Intraday return patterns and the extension of trading hours

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Abstract

Although studies argue that periodic market closure induces the well-known intraday price overreaction, namely, a negative association between intraday futures returns and the latest overnight returns, no study argues and examines whether the overreaction phenomenon is weaken or worsen by extending trading hours. In this current study, I empirically examine it by investigating two Japanese stock futures markets whose trading hours have been significantly and asynchronously extended by introducing extended sessions. I find that, the stronger overreaction is observed when an extended-hours trading session is longer, indicating that such extended sessions induce the stronger overreaction. The results suggest that the intraday return patterns induced by periodic market closure are not easily and straightforwardly mitigated by an extension of trading hours..

Keywords: intraday price overreaction; stock futures; opening price; extension of trading hours.
JEL classifications: G14; G17; G2.

1. Introduction

Most financial markets are closed overnight. Studies such as Glosten and Milgrom (1985), Kyle (1985), Foster and Viswanathan (1990), and Easlay and O'Hara (1992) argue that public and private information accumulates overnight. Thus, market closures result in high information uncertainty at the open of trading sessions, which disturb efficient incorporation of information into prices and result in significant price concessions required by liquidity providers. This information uncertainty at the open of trading sessions could cause intraday return patterns.

In accordance with this argument, several studies show that periodical market closures induce the well-known intraday return pattern, namely, the intraday overreaction phenomenon characterized by intraday price reversals following price changes at the market open. Atkins and Dyl (1990) find evidence of strong price reversals among common stocks after large price changes when a market opens. Fung et al. (2000) and Grant et al. (2005) find highly significant intraday price reversals in the US and HK stock index futures markets. Corte et al. (2015) show that such a reversal pattern can be observed in international stocks, equity indexes, interest rates, commodities, and currency futures. In terms of driver of these overreaction phenomenon, Ekman (1992) Daigler (1997) argue that the overreaction phenomenon is related to information uncertainty at the open, which is induced by periodic market closure. In addition, Corte et al. (2015) argue that the overreaction phenomenon is attributed to price concessions, increased by information uncertainty at the open.

On the other hand, the extension of trading hours has increasingly been discussed in several markets (Osaki, 2014). Moreover, in the NYSE and NASDAQ, pre-market and after-hours trading sessions have already been introduced, while in the Tokyo Stock Exchange, the trading hours of stock futures (e.g., Nikkei 225 futures and TOPIX futures) have been significantly extended. Since periodic market closures induce the overreaction phenomenon, it would seem that the overreaction phenomenon is weaken by shorting market closure, namely, the extension of trading hours; for example, by introducing or expanding extended-hours sessions.

However, the effect of extensions may not be so straightforward. Miwa and Ueda (2016) focus on the low liquidity features of asset prices during extended-hours sessions (Barclay and Hendershott, 2003). Their simulation-based analysis shows that an extension of trading-hours could disturb efficient price formation at the open because of low liquidity during the prior extended-hours session. In addition, assets can be traded with high information uncertainty during an extended-hours session. For example, information uncertainty in stock futures can be higher during an extended-hours session (a night session) than during a regular session because the corresponding spot market is closed (thus, the corresponding spot index value is unavailable) during the extended-hours session. Higher information

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uncertainty induces erroneous pricing during the session which increases information uncertainty and required price concession at the opening of the subsequent regular session. Thus, it is possible that an extension of trading hours strengthens the intraday overreaction phenomenon. However, to the best of my knowledge, no study provides empirical evidence about whether the price overreaction phenomenon could be strengthened by an extension of trading hours.

In this study, I empirically analyze whether the well-known price overreaction phenomenon can be made worse by extending trading hours. The analysis can achieves further understanding of not only the overreaction phenomenon but also the effect of the extension of trading hours.

