	0.3734	15
14:46-15:00	0.2202	0.0656	0.1145	0.3247	15
15:01-15:15					
Total Time	0.3409	0.1391	-0.4764	0.7340	270
Mor.Session	0.3424	0.1457	-0.2610	0.7340	120
Aft.Session	0.3398	0.1340	-0.4764	0.6416	150

Futures: Monday

	Average	St.Dev.	Minimum	Maximum	Num.Obs
9:00	-0.0358	-	-	-	1
9:00-9:15	0.0087	0.0363	-0.0382	0.0877	16
9:16-9:30	0.0056	0.0457	-0.0899	0.0856	15
9:31-9:45	-0.0381	0.1316	-0.4232	0.1291	15
9:46-10:00	0.0082	0.0660	-0.0659	0.1550	15
10:01-10:15	0.0244	0.1065	-0.2596	0.1540	15
10:16-10:30	0.0545	0.0726	-0.0882	0.1817	15
10:31-10:45	0.0396	0.0743	-0.1027	0.1635	15
10:46-11:00	0.0486	0.0790	-0.1484	0.1788	15
11:01-11:15	0.0210	0.1160	-0.1858	0.1691	15
Aft.Opening	-0.0972	-	-	-	1
12:30-12:45	-0.0225	0.0993	-0.2415	0.1212	16
12:46-13:00	-0.0313	0.1143	-0.2227	0.1431	15
13:01-13:15	0.0060	0.0529	-0.0742	0.1055	15
13:16-13:30	-0.0171	0.0930	-0.1396	0.1572	15
13:31-13:45	-0.0312	0.0614	-0.1358	0.0764	15
13:46-14:00	0.0028	0.0355	-0.0546	0.0651	15
14:01-14:15	0.0102	0.0682	-0.1307	0.1156	15
14:16-14:30	0.0423	0.0745	-0.1124	0.1667	15
14:31-14:45	0.0330	0.0649	-0.0948	0.1425	15
14:46-15:00	0.0556	0.0809	-0.0368	0.1953	15
15:01-15:15	-0.0381	0.1094	-0.2172	0.2122	15
Total Time	0.0090	0.0862	-0.4232	0.2122	302
Mor.Session	0.0191	0.0874	-0.4232	0.1817	136
Aft.Session	0.0008	0.0845	-0.2415	0.2122	166

NSA: Tuesday

	Average	St.Dev.	Minimum	Maximum	Num.Obs
9:01	-0.0591	-	-	-	1
9:01-9:15	0.4878	0.2380	-0.0591	0.7085	15
9:16-9:30	0.3618	0.0684	0.2358	0.4624	15
9:31-9:45	0.3097	0.0781	0.1954	0.4822	15
9:46-10:00	0.3358	0.0891	0.2285	0.4974	15
10:01-10:15	0.3074	0.0609	0.2083	0.3911	15
10:16-10:30	0.2916	0.1135	0.1218	0.4799	15
10:31-10:45	0.3319	0.0844	0.1691	0.5339	15
10:46-11:00	0.3458	0.0692	0.2493	0.4474	15
11:01-11:15					
Aft.Opening	0.0165	-	-	-	1
12:31-12:45	0.4013	0.1536	0.0165	0.5955	15
12:46-13:00	0.3614	0.0678	0.2117	0.4499	15
13:01-13:15	0.3404	0.1012	0.0929	0.5208	15
13:16-13:30	0.3116	0.0627	0.2122	0.4612	15
13:31-13:45	0.3181	0.0842	0.1880	0.4889	15
13:46-14:00	0.3609	0.0803	0.2137	0.4887	15
14:01-14:15	0.3302	0.1170	0.1713	0.5306	15
14:16-14:30	0.3875	0.0832	0.1848	0.5054	15
14:31-14:45	0.3516	0.0619	0.2419	0.4725	15
14:46-15:00	0.2156	0.1402	0.0050	0.4826	15
15:01-15:15					
Total Time	0.3417	0.1159	-0.0591	0.7085	270
Mor.Session	0.3465	0.1247	-0.0591	0.7085	120
Aft.Session	0.3379	0.1086	0.0050	0.5955	150

Futures: Tuesday

	Average	St.Dev.	Minimum	Maximum	Num.Obs
9:00	0.0077	-	-	-	1
9:00-9:15	0.0295	0.0646	-0.1012	0.2100	16
9:16-9:30	0.0236	0.0553	-0.0653	0.1097	15
9:31-9:45	0.0199	0.0392	-0.0484	0.0879	15
9:46-10:00	0.0221	0.0370	-0.0378	0.0925	15
10:01-10:15	0.0278	0.0687	-0.0798	0.1538	15
10:16-10:30	0.0488	0.0668	-0.0667	0.2203	15
10:31-10:45	0.0711	0.0742	-0.0868	0.1784	15
10:46-11:00	0.0460	0.0676	-0.0455	0.1832	15
11:01-11:15	0.0070	0.1261	-0.1429	0.3277	15
Aft.Opening	-0.0207	-	-	-	1
12:30-12:45	-0.0140	0.0850	-0.1353	0.1862	16
12:46-13:00	-0.0092	0.0747	-0.1276	0.1202	15
13:01-13:15	-0.0100	0.0663	-0.1119	0.1073	15
13:16-13:30	0.0062	0.0712	-0.0887	0.1550	15
13:31-13:45	0.0502	0.0690	-0.0791	0.1540	15
13:46-14:00	0.0211	0.0975	-0.2348	0.1842	15
14:01-14:15	0.0176	0.0666	-0.1944	0.0893	15
14:16-14:30	0.0348	0.0540	-0.0647	0.1479	15
14:31-14:45	0.0552	0.0625	-0.0752	0.1797	15
14:46-15:00	0.0826	0.0754	-0.0319	0.2461	15
15:01-15:15	0.0130	0.0698	-0.1410	0.1084	15
Total Time	0.0270	0.0742	-0.2348	0.3277	302
Mor.Session	0.0328	0.0711	-0.1429	0.3277	136
Aft.Session	0.0223	0.0765	-0.2348	0.2461	166

Table 4 (B)

NSA: Wednesday

	Average	St.Dev.	Minimum	Maximum	Num.Obs
9:01	0.0363	-	-	-	1
9:01-9:15	0.5050	0.1725	0.0363	0.7133	15
9:16-9:30	0.3277	0.0859	0.2099	0.4770	15
9:31-9:45	0.3248	0.0968	0.1695	0.4888	15
9:46-10:00	0.3085	0.0970	0.0467	0.4636	15
10:01-10:15	0.3283	0.0706	0.2283	0.4376	15
10:16-10:30	0.2726	0.1149	-0.0023	0.4407	15
10:31-10:45	0.3576	0.1290	0.0086	0.5650	15
10:46-11:00	0.3361	0.0797	0.1495	0.4678	15
11:01-11:15					
Aft.Opening	-0.0457	-	-	-	1
12:31-12:45	0.3536	0.1490	-0.0457	0.5547	15
12:46-13:00	0.3615	0.1531	0.0274	0.5970	15
13:01-13:15	0.3539	0.1372	-0.0287	0.5245	15
13:16-13:30	0.3285	0.1262	0.0501	0.5193	15
13:31-13:45	0.3174	0.1113	0.1364	0.4955	15
13:46-14:00	0.3404	0.0963	0.1698	0.4878	15
14:01-14:15	0.3340	0.1217	0.1450	0.5311	15
14:16-14:30	0.3395	0.0752	0.1951	0.4580	15
14:31-14:45	0.3550	0.0941	0.1973	0.5134	15
14:46-15:00	0.1984	0.0966	0.0804	0.3454	15
15:01-15:15					
Total Time	0.3357	0.1243	-0.0457	0.7133	270
Mor.Session	0.3451	0.1250	-0.0023	0.7133	120
Aft.Session	0.3282	0.1236	-0.0457	0.5970	150

Futures: Wednesday

	Average	St.Dev.	Minimum	Maximum	Num.Obs
9:00	-0.0335	-	-	-	1
9:00-9:15	0.0195	0.0591	-0.1047	0.1116	16
9:16-9:30	0.0194	0.0510	-0.0854	0.1474	15
9:31-9:45	0.0139	0.0687	-0.1026	0.1425	15
9:46-10:00	-0.0011	0.0687	-0.1085	0.1141	15
10:01-10:15	0.0480	0.0557	0.0379	0.1403	15
10:16-10:30	0.0346	0.0901	-0.1154	0.1603	15
10:31-10:45	0.0483	0.0688	-0.0810	0.1853	15
10:46-11:00	0.0592	0.0656	-0.0486	0.1832	15
11:01-11:15	-0.0404	0.2085	-0.4667	0.2675	15
Aft.Opening	0.0059	-	-	-	1
12:30-12:45	0.0183	0.1025	-0.1431	0.1990	16
12:46-13:00	-0.0407	0.0971	-0.2356	0.1212	15
13:01-13:15	-0.0167	0.0803	-0.1558	0.1412	15
13:16-13:30	-0.0098	0.0500	-0.1051	0.0625	15
13:31-13:45	0.0156	0.0685	-0.0803	0.1366	15
13:46-14:00	0.0230	0.0813	-0.1369	0.1650	15
14:01-14:15	0.0243	0.0676	-0.1050	0.1074	15
14:16-14:30	0.0659	0.0733	-0.0402	0.2184	15
14:31-14:45	0.0811	0.0751	-0.0426	0.2210	15
14:46-15:00	0.0536	0.0767	-0.0611	0.2024	15
15:01-15:15	-0.0261	0.1269	-0.2427	0.2668	15
Total Time	0.0195	0.0920	-0.4667	0.2675	302
Mor.Session	0.0224	0.0952	-0.4667	0.2675	136
Aft.Session	0.0171	0.0896	-0.2427	0.2668	166

NSA: Thursday

	Average	St.Dev.	Minimum	Maximum	Num.Obs
9:01	-0.0409	-	-	-	1
9:01-9:15	0.4678	0.2030	-0.0409	0.7355	15
9:16-9:30	0.2883	0.0677	0.1199	0.4016	15
9:31-9:45	0.3285	0.0768	0.1488	0.4818	15
9:46-10:00	0.3568	0.0445	0.2786	0.4088	15
10:01-10:15	0.3357	0.0779	0.2007	0.5009	15
10:16-10:30	0.3529	0.0697	0.2137	0.4590	15
10:31-10:45	0.2693	0.1411	0.0425	0.4419	15
10:46-11:00	0.3555	0.0662	0.2690	0.5101	15
11:01-11:15					
Aft.Opening	0.1926	-	-	-	1
12:31-12:45	0.3010	0.2064	-0.1997	0.6300	15
12:46-13:00	0.3293	0.1463	-0.0726	0.5085	15
13:01-13:15	0.3543	0.1251	0.0990	0.6071	15
13:16-13:30	0.2746	0.1039	0.0515	0.4236	15
13:31-13:45	0.2945	0.1469	-0.0284	0.5926	15
13:46-14:00	0.2759	0.1302	0.0659	0.5422	15
14:01-14:15	0.3428	0.0965	0.1532	0.5067	15
14:16-14:30	0.2708	0.1077	0.0755	0.4234	15
14:31-14:45	0.2978	0.0677	0.1659	0.3805	15
14:46-15:00	0.2621	0.1048	0.0799	0.5037	15
15:01-15:15					
Total Time	0.3199	0.1249	-0.1997	0.7355	270
Mor.Session	0.3444	0.1165	-0.0409	0.7355	120
Aft.Session	0.3003	0.1283	-0.1997	0.6300	150

Futures: Thursday

	Average	St.Dev.	Minimum	Maximum	Num.Obs
9:00	-0.0658	-	-	-	1
9:00-9:15	0.0200	0.0563	-0.0916	0.0913	16
9:16-9:30	0.0110	0.0462	-0.0428	0.1091	15
9:31-9:45	0.0229	0.1052	-0.1778	0.2416	15
9:46-10:00	0.0098	0.0566	-0.0727	0.1320	15
10:01-10:15	0.0229	0.0630	-0.0842	0.1084	15
10:16-10:30	0.0199	0.0408	-0.0466	0.0792	15
10:31-10:45	0.0355	0.0594	-0.0730	0.1395	15
10:46-11:00	0.0694	0.0688	-0.0216	0.2229	15
11:01-11:15	0.0457	0.1547	-0.2561	0.2459	15
Aft.Opening	-0.0806	-	-	-	1
12:30-12:45	-0.0094	0.0839	-0.1570	0.1137	16
12:46-13:00	-0.0180	0.0803	-0.1476	0.1202	15
13:01-13:15	0.0168	0.0656	-0.0937	0.1670	15
13:16-13:30	-0.0040	0.0527	-0.0670	0.1036	15
13:31-13:45	-0.0028	0.0808	-0.1296	0.1474	15
13:46-14:00	0.0173	0.0578	-0.0717	0.1212	15
14:01-14:15	0.0399	0.0791	-0.0825	0.1526	15
14:16-14:30	0.0524	0.0621	-0.0441	0.1600	15
14:31-14:45	0.0816	0.0610	-0.0698	0.1646	15
14:46-15:00	0.0550	0.0520	-0.0641	0.1412	15
15:01-15:15	-0.0264	0.1264	-0.1776	0.3663	15
Total Time	0.0229	0.0800	-0.2561	0.3663	302
Mor.Session	0.0285	0.0793	-0.2561	0.2459	136
Aft.Session	0.0182	0.0805	-0.1776	0.3663	166

NSA: Friday

	Average	St.Dev.	Minimum	Maximum	Num.Obs
9:01	-0.0733	-	-	-	1
9:01-9:15	0.4779	0.2011	-0.0733	0.7388	15
9:16-9:30	0.3383	0.0541	0.2518	0.4503	15
9:31-9:45	0.3253	0.0883	0.1743	0.4579	15
9:46-10:00	0.3264	0.1148	0.1248	0.5025	15
10:01-10:15	0.3206	0.0943	0.1799	0.5327	15
10:16-10:30	0.3654	0.1023	0.2010	0.5260	15
10:31-10:45	0.2906	0.0967	0.1269	0.5159	15
10:46-11:00	0.3219	0.0686	0.2117	0.4094	15
11:01-11:15					
Aft.Opening	0.2012	-	-	-	1
12:31-12:45	0.4035	0.1254	0.1734	0.6195	15
12:46-13:00	0.3826	0.1396	0.1246	0.5834	15
13:01-13:15	0.3565	0.1561	0.0284	0.5710	15
13:16-13:30	0.4155	0.1029	0.2959	0.6786	15
13:31-13:45	0.3188	0.0997	0.1292	0.4680	15
13:46-14:00	0.3138	0.1031	0.1203	0.5432	15
14:01-14:15	0.3512	0.0879	0.2384	0.5453	15
14:16-14:30	0.2825	0.0873	0.1303	0.4032	15
14:31-14:45	0.3377	0.0708	0.1630	0.4555	15
14:46-15:00	0.1946	0.0856	0.0134	0.3303	15
15:01-15:15					
Total Time	0.3402	0.1210	-0.0733	0.7388	270
Mor.Session	0.3458	0.1200	-0.0733	0.7388	120
Aft.Session	0.3357	0.1220	0.0134	0.6786	150

Futures: Friday

	Average	St.Dev.	Minimum	Maximum	Num.Obs
9:00	-0.0706	-	-	-	1
9:00-9:15	0.0356	0.0510	-0.0706	0.1608	16
9:16-9:30	0.0153	0.0664	-0.0653	0.1633	15
9:31-9:45	-0.0038	0.0690	-0.1107	0.0997	15
9:46-10:00	0.0453	0.0546	-0.0478	0.1626	15
10:01-10:15	0.0321	0.0623	-0.0923	0.1232	15
10:16-10:30	0.0116	0.0755	-0.1166	0.2003	15
10:31-10:45	0.0415	0.0829	-0.1084	0.1777	15
10:46-11:00	0.0526	0.0762	-0.0626	0.2474	15
11:01-11:15	0.0225	0.2364	-0.3627	0.6551	15
Aft.Opening	-0.0109	-	-	-	1
12:30-12:45	0.0278	0.0833	-0.1324	0.1773	16
12:46-13:00	0.0229	0.0754	-0.1426	0.1214	15
13:01-13:15	-0.0081	0.0698	-0.0898	0.1734	15
13:16-13:30	0.0382	0.0656	-0.0808	0.1689	15
13:31-13:45	-0.0106	0.0872	-0.1226	0.1573	15
13:46-14:00	0.0123	0.0597	-0.0570	0.1435	15
14:01-14:15	0.0245	0.0601	-0.0654	0.1276	15
14:16-14:30	0.0638	0.0737	-0.0689	0.2278	15
14:31-14:45	0.0583	0.0661	-0.1064	0.1310	15
14:46-15:00	0.0544	0.0626	-0.0516	0.1664	15
15:01-15:15	-0.0115	0.1146	-0.1402	0.2216	15
Total Time	0.0240	0.0890	-0.3627	0.6551	302
Mor.Session	0.0281	0.0997	-0.3627	0.6551	136
Aft.Session	0.0206	0.0794	-0.1426	0.2278	166

adopted here to examine return reversals.

Table 3 represents summary statistics of the estimated correlations between the minute and the previous minute averaged for each 15-minute interval during the whole period and the two subperiods. For example, the correlation at time t, C_t, is computed by using two return series, rt and r_{t-1}, and the values for the 15 minute interval, $C_{t,t+14}$, are the arithmetic averages of 15 correlations, C_t, C_{t+1}, C_{t+2}, · · ·, C_{t+14}. The pattern of the NSA adjacent one-minute correlations is similar to the result of Chang et al. (1993); the first correlations of the morning and afternoon sessions are very low and those of the next 15 minutes are the highest for the day. Then, the correlations gradually decline during the middle of the sessions, and again increase toward the end of the sessions. However, the averages of the correlations in this study are 0.3, which is much higher than 0.15 for the whole period and -0.1 for the bull market period reported by Chang et al. (1993), but similar to the bear market period of the same study. Low correlations between the adjacent return series suggest a large degree of return reversals. Therefore, the NSA returns tend to lean to one side, particularly during the few minutes after the opening and near the closing. On the other hand, the futures returns show no such trend and the correlation level is quite low compared to the NSA. Thus, the futures returns have characteristics of a larger degree of reversals.

