A Note on the Intraday Price Behaviors of the Stock Index and the Stock Index Futures

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要　旨

本稿ではChang et al.（1993）がTOPIXを対象にして行なったイントラディの分析手法とEkman（1992）がS&P500先物を対象にして行なったイントラディ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。リターンに関しては，Chung et al.（1993）が得たW字型のパターンは確認できなかったが，日経平均株価のオーバーナイト・リターンが絶対値では日経平均先物のオーバーナイト・リターンを常に上回っていることが明らかになった。ボラティリティに関しては，従来の研究と同様にW字型のパターンを確認したが，リターンとは逆に，日経平均株価のオーバーナイト・ボラティリティが日経平均先物のオーバーナイト・ボラティリティを常に下回っていることが明らかになった。歪度に関しては，日経平均先物では前場寄り付き直後に大きな値を得たが，日経平均株価ではChang et al.（1993）に反してこのような傾向は見られなかった。尖度に関しては，日経平均株価だけでなく，日経平均先物でも前場・後場の半ばに大きな値を確認した。リバーサルに関しては，日経平均株価ではChang et al.（1993）と同様，前後場の開始直後に大きな値を示し，その後は徐々に値が低下し，引け際に値が再び上昇するという傾向が見られたが，日経平均先物ではこうした傾向は確認できず，はるかに小さな値を示し，リバーサルの程度が大きかった。

Contents

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I. Introduction

Recently, 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 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. Turning to the stock index futures, Ekman (1992) also shows the U-shaped pattern in returns and volatility for the S&P 500 index futures.

Then, analysis of market microstructure has 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 study 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 except the S&P 500 index futures.

This note is organized as follows. Section II describes the data. Intraday returns and return volatility are analyzed in section III and IV. Section V considers the skewness and kurtosis of intraday returns. Return reversals are investigated in section VI. Final section provides summary of the results.

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 outcry 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 and 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.

As for the data of 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). As a result, the number of the intraday data for the Nikkei 225 futures is 15 minutes larger than the NSA for each morning and afternoon sessions prior to October 2, 1990, 10 minutes larger for afternoon sessions before February 6, 1992 and now just the same as the NSA.

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 execute a transaction. 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 market 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 on December 17, 1991, it was further reduced to 20 points for 5 minutes after 15:00. As a result, the maximum range of the Nikkei 225 futures price movement had been restricted 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 have a large influence on intraday price movement.

In addition to the special quote regulation, there are other regulations. The regulation for margins of 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 decreased 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 decreased 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 14, 1995, the margin rates for the Nikkei 225 futures and TOPIX futures were further reduced to the same rates as 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 commissions 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. As for 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. Other observers report similar results. However, this

Table. 1

NSA : the Whole Period

	Average(%)	St.Dev.(%)	Skewness	Kurtosis	Num.Obs
9:01	0.0486	0.2046	-0.1315	0.5057	1,472
9:00-9:15	0.0047	0.0697	-0.0169	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
12:30-12:45	-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 : the 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 : the Non-Regulated Period

	Average(%)	St.Dev.(%)	Skewness	Kurtosis	Num.Obs
9:01	0.0778	0.1448	-0.3081	0.2768	390
9:00-9:15	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					
12:30-12:45					
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 : the 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.Closin	-0.0007	0.0597	-0.7362	4.4713	389

NSA : the Most Regulated Period

	Average(%)	St.Dev.(%)	Skewness	Kurtosis	Num.Obs
9:01	0.0561	0.2333	0.0898	0.4553	468
9:00-9:15	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
12:30-12:45	-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	0.0569	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 : the Most 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	0.2080	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

study discovered 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 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. 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 change 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 for this, but market sentiment might have an 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.