Table 4 presents summary statistics of these correlations averaged for each interval during the non-Saturday period and the five weekdays subsamples. There are no distinctive features between the 5 weekdays; the shapes of the intraday estimated correlations are similar. This result is consistent with the results of Ekman (1992).

Ⅵ. Lead-Lag Relations

It is well known that stock indexes have positive autocorrelations because some of the stocks included in the index are not traded frequently and information spreads from liquid stocks to illiquid stocks. On the other hand, the stock index futures have fewer autocorrelations because of its active trade and hence its enormous liquidity. Furthermore, for the S&P 500 and the S&P 500 stock index futures, Kawaller, Koch, and Koch (1987), Stoll and Whaley (1990), Chan, Chan, and Karolyi (1991), and Chan (1992) find that the stock index futures lead the stock index, but the stock index does not lead the stock index futures as well. As for the NSA and the Nikkei 225 futures, Chung, Kang, and Rhee (1994), by using the 5-minute returns during the period between September, 1988 and September, 1991, document that the Nikkei 225 futures leads the NSA for 20 minutes and the NSA leads the Nikkei 225 futures for 15 minutes. In this paper, minute-by-minute data is used to examine the relations and the vector autoregressive model is adopted according to Kawaller, Koch, and Koch (1987).

The autocorrelations are presented in Panel A of Table 5 to Panel A of Table 7 for the whole period

and the two subperiods. As for the whole period, the autocorrelations of the NSA are statistically significant until 25 minutes and those of the Nikkei 225 futures are significant for more than 25 minutes. This result is contrary to the expectation. However, during the non-regulated period, the autocorrelations of the NSA are significant until 35 minutes and those of the futures are significant until 19 minutes. During the regulated period, those of the NSA are significant until 11 minutes and those of the futures are less than those of the NSA. In both subperiods, the autocorrelations of the NSA are larger than those of the Nikkei 225 futures. In addition, the autocorrelations of the NSA and the futures decrease during the regulated period compared to the non-regulated period. These results are consistent with the expectation, the strange result for the whole period can be explained partly by a error of synthesis.

Similarly, the autocorrelations for the five subsamples from Monday to Friday are presented in Panel A of Table 8 to Panel A of Table 12. The result of Monday is similar to that of the whole period, but in the other weekdays the autocorrelations of the NSA are below 17 minutes.

As for the lead-lag relations between the NSA and the Nikkei 225 futures, the multiple regression model is examined first by using 46 variables which include the same minute (lag 0). The results of the multiple regressions are reported in Panel B of Table 5 to Panel B of Table 7 for the whole period and the two subperiods. During the whole period, the coefficients of the futures which show the explanatory power for the NSA are statistically significant until 15 minutes and those of the NSA for the futures are significant until 14 minutes. During the non-regulated period, the coefficients of the futures for the NSA are significant until 20 minutes and those of the NSA for the futures are significant until 8 minutes. During the regulated period, the coefficients of the futures for the NSA are significant until 11 minutes and those of the NSA for the futures are significant until 12 minutes. Although the numbers of the significant coefficients of the futures and those of the NSA are similar during the whole period and the regulated period, the number of the significant coefficients of the futures decreases in the regulated period compared to the non-regulated period and that of the NSA increases in the regulated period compared to the non-regulated period.

Similar results are presented in Panel B of Table 8 to Panel B of Table 12 for the five subsamples from Monday to Friday. The coefficients of the futures for the NSA are significant until about 10 minutes in each weekday, but those of the NSA for the futures are different on Monday and Thursday (significant more than 12 minutes) from other weekdays. Incidentally, this difference coincides with the difference of the shapes of the cumulative returns.

In this multiple regression model the explaining variables are correlated each other, so these correlations, which reported as autocorrelations in Panel A, must be removed. Kawaller, Koch, and Koch (1987) use the special kind of vector autoregressive model in which the explaining variables are 60 autolags and 46 cross-lags including the same minute. Here, the standard vector autoregressive model

Table 5 (A) Whole Period

Panel A : Autocorelation

NSA			Futures		
lag	Autocorr.	t-Value	lag	Autocorr.	t-Value
1	0.3235	209.5668 ***	1	0.0241	14.7897 ***
2	0.1589	98.6409 ***	2	0.0173	10.5903 ***
3	0.1227	75.8135 ***	3	0.0228	13.9950 ***
4	0.0995	61.2828 ***	4	0.0042	2.5598 *
5	0.0887	54.5673 ***	5	0.0348	21.3447 ***
6	0.0678	41.6585 ***	6	0.0767	47.1639 ***
7	0.0565	34.6676 ***	7	0.0288	17.6409 ***
8	0.0478	29.3424 ***	8	0.0129	7.8961 ***
9	0.0428	26.2376 ***	9	0.0160	9.8158 ***
10	0.0340	20.8243 ***	10	0.0251	15.3677 ***
11	0.0287	17.6127 ***	11	0.0057	3.4643 ***
12	0.0231	14.1647 ***	12	0.0473	29.0051 ***
13	0.0193	11.8225 ***	13	0.0080	4.8855 ***
14	0.0147	9.0426 ***	14	0.0131	8.0014 ***
15	0.0164	10.0297 ***	15	0.0200	12.2593 ***
16	0.0123	7.5375 ***	16	0.0055	3.3684 ***
17	0.0094	5.7501 ***	17	0.0043	2.6559 **
18	0.0051	3.1280 **	18	0.0271	16.5968 ***
19	0.0063	3.8906 ***	19	0.0095	5.8121 ***
20	0.0048	2.9630 **	20	0.0126	7.7260 ***
21	0.0068	4.1512 ***	21	0.0106	6.4798 ***
22	0.0039	2.3901 *	22	0.0043	2.6143 **
23	0.0046	2.8473 **	23	-0.0001	0.0909
24	0.0037	2.2616 *	24	0.0224	13.7206 ***
25	0.0051	3.1396 **	25	0.0119	7.3209 ***
26	0.0032	1.9650	26	0.0056	3.4275 ***
27	0.0032	1.9342	27	0.0028	1.7119
28	0.0010	0.6002	28	0.0056	3.4632 ***
29	0.0032	1.9352	29	0.0054	3.2870 **
30	0.0049	3.0062 **	30	0.0198	12.1428 ***
31	0.0031	1.9112	31	0.0043	2.6354 **
32	-0.0014	0.8541	32	0.0036	2.1940
33	-0.0006	0.3455	33	0.0024	1.4627
34	0.0009	0.5449	34	0.0041	2.5017 *
35	-0.0002	0.1349	35	0.0072	4.4396 ***
36	0.0001	0.0527	36	0.0138	8.4741 ***
37	-0.0013	0.7837	37	0.0031	1.8982
38	0.0020	1.2386	38	0.0012	0.7218
39	0.0007	0.4220	39	0.0066	4.0161 ***
40	-0.0012	0.7123	40	0.0056	3.4472 ***
41	-0.0003	0.2012	41	0.0082	5.0353 ***
42	0.0004	0.2470	42	0.0075	4.5783 ***
43	0.0015	0.9500	43	0.0042	2.6028 **
44	-0.0014	0.8346	44	0.0035	2.1493 *
45	-0.0056	3.4621 ***	45	0.0039	2.3787 *
46	-0.0022	1.3406	46	0.0041	2.5432 *
47	-0.0005	0.3185	47	0.0050	3.0605 **
48	-0.0040	2.4456 *	48	0.0090	5.4889 ***
49	0.0006	0.3838	49	0.0037	2.2591 *
50	-0.0016	1.0043	50	0.0038	2.3209 *
51	-0.0026	1.5645	51	0.0021	1.2820
52	-0.0041	2.5069 *	52	0.0007	0.4324
53	-0.0018	1.1114	53	0.0019	1.1450
54	-0.0012	0.7472	54	0.0037	2.2849 *
55	-0.0018	1.1134	55	0.0046	2.7943 **
56	-0.0008	0.4784	56	-0.0015	0.9428
57	-0.0006	0.3734	57	0.0050	3.0729 **
58	0.0002	0.1428	58	0.0028	1.7105
59	0.0028	1.7271	59	0.0023	1.4349
60	0.0018	1.0978	60	0.0070	4.2748 ***

Panel B : Multiple Regression

NSA<=FUT			NSA=>FUT		
lag	Coeff.	t-Value	lag	Coeff.	t-Value
0	0.0867	68.0855 ***	0	0.1207	56.7684 ***
1	0.0944	74.0992 ***	1	0.0648	29.2204 ***
2	0.0932	73.1635 ***	2	0.0183	8.2306 ***
3	0.0748	58.6994 ***	3	0.0108	4.8687 ***
4	0.0611	47.9686 ***	4	0.0124	5.6027 ***
5	0.0508	39.8289 ***	5	0.0204	9.1814 ***
6	0.0355	27.8138 ***	6	0.0205	9.2421 ***
7	0.0271	21.2060 ***	7	0.0009	0.4034
8	0.0199	15.5664 ***	8	0.0076	3.4232 ***
9	0.0172	13.4878 ***	9	0.0066	2.9560 **
10	0.0129	10.1272 ***	10	0.0116	5.2136 ***
11	0.0113	8.8398 ***	11	0.0061	2.7335 **
12	0.0069	5.3754 ***	12	0.0124	5.5851 ***
13	0.0051	4.0221 ***	13	0.0047	2.1207 *
14	0.0060	4.6791 ***	14	0.0076	3.4265 ***
15	0.0043	3.3779 ***	15	0.0044	1.9825 *
16	0.0004	0.2951	16	0.0046	2.0487 *
17	0.0021	1.6643	17	0.0047	2.0944 *
18	0.0000	0.0110	18	0.0078	3.5098 ***
19	-0.0021	-1.6321	19	0.0054	2.4202 *
20	-0.0008	-0.5970	20	0.0070	3.1555 **
21	-0.0020	-1.5521	21	0.0028	1.2573
22	-0.0005	-0.4049	22	0.0039	1.7617
23	0.0018	1.4245	23	0.0022	1.0096
24	-0.0014	-1.1292	24	0.0066	2.9843 **
25	-0.0025	-1.9601	25	0.0042	1.9064
26	-0.0037	-2.8751 **	26	0.0002	0.0825
27	-0.0003	-0.2057	27	0.0022	0.9947
28	-0.0008	-0.6347	28	0.0048	2.1680 *
29	0.0007	0.5610	29	0.0033	1.4620
30	0.0009	0.6774	30	0.0078	3.5235 ***
31	0.0007	0.5769	31	0.0013	0.5961
32	-0.0011	-0.8908	32	-0.0036	-1.6129
33	-0.0002	-0.1587	33	0.0029	1.2849
34	0.0007	0.5390	34	0.0021	0.9345
35	0.0012	0.9528	35	0.0038	1.6951
36	-0.0009	-0.6896	36	0.0037	1.6807
37	0.0013	1.0404	37	0.0032	1.4440
38	0.0010	0.7951	38	-0.0016	-0.7134
39	-0.0018	-1.3720	39	0.0048	2.1699 *
40	0.0008	0.6237	40	0.0036	1.6273
41	-0.0024	-1.8996	41	0.0012	0.5406
42	-0.0022	-1.7043	42	0.0017	0.7779
43	-0.0010	-0.7776	43	-0.0009	-0.4080
44	-0.0009	-0.7107	44	0.0011	0.5107
45	-0.0014	-1.0870	45	0.0061	2.8609 **
constant		-2.9E-07			-5.6E-07
Num. of Obs.		375810			375810
Sd. error of regression		0.0004			0.0006
R-squared		0.0738			0.0223
Adj. R-squared		0.0737			0.0222
F-statistic		650.7788 ***			186.6622 ***
Durbin-Watson statistic		1.4649			2.0025

Note: * represents significant at the 5% level.
** represents significant at the 1% level.
*** represents significant at the 0.1% level.

Table 5 (B) Whole Period

Panel C : Vector Autoregression 1

NSA<=FUT			NSA<=NSA		
lag	Coeff.	t-Value	lag	Coeff.	t-Value
1	0.0703	56.6892 ***	1	0.2673	163.1413 ***
2	0.0651	52.2695 ***	2	0.0159	9.3882 ***
3	0.0459	36.7037 ***	3	0.0288	16.9623 ***
4	0.0343	27.4004 ***	4	0.0142	8.3428 ***
5	0.0300	23.9155 ***	5	0.0202	11.9197 ***
6	0.0215	17.1169 ***	6	0.0021	1.2423
7	0.0138	10.9840 ***	7	0.0036	2.1033 *
8	0.0085	6.7513 ***	8	0.0017	0.9916
9	0.0089	7.0403 ***	9	0.0047	2.7905 **
10	0.0072	5.7196 ***	10	-0.0015	-0.8860
11	0.0056	4.4404 ***	11	-0.0001	-0.0400
12	0.0058	4.5949 ***	12	-0.0026	-1.5168
13	0.0027	2.1771 *	13	-0.0019	-1.1470
14	0.0052	4.1547 ***	14	-0.0052	-3.0593 **
15	0.0042	3.3336 ***	15	0.0019	1.1315
16	-0.0001	-0.0753	16	-0.0030	-1.7537
17	0.0029	2.2771 *	17	-0.0019	-1.1144
18	0.0022	1.7620	18	-0.0061	-3.5925 ***
19	-0.0003	-0.2427	19	-0.0008	-0.4921
20	0.0020	1.5960	20	-0.0043	-2.5564 *
21	0.0004	0.2846	21	0.0007	0.4006
22	0.0018	1.3970	22	-0.0044	-2.5837 **
23	0.0033	2.6469 **	23	-0.0006	-0.3753
24	0.0010	0.7561	24	-0.0028	-1.6307
25	0.0000	0.0195	25	0.0006	0.3538
26	-0.0014	-1.0977	26	-0.0031	-1.8438
27	0.0021	1.6991	27	-0.0008	-0.4513
28	0.0011	0.8935	28	-0.0046	-2.6858 **
29	0.0027	2.1209 *	29	-0.0005	-0.3141
30	0.0032	2.5693 *	30	0.0008	0.4891
31	0.0020	1.6003	31	-0.0011	-0.6595
32	0.0002	0.1235	32	-0.0061	-3.5790 **
33	0.0015	1.1622	33	-0.0021	-1.2382
34	0.0024	1.8775	34	-0.0006	-0.3734
35	0.0029	2.2931 *	35	-0.0028	-1.6668
36	0.0009	0.7519	36	-0.0011	-0.6636
37	0.0029	2.2820 *	37	-0.0039	-2.2758 *
38	0.0017	1.3276	38	0.0017	1.0054
39	-0.0005	-0.4058	39	-0.0012	-0.7099
40	0.0027	2.1135 *	40	-0.0029	-1.6876
41	-0.0010	-0.8013	41	-0.0010	-0.6070
42	-0.0003	-0.2510	42	-0.0008	-0.4547
43	0.0007	0.5823	43	0.0012	0.7313
44	0.0006	0.4915	44	-0.0019	-1.1041
45	0.0001	0.1068	45	-0.0068	-4.1990 ***
constant					-2.6E-07
Numbers of Observation					375810
Sum of squared residuals					0.0702
Standard error of regression					0.0004
R-squared					0.1360
Adjusted R-squard					0.1359
F-statistic					656.8564 ***
Durbin-Watson statistic					2.0000

Panel D : Vector Autoregression 2

FUT<=NSA			FUT<=FUT		
lag	Coeff.	t-Value	lag	Coeff.	t-Value
1	0.0959	44.3204 ***	1	0.0069	4.2077 ***
2	0.0193	8.6197 ***	2	-0.0006	-0.3875
3	0.0115	5.1323 ***	3	0.0032	1.9581
4	0.0092	4.1183 ***	4	-0.0154	-9.3158 ***
5	0.0169	7.5513 ***	5	0.0171	10.3191 ***
6	0.0147	6.5411 ***	6	0.0580	34.9682 ***
7	-0.0033	-1.4797	7	0.0125	7.5104 ***
8	0.0058	2.6037 **	8	-0.0022	-1.3219
9	0.0055	2.4598 *	9	0.0013	0.7938
10	0.0086	3.8322 ***	10	0.0135	8.1246 ***
11	0.0027	1.2019	11	-0.0089	-5.3372 ***
12	0.0093	4.1477 ***	12	0.0303	18.2441 ***
13	0.0026	1.1796	13	-0.0058	-3.5020 ***
14	0.0064	2.8631 **	14	0.0026	1.5360
15	0.0034	1.5000	15	0.0081	4.8587 ***
16	0.0027	1.1845	16	-0.0048	-2.9056 **
17	0.0030	1.3318	17	-0.0054	-3.2482 **
18	0.0048	2.1553 *	18	0.0137	8.2692 ***
19	0.0038	1.7053	19	0.0001	0.0544
20	0.0054	2.3845 *	20	0.0042	2.5147 *
21	0.0021	0.9415	21	0.0018	1.0985
22	0.0024	1.0732	22	-0.0029	-1.7633
23	0.0010	0.4245	23	-0.0068	-4.0988 ***
24	0.0043	1.9275	24	0.0120	7.2208 ***
25	0.0028	1.2600	25	0.0051	3.0544 **
26	-0.0013	-0.5698	26	-0.0005	-0.2875
27	0.0014	0.6254	27	-0.0039	-2.3198 *
28	0.0033	1.4540	28	0.0011	0.6769
29	0.0019	0.8539	29	0.0006	0.3456
30	0.0061	2.7185 **	30	0.0114	6.8476 ***
31	0.0003	0.1446	31	-0.0018	-1.0764
32	-0.0046	-2.0651 *	32	-0.0009	-0.5246
33	0.0020	0.8835	33	-0.0021	-1.2576
34	0.0007	0.2979	34	0.0000	0.0257
35	0.0020	0.9058	35	0.0030	1.7801
36	0.0018	0.7823	36	0.0071	4.2941 ***
37	0.0018	0.8219	37	-0.0009	-0.5658
38	-0.0020	-0.8747	38	-0.0024	-1.4690
39	0.0035	1.5739	39	0.0030	1.7980
40	0.0016	0.7174	40	0.0022	1.3346
41	-0.0002	-0.0974	41	0.0050	3.0271 **
42	0.0001	0.0448	42	0.0024	1.4308
43	-0.0015	-0.6684	43	0.0018	1.0671
44	0.0005	0.2333	44	0.0010	0.5946
45	0.0041	1.9068	45	0.0008	0.5023
constant					-5.5E-07
Numbers of Observation					375810
Sum of squared residuals					0.1225
Standard error of regression					0.0006
R-squared					0.0202
Adjusted R-squard					0.0202
F-statistic					86.0296 ***
Durbin-Watson statistic					2.0000

Note: * represents significant at the 5% level. ** represents significant at the 1% level. *** represents significant at the 0.1% level.

Table 6 (A) Non-Regulated Period

Panel A : Autocorelation

NSA			Futures		
lag	Autocorr.	t-Value	lag	Autocorr.	t-Value
1	0.3448	112.3722 ***	1	0.0317	9.7005 ***
2	0.2492	78.7163 ***	2	0.0348	10.6588 ***
3	0.2023	63.1829 ***	3	0.0256	7.8459 ***
4	0.1694	52.5883 ***	4	0.0192	5.8629 ***
5	0.1479	45.7582 ***	5	0.0424	12.9956 ***
6	0.1215	37.4548 ***	6	0.0639	19.5811 ***
7	0.1029	31.6482 ***	7	0.0419	12.8193 ***
8	0.0916	28.1353 ***	8	0.0351	10.7460 ***
9	0.0827	25.3788 ***	9	0.0220	6.7179 ***
10	0.0779	23.8956 ***	10	0.0246	7.5366 ***
11	0.0733	22.4854 ***	11	0.0165	5.0367 ***
12	0.0662	20.2928 ***	12	0.0347	10.6323 ***
13	0.0607	18.6009 ***	13	0.0101	3.0914 **
14	0.0543	16.6438 ***	14	0.0159	4.8565 ***
15	0.0541	16.5597 ***	15	0.0189	5.7913 ***
16	0.0417	12.7581 ***	16	0.0123	3.7721 ***
17	0.0393	12.0333 ***	17	0.0055	1.6786
18	0.0318	9.7401 ***	18	0.0145	4.4489 ***
19	0.0331	10.1307 ***	19	0.0123	3.7512 ***
20	0.0315	9.6516 ***	20	0.0084	2.5589 *
21	0.0282	8.6259 ***	21	-0.0016	0.4897
22	0.0230	7.0420 ***	22	0.0047	1.4423
23	0.0245	7.4844 ***	23	-0.0061	1.8775
24	0.0200	6.1157 ***	24	0.0094	2.8628 **
25	0.0206	6.3172 ***	25	0.0029	0.8884
26	0.0174	5.3196 ***	26	0.0102	3.1274 **
27	0.0201	6.1558 ***	27	-0.0005	0.1414
28	0.0173	5.3052 ***	28	0.0041	1.2445
29	0.0173	5.2931 ***	29	0.0044	1.3390
30	0.0177	5.4160 ***	30	0.0125	3.8180 ***
31	0.0105	3.2051 **	31	0.0010	0.3133
32	0.0125	3.8215 ***	32	0.0028	0.8548
33	0.0098	2.9989 **	33	0.0090	2.7503 **
34	0.0069	2.1124 *	34	0.0107	3.2792 **
35	0.0110	3.3552 ***	35	-0.0021	0.6512
36	0.0090	2.7534 **	36	0.0104	3.1880 **
37	0.0073	2.2261 *	37	-0.0071	2.1670 *
38	0.0069	2.1108 *	38	0.0034	1.0463
39	0.0048	1.4829	39	0.0043	1.3033
40	0.0030	0.9104	40	0.0033	1.0128
41	0.0037	1.1220	41	0.0078	2.3867 *
42	0.0028	0.8626	42	0.0099	3.0358 **
43	-0.0010	0.3018	43	0.0110	3.3769 ***
44	-0.0007	0.2183	44	0.0034	1.0517
45	-0.0044	1.3439	45	0.0008	0.2549
46	-0.0062	1.8960	46	0.0026	0.7884
47	-0.0072	2.1961 *	47	-0.0021	0.6282
48	-0.0062	1.8962	48	0.0110	3.3549 ***
49	-0.0035	1.0845	49	0.0052	1.5921
50	-0.0041	1.2669	50	-0.0033	1.0155
51	-0.0111	3.4100 ***	51	-0.0060	1.8415
52	-0.0139	4.2444 ***	52	0.0015	0.4589
53	-0.0112	3.4285 ***	53	-0.0043	1.3157
54	-0.0027	0.8108	54	-0.0022	0.6744
55	-0.0042	1.2745	55	-0.0009	0.2660
56	-0.0070	2.1332 *	56	-0.0062	1.9038
57	-0.0014	0.4418	57	0.0079	2.4227 *
58	-0.0030	0.9289	58	0.0044	1.3437
59	0.0039	1.1907	59	-0.0005	0.1423
60	0.0051	1.5556	60	0.0064	1.9676 **

Panel B : Multiple Regression

NSA<=FUT			NSA=>FUT		
lag	Coeff.	t-Value	lag	Coeff.	t-Value
0	0.1096	56.4269 ***	0	0.2398	44.5511 ***
1	0.0752	38.7198 ***	1	0.1606	28.8058 ***
2	0.0736	37.8407 ***	2	0.0514	9.1738 ***
3	0.0762	39.1793 ***	3	0.0119	2.1177 *
4	0.0679	34.9256 ***	4	0.0149	2.6567 **
5	0.0638	32.8233 ***	5	0.0074	1.3158
6	0.0501	25.7024 ***	6	0.0117	2.0786 *
7	0.0449	23.0418 ***	7	-0.0130	-2.3087 *
8	0.0346	17.7292 ***	8	0.0181	3.2196 **
9	0.0244	12.5269 ***	9	0.0024	0.4216
10	0.0234	11.9959 ***	10	0.0065	1.1578
11	0.0173	8.8779 ***	11	-0.0107	-1.9014
12	0.0143	7.3562 ***	12	0.0023	0.4068
13	0.0135	6.9378 ***	13	-0.0010	-0.1858
14	0.0136	6.9510 ***	14	-0.0052	-0.9170
15	0.0107	5.4642 ***	15	0.0093	1.6612
16	0.0074	3.8117 ***	16	0.0015	0.2656
17	0.0094	4.8147 ***	17	-0.0041	-0.7218
18	0.0061	3.1035 **	18	0.0035	0.6160
19	0.0074	3.7953 ***	19	-0.0019	-0.3413
20	0.0088	4.5053 ***	20	-0.0003	-0.0559
21	0.0045	2.3125 *	21	0.0009	0.1564
22	0.0021	1.0994	22	-0.0019	-0.3406
23	0.0043	2.1818 *	23	-0.0147	-2.6123 **
24	0.0028	1.4259	24	0.0061	1.0865
25	0.0052	2.6731 **	25	0.0136	2.4123 *
26	0.0015	0.7560	26	-0.0040	-0.7052
27	0.0017	0.8819	27	-0.0044	-0.7850
28	0.0033	1.6798	28	0.0053	0.9360
29	0.0017	0.8837	29	-0.0009	-0.1631
30	0.0002	0.1169	30	-0.0036	-0.6365
31	0.0011	0.5501	31	-0.0036	-0.6412
32	0.0017	0.8945	32	-0.0016	-0.2869
33	0.0045	2.2959	33	-0.0080	-1.4274
34	-0.0004	-0.2080	34	0.0069	1.2210
35	-0.0006	-0.3257	35	-0.0055	-0.9803
36	-0.0016	-0.8248	36	-0.0032	-0.5690
37	-0.0009	-0.4678	37	0.0113	2.0009 *
38	0.0061	3.1368 **	38	-0.0055	-0.9822
39	0.0053	2.7029 **	39	0.0111	1.9684 *
40	0.0056	2.8713 **	40	0.0040	0.7130
41	0.0022	1.1300	41	-0.0007	-0.1220
42	0.0009	0.4502	42	-0.0084	-1.4902
43	0.0014	0.6967	43	-0.0011	-0.1939
44	0.0023	1.1811	44	-0.0112	-2.0013 *
45	0.0003	0.1482	45	0.0106	1.9683 *
constant		-6.5E-07			-1.5E-06
Num. of Obs.		93600			93600
Sd. error of regression		0.0003			0.0005
R-squared		0.1529			0.0554
Adj. R-squared		0.1525			0.0550
F-statistic		367.0170 ***			119.2729 ***
Durbin-Watson statistic		1.5630			2.0432

Note: * represents significant at the 5% level.
** represents significant at the 1% level.
*** represents significant at the 0.1% level.

Table 6 (B) Non-Regulated Period

Panel C : Vector Autoregression 1

NSA<=FUT			NSA<=NSA		
lag	Coeff.	t-Value	lag	Coeff.	t-Value
1	0.0452	23.0922 ***	1	0.2268	68.5773 ***
2	0.0492	25.0800 ***	2	0.0682	20.0181 ***
3	0.0529	26.8257 ***	3	0.0280	8.1849 ***
4	0.0442	22.3371 ***	4	0.0095	2.7795 **
5	0.0454	22.8528 ***	5	0.0060	1.7420
6	0.0367	18.4159 ***	6	-0.0086	-2.5306 *
7	0.0330	16.5658 ***	7	-0.0120	-3.4996 ***
8	0.0242	12.1124 ***	8	-0.0075	-2.1906 *
9	0.0156	7.7893 ***	9	-0.0058	-1.6971
10	0.0178	8.9193 ***	10	-0.0015	-0.4421
11	0.0120	5.9851 ***	11	0.0006	0.1657
12	0.0128	6.4119 ***	12	-0.0016	-0.4551
13	0.0106	5.2799 ***	13	-0.0012	-0.3551
14	0.0117	5.8221 ***	14	-0.0036	-1.0484
15	0.0094	4.7185 ***	15	0.0049	1.4432
16	0.0068	3.3943 ***	16	-0.0085	-2.5009 *
17	0.0087	4.3598 ***	17	-0.0020	-0.5803
18	0.0062	3.0952 **	18	-0.0086	-2.5272 *
19	0.0080	3.9839 ***	19	-0.0004	-0.1041
20	0.0088	4.4064 ***	20	-0.0007	-0.1981
21	0.0033	1.6461	21	-0.0013	-0.3713
22	0.0023	1.1476	22	-0.0052	-1.5343
23	0.0040	1.9731 *	23	0.0014	0.4082
24	0.0038	1.8982	24	-0.0037	-1.0762
25	0.0059	2.9335 **	25	-0.0001	-0.0166
26	0.0024	1.1885	26	-0.0044	-1.3004
27	0.0019	0.9640	27	0.0029	0.8447
28	0.0042	2.0749 *	28	-0.0017	-0.4851
29	0.0023	1.1703	29	0.0003	0.1020
30	0.0020	0.9977	30	0.0028	0.8267
31	0.0022	1.1191	31	-0.0069	-2.0207 *
32	0.0028	1.4099	32	0.0006	0.1610
33	0.0063	3.1612 **	33	-0.0031	-0.9155
34	0.0008	0.4229	34	-0.0054	-1.5718
35	-0.0001	-0.0637	35	0.0030	0.8849
36	0.0007	0.3439	36	-0.0003	-0.0985
37	0.0001	0.0333	37	-0.0014	-0.4130
38	0.0083	4.1562 ***	38	-0.0018	-0.5386
39	0.0064	3.1966 **	39	-0.0037	-1.0855
40	0.0063	3.1619 **	40	-0.0053	-1.5490
41	0.0034	1.6941	41	-0.0017	-0.5031
42	0.0030	1.5201	42	-0.0014	-0.4255
43	0.0044	2.2075 *	43	-0.0050	-1.4891
44	0.0045	2.2371 *	44	-0.0019	-0.5507
45	0.0019	0.9814	45	-0.0056	-1.7305
constant					-7.3E-07
Numbers of Observation					93600
Sum of squared residuals					0.0080
Standard error of regression					0.0003
R-squared					0.1813
Adjusted R-squard					0.1812
F-statistic					229.9976 ***
Durbin-Watson statistic					1.9999

Panel D : Vector Autoregression 2

FUT<=NSA			FUT<=FUT		
lag	Coeff.	t-Value	lag	Coeff.	t-Value
1	0.2284	40.8637 ***	1	-0.0124	-3.7364 ***
2	0.0793	13.7805 ***	2	-0.0043	-1.3035
3	0.0289	5.0052 ***	3	-0.0123	-3.6826 ***
4	0.0278	4.8140 ***	4	-0.0206	-6.1560 ***
5	0.0153	2.6526 **	5	0.0064	1.9112
6	0.0103	1.7770	6	0.0297	8.8266 ***
7	-0.0160	-2.7657 **	7	0.0103	3.0467 **
8	0.0183	3.1668 **	8	0.0042	1.2381
9	0.0050	0.8691	9	-0.0053	-1.5653
10	0.0100	1.7239	10	0.0013	0.3724
11	-0.0064	-1.1157	11	-0.0056	-1.6612
12	0.0040	0.6858	12	0.0135	3.9958 ***
13	0.0024	0.4210	13	-0.0097	-2.8700 **
14	-0.0019	-0.3313	14	-0.0025	-0.7421
15	0.0138	2.3958 *	15	0.0027	0.7887
16	0.0026	0.4503	16	-0.0026	-0.7602
17	0.0007	0.1292	17	-0.0084	-2.4795 *
18	0.0057	0.9863	18	0.0004	0.1068
19	0.0018	0.3119	19	0.0008	0.2371
20	0.0029	0.5030	20	-0.0036	-1.0672
21	0.0050	0.8620	21	-0.0132	-3.8958 ***
22	0.0004	0.0696	22	-0.0046	-1.3470
23	-0.0109	-1.8816	23	-0.0140	-4.1347 ***
24	0.0065	1.1228	24	0.0001	0.0180
25	0.0145	2.5049 *	25	-0.0042	-1.2450
26	-0.0059	-1.0223	26	0.0043	1.2815
27	-0.0047	-0.8189	27	-0.0055	-1.6299
28	0.0040	0.6974	28	0.0001	0.0297
29	-0.0015	-0.2558	29	0.0021	0.6318
30	-0.0064	-1.1110	30	0.0105	3.0988 **
31	-0.0081	-1.3958	31	-0.0006	-0.1886
32	-0.0028	-0.4868	32	0.0013	0.3780
33	-0.0108	-1.8725	33	0.0085	2.5057 *
34	0.0020	0.3410	34	0.0088	2.6033 **
35	-0.0061	-1.0526	35	-0.0037	-1.0820
36	-0.0057	-0.9797	36	0.0083	2.4516 *
37	0.0102	1.7736	37	-0.0087	-2.5849 **
38	-0.0062	-1.0774	38	0.0022	0.6410
39	0.0090	1.5672	39	0.0014	0.4136
40	0.0013	0.2278	40	0.0002	0.0536
41	-0.0020	-0.3429	41	0.0055	1.6330
42	-0.0111	-1.9346	42	0.0085	2.5245 *
43	-0.0052	-0.9066	43	0.0117	3.4570 ***
44	-0.0138	-2.4219 *	44	0.0021	0.6383
45	0.0086	1.5657	45	-0.0008	-0.2454
constant					-1.8E-06
Numbers of Observation					93600
Sum of squared residuals					0.0229
Standard error of regression					0.0005
R-squared					0.0385
Adjusted R-squard					0.0385
F-statistic					41.5690 ***
Durbin-Watson statistic					2.0000

Note: * represents significant at the 5% level.
** represents significant at the 1% level.
*** represents significant at the 0.1% level.