Figure 1

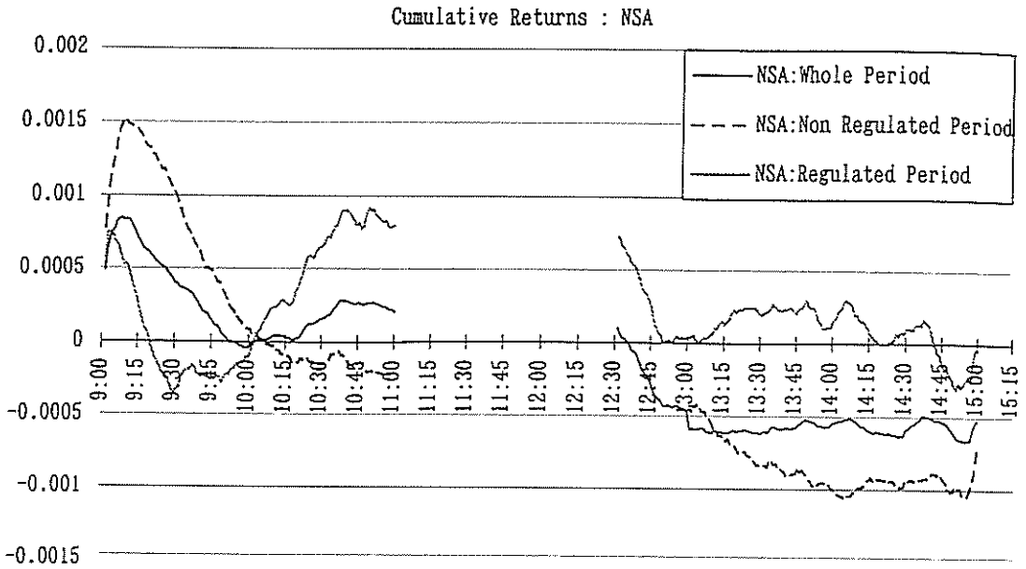


Figure 2

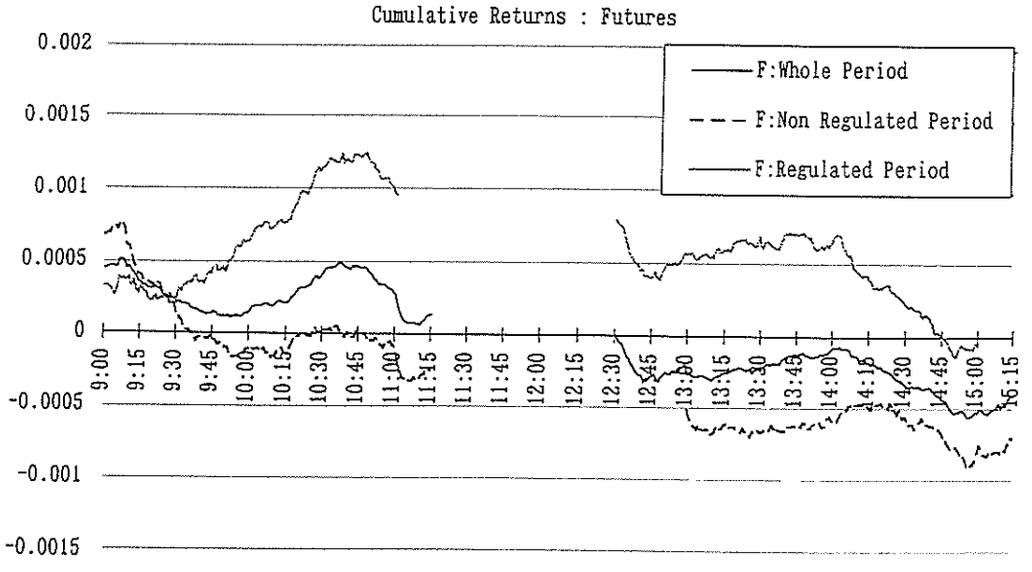


Table. 2 (A)

NSA : the Non-Saturday Period

	Average(%)	St.Dev.(%)	Skewness	Kurtosis	Num.Obs
9:01	0.0476	0.2095	-0.1204	0.3753	1,387
9:00-9:15	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
12:30-12:45	-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 : the 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	7.1562	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
9:00-9:15	-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
12:30-12:45	-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
9:00-9:15	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
12:30-12:45	-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
9:00-9:15	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
12:30-12:45	-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
9:00-9:15	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
12:30-12:45	-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
9:00-9:15	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
12:30-12:45	-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

Futures : 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

As for the weekly patterns of average 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 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 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 distinct 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. The 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 settlement price of the Nikkei 225 options was decided 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. 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.