Table 7 (A) Regulated Period

Panel A : Autocorelation

NSA			Futures		
lag	Autocorr.	t-Value	lag	Autocorr.	t-Value
1	0.3128	116.9258 ***	1	0.0416	14.7730 ***
2	0.1430	51.2899 ***	2	0.0170	6.0236 ***
3	0.1122	40.0822 ***	3	0.0076	2.6989 **
4	0.0848	30.2174 ***	4	-0.0016	0.5657
5	0.0722	25.7000 ***	5	0.0018	0.6411
6	0.0493	17.5232 ***	6	0.0884	31.5157 ***
7	0.0399	14.1768 ***	7	0.0057	2.0116 **
8	0.0300	10.6709 ***	8	-0.0002	0.0655
9	0.0261	9.2604 ***	9	0.0134	4.7591 ***
10	0.0167	5.9410 ***	10	0.0091	3.2215 **
11	0.0134	4.7655 ***	11	0.0022	0.7786
12	0.0041	1.4461	12	0.0610	21.7065 ***
13	0.0022	0.7760	13	0.0062	2.2021 *
14	-0.0017	0.5963	14	0.0046	1.6310
15	-0.0004	0.1512	15	0.0071	2.5272 *
16	-0.0043	1.5292	16	0.0001	0.0197
17	-0.0039	1.3868	17	0.0041	1.4657
18	-0.0093	3.2915 ***	18	0.0410	14.5645 ***
19	-0.0037	1.3077	19	0.0069	2.4329 *
20	-0.0037	1.3226	20	0.0064	2.2848 *
21	0.0012	0.4318	21	0.0079	2.8071 **
22	-0.0020	0.6972	22	0.0030	1.0546
23	-0.0023	0.8151	23	-0.0030	1.0635
24	-0.0012	0.4294	24	0.0334	11.8614 ***
25	-0.0005	0.1793	25	0.0063	2.2523 *
26	0.0005	0.1742	26	0.0038	1.3452
27	0.0020	0.7085	27	-0.0014	0.4832
28	0.0009	0.3054	28	0.0031	1.0971
29	0.0016	0.5741	29	0.0040	1.4369
30	0.0031	1.0941	30	0.0264	9.3885 ***
31	0.0019	0.6791	31	0.0006	0.2036
32	-0.0039	1.3804	32	0.0012	0.4252
33	-0.0022	0.7677	33	0.0013	0.4769
34	0.0005	0.1850	34	0.0006	0.2299
35	-0.0031	1.0984	35	0.0039	1.3929
36	-0.0014	0.5057	36	0.0203	7.2033 ***
37	-0.0025	0.8959	37	0.0024	0.8431
38	-0.0002	0.0540	38	0.0022	0.7900
39	-0.0012	0.4214	39	0.0120	4.2773 ***
40	-0.0033	1.1636	40	0.0037	1.3123
41	-0.0017	0.5895	41	0.0071	2.5305 *
42	-0.0015	0.5481	42	0.0088	3.1273 **
43	0.0037	1.3254	43	0.0003	0.1209
44	-0.0004	0.1571	44	0.0028	1.0082
45	-0.0059	2.0984 *	45	0.0046	1.6343
46	-0.0015	0.5158	46	0.0057	2.0307 *
47	0.0010	0.3452	47	0.0075	2.6681 **
48	-0.0057	2.0260 *	48	0.0116	4.1255 ***
49	-0.0023	0.8003	49	0.0037	1.3255
50	-0.0036	1.2735	50	0.0061	2.1768 *
51	-0.0018	0.6398	51	0.0028	1.0109
52	-0.0014	0.5078	52	-0.0035	1.2452
53	0.0003	0.1235	53	0.0037	1.3047
54	-0.0018	0.6514	54	0.0046	1.6325
55	-0.0028	1.0054	55	0.0070	2.4781 *
56	-0.0014	0.4837	56	-0.0020	0.7147
57	-0.0006	0.2292	57	0.0051	1.8111
58	0.0003	0.1130	58	0.0025	0.8973
59	0.0016	0.5622	59	0.0037	1.3140
60	0.0000	0.0069	60	0.0085	3.0280 **

Panel B : Multiple Regression

NSA<=FUT			NSA=>FUT		
lag	Coeff.	t-Value	lag	Coeff.	t-Value
0	0.1077	46.2302 ***	0	0.1304	39.2251 ***
1	0.1737	74.4618 ***	1	0.0641	18.5169 ***
2	0.1607	68.8805 ***	2	0.0151	4.3563 ***
3	0.1141	48.9029 ***	3	0.0011	0.3129
4	0.0853	36.5752 ***	4	0.0061	1.7620
5	0.0647	27.7177 ***	5	0.0183	5.2696 ***
6	0.0393	16.8068 ***	6	0.0237	6.8283 ***
7	0.0240	10.2565 ***	7	0.0024	0.6859
8	0.0157	6.7265 ***	8	-0.0001	-0.0191
9	0.0171	7.2975 ***	9	0.0137	3.9419 ***
10	0.0148	6.3437 ***	10	0.0071	2.0456 *
11	0.0114	4.8620 ***	11	0.0136	3.9338 ***
12	0.0024	1.0124	12	0.0214	6.1652 ***
13	-0.0026	-1.0941	13	0.0021	0.5944
14	0.0009	0.3882	14	0.0100	2.8747 **
15	-0.0008	-0.3514	15	0.0047	1.3653
16	-0.0054	-2.2898 *	16	0.0053	1.5310
17	0.0000	0.0012	17	0.0121	3.5025 ***
18	-0.0035	-1.4763	18	0.0082	2.3588 *
19	-0.0093	-3.9478 ***	19	0.0028	0.7949
20	-0.0056	-2.3793 *	20	0.0057	1.6305
21	-0.0056	-2.3709 *	21	0.0054	1.5553
22	-0.0053	-2.2491 *	22	0.0088	2.5381 *
23	0.0008	0.3504	23	0.0135	3.8914 ***
24	-0.0028	-1.1861	24	0.0085	2.4578 *
25	-0.0046	-1.9820 *	25	0.0026	0.7469
26	-0.0048	-2.0606 *	26	-0.0031	-0.8847
27	-0.0029	-1.2459	27	0.0067	1.9171
28	-0.0067	-2.8439 **	28	0.0025	0.7168
29	0.0016	0.6856	29	0.0081	2.3475 *
30	-0.0029	-1.2406	30	0.0102	2.9502 **
31	-0.0030	-1.3012	31	-0.0019	-0.5609
32	0.0000	-0.0156	32	-0.0064	-1.8460
33	-0.0037	-1.5929	33	0.0072	2.0765 *
34	0.0007	0.3190	34	0.0025	0.7330
35	0.0008	0.3404	35	0.0102	2.9464 **
36	0.0005	0.2338	36	0.0042	1.2013
37	0.0034	1.4683	37	0.0039	1.1365
38	0.0014	0.6004	38	-0.0053	-1.5283
39	-0.0052	-2.2430 *	39	0.0116	3.3435 ***
40	-0.0035	-1.4793	40	-0.0010	-0.2884
41	-0.0057	-2.4601 *	41	0.0101	2.9201 **
42	-0.0029	-1.2347	42	0.0044	1.2752
43	-0.0046	-1.9888 *	43	0.0021	0.6162
44	-0.0034	-1.4497	44	0.0003	0.0990
45	-0.0003	-0.1131	45	0.0119	3.5917 ***
constant		-4.9E-08			-2.2E-07
Num. of Obs.		126030			126030
Sd. error of regression		0.0005			0.0006
R-squared		0.1374			0.0281
Adj. R-squared		0.1370			0.0278
F-statistic		435.9295 ***			79.2021 ***
Durbin-Watson statistic		1.5863			1.9945

Note: * represents significant at the 5% level.
** represents significant at the 1% level.
*** represents significant at the 0.1% level.

Table 7 (B) Regulated Period

Panel C : Vector Autoregression 1

NSA<=FUT			NSA<=NSA		
lag	Coeff.	t-Value	lag	Coeff.	t-Value
1	0.1579	68.0992 ***	1	0.2174	76.6242 ***
2	0.1281	54.2364 ***	2	-0.0200	-6.8846 ***
3	0.0842	35.2324 ***	3	0.0110	3.7766 ***
4	0.0639	26.5858 ***	4	-0.0043	-1.4691
5	0.0498	20.6448 ***	5	0.0072	2.4878 *
6	0.0385	15.9232 ***	6	-0.0120	-4.1330 ***
7	0.0211	8.7043 ***	7	-0.0079	-2.7037 **
8	0.0174	7.1840 ***	8	-0.0130	-4.4528 **
9	0.0235	9.6813 ***	9	-0.0055	-1.9014
10	0.0215	8.8600 ***	10	-0.0149	-5.1249 ***
11	0.0190	7.8202 ***	11	-0.0084	-2.8791 **
12	0.0171	7.0331 ***	12	-0.0184	-6.3233 ***
13	0.0098	4.0560 ***	13	-0.0147	-5.0606 ***
14	0.0152	6.2703 ***	14	-0.0176	-6.0315 ***
15	0.0133	5.4689 ***	15	-0.0114	-3.8982 ***
16	0.0087	3.5778 ***	16	-0.0171	-5.8757 ***
17	0.0158	6.5198 ***	17	-0.0103	-3.5388 ***
18	0.0134	5.5381 ***	18	-0.0200	-6.8548 ***
19	0.0055	2.2734 *	19	-0.0088	-3.0155 **
20	0.0097	4.0123 ***	20	-0.0133	-4.5720 ***
21	0.0083	3.4020 ***	21	-0.0050	-1.6997
22	0.0075	3.0981 **	22	-0.0128	-4.3880 ***
23	0.0124	5.1173 ***	23	-0.0108	-3.7210 ***
24	0.0102	4.2013 ***	24	-0.0109	-3.7471 ***
25	0.0066	2.7058 **	25	-0.0100	-3.4172 ***
26	0.0060	2.4569 *	26	-0.0090	-3.0879 **
27	0.0065	2.6937 **	27	-0.0054	-1.8454
28	0.0025	1.0248	28	-0.0089	-3.0642 **
29	0.0111	4.5857 ***	29	-0.0067	-2.3014 *
30	0.0058	2.4011 *	30	-0.0058	-1.9918 *
31	0.0044	1.8328	31	-0.0069	-2.3841 *
32	0.0074	3.0505 **	32	-0.0134	-4.5977 ***
33	0.0035	1.4348	33	-0.0072	-2.4690 *
34	0.0087	3.6109 ***	34	-0.0050	-1.7096
35	0.0077	3.1855 **	35	-0.0114	-3.9063 *
36	0.0086	3.5648 ***	36	-0.0070	-2.4061 *
37	0.0097	4.0242 ***	37	-0.0089	-3.0536 **
38	0.0067	2.7597 **	38	-0.0041	-1.4228
39	0.0012	0.4932	39	-0.0045	-1.5350
40	0.0031	1.2934	40	-0.0081	-2.7779 **
41	0.0005	0.1950	41	-0.0046	-1.5958
42	0.0029	1.2029	42	-0.0074	-2.5528 *
43	0.0000	0.0132	43	0.0002	0.0527
44	0.0018	0.7371	44	-0.0064	-2.2370 *
45	0.0044	1.8367	45	-0.0127	-4.6203 ***
constant					-6E-08
Numbers of Observation					126030
Sum of squared residuals					0.0337
Standard error of regression					0.0005
R-squared					0.1681
Adjusted R-squard					0.1680
F-statistic					282.5744 ***
Durbin-Watson statistic					2.0002

Panel D : Vector Autoregression 2

FUT<=NSA			FUT<=FUT		
lag	Coeff.	t-Value	lag	Coeff.	t-Value
1	0.1083	31.1963 ***	1	0.0234	8.2520 ***
2	0.0272	7.6500 ***	2	-0.0110	-3.8053 ***
3	0.0155	4.3474 ***	3	-0.0243	-8.2984 ***
4	0.0118	3.3098 ***	4	-0.0299	-10.1655 ***
5	0.0212	5.9620 ***	5	-0.0261	-8.8524 ***
6	0.0296	8.3029 ***	6	0.0578	19.5484 ***
7	0.0068	1.9128	7	-0.0225	-7.5843 ***
8	0.0062	1.7489	8	-0.0227	-7.6527 ***
9	0.0204	5.7346 ***	9	-0.0055	-1.8388
10	0.0090	2.5368 *	10	-0.0090	-3.0464 **
11	0.0141	3.9563 ***	11	-0.0180	-6.0819 ***
12	0.0243	6.8243 ***	12	0.0324	10.9083 ***
13	0.0069	1.9372	13	-0.0144	-4.8368 ***
14	0.0167	4.6906 ***	14	-0.0116	-3.8975 ***
15	0.0099	2.7828 **	15	-0.0108	-3.6457 ***
16	0.0080	2.2316 *	16	-0.0155	-5.2364 ***
17	0.0135	3.7775 ***	17	-0.0087	-2.9207 **
18	0.0087	2.4478 *	18	0.0163	5.4830 ***
19	0.0072	2.0103 *	19	-0.0078	-2.6302 **
20	0.0105	2.9500 **	20	-0.0051	-1.7146
21	0.0110	3.0921 **	21	-0.0050	-1.6760
22	0.0128	3.5941 ***	22	-0.0083	-2.8113 **
23	0.0150	4.1995 ***	23	-0.0158	-5.3217 ***
24	0.0114	3.2096 **	24	0.0118	3.9834 ***
25	0.0075	2.0956 *	25	-0.0061	-2.0436 *
26	0.0020	0.5518	26	-0.0066	-2.2343 *
27	0.0109	3.0623 **	27	-0.0126	-4.2567 ***
28	0.0052	1.4613	28	-0.0050	-1.6965
29	0.0092	2.5878 **	29	-0.0038	-1.2726
30	0.0129	3.6221 ***	30	0.0096	3.2309 **
31	0.0019	0.5244	31	-0.0090	-3.0370 **
32	-0.0027	-0.7499	32	-0.0058	-1.9671 *
33	0.0102	2.8533 **	33	-0.0055	-1.8591
34	0.0045	1.2653	34	-0.0054	-1.8102
35	0.0097	2.7293 **	35	-0.0026	-0.8870
36	0.0046	1.3050	36	0.0072	2.4355 *
37	0.0056	1.5856	37	-0.0043	-1.4626
38	-0.0026	-0.7248	38	-0.0047	-1.5797
39	0.0131	3.6777 ***	39	0.0065	2.2091 *
40	0.0001	0.0322	40	-0.0021	-0.7093
41	0.0116	3.2735 **	41	0.0018	0.6018
42	0.0057	1.5972	42	-0.0024	-0.8223
43	0.0058	1.6519	43	-0.0052	-1.7765
44	0.0035	1.0048	44	-0.0020	-0.6818
45	0.0123	3.6619 ***	45	-0.0017	-0.5695
constant					-2.7E-07
Numbers of Observation					126030
Sum of squared residuals					0.0504
Standard error of regression					0.0006
R-squared					0.0277
Adjusted R-squard					0.0277
F-statistic					39.8169 ***
Durbin-Watson statistic					2.0000

Note: * represents significant at the 5% level.
** represents significant at the 1% level.
*** represents significant at the 0.1% level.

Table 8 (A) Monday

Panel A : Autocorelation

NSA			Futures		
lag	Autocorr.	t-Value	lag	Autocorr.	t-Value
1	0.3330	93.2712 ***	1	0.0118	3.1201 **
2	0.1686	45.1770 ***	2	0.0106	2.7945 **
3	0.1329	35.4242 ***	3	0.0210	5.5568 ***
4	0.1110	29.5047 ***	4	0.0034	0.9056
5	0.0921	24.4131 ***	5	0.0373	9.8576 ***
6	0.0641	16.9728 ***	6	0.0981	26.0320 ***
7	0.0607	16.0664 ***	7	0.0270	7.1450 ***
8	0.0577	15.2664 ***	8	0.0086	2.2664 *
9	0.0521	13.7859 ***	9	0.0190	5.0268 ***
10	0.0491	12.9882 ***	10	0.0290	7.6578 ***
11	0.0398	10.5246 ***	11	0.0063	1.6674
12	0.0328	8.6647 ***	12	0.0650	17.2055 ***
13	0.0351	9.2709 ***	13	0.0080	2.1226 *
14	0.0302	7.9662 ***	14	0.0131	3.4688 ***
15	0.0309	8.1583 ***	15	0.0170	4.4899 ***
16	0.0249	6.5760 ***	16	0.0076	2.0006 *
17	0.0180	4.7446 ***	17	0.0029	0.7760
18	0.0106	2.8033 ***	18	0.0417	11.0273 ***
19	0.0125	3.2949 ***	19	0.0104	2.7377 **
20	0.0124	3.2767 **	20	0.0174	4.5917 ***
21	0.0173	4.5623 ***	21	0.0191	5.0384 ***
22	0.0163	4.3123 ***	22	0.0050	1.3318
23	0.0070	1.8421	23	0.0064	1.6980
24	0.0107	2.8183 **	24	0.0307	8.1191 ***
25	0.0158	4.1814 ***	25	0.0171	4.5158 ***
26	0.0100	2.6294 **	26	0.0084	2.2161 *
27	0.0099	2.6049 **	27	0.0105	2.7676 **
28	0.0095	2.5123 *	28	0.0098	2.5960 **
29	0.0083	2.1906 *	29	0.0097	2.5654 *
30	0.0098	2.5915 **	30	0.0319	8.4383 ***
31	0.0147	3.8746 ***	31	0.0088	2.3345 *
32	0.0130	3.4299 ***	32	0.0063	1.6685
33	0.0127	3.3412 ***	33	0.0069	1.8193
34	0.0126	3.3238 ***	34	0.0118	3.1095 **
35	0.0105	2.7769 **	35	0.0145	3.8358 ***
36	0.0142	3.7503 ***	36	0.0266	7.0351 ***
37	0.0017	0.4458	37	0.0072	1.9011
38	0.0029	0.7540	38	0.0108	2.8560 **
39	0.0098	2.5919 **	39	0.0067	1.7733
40	0.0137	3.6110 ***	40	0.0090	2.3844 *
41	0.0083	2.1927 *	41	0.0068	1.8043
42	0.0099	2.6013 **	42	0.0175	4.6095 ***
43	0.0173	4.5644 ***	43	0.0073	1.9336
44	0.0053	1.4028	44	0.0022	0.5862
45	0.0044	1.1729	45	0.0002	0.0420
46	0.0077	2.0286 *	46	0.0106	2.8037 **
47	-0.0039	1.0403	47	0.0009	0.2402
48	-0.0067	1.7613	48	0.0223	5.8843 ***
49	0.0033	0.8722	49	0.0033	0.8813
50	0.0010	0.2666	50	0.0057	1.4990
51	0.0054	1.4381	51	0.0109	2.8713 **
52	-0.0021	0.5524	52	0.0033	0.8758
53	-0.0004	0.1126	53	0.0048	1.2689
54	0.0049	1.2940	54	0.0183	4.8348 ***
55	0.0050	1.3216	55	0.0075	1.9788 *
56	0.0030	0.7975	56	-0.0042	1.1016
57	-0.0009	0.2503	57	0.0059	1.5486
58	0.0004	0.1132	58	0.0027	0.7086
59	-0.0023	0.6017	59	0.0051	1.3488
60	0.0043	1.1231	60	0.0094	2.4890 *

Panel B : Multiple Regression

NSA<=FUT			NSA=>FUT		
lag	Coeff.	t-Value	lag	Coeff.	t-Value
0	0.1129	37.6598 ***	0	0.1419	29.7429 ***
1	0.1386	46.2242 ***	1	0.0753	15.1234 ***
2	0.1285	42.8715 ***	2	0.0133	2.6713 **
3	0.0979	32.6631 ***	3	0.0227	4.5569 ***
4	0.0785	26.1754 ***	4	0.0021	0.4305
5	0.0617	20.5713 ***	5	0.0278	5.5745 ***
6	0.0320	10.6218 ***	6	0.0246	4.9259 ***
7	0.0259	8.5923 ***	7	-0.0051	-1.0275
8	0.0190	6.2924 ***	8	-0.0004	-0.0876
9	0.0145	4.8146 ***	9	0.0109	2.1791 *
10	0.0162	5.3861 ***	10	0.0186	3.7164 ***
11	0.0068	2.2447 *	11	0.0146	2.9216 **
12	0.0023	0.7473	12	0.0168	3.3724 ***
13	0.0011	0.3573	13	-0.0010	-0.2014
14	0.0033	1.0800	14	0.0084	1.6840
15	0.0040	1.3222	15	0.0033	0.6612
16	0.0033	1.0994	16	0.0083	1.6530
17	-0.0007	-0.2165	17	0.0064	1.2749
18	-0.0008	-0.2522	18	0.0017	0.3422
19	-0.0020	-0.6633	19	0.0041	0.8158
20	-0.0007	-0.2443	20	0.0065	1.2939
21	-0.0038	-1.2616	21	-0.0034	-0.6888
22	0.0028	0.9169	22	0.0069	1.3718
23	0.0046	1.5090	23	0.0103	2.0548
24	0.0035	1.1443	24	0.0182	3.6461 ***
25	0.0019	0.6227	25	0.0045	0.8910
26	0.0016	0.5215	26	-0.0074	-1.4730
27	0.0033	1.1045	27	0.0000	0.0039
28	-0.0069	-2.2866 *	28	0.0060	1.1912
29	-0.0014	-0.4486	29	0.0067	1.3322
30	-0.0043	-1.4285	30	0.0104	2.0794 *
31	0.0007	0.2220	31	0.0007	0.1474
32	-0.0015	-0.4815	32	-0.0066	-1.3132
33	0.0027	0.8821	33	0.0073	1.4590
34	0.0045	1.5065	34	0.0014	0.2857
35	0.0023	0.7539	35	0.0157	3.1360 **
36	0.0005	0.1762	36	-0.0016	-0.3225
37	0.0055	1.8149	37	0.0054	1.0888
38	0.0038	1.2486	38	0.0020	0.3926
39	-0.0038	-1.2572	39	0.0085	1.6999
40	0.0019	0.6412	40	0.0072	1.4405
41	-0.0030	-1.0129	41	0.0057	1.1330
42	0.0005	0.1787	42	-0.0045	-0.8949
43	0.0012	0.3949	43	0.0078	1.5705
44	0.0033	1.1088	44	-0.0005	-0.1051
45	0.0024	0.8056	45	0.0129	2.6972 **
constant		-3.4E-06			-4.2E-06
Num. of Obs.		139500			139500
Sd. error of regression		0.0004			0.0005
R-squared		0.1163			0.0344
Adj. R-squared		0.1157			0.0337
F-statistic		199.3110 ***			53.9121 ***
Durbin-Watson statistic		1.5135			2.0579

Note: * represents significant at the 5% level.
** represents significant at the 1% level.
*** represents significant at the 0.1% level.

Table 8 (B) Monday

Panel C : Vector Autoregression 1

NSA<=FUT			NSA<=NSA		
lag	Coeff.	t-Value	lag	Coeff.	t-Value
1	0.1090	36.7458 ***	1	0.2542	66.6064 ***
2	0.0911	30.3915 ***	2	0.0043	1.1003
3	0.0626	20.7368 ***	3	0.0221	5.6098 ***
4	0.0476	15.7170 ***	4	0.0131	3.3166 ***
5	0.0398	13.1179 ***	5	0.0124	3.1478 **
6	0.0217	7.1367 ***	6	-0.0122	-3.0991 **
7	0.0167	5.4980 ***	7	0.0021	0.5265
8	0.0098	3.2322 **	8	0.0047	1.1944
9	0.0084	2.7576 **	9	0.0039	0.9940
10	0.0130	4.2517 ***	10	0.0071	1.7941
11	0.0007	0.2401	11	-0.0021	-0.5410
12	0.0050	1.6500	12	-0.0058	-1.4626
13	0.0003	0.0992	13	0.0029	0.7332
14	0.0042	1.3752	14	-0.0033	-0.8446
15	0.0045	1.4920	15	0.0034	0.8622
16	0.0034	1.1313	16	-0.0017	-0.4339
17	0.0000	-0.0102	17	-0.0051	-1.2929
18	0.0050	1.6284	18	-0.0114	-2.8920 **
19	0.0016	0.5163	19	-0.0033	-0.8277
20	0.0045	1.4711	20	-0.0059	-1.5025
21	0.0012	0.4072	21	0.0012	0.2961
22	0.0071	2.3251 *	22	0.0009	0.2383
23	0.0073	2.4087 *	23	-0.0121	-3.0674 **
24	0.0076	2.4873 *	24	-0.0036	-0.9169
25	0.0057	1.8673	25	0.0016	0.4154
26	0.0044	1.4546	26	-0.0083	-2.0930 *
27	0.0065	2.1176 *	27	-0.0017	-0.4189
28	-0.0041	-1.3429	28	-0.0020	-0.5015
29	0.0037	1.2107	29	-0.0044	-1.1113
30	0.0007	0.2175	30	-0.0038	-0.9715
31	0.0045	1.4601	31	0.0024	0.5979
32	0.0008	0.2751	32	-0.0034	-0.8691
33	0.0052	1.7214	33	-0.0007	-0.1854
34	0.0067	2.1982 *	34	-0.0010	-0.2625
35	0.0042	1.3770	35	-0.0054	-1.3614
36	0.0043	1.4182	36	0.0038	0.9506
37	0.0081	2.6614 **	37	-0.0146	-3.7031 ***
38	0.0062	2.0461 *	38	-0.0069	-1.7548
39	-0.0014	-0.4658	39	0.0004	0.1086
40	0.0058	1.9220	40	0.0032	0.8142
41	-0.0012	-0.4079	41	-0.0068	-1.7358
42	0.0041	1.3666	42	-0.0030	-0.7583
43	0.0032	1.0489	43	0.0092	2.3306 *
44	0.0044	1.4619	44	-0.0109	-2.7743 **
45	0.0027	0.9091	45	-0.0044	-1.1770
constant					-3.2E-06
Numbers of Observation					139500
Sum of squared residuals					0.0121
Standard error of regression					0.0004
R-squared					0.1594
Adjusted R-squard					0.1589
F-statistic					146.6699 ***
Durbin-Watson statistic					2.0000

Panel D : Vector Autoregression 2

FUT<=NSA			FUT<=FUT		
lag	Coeff.	t-Value	lag	Coeff.	t-Value
1	0.1236	25.1694 ***	1	-0.0147	-3.8600 ***
2	0.0211	4.1556 ***	2	-0.0191	-4.9549 ***
3	0.0298	5.8687 ***	3	-0.0106	-2.7205 **
4	0.0014	0.2723	4	-0.0263	-6.7477 ***
5	0.0230	4.5359 ***	5	0.0109	2.7936 **
6	0.0189	3.7123 ***	6	0.0691	17.6706 ***
7	-0.0064	-1.2520	7	0.0073	1.8564
8	0.0004	0.0803	8	-0.0098	-2.5011 *
9	0.0109	2.1520 *	9	0.0002	0.0546
10	0.0182	3.5793 ***	10	0.0134	3.4269 ***
11	0.0103	2.0220 *	11	-0.0150	-3.8138 ***
12	0.0156	3.0757 **	12	0.0383	9.7811 ***
13	0.0009	0.1796	13	-0.0108	-2.7595 **
14	0.0114	2.2442 *	14	-0.0012	-0.3064
15	0.0040	0.7959	15	-0.0011	-0.2916
16	0.0074	1.4469	16	-0.0074	-1.8776
17	0.0030	0.5874	17	-0.0111	-2.8216 **
18	-0.0022	-0.4276	18	0.0210	5.3456 ***
19	0.0025	0.4993	19	-0.0015	-0.3774
20	0.0046	0.8992	20	0.0082	2.0801 *
21	-0.0041	-0.8014	21	0.0085	2.1730 *
22	0.0057	1.1202	22	-0.0042	-1.0751
23	0.0068	1.3410	23	-0.0032	-0.8121
24	0.0163	3.2174 **	24	0.0110	2.8012 **
25	0.0049	0.9652	25	0.0057	1.4622
26	-0.0090	-1.7786	26	-0.0026	-0.6695
27	-0.0004	-0.0777	27	-0.0003	-0.0671
28	0.0036	0.7047	28	0.0009	0.2339
29	0.0029	0.5660	29	0.0025	0.6266
30	0.0068	1.3420	30	0.0166	4.2430 ***
31	0.0005	0.0897	31	0.0004	0.0914
32	-0.0064	-1.2660	32	-0.0018	-0.4530
33	0.0065	1.2769	33	-0.0014	-0.3694
34	-0.0010	-0.2003	34	0.0038	0.9786
35	0.0124	2.4505 *	35	0.0057	1.4524
36	-0.0025	-0.4901	36	0.0126	3.2162 **
37	0.0042	0.8237	37	-0.0021	-0.5478
38	0.0034	0.6679	38	0.0026	0.6652
39	0.0097	1.9152	39	-0.0032	-0.8218
40	0.0083	1.6272	40	-0.0012	-0.3082
41	0.0048	0.9487	41	-0.0039	-0.9957
42	-0.0036	-0.7046	42	0.0039	0.9981
43	0.0112	2.2093 *	43	-0.0020	-0.5140
44	0.0004	0.0785	44	-0.0070	-1.8046
45	0.0128	2.6562 **	45	-0.0097	-2.4940 **
constant					-4.8E-06
Numbers of Observation					139500
Sum of squared residuals					0.0200
Standard error of regression					0.0005
R-squared					0.0327
Adjusted R-squard					0.0321
F-statistic					26.1288 ***
Durbin-Watson statistic					1.9999

Note: * represents significant at the 5% level.
** represents significant at the 1% level.
*** represents significant at the 0.1% level.

Table 9 (A) Tuesday

Panel A : Autocorelation

NSA			Futures		
lag	Autocorr.	t-Value	lag	Autocorr.	t-Value
1	0.3111	87.9000 ***	1	0.0282	7.5851 ***
2	0.1590	43.2384 ***	2	0.0206	5.5448 ***
3	0.1234	33.3952 ***	3	0.0179	4.8105 ***
4	0.0998	26.9345 ***	4	0.0086	2.3085 *
5	0.0907	24.4436 ***	5	0.0314	8.4450 **
6	0.0662	17.7991 ***	6	0.0854	23.0062 ***
7	0.0503	13.5213 ***	7	0.0256	6.8876 ***
8	0.0428	11.4962 ***	8	0.0018	0.4830
9	0.0414	11.1292 ***	9	0.0184	4.9470 ***
10	0.0253	6.8041 ***	10	0.0158	4.2306 ***
11	0.0262	7.0457 ***	11	0.0048	1.2947
12	0.0211	5.6588 ***	12	0.0529	14.2350 ***
13	0.0131	3.5117 ***	13	0.0034	0.9065
14	0.0090	2.4131 *	14	0.0074	1.9855 *
15	0.0089	2.3861 *	15	0.0163	4.3661 ***
16	0.0069	1.8639	16	0.0100	2.6752 **
17	0.0050	1.3353	17	0.0099	2.6474 **
18	0.0063	1.7027	18	0.0337	9.0423 ***
19	0.0057	1.5325	19	0.0050	1.3518
20	0.0117	3.1303 **	20	0.0097	2.6040 **
21	0.0099	2.6687 **	21	0.0104	2.7953 **
22	0.0005	0.1243	22	0.0058	1.5598
23	0.0055	1.4768	23	-0.0060	1.6016
24	0.0055	1.4763	24	0.0297	7.9842 ***
25	0.0068	1.8287	25	0.0045	1.2141
26	0.0092	2.4756 *	26	0.0133	3.5672 ***
27	0.0088	2.3539 *	27	0.0069	1.8494
28	0.0050	1.3325	28	0.0065	1.7400
29	0.0104	2.7898 **	29	0.0032	0.8686
30	0.0087	2.3432 *	30	0.0223	5.9855 ***
31	0.0023	0.6120	31	0.0028	0.7490
32	-0.0006	0.1578	32	0.0056	1.4972
33	0.0004	0.1113	33	0.0052	1.4080
34	0.0070	1.8836	34	0.0025	0.6655
35	0.0002	0.0608	35	0.0015	0.4076
36	-0.0014	0.3744	36	0.0155	4.1675 ***
37	-0.0067	1.7868	37	0.0102	2.7273 **
38	0.0012	0.3151	38	0.0061	1.6301
39	-0.0051	1.3585	39	0.0042	1.1211
40	-0.0005	0.1393	40	0.0049	1.3071
41	0.0007	0.1817	41	0.0035	0.9301
42	-0.0009	0.2319	42	0.0152	4.0737 ***
43	-0.0027	0.7219	43	0.0056	1.5005
44	-0.0030	0.8184	44	0.0009	0.2366
45	-0.0015	0.3997	45	0.0049	1.3149
46	-0.0040	1.0791	46	0.0000	0.0076
47	0.0057	1.5176	47	0.0069	1.8598
48	-0.0041	1.1063	48	0.0061	1.6335
49	-0.0024	0.6362	49	0.0108	2.8868 ***
50	0.0025	0.6636	50	0.0050	1.3359
51	-0.0028	0.7445	51	0.0018	0.4821
52	-0.0031	0.8446	52	0.0016	0.4285
53	0.0059	1.5747	53	0.0026	0.6929
54	-0.0019	0.4967	54	0.0038	1.0269
55	-0.0029	0.7654	55	0.0065	1.7331
56	-0.0013	0.3585	56	-0.0056	1.5054
57	0.0016	0.4411	57	0.0096	2.5808 **
58	-0.0014	0.3815	58	0.0016	0.4404
59	0.0030	0.7967	59	0.0076	2.0351 *
60	-0.0057	1.5231	60	0.0009	0.2435

Panel B : Multiple Regression

NSA<=FUT			NSA=>FUT		
lag	Coeff.	t-Value	lag	Coeff.	t-Value
0	0.1194	39.0240 ***	0	0.1409	31.6974 ***
1	0.1518	49.6142 ***	1	0.0857	18.5553 ***
2	0.1363	44.5253 ***	2	0.0240	5.1998 ***
3	0.1005	32.8228 ***	3	0.0063	1.3604
4	0.0780	25.5007 ***	4	0.0104	2.2407 *
5	0.0636	20.7895 ***	5	0.0193	4.1583 ***
6	0.0422	13.7517 ***	6	0.0321	6.9266 ***
7	0.0265	8.6306 ***	7	0.0015	0.3202
8	0.0150	4.8827 ***	8	0.0065	1.4029
9	0.0154	5.0127 ***	9	0.0048	1.0278
10	0.0122	3.9696 ***	10	0.0068	1.4733
11	0.0102	3.3321 ***	11	0.0043	0.9303
12	0.0047	1.5212	12	0.0205	4.4180 ***
13	-0.0001	-0.0395	13	0.0013	0.2776
14	0.0072	2.3464 *	14	0.0116	2.4998 *
15	0.0021	0.6785	15	0.0018	0.3888
16	-0.0040	-1.2993	16	0.0086	1.8477
17	-0.0018	-0.5702	17	0.0076	1.6470
18	-0.0052	-1.7006	18	0.0148	3.1915 **
19	-0.0030	-0.9599	19	-0.0036	-0.7707
20	0.0019	0.6158	20	0.0038	0.8288
21	-0.0031	-1.0239	21	0.0022	0.4694
22	0.0013	0.4218	22	0.0042	0.9008
23	0.0044	1.4432	23	0.0082	1.7676
24	-0.0021	-0.6741	24	0.0114	2.4522 *
25	0.0015	0.4908	25	0.0145	3.1387 **
26	-0.0022	-0.7228	26	-0.0045	-0.9691
27	0.0009	0.3062	27	0.0019	0.4158
28	0.0041	1.3269	28	0.0070	1.5177
29	-0.0012	-0.3826	29	0.0057	1.2335
30	-0.0060	-1.9547	30	0.0074	1.5989
31	-0.0051	-1.6744	31	0.0063	1.3596
32	0.0024	0.7764	32	-0.0069	-1.4880
33	-0.0068	-2.2203 *	33	0.0031	0.6777
34	-0.0005	-0.1738	34	-0.0014	-0.2984
35	0.0023	0.7435	35	0.0103	2.2341 *
36	0.0032	1.0455	36	-0.0033	-0.7079
37	-0.0012	-0.4052	37	0.0109	2.3543 *
38	-0.0084	-2.7479 **	38	-0.0133	-2.8659 **
39	0.0026	0.8450	39	0.0139	2.9966 **
40	-0.0012	-0.4026	40	-0.0046	-0.9939
41	-0.0003	-0.0883	41	0.0037	0.7953
42	-0.0001	-0.0257	42	0.0041	0.8816
43	-0.0088	-2.8887 **	43	0.0011	0.2369
44	-0.0073	-2.3750 *	44	0.0017	0.3767
45	0.0039	1.2713	45	0.0026	0.5736
constant		1.53E-06			2.77E-06
Num. of Obs.		144180			144180
Sd. error of regression		0.0005			0.0006
R-squared		0.1220			0.0371
Adj. R-squared		0.1214			0.0364
F-statistic		217.7969 ***			60.3448 ***
Durbin-Watson statistic		1.5737			2.0323

Note: * represents significant at the 5% level
** represents significant at the 1% level.
*** represents significant at the 0.1% level.