Figure 3

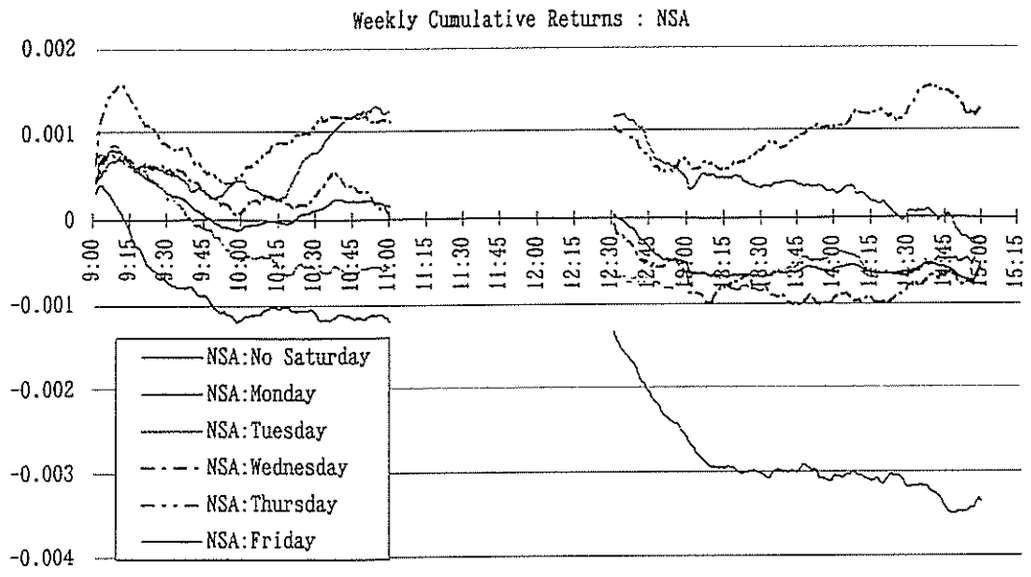
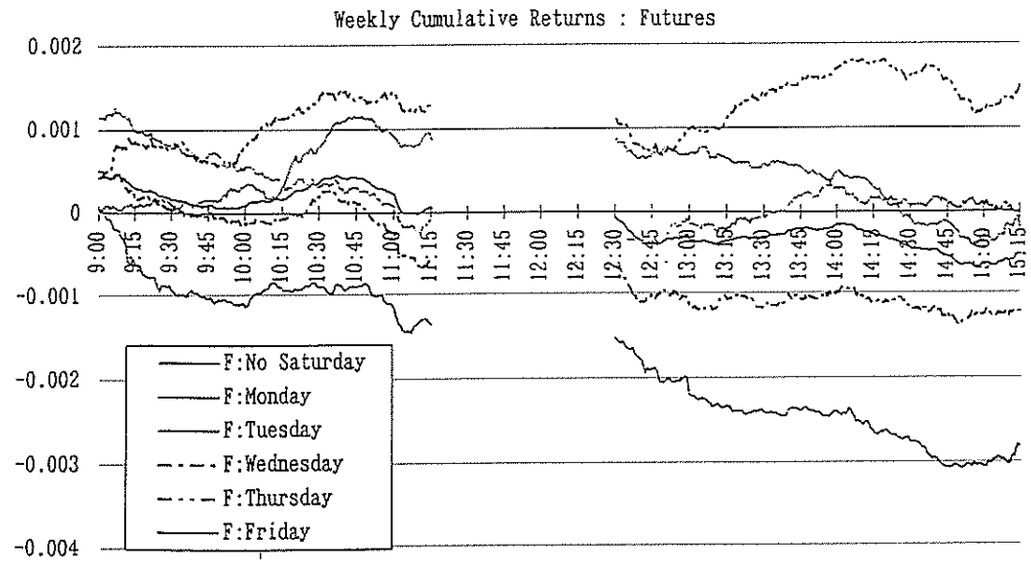


Figure 4



Ⅳ. Intraday Return Volatility

Table 1 also 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 systems between opening of sessions and following sessions which is specific to the Japanese market.[2)]

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. One possible reason is the stale price effect which emerges after 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.

Ⅴ. Skewness and Kurtosis of the Intraday Returns

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.

Ⅵ. 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. They are also documented for the TOPIX by Chang et

al. (1993) who used the correlations 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. The correlations of adjacent minute-by-minute return series are 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, r_t 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}, $\cdots$, 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 10 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. In this 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).

Ⅶ. Summary

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 Chang 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

Table. 3

NSA : Whole Period

	Average	St.Dev.	Minimum	Maximum	Num.Obs
9:01	-0.0187	-	-	-	1
9:00-9:15	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	0.4101	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	0.1321	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
9:00-9:15	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	14
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
13:01-13:15	0.0544	0.0946	-0.1519	0.2017	15
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
9:00-9:15	0.4436	0.1399	0.1563	0.7121	14
9:16-9:30	0.3436	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	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	14
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	15
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	-0.0559	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
9:00-9:15	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
9:00-9:15	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
9:00-9:15	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	-0.1351	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
9:00-9:15	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	0.0183	0.0688	-0.0810	0.1853	15
10:46-11:00	0.0592	0.0656	-0.0468	0.1832	15
11:01-11:15	-0.0404	0.2085	-0.4667	0.2675	
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	
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
9:00-9:15	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
9:00-9:15	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	
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

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.

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Notes

1) For situations concerning the stock index futures in Japan, see Arai, Akamatsu, and Yoshida (1993) and Miller (1993).
2) 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), Chang et al. (1993), and Lehman and Modest (1994).

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