Table 9 (B) Tuesday

Panel C : Vector Autoregression 1

NSA<=FUT			NSA<=NSA		
lag	Coeff.	t-Value	lag	Coeff.	t-Value
1	0.1240	42.7648 ***	1	0.2452	65.2515 ***
2	0.1028	35.0148 ***	2	-0.0126	-3.2602 **
3	0.0769	25.9676 ***	3	0.0098	2.5220 *
4	0.0557	18.7234 ***	4	-0.0053	-1.3780
5	0.0495	16.5888 ***	5	0.0048	1.2338
6	0.0387	12.9309 ***	6	-0.0057	-1.4719
7	0.0258	8.6089 ***	7	-0.0142	-3.6513 ***
8	0.0177	5.8876 ***	8	-0.0119	-3.0726 **
9	0.0195	6.4948 ***	9	0.0009	0.2419
10	0.0184	6.1240 ***	10	-0.0087	-2.2389 *
11	0.0100	3.3442 ***	11	-0.0061	-1.5838
12	0.0122	4.0587 ***	12	-0.0122	-3.1462 **
13	0.0119	3.9685 ***	13	-0.0138	-3.5425 ***
14	0.0106	3.5306 ***	14	-0.0113	-2.9093 **
15	0.0129	4.3092 ***	15	-0.0078	-2.0041 *
16	0.0007	0.2478	16	-0.0092	-2.3559 *
17	0.0042	1.4043	17	-0.0041	-1.0534
18	0.0035	1.1521	18	-0.0081	-2.0885 *
19	0.0107	3.5525 ***	19	-0.0086	-2.2254 *
20	0.0041	1.3750	20	-0.0052	-1.3498
21	0.0067	2.2344 *	21	0.0028	0.7238
22	-0.0017	-0.5562	22	-0.0123	-3.1613 **
23	0.0027	0.9097	23	-0.0020	-0.5040
24	0.0054	1.7801	24	-0.0056	-1.4425
25	0.0051	1.6828	25	-0.0008	-0.1935
26	0.0045	1.5100	26	-0.0124	-3.1871 **
27	-0.0035	-1.1767	27	-0.0001	-0.0211
28	-0.0014	-0.4499	28	-0.0126	-3.2543 **
29	0.0018	0.6028	29	0.0045	1.1474
30	0.0008	0.2638	30	0.0081	2.0975 *
31	-0.0009	-0.2838	31	-0.0083	-2.1278 *
32	0.0049	1.6226	32	-0.0106	-2.7418 **
33	-0.0047	-1.5681	33	-0.0008	-0.2146
34	-0.0004	-0.1329	34	0.0010	0.2545
35	0.0045	1.5063	35	-0.0114	-2.9291 **
36	-0.0011	-0.3674	36	-0.0032	-0.8352
37	0.0053	1.7840	37	-0.0028	-0.7298
38	-0.0020	-0.6681	38	-0.0033	-0.8449
39	0.0067	2.2239 *	39	0.0025	0.6441
40	0.0054	1.7994	40	-0.0076	-1.9720 *
41	0.0040	1.3250	41	0.0001	0.0227
42	-0.0052	-1.7334	42	-0.0019	-0.4800
43	0.0057	1.9129	43	-0.0055	-1.4182
44	-0.0015	-0.5170	44	0.0056	1.4520
45	0.0012	0.3986	45	-0.0058	-1.5952
constant					8.39E-07
Numbers of Observation					144180
Sum of squared residuals					0.0131
Standard error of regression					0.0004
R-squared					0.1696
Adjusted R-squard					0.1691
F-statistic					163.3348 **
Durbin-Watson statistic					1.9999

Panel D : Vector Autoregression 2

FUT<=NSA			FUT<=FUT		
lag	Coeff.	t-Value	lag	Coeff.	t-Value
1	0.1352	27.7479 ***	1	0.0038	1.0039
2	0.0416	8.2794 ***	2	-0.0181	-4.7507 ***
3	0.0161	3.2074 **	3	-0.0091	-2.3765 *
4	0.0167	3.3157 **	4	-0.0311	-8.0487 ***
5	0.0264	5.2458 ***	5	0.0090	2.3323 *
6	0.0245	4.8669 ***	6	0.0463	11.9324 ***
7	0.0016	0.3205	7	0.0011	0.2803
8	0.0126	2.5129 *	8	-0.0164	-4.2260 ***
9	0.0103	2.0479 *	9	-0.0048	-1.2216
10	0.0129	2.5676 *	10	0.0174	4.4812 ***
11	0.0165	3.2865 **	11	-0.0199	-5.1216 ***
12	0.0263	5.2254 ***	12	0.0183	4.7057 ***
13	0.0081	1.6066	13	-0.0196	-5.0217 ***
14	0.0195	3.8664 ***	14	0.0037	0.9557
15	0.0025	0.5028	15	0.0121	3.1024 **
16	0.0109	2.1649 *	16	-0.0150	-3.8604 ***
17	0.0014	0.2876	17	-0.0172	-4.4200 ***
18	0.0039	0.7669	18	0.0035	0.8938
19	0.0083	1.6500	19	-0.0015	-0.3889
20	0.0068	1.3444	20	-0.0057	-1.4660
21	0.0133	2.6425 **	21	0.0036	0.9342
22	0.0054	1.0783	22	-0.0126	-3.2444 **
23	0.0078	1.5505	23	-0.0034	-0.8715
24	-0.0024	-0.4854	24	0.0001	0.0302
25	0.0058	1.1608	25	0.0059	1.5080
26	0.0007	0.1443	26	-0.0045	-1.1660
27	0.0075	1.4922	27	-0.0074	-1.9117
28	-0.0029	-0.5742	28	-0.0052	-1.3353
29	0.0041	0.8167	29	-0.0027	-0.6837
30	0.0066	1.3178	30	0.0143	3.6657 ***
31	-0.0091	-1.8105	31	-0.0113	-2.8933 **
32	-0.0098	-1.9368	32	0.0015	0.3816
33	0.0035	0.6956	33	-0.0054	-1.3864
34	0.0014	0.2810	34	-0.0015	-0.3756
35	-0.0016	-0.3169	35	-0.0008	-0.1957
36	-0.0004	-0.0710	36	0.0067	1.7221
37	0.0064	1.2805	37	-0.0026	-0.6654
38	0.0002	0.0399	38	-0.0079	-2.0336 *
39	0.0013	0.2540	39	0.0038	0.9887
40	-0.0033	-0.6543	40	0.0033	0.8464
41	0.0055	1.0983	41	0.0071	1.8405
42	-0.0047	-0.9294	42	-0.0016	-0.4029
43	0.0108	2.1500 *	43	0.0026	0.6642
44	-0.0091	-1.8210	44	-0.0010	-0.2658
45	0.0000	0.0034	45	0.0074	1.9286
constant					-8.9E-07
Numbers of Observation					144180
Sum of squared residuals					0.0220
Standard error of regression					0.0006
R-squared					0.0315
Adjusted R-squard					0.0309
F-statistic					26.0381 **
Durbin-Watson statistic					2.0000

Note: * represents significant at the 5% level.
** represents significant at the 1% level
*** represents significant at the 0.1% level.

Table 10 (A) Wednesday

Panel A : Autocorelation

NSA			Futures		
lag	Autocorr.	t-Value	lag	Autocorr.	t-Value
1	0.3261	92.2736 ***	1	0.0255	6.8119 ***
2	0.1521	41.1537 ***	2	0.0213	5.6923 ***
3	0.1198	32.2753 ***	3	0.0271	7.2444 ***
4	0.1002	26.9502 ***	4	-0.0007	0.1788
5	0.0936	25.1470 ***	5	0.0297	7.9493 ***
6	0.0689	18.4724 ***	6	0.0743	19.9413 ***
7	0.0525	14.0527 ***	7	0.0260	6.9572 ***
8	0.0442	11.8228 ***	8	0.0207	5.5506 ***
9	0.0322	8.6202 ***	9	0.0091	2.4320 *
10	0.0270	7.2264 ***	10	0.0241	6.4510 ***
11	0.0263	7.0447 ***	11	0.0023	0.6131
12	0.0216	5.7801 ***	12	0.0466	12.4723 ***
13	0.0175	4.6904 ***	13	0.0090	2.4092 *
14	0.0132	3.5240 ***	14	0.0106	2.8257 **
15	0.0134	3.5714 ***	15	0.0208	5.5728 ***
16	0.0092	2.4711 *	16	0.0084	2.2497 *
17	0.0026	0.6864	17	0.0055	1.4754
18	-0.0006	0.1505	18	0.0215	5.7525 ***
19	-0.0017	0.4565	19	0.0058	1.5524
20	0.0001	0.0330	20	0.0120	3.2049 ***
21	-0.0052	1.4020	21	0.0082	2.2061 *
22	-0.0073	1.9493	22	0.0091	2.4275 *
23	-0.0016	0.4221	23	-0.0010	0.2762
24	-0.0072	1.9264	24	0.0090	2.4013 *
25	-0.0071	1.8928	25	0.0065	1.7360
26	-0.0110	2.9387 **	26	-0.0031	0.8418
27	-0.0073	1.9650	27	-0.0110	2.9347 **
28	-0.0010	0.2616	28	0.0052	1.3916
29	0.0017	0.4543	29	-0.0015	0.3879
30	0.0014	0.3675	30	0.0171	4.5763 ***
31	-0.0020	0.5392	31	0.0030	0.8026
32	-0.0041	1.1053	32	-0.0037	0.9983
33	0.0007	0.2001	33	-0.0014	0.3857
34	0.0044	1.1767	34	0.0026	0.7054
35	0.0011	0.2848	35	0.0115	3.0638 **
36	0.0020	0.5423	36	0.0041	1.1077
37	0.0058	1.5503	37	-0.0016	0.4387
38	0.0073	1.9619	38	0.0036	0.9749
39	0.0013	0.3534	39	0.0011	0.3026
40	-0.0030	0.7904	40	0.0048	1.2707
41	0.0005	0.1309	41	0.0053	1.4216
42	0.0001	0.0365	42	0.0067	1.8026
43	-0.0023	0.6044	43	0.0018	0.4706
44	-0.0051	1.3712	44	0.0029	0.7650
45	-0.0131	3.5061 **	45	0.0010	0.2628
46	-0.0031	0.8221	46	0.0033	0.8740
47	0.0003	0.0699	47	0.0010	0.2761
48	-0.0011	0.2837	48	0.0008	0.2199
49	-0.0044	1.1853	49	-0.0005	0.1243
50	-0.0113	3.0329 **	50	0.0090	2.3960 *
51	-0.0047	1.2561	51	0.0030	0.8136
52	-0.0063	1.6960	52	-0.0038	1.0191
53	-0.0104	2.7700 **	53	0.0033	0.8905
54	-0.0126	3.3583 ***	54	-0.0068	1.8172
55	-0.0105	2.8176 **	55	0.0007	0.1785
56	-0.0102	2.7320 **	56	0.0083	2.2146 *
57	-0.0046	1.2181	57	0.0054	1.4561
58	-0.0037	0.9803	58	0.0006	0.1572
59	-0.0031	0.8417	59	0.0047	1.2634
60	-0.0027	0.7108	60	-0.0032	0.8578

Panel B : Multiple Regression

NSA<=FUT			NSA=>FUT		
lag	Coeff.	t-Value	lag	Coeff.	t-Value
0	0.1187	39.8685 ***	0	0.1495	32.3402 ***
1	0.1454	48.8399 ***	1	0.0771	15.9726 ***
2	0.1292	43.3828 ***	2	0.0317	6.5722 ***
3	0.0999	33.5426 ***	3	0.0095	1.9721 *
4	0.0831	27.8989 ***	4	0.0132	2.7354 **
5	0.0640	21.4771 ***	5	0.0248	5.1286 ***
6	0.0379	12.6881 ***	6	0.0254	5.2515 ***
7	0.0227	7.6084 ***	7	0.0031	0.6375
8	0.0173	5.8018 ***	8	0.0045	0.9306
9	0.0190	6.3730 ***	9	0.0190	3.9372 ***
10	0.0168	5.6148 ***	10	0.0124	2.5615
11	0.0129	4.3039 ***	11	0.0089	1.8427
12	0.0056	1.8645	12	0.0105	2.1662 *
13	-0.0016	-0.5455	13	0.0054	1.1173
14	0.0052	1.7389	14	0.0063	1.3023
15	0.0002	0.0631	15	0.0069	1.4335
16	0.0012	0.4124	16	0.0028	0.5712
17	0.0031	1.0335	17	0.0134	2.7663 **
18	0.0032	1.0613	18	0.0049	1.0208
19	-0.0070	-2.3419 *	19	0.0042	0.8738
20	-0.0027	-0.8924	20	0.0021	0.4428
21	-0.0057	-1.9066	21	-0.0017	-0.3569
22	-0.0067	-2.2458 *	22	-0.0010	-0.2010
23	0.0018	0.6030	23	0.0066	1.3562
24	-0.0058	-1.9465	24	0.0056	1.1580
25	-0.0029	-0.9789	25	-0.0001	-0.0257
26	-0.0051	-1.7203	26	0.0036	0.7367
27	0.0017	0.5749	27	0.0050	1.0369
28	-0.0022	-0.7497	28	0.0037	0.7722
29	0.0002	0.0778	29	-0.0029	-0.6065
30	0.0021	0.7139	30	0.0008	0.1588
31	-0.0043	-1.4337	31	0.0066	1.3574
32	-0.0008	-0.2555	32	0.0021	0.4318
33	-0.0034	-1.1215	33	0.0045	0.9403
34	0.0000	-0.0117	34	0.0014	0.2898
35	-0.0038	-1.2811	35	-0.0046	-0.9571
36	0.0034	1.1277	36	0.0082	1.7003
37	0.0008	0.2742	37	0.0051	1.0600
38	0.0055	1.8270	38	-0.0095	-1.9629
39	-0.0016	-0.5468	39	0.0014	0.2904
40	0.0017	0.5556	40	-0.0015	-0.3028
41	-0.0006	-0.1869	41	0.0059	1.2279
42	0.0015	0.5198	42	0.0035	0.7215
43	-0.0009	-0.2994	43	0.0002	0.0320
44	-0.0034	-1.1277	44	0.0018	0.3716
45	-0.0018	-0.6101	45	0.0037	0.8023
constant		1.19E-06			-2.4E-06
Num. of Obs.		143100			143100
Sd. error of regression		0.0004			0.0006
R-squared		0.1241			0.0366
Adj. R-squared		0.1235			0.0360
F-statistic		220.1081 ***			59.0578 ***
Durbin-Watson statistic		1.5429			2.0385

Note: * represents significant at the 5% level.
** represents significant at the 1% level.
*** represents significant at the 0.1% level.

Table 10 (B) Wednesday

Panel C : Vector Autoregression 1

NSA<=FUT			NSA<=NSA		
lag	Coeff.	t-Value	lag	Coeff.	t-Value
1	0.1207	40.7094 ***	1	0.2441	64.7044 ***
2	0.0975	32.5007 ***	2	-0.0151	-3.8884 ***
3	0.0728	24.0882 ***	3	0.0113	2.8960 **
4	0.0589	19.4087 ***	4	0.0013	0.3323
5	0.0475	15.5941 ***	5	0.0154	3.9658 ***
6	0.0318	10.4230 ***	6	-0.0075	-1.9347
7	0.0188	6.1397 ***	7	-0.0104	-2.6788 **
8	0.0184	6.0033 ***	8	-0.0065	-1.6573
9	0.0212	6.9443 ***	9	-0.0138	-3.5416 ***
10	0.0218	7.1276 ***	10	-0.0125	-3.2090 **
11	0.0166	5.4183 ***	11	-0.0072	-1.8400
12	0.0159	5.1870 ***	12	-0.0093	-2.3735 *
13	0.0060	1.9655 *	13	-0.0094	-2.4053 *
14	0.0150	4.8890 ***	14	-0.0111	-2.8424 **
15	0.0096	3.1299 **	15	-0.0063	-1.6116
16	0.0109	3.5633 ***	16	-0.0090	-2.3145 *
17	0.0124	4.0527 ***	17	-0.0124	-3.1705 **
18	0.0138	4.5072 ***	18	-0.0124	-3.1922 **
19	0.0021	0.6898	19	-0.0115	-2.9580 **
20	0.0096	3.1469 **	20	-0.0059	-1.5036
21	0.0048	1.5699	21	-0.0122	-3.1250 **
22	0.0044	1.4330	22	-0.0121	-3.1099 **
23	0.0116	3.7743 ***	23	-0.0011	-0.2828
24	0.0025	0.8260	24	-0.0126	-3.2346 **
25	0.0074	2.4076 *	25	-0.0072	-1.8389
26	0.0032	1.0547	26	-0.0141	-3.6258 ***
27	0.0093	3.0286 **	27	-0.0081	-2.0729
28	0.0047	1.5329	28	-0.0037	-0.9574
29	0.0068	2.2103 *	29	-0.0028	-0.7152
30	0.0094	3.0723 **	30	-0.0022	-0.5603
31	0.0006	0.1888	31	-0.0058	-1.4850
32	0.0044	1.4445	32	-0.0088	-2.2477 *
33	0.0010	0.3367	33	-0.0029	-0.7465
34	0.0054	1.7586	34	-0.0004	-0.1076
35	0.0014	0.4497	35	-0.0072	-1.8357
36	0.0082	2.6914 **	36	-0.0035	-0.8915
37	0.0027	0.8709	37	-0.0004	-0.1069
38	0.0084	2.7666 **	38	0.0011	0.2776
39	0.0000	0.0009	39	-0.0047	-1.1972
40	0.0055	1.8046	40	-0.0071	-1.8240
41	0.0023	0.7437	41	-0.0003	-0.0835
42	0.0051	1.6753	42	-0.0027	-0.6846
43	0.0017	0.5504	43	-0.0044	-1.1444
44	0.0007	0.2400	44	-0.0037	-0.9516
45	0.0025	0.8214	45	-0.0152	-4.1213 ***

constant	1.14E-06
Numbers of Observation	143100
Sum of squared residuals	0.0137
Standard error of regression	0.0004
R-squared	0.1602
Adjusted R-squard	0.1597
F-statistic	151.3794 ***
Durbin-Watson statistic	2.0000

Panel D : Vector Autoregression 2

FUT<=NSA			FUT<=FUT		
lag	Coeff.	t-Value	lag	Coeff.	t-Value
1	0.1282	26.7002 ***	1	-0.0026	-0.6877
2	0.0411	8.3036 ***	2	-0.0126	-3.3072 ***
3	0.0218	4.4013 ***	3	-0.0087	-2.2499 *
4	0.0195	3.9318 ***	4	-0.0368	-9.5341 ***
5	0.0302	6.0846 ***	5	-0.0042	-1.0821
6	0.0273	5.5109 ***	6	0.0414	10.6491 ***
7	0.0056	1.1236	7	-0.0033	-0.8548
8	0.0095	1.9100	8	-0.0056	-1.4294
9	0.0241	4.8697 ***	9	-0.0168	-4.3152 ***
10	0.0164	3.3087 ***	10	0.0019	0.4794
11	0.0111	2.2439 *	11	-0.0217	-5.5667 ***
12	0.0127	2.5652 *	12	0.0222	5.7069 ***
13	0.0088	1.7758	13	-0.0128	-3.2807 **
14	0.0095	1.9244	14	-0.0070	-1.8010
15	0.0107	2.1634 *	15	0.0035	0.8945
16	0.0059	1.1791	16	-0.0073	-1.8738
17	0.0155	3.1307 **	17	-0.0089	-2.2898 *
18	0.0069	1.3909	18	0.0028	0.7254
19	0.0066	1.3258	19	-0.0075	-1.9297
20	0.0052	1.0466	20	0.0005	0.1385
21	0.0005	0.0978	21	-0.0018	-0.4655
22	0.0025	0.4996	22	-0.0008	-0.2036
23	0.0112	2.2585 *	23	-0.0098	-2.5178 *
24	0.0088	1.7668	24	-0.0028	-0.7136
25	0.0047	0.9540	25	-0.0021	-0.5433
26	0.0074	1.4978	26	-0.0116	-2.9637 **
27	0.0093	1.8727	27	-0.0205	-5.2537 ***
28	0.0082	1.6520	28	-0.0035	-0.8893
29	-0.0009	-0.1872	29	-0.0079	-2.0360 *
30	0.0028	0.5622	30	0.0094	2.4205 *
31	0.0087	1.7551	31	-0.0037	-0.9564
32	0.0042	0.8423	32	-0.0092	-2.3724 *
33	0.0069	1.3817	33	-0.0059	-1.5107
34	0.0033	0.6622	34	-0.0018	-0.4531
35	-0.0036	-0.7227	35	0.0072	1.8573
36	0.0095	1.9120	36	-0.0024	-0.6105
37	0.0070	1.4054	37	-0.0063	-1.6251
38	-0.0076	-1.5334	38	0.0006	0.1669
39	0.0011	0.2127	39	-0.0003	-0.0675
40	-0.0020	-0.4081	40	0.0013	0.3465
41	0.0070	1.4058	41	0.0019	0.4790
42	0.0037	0.7453	42	0.0031	0.8011
43	0.0005	0.0973	43	-0.0012	-0.3094
44	0.0029	0.5930	44	0.0007	0.1749
45	0.0031	0.6612	45	-0.0013	-0.3280

constant	-2.8E-06
Numbers of Observation	143100
Sum of squared residuals	0.0223
Standard error of regression	0.0006
R-squared	0.0284
Adjusted R-squard	0.0278
F-statistic	23.1889 ***
Durbin-Watson statistic	2.0000

Note: * represents significant at the 5% level.
** represents significant at the 1% level.
*** represents significant at the 0.1% level.

Table 11 (A) Thursday

Panel A : Autocorelation

NSA			Futures		
lag	Autocorr.	t-Value	lag	Autocorr.	t-Value
1	0.3339	95.1968 ***	1	0.0330	8.8671 ***
2	0.1620	44.1162 ***	2	0.0174	4.6862 ***
3	0.1253	33.9461 ***	3	0.0288	7.7466 ***
4	0.0982	26.5099 ***	4	0.0067	1.8101
5	0.0864	23.3071 ***	5	0.0426	11.4448 ***
6	0.0686	18.4814 ***	6	0.0788	21.2385 ***
7	0.0499	13.4165 ***	7	0.0306	8.2232 ***
8	0.0409	11.0009 ***	8	0.0100	2.6912 **
9	0.0426	11.4702 ***	9	0.0219	5.8812 ***
10	0.0331	8.9066 ***	10	0.0383	10.2935 ***
11	0.0274	7.3539 ***	11	0.0059	1.5845
12	0.0190	5.0939 ***	12	0.0438	11.7830 ***
13	0.0136	3.6655 ***	13	0.0042	1.1415
14	0.0122	3.2750 **	14	0.0220	5.9064 ***
15	0.0125	3.3518 ***	15	0.0341	9.1604 ***
16	0.0096	2.5887 **	16	0.0037	1.0000
17	0.0102	2.7351 **	17	-0.0026	0.7060
18	0.0062	1.6590	18	0.0190	5.0952 ***
19	0.0032	0.8530	19	0.0094	2.5338 *
20	0.0054	1.4551	20	0.0088	2.3701 *
21	0.0093	2.5092 *	21	0.0168	4.5232 ***
22	0.0004	0.1201	22	-0.0021	0.5717
23	0.0030	0.8085	23	0.0022	0.5899
24	0.0024	0.6332	24	0.0116	3.1294 **
25	0.0017	0.4456	25	0.0132	3.5398 ***
26	-0.0069	1.8424	26	0.0019	0.5037
27	-0.0039	1.0380	27	-0.0003	0.0718
28	-0.0091	2.4483 *	28	-0.0030	0.8148
29	0.0013	0.3487	29	0.0001	0.0151
30	0.0069	1.8530	30	0.0187	5.0165 ***
31	-0.0055	1.4766	31	-0.0080	2.1588 *
32	-0.0133	3.5805 ***	32	-0.0005	0.1302
33	-0.0090	2.4272 *	33	-0.0042	1.1373
34	-0.0066	1.7849	34	-0.0039	1.0369
35	-0.0138	3.7210 ***	35	0.0002	0.0526
36	-0.0104	2.7970 **	36	0.0084	2.2454 *
37	-0.0081	2.1888 *	37	-0.0037	1.0014
38	-0.0055	1.4770	38	-0.0084	2.2646 *
39	-0.0013	0.3523	39	0.0038	1.0158
40	-0.0065	1.7571	40	0.0040	1.0809
41	-0.0040	1.0770	41	0.0064	1.7146
42	-0.0036	0.9606	42	0.0013	0.3398
43	-0.0055	1.4762	43	-0.0001	0.0260
44	0.0021	0.5653	44	-0.0010	0.2647
45	-0.0035	0.9378	45	0.0075	2.0028 *
46	0.0019	0.5057	46	-0.0009	0.2443
47	-0.0016	0.4432	47	0.0055	1.4744
48	-0.0047	1.2610	48	0.0019	0.5056
49	-0.0056	1.4948	49	-0.0056	1.5015
50	-0.0026	0.7063	50	-0.0067	1.8032
51	-0.0052	1.4071	51	0.0038	1.0228
52	-0.0037	0.9878	52	-0.0008	0.2118
53	0.0021	0.5753	53	-0.0016	0.4262
54	0.0007	0.1875	54	0.0010	0.2590
55	-0.0015	0.3900	55	0.0015	0.4130
56	-0.0009	0.2435	56	-0.0021	0.5697
57	-0.0014	0.3833	57	0.0003	0.0870
58	-0.0042	1.1294	58	0.0039	1.0423
59	0.0003	0.0689	59	-0.0024	0.6558
60	0.0035	0.9356	60	0.0104	2.8035 **

Panel B : Multiple Regression

NSA<=FUT			NSA=>FUT		
lag	Coeff.	t-Value	lag	Coeff.	t-Value
0	0.1165	40.0469 ***	0	0.1533	32.7552 ***
1	0.1477	50.7391 ***	1	0.0833	17.0164 ***
2	0.1356	46.5783 ***	2	0.0325	6.6394 ***
3	0.1054	36.2149 ***	3	0.0058	1.1780
4	0.0799	27.4559 ***	4	0.0152	3.1016 **
5	0.0625	21.4395 ***	5	0.0259	5.2902 ***
6	0.0423	14.4881 ***	6	0.0243	4.9540 ***
7	0.0291	9.9792 ***	7	0.0012	0.2432
8	0.0192	6.5590 ***	8	0.0105	2.1343 *
9	0.0169	5.7806 ***	9	0.0062	1.2559
10	0.0123	4.2048 ***	10	0.0109	2.2219 *
11	0.0068	2.3325 *	11	0.0167	3.4035 ***
12	0.0023	0.7919	12	0.0244	4.9764 ***
13	0.0048	1.6581	13	0.0063	1.2916
14	0.0009	0.3239	14	0.0164	3.3366 ***
15	0.0017	0.5954	15	-0.0011	-0.2261
16	-0.0066	-2.2525 *	16	0.0076	1.5393
17	-0.0043	-1.4651	17	-0.0014	-0.2943
18	-0.0060	-2.0615 *	18	0.0019	0.3965
19	0.0019	0.6417	19	0.0068	1.3925
20	-0.0019	-0.6552	20	0.0056	1.1405
21	-0.0010	-0.3541	21	0.0094	1.9175
22	-0.0065	-2.2185 *	22	0.0044	0.8985
23	-0.0042	-1.4459	23	0.0051	1.0347
24	-0.0007	-0.2529	24	-0.0032	-0.6598
25	-0.0009	-0.3041	25	0.0031	0.6304
26	-0.0002	-0.0584	26	0.0013	0.2735
27	-0.0078	-2.6611 **	27	0.0051	1.0473
28	-0.0067	-2.2812 *	28	-0.0026	-0.5240
29	-0.0029	-0.9989	29	0.0023	0.4605
30	-0.0043	-1.4573	30	0.0040	0.8069
31	-0.0031	-1.0486	31	-0.0088	-1.7868
32	0.0014	0.4900	32	-0.0098	-2.0056 *
33	-0.0066	-2.2679 *	33	0.0028	0.5686
34	-0.0047	-1.6208	34	0.0004	0.0793
35	0.0008	0.2727	35	0.0007	0.1472
36	-0.0047	-1.6139	36	-0.0001	-0.0184
37	0.0014	0.4930	37	0.0059	1.2106
38	-0.0033	-1.1466	38	-0.0003	-0.0615
39	0.0030	1.0134	39	0.0014	0.2774
40	0.0039	1.3328	40	-0.0009	-0.1859
41	0.0019	0.6601	41	0.0061	1.2521
42	-0.0062	-2.1406 *	42	-0.0035	-0.7225
43	0.0026	0.8783	43	0.0116	2.3695 *
44	-0.0018	-0.6342	44	-0.0093	-1.8957
45	-0.0011	-0.3842	45	0.0012	0.2632
constant		1.53E-06			-8.7E-07
Num. of Obs.		144420			144420
Sd. error of regression		0.0004			0.0006
R-squared		0.1348			0.0390
Adj. R-squared		0.1343			0.0384
F-statistic		243.9430 ***			63.5173 ***
Durbin-Watson statistic		1.5439			2.0291

Note: * represents significant at the 5% level.
** represents significant at the 1% level.
*** represents significant at the 0.1% level.

Table 11 (B) Thursday

Panel C : Vector Autoregression 1

NSA<=FUT			NSA<=NSA		
lag	Coeff.	t-Value	lag	Coeff.	t-Value
1	0.1274	41.6911 ***	1	0.2258	60.1519 ***
2	0.1031	33.3332 ***	2	0.0038	0.9952
3	0.0690	22.1414 ***	3	0.0132	3.4201 ***
4	0.0530	16.9429 ***	4	0.0036	0.9204
5	0.0468	14.9022 ***	5	0.0152	3.9277 ***
6	0.0355	11.3076 ***	6	-0.0053	-1.3701
7	0.0194	6.1678 ***	7	-0.0092	-2.3817 *
8	0.0103	3.2630 **	8	-0.0065	-1.6951
9	0.0166	5.2656 ***	9	0.0030	0.7772
10	0.0139	4.4061 ***	10	-0.0153	-3.9734 ***
11	0.0120	3.7986 ***	11	-0.0017	-0.4403
12	0.0130	4.1178 ***	12	-0.0053	-1.3647
13	0.0048	1.5230	13	-0.0120	-3.0968 **
14	0.0147	4.6480 ***	14	-0.0110	-2.8437 **
15	0.0092	2.9116 **	15	-0.0076	-1.9724
16	0.0040	1.2809	16	-0.0081	-2.0874 *
17	0.0075	2.3746 *	17	-0.0096	-2.4783 *
18	0.0055	1.7408	18	-0.0066	-1.7030
19	0.0055	1.7404	19	-0.0098	-2.5322 *
20	0.0101	3.2058 **	20	-0.0002	-0.0402
21	0.0036	1.1488	21	-0.0028	-0.7149
22	0.0084	2.6713 **	22	-0.0148	-3.8284 ***
23	0.0092	2.9233 **	23	-0.0031	-0.7960
24	0.0054	1.7207	24	-0.0066	-1.6994
25	0.0077	2.4325 *	25	-0.0057	-1.4814
26	0.0039	1.2327	26	-0.0042	-1.0771
27	0.0067	2.1384 *	27	-0.0026	-0.6627
28	0.0086	2.7302 **	28	-0.0075	-1.9485
29	0.0022	0.6996	29	0.0016	0.4184
30	-0.0001	-0.0284	30	-0.0016	-0.4208
31	0.0002	0.0658	31	-0.0082	-2.1287 *
32	0.0081	2.5750 *	32	-0.0090	-2.3263 *
33	-0.0027	-0.8476	33	-0.0065	-1.6904
34	0.0055	1.7326	34	0.0035	0.9009
35	0.0065	2.0738 *	35	-0.0082	-2.1120 *
36	0.0082	2.6188 **	36	-0.0048	-1.2396
37	0.0034	1.0945	37	-0.0120	-3.1019 **
38	-0.0030	-0.9631	38	0.0018	0.4768
39	0.0087	2.7658 **	39	-0.0095	-2.4710 *
40	0.0022	0.7063	40	-0.0016	-0.4093
41	0.0037	1.1705	41	-0.0011	-0.2854
42	0.0044	1.4029	42	-0.0021	-0.5377
43	-0.0057	-1.8308	43	-0.0046	-1.2085
44	-0.0029	-0.9389	44	-0.0044	-1.1454
45	0.0083	2.6515 **	45	-0.0038	-1.0290
constant					1.66E-06
Numbers of Observation					144420
Sum of squared residuals					0.0146
Standard error of regression					0.0005
R-squared					0.1521
Adjusted R-squard					0.1516
F-statistic					143.6431 ***
Durbin-Watson statistic					2.0000

Panel D : Vector Autoregression 2

FUT<=NSA			FUT<=FUT		
lag	Coeff.	t-Value	lag	Coeff.	t-Value
1	0.1296	28.1264 ***	1	0.0011	0.2821
2	0.0353	7.4439 ***	2	-0.0122	-3.2083 **
3	0.0163	3.4403 ***	3	-0.0174	-4.5473 ***
4	0.0135	2.8581 **	4	-0.0244	-6.3480 ***
5	0.0213	4.4926 ***	5	0.0013	0.3496
6	0.0328	6.9106 ***	6	0.0526	13.6208 ***
7	0.0029	0.6215	7	-0.0023	-0.5915
8	0.0113	2.3725 *	8	-0.0234	-6.0601 ***
9	0.0115	2.4179 *	9	-0.0030	-0.7660
10	0.0079	1.6633	10	-0.0036	-0.9328
11	0.0052	1.0904	11	-0.0170	-4.3815 ***
12	0.0219	4.6105 ***	12	0.0273	7.0546 ***
13	0.0027	0.5621	13	-0.0159	-4.0966 ***
14	0.0143	3.0151 **	14	-0.0075	-1.9322
15	0.0039	0.8187	15	-0.0010	-0.2680
16	0.0098	2.0588 *	16	-0.0050	-1.2835
17	0.0079	1.6705	17	-0.0038	-0.9738
18	0.0151	3.1869 **	18	0.0141	3.6353 ***
19	-0.0017	-0.3552	19	-0.0084	-2.1770 *
20	0.0079	1.6649	20	-0.0010	-0.2606
21	0.0061	1.2770	21	-0.0031	-0.8086
22	0.0056	1.1906	22	-0.0055	-1.4209
23	0.0099	2.0797 *	23	-0.0186	-4.7987 ***
24	0.0119	2.5164 *	24	0.0123	3.1650 **
25	0.0166	3.5084 ***	25	-0.0075	-1.9382
26	-0.0021	-0.4431	26	0.0024	0.6142
27	0.0044	0.9238	27	-0.0053	-1.3703
28	0.0083	1.7556	28	-0.0026	-0.6838
29	0.0077	1.6317	29	-0.0058	-1.4958
30	0.0074	1.5668	30	0.0082	2.1307 *
31	0.0069	1.4516	31	-0.0062	-1.6003
32	-0.0058	-1.2162	32	-0.0017	-0.4486
33	0.0044	0.9258	33	-0.0025	-0.6489
34	-0.0002	-0.0494	34	-0.0028	-0.7231
35	0.0089	1.8851	35	-0.0031	-0.7917
36	-0.0056	-1.1800	36	0.0055	1.4229
37	0.0088	1.8627	37	0.0058	1.5112
38	-0.0124	-2.6165 **	38	0.0017	0.4442
39	0.0129	2.7137 **	39	0.0011	0.2963
40	-0.0054	-1.1366	40	0.0013	0.3295
41	0.0027	0.5710	41	0.0011	0.2761
42	0.0026	0.5400	42	0.0086	2.2328 *
43	0.0002	0.0360	43	0.0019	0.4912
44	0.0024	0.5140	44	-0.0019	-0.5037
45	0.0026	0.5707	45	0.0027	0.6984
constant					2.93E-06
Numbers of Observation					144420
Sum of squared residuals					0.0220
Standard error of regression					0.0006
R-squared					0.0311
Adjusted R-squard					0.0305
F-statistic					25.6890 ***
Durbin-Watson statistic					2.0000

Note: * represents significant at the 5% level.
** represents significant at the 1% level.
*** represents significant at the 0.1% level.

Table 12 (A) Friday

Panel A : Autocorelation

NSA			Futures		
lag	Autocorr.	t-Value	lag	Autocorr.	t-Value
1	0.3310	93.5543 ***	1	0.0241	6.4334 ***
2	0.1667	45.0834 ***	2	0.0120	3.2033 **
3	0.1275	34.2762 ***	3	0.0176	4.6906 ***
4	0.1065	28.5519 ***	4	0.0049	1.2938
5	0.0874	23.3937 ***	5	0.0256	6.8421 ***
6	0.0690	18.4361 ***	6	0.0648	17.3276 ***
7	0.0586	15.6468 ***	7	0.0252	6.7289 ***
8	0.0449	11.9896 ***	8	0.0081	2.1678 *
9	0.0331	8.8335 ***	9	0.0051	1.3681
10	0.0342	9.1227 ***	10	0.0199	5.2982 ***
11	0.0188	5.0174 ***	11	-0.0021	0.5679
12	0.0085	2.2789 *	12	0.0370	9.8831 ***
13	0.0068	1.8212	13	0.0048	1.2887
14	0.0038	1.0192	14	0.0105	2.8095 **
15	0.0018	0.4917	15	0.0106	2.8337 **
16	0.0034	0.8935	16	0.0007	0.1986
17	-0.0037	0.9785	17	-0.0017	0.4522
18	-0.0008	0.2035	18	0.0192	5.1300 ***
19	-0.0007	0.1988	19	0.0042	1.1130
20	-0.0041	1.0851	20	0.0098	2.6005 **
21	-0.0036	0.9476	21	0.0018	0.4825
22	-0.0045	1.1920	22	-0.0046	1.2150
23	-0.0037	0.9969	23	-0.0073	1.9500
24	-0.0064	1.7133	24	0.0178	4.7539 ***
25	-0.0039	1.0267	25	0.0121	3.2322 **
26	-0.0001	0.0173	26	-0.0031	0.8264
27	-0.0001	0.0222	27	0.0004	0.1030
28	-0.0010	0.2739	28	0.0046	1.2299
29	-0.0006	0.1705	29	0.0044	1.1808
30	0.0051	1.3692	30	0.0137	3.6592 ***
31	0.0018	0.4669	31	0.0005	0.1249
32	-0.0081	2.1603 *	32	0.0032	0.8441
33	-0.0061	1.6330	33	-0.0012	0.3178
34	-0.0038	1.0197	34	0.0013	0.3533
35	-0.0018	0.4778	35	0.0015	0.3985
36	-0.0029	0.7741	36	0.0139	3.7179 ***
37	0.0015	0.4016	37	-0.0009	0.2485
38	-0.0017	0.4504	38	-0.0096	2.5611 *
39	-0.0055	1.4712	39	0.0066	1.7497
40	0.0021	0.5482	40	0.0002	0.0512
41	0.0015	0.3916	41	0.0071	1.8922
42	-0.0010	0.2583	42	-0.0007	0.1974
43	-0.0038	1.0131	43	-0.0039	1.0303
44	-0.0021	0.5653	44	-0.0007	0.1805
45	-0.0068	1.8169	45	0.0023	0.6239
46	-0.0056	1.4894	46	-0.0012	0.3107
47	-0.0102	2.7291 **	47	0.0055	1.4560
48	-0.0110	2.9429 **	48	0.0092	2.4403 *
49	-0.0025	0.6689	49	-0.0024	0.6334
50	-0.0096	2.5472 *	50	-0.0050	1.3459
51	-0.0124	3.3091 ***	51	-0.0027	0.7234
52	-0.0105	2.7881 **	52	-0.0055	1.4721
53	-0.0121	3.2186 **	53	-0.0018	0.4831
54	-0.0067	1.7875	54	0.0012	0.3244
55	-0.0045	1.2040	55	0.0017	0.4486
56	-0.0016	0.4186	56	-0.0021	0.5599
57	0.0008	0.2130	57	0.0019	0.5094
58	0.0051	1.3663	58	0.0018	0.4849
59	0.0002	0.0424	59	0.0032	0.8415
60	0.0002	0.0542	60	0.0035	0.9408

Panel B : Multiple Regression

NSA<=FUT			NSA=>FUT		
lag	Coeff.	t-Value	lag	Coeff.	t-Value
0	0.0977	36.3907 ***	0	0.1536	29.4011 ***
1	0.1264	47.0362 ***	1	0.0748	13.7094 ***
2	0.1159	43.1246 ***	2	0.0178	3.2631 **
3	0.0818	30.4625 ***	3	0.0209	3.8268 ***
4	0.0630	23.4582 ***	4	0.0109	1.9945 *
5	0.0464	17.2769 ***	5	0.0270	4.9357 ***
6	0.0305	11.3389 ***	6	0.0162	2.9716 **
7	0.0255	9.4696 ***	7	0.0031	0.5746
8	0.0199	7.3794 ***	8	0.0140	2.5600 *
9	0.0164	6.0799 ***	9	0.0123	2.2540 *
10	0.0074	2.7327 **	10	0.0032	0.5785
11	0.0082	3.0367 **	11	0.0098	1.7967
12	0.0039	1.4345	12	0.0137	2.5044 *
13	0.0032	1.1836	13	0.0089	1.6210
14	-0.0016	-0.5793	14	-0.0013	-0.2352
15	0.0010	0.3673	15	0.0120	2.2006 *
16	-0.0015	-0.5398	16	-0.0027	-0.4958
17	0.0053	1.9586	17	0.0161	2.9367 **
18	0.0002	0.0731	18	0.0065	1.1871
19	-0.0001	-0.0453	19	-0.0017	-0.3106
20	-0.0033	-1.2168	20	0.0110	2.0114 *
21	-0.0054	-2.0047 *	21	0.0111	2.0342 *
22	-0.0013	-0.4985	22	0.0041	0.7481
23	-0.0008	-0.2837	23	-0.0027	-0.5022
24	-0.0009	-0.3513	24	0.0135	2.4629 *
25	-0.0067	-2.4842 *	25	-0.0007	-0.1243
26	-0.0084	-3.1315 **	26	0.0013	0.2380
27	-0.0024	-0.9027	27	0.0002	0.0374
28	0.0012	0.4568	28	0.0014	0.2569
29	0.0033	1.2383	29	0.0116	2.1137 *
30	0.0067	2.4925 *	30	0.0053	0.9611
31	0.0046	1.6982	31	-0.0067	-1.2224
32	-0.0056	-2.0917 *	32	-0.0035	-0.6404
33	0.0008	0.2836	33	0.0047	0.8545
34	0.0017	0.6473	34	0.0000	0.0008
35	0.0004	0.1600	35	-0.0005	-0.0859
36	-0.0066	-2.4516 *	36	0.0077	1.3990
37	-0.0043	-1.6048	37	0.0076	1.3845
38	0.0008	0.2949	38	-0.0025	-0.4566
39	-0.0007	-0.2630	39	0.0077	1.4079
40	-0.0002	-0.0859	40	-0.0084	-1.5391
41	0.0002	0.0860	41	0.0027	0.4909
42	0.0006	0.2183	42	-0.0052	-0.9489
43	-0.0045	-1.6763	43	0.0073	1.3368
44	0.0009	0.3341	44	-0.0022	-0.4010
45	0.0009	0.3311	45	0.0047	0.8904
constant		-1.8E-06			1.55E-06
Num. of Obs.		142260			142260
Sd. error of regression		0.0005			0.0006
R-squared		0.1082			0.0290
Adj. R-squared		0.1076			0.0284
F-statistic		187.3396 ***			46.1289 ***
Durbin-Watson statistic		1.5013			2.0241

Note: * represents significant at the 5% level.
** represents significant at the 1% level.
*** represents significant at the 0.1% level.

Table 12 (B) Friday

Panel C : Vector Autoregression 1

NSA<=FUT			NSA<=NSA		
lag	Coeff.	t-Value	lag	Coeff.	t-Value
1	0.1020	38.5069 ***	1	0.2556	67.6565 ***
2	0.0821	30.6779 ***	2	0.0092	2.3556 *
3	0.0500	18.5647 ***	3	0.0213	5.4496 ***
4	0.0372	13.7751 ***	4	0.0158	4.0535 ***
5	0.0274	10.1035 ***	5	0.0100	2.5482 *
6	0.0203	7.5073 ***	6	0.0001	0.0284
7	0.0169	6.2426 ***	7	0.0031	0.7850
8	0.0125	4.6142 ***	8	-0.0021	-0.5493
9	0.0113	4.1738 ***	9	-0.0083	-2.1269 *
10	0.0061	2.2490 *	10	0.0057	1.4567
11	0.0079	2.8942 **	11	-0.0109	-2.7958 **
12	0.0083	3.0519 **	12	-0.0126	-3.2227 **
13	0.0068	2.5107 *	13	-0.0077	-1.9741
14	0.0038	1.3993	14	-0.0094	-2.3994 *
15	0.0078	2.8684 **	15	-0.0085	-2.1711 *
16	0.0040	1.4632	16	-0.0031	-0.8031
17	0.0111	4.0742 ***	17	-0.0125	-3.1974 **
18	0.0059	2.1801 *	18	-0.0041	-1.0446
19	0.0055	2.0324 *	19	-0.0041	-1.0579
20	0.0027	0.9823	20	-0.0077	-1.9777 *
21	0.0007	0.2428	21	-0.0051	-1.2934
22	0.0045	1.6529	22	-0.0076	-1.9453
23	0.0039	1.4510	23	-0.0048	-1.2225
24	0.0057	2.1020 *	24	-0.0078	-1.9973 *
25	-0.0008	-0.2912	25	-0.0048	-1.2165
26	-0.0028	-1.0402	26	-0.0018	-0.4729
27	0.0036	1.3226	27	-0.0038	-0.9710
28	0.0063	2.3175 *	28	-0.0053	-1.3488
29	0.0071	2.6327 **	29	-0.0057	-1.4465
30	0.0102	3.7757 ***	30	0.0027	0.6823
31	0.0058	2.1274 *	31	-0.0019	-0.4832
32	-0.0037	-1.3453	32	-0.0123	-3.1455 **
33	0.0050	1.8586	33	-0.0037	-0.9477
34	0.0045	1.6433	34	-0.0031	-0.7927
35	0.0026	0.9447	35	-0.0003	-0.0674
36	-0.0033	-1.2251	36	-0.0041	-1.0425
37	-0.0009	-0.3361	37	0.0026	0.6708
38	0.0026	0.9692	38	-0.0041	-1.0619
39	0.0017	0.6128	39	-0.0088	-2.2487 *
40	0.0020	0.7327	40	0.0034	0.8824
41	0.0027	0.9920	41	-0.0002	-0.0486
42	0.0016	0.6074	42	-0.0013	-0.3347
43	-0.0037	-1.3765	43	-0.0042	-1.0827
44	0.0035	1.3052	44	0.0001	0.0260
45	0.0024	0.8954	45	-0.0085	-2.3074 *
constant					-1.5E-06
Numbers of Observation					142260
Sum of squared residuals					0.0139
Standard error of regression					0.0004
R-squared					0.1560
Adjusted R-squard					0.1555
F-statistic					145.7985 ***
Durbin-Watson statistic					2.0001

Panel D : Vector Autoregression 2

FUT<=NSA			FUT<=FUT		
lag	Coeff.	t-Value	lag	Coeff.	t-Value
1	0.1258	23.3472 ***	1	0.0026	0.6877
2	0.0288	5.1646 ***	2	-0.0150	-3.9372 ***
3	0.0311	5.5828 ***	3	-0.0106	-2.7592 **
4	0.0157	2.8234 ***	4	-0.0229	-5.9287 ***
5	0.0277	4.9629 ***	5	0.0003	0.0748
6	0.0172	3.0803 **	6	0.0400	10.3424 ***
7	0.0074	1.3309	7	0.0030	0.7662
8	0.0192	3.4422 ***	8	-0.0122	-3.1570 **
9	0.0164	2.9430 **	9	-0.0145	-3.7504 ***
10	0.0082	1.4744	10	0.0035	0.8983
11	0.0096	1.7211	11	-0.0195	-5.0421 ***
12	0.0151	2.7153 **	12	0.0180	4.6629 ***
13	0.0112	2.0172 *	13	-0.0114	-2.9534 **
14	0.0027	0.4777	14	-0.0020	-0.5137
15	0.0157	2.8102 **	15	-0.0016	-0.4097
16	0.0019	0.3418	16	-0.0111	-2.8574 **
17	0.0174	3.1221 **	17	-0.0125	-3.2315 **
18	0.0093	1.6698	18	0.0049	1.2706
19	0.0019	0.3374	19	-0.0075	-1.9289
20	0.0152	2.7299 **	20	-0.0005	-0.1400
21	0.0156	2.7928 **	21	-0.0082	-2.1116 *
22	0.0077	1.3876	22	-0.0138	-3.5521 ***
23	-0.0017	-0.3056	23	-0.0149	-3.8375 ***
24	0.0142	2.5439 *	24	0.0079	2.0434 *
25	0.0012	0.2068	25	0.0051	1.3073
26	0.0036	0.6541	26	-0.0092	-2.3866 *
27	0.0009	0.1533	27	-0.0040	-1.0218
28	0.0025	0.4437	28	0.0016	0.4173
29	0.0121	2.1640 *	29	0.0009	0.2205
30	0.0071	1.2743	30	0.0059	1.5270
31	-0.0043	-0.7708	31	-0.0056	-1.4566
32	-0.0031	-0.5483	32	-0.0001	-0.0352
33	0.0059	1.0524	33	-0.0036	-0.9411
34	0.0010	0.1740	34	-0.0020	-0.5190
35	0.0001	0.0257	35	-0.0022	-0.5740
36	0.0085	1.5170	36	0.0092	2.3814 *
37	0.0108	1.9305	37	-0.0040	-1.0443
38	-0.0006	-0.1097	38	-0.0129	-3.3405 ***
39	0.0078	1.3944	39	0.0036	0.9215
40	-0.0064	-1.1558	40	-0.0024	-0.6325
41	0.0044	0.7988	41	0.0059	1.5407
42	-0.0045	-0.8156	42	-0.0049	-1.2780
43	0.0085	1.5375	43	-0.0052	-1.3591
44	-0.0012	-0.2096	44	-0.0010	-0.2656
45	0.0043	0.8076	45	0.0008	0.2081
constant					1.68E-06
Numbers of Observation					142260
Sum of squared residuals					0.0282
Standard error of regression					0.0006
R-squared					0.0223
Adjusted R-squard					0.0217
F-statistic					18.0185 ***
Durbin-Watson statistic					2.0000

Note: * represents significant at the 5% level.
** represents significant at the 1% level.
*** represents significant at the 0.1% level.

with 45 lags is adopted to examine the lead-lag relations between the NSA and the Nikkei 225 futures. The results of this vector autoregressive model are presented in Panel C and D of Table 5 to Panel C and D of Table 7 for the whole period and the two subperiods. The coefficients of the futures for the NSA are statistically significant until 15 minutes and those of the NSA for the futures are significant until 12 minutes during the whole period. During the non-regulated period, the coefficients of the futures are significant until 20 minutes and those of the NSA are significant until 8 minutes. During the regulated period, the coefficients of the futures are significant until 24 minutes and those of the NSA are significant until 23 minutes. These results are almost the same as those for the multiple regression model during the whole period and the non-regulated period, but the numbers of the significant lags are more than twice during the regulated period. In addition, during the regulated period, the autocorrelations in these vector autoregressive models also increase more than three times compared to the non-regulated period.

Similar results are reported in Panel C and D of Table 8 to Panel C and D of Table 12 for the five subsamples from Monday to Friday. The numbers of the significant coefficients in the vector autoregressive models generally increase compared to those of the multiple regression model. However, the numbers of the significant coefficients of the NSA decrease.

The results of the vector autoregressive model are more difficult to explain than those of the multiple regression model. In addition, the results of this vector autoregressive model are quite different from the results of Kawaller, Koch, and Koch (1987) though the numbers of lags are not the same and they use only one day data for calculation. Therefore, much more investigation is needed for this lead-lag relationship.

Ⅶ. Summary and Conclusions

The intraday price behaviors of the NSA and the Nikkei 225 futures are investigated by using minute-by-minute data during the period between October 3, 1988 and September 8, 1994. As for the returns, the W-shaped patterns reported by Chung et al. (1993) for the TOPIX are not found, although the opening returns of the morning session indicate positive and large absolute values with the exception of the futures on Monday and Tuesday. In addition, this study discovers that the overnight NSA returns exceed the overnight futures returns. As for the return volatility, W-shaped patterns are recognized as others reported. In contrast to the returns, the standard deviations of the overnight NSA returns are less than those of the overnight futures returns. As for the skewness, the futures show large values for the opening of the morning session, but there is not a similar result for the NSA, contrary to Chang et al. (1993) regarding the TOPIX. As for the kurtosis, large values are recorded during the middle of sessions not only for the NSA but also for the futures, which also contradicts Chang et al.

(1993). As for the return reversals, the correlations of adjacent minute-by-minute return series for the NSA exhibit a result similar to Chang et al. (1993), which show that large values follow the small values for the opening, then gradually decline and the trends reverse near the closing. However, those of the futures do not show similar results and their average levels are very low, which means strong return reversals of the futures.

The lead-lag relations of the NSA and the Nikkei 225 futures are investigated by using the autocorrelations, the multiple regression model, and the vector autoregressive model. The autocorrelations of the NSA are larger than those of the futures and these autocorrelations are larger during the non-regulated period than the regulated period. The lead-lag relations between the NSA and the futures are almost the same (15 minutes) during the whole period, but the futures lead the NSA strongly during the non-regulated period. In the regulated period, two effects seem to be mixed complexly; one is the effect of the futures regulation and the other is the effect of the maturing of the futures market.

The market microstructure analysis become popular in the U.S. market because the stock exchanges and the market operators deliver the data. In contrast, the data availability is limited in the Japan market. The data accessibility is important not only for academicians to compete their achievements, but also for practitioners and regulators to recognize the market in order to revise their activity. The change of recognition and also the market practice must improve the market and the economy as a whole.

Notes

1) For situations concerning the stock index futures in Japan, see Arai, Akamatsu, and Yoshida (1993) and Miller (1993).
2) Chang, Rhee, and Yoshikawa (2001) investigate the intraday price movement related to the Nikkei 225 options.
3) The opening trading method is called 'Itayose' and the following daytime trading method is called 'Zaraba' in the Japanese stock market. As for details of these trading methods, see Amihud and Mendelson (1991) and Chang et al. (1993).

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