The difficulty of empirical analyses on the effect of the extension of trading hours is that there are few suitable samples with which to compare price behavior between a market with an extended-hours session and one without such an extension. Some studies examine the effect of extending trading hours on price volatility and trading volume. For example, Houston and Ryngaert (1992) find that reductions in NYSE trading hours had little effect on return volatility and trading volume during the week in which the reductions occurred. Further, Fan and Lai (2006) report that a significant change in the intraday pattern of return volatility and trading volume could not be observed after extending the trading session of the Taiwan Stock Exchange by 1.5 hours. Although these studies may indicate that asset pricing and trading are unaffected by a change in trading hours, the results may be due to an insufficient change in trading hours; thus, these studies cannot provide robust evidence regarding the effect of extending trading hours.

However, recently, the trading hours of two representative futures of the Japanese stock market, namely Nikkei 225 futures and TOPIX futures, have been significantly extended. Indeed, trading had been extended by 11 hours for about 6 years through implementation of an extended-hours session called a “night session.” This significant extension enables us to perform time-series (before and after) comparisons of the price overreaction phenomenon. Further, both extensions have not been introduced synchronously. There is a period during which the extended-hours session of Nikkei 225 futures were significantly longer than those of TOPIX futures. This circumstance enables us to perform a cross-sectional comparison; namely, a comparison of stock futures with different durations of an extended-hours session, in order to analyze whether the price overreaction phenomenon could be made worse by extending trading hours. In addition, the extension of the two Japanese stock futures can be considered the best sample for the following two additional reasons. First, stock futures are likely to be traded under a condition of higher information uncertainty during the night sessions because their corresponding spot markets (the Tokyo Stock Exchange and Osaka Stock Exchange) are closed during each session. These futures transactions that are made under a condition of high information uncertainty may increase the risk of increasing the price overreaction phenomenon. Second, high demand for the immediacy of the futures market causes the market to be designed to supply maximal immediacy of order execution at its opening (Grossman and Miller, 1988); consequently, illiquidity-based transaction costs are trivial at the opening of the futures market.

Thus, in this study, I perform both time-series and cross-sectional comparisons on these Japanese stock futures to provide empirical evidence regarding the effect of extending trading hours on the well-known intraday return patterns.

2. Empirical evidence

2.1. Sample construction

I utilize TOPIX futures contracts and Nikkei 225 futures contracts traded on the Osaka Stock Exchange to test opening price overreaction. The sample spans January 2002–December 2015. I use transaction prices rather than bid–ask prices because bid and ask prices are sometimes not updated as quickly as the trading prices move. Consequently, the day’s closing price reflects the last transaction price rather than the settlement price.

The expiration dates for TOPIX and Nikkei 225 futures are scheduled on a quarterly basis: the second Friday of March, June, September, and December. The futures are cash-settled contracts, with multiple contracts traded simultaneously on any given day. I utilize the values of the closest contract, which is usually the most heavily traded.

I exclude the following days from the analysis: the expiration days, since the opening prices of

futures are quite volatile because of special quotation (SQ) events (calculating SQs for expired contracts); and the first trading day of each calendar year, since there is no extended-hours session for the prior (year-end day's) trading session.

Regular trading hours for these futures are from 9:00 to 15:10 (15:15 after Jul. 20, 2010). Extended-hours sessions, called night sessions, for Nikkei 225 futures and TOPIX futures were introduced on Sep. 17, 2007 and Jul. 16, 2008 respectively. Then, the extended-hours sessions were extended as shown in Table 1, panel (a).

Table 1
Trading hours of index futures

<table>
<tr><th></th><th>Nikkei 225</th><th>TOPIX</th></tr>
<tr><td>- 9/17/2007</td><td>Null</td><td rowspan="2">Null</td></tr>
<tr><td>9/18/2007-2008/06/15</td><td rowspan="2">16:30～19:00</td></tr>
<tr><td>6/16/2008-10/13/2008</td><td rowspan="3">16:30～19:00</td></tr>
<tr><td>10/14/2008-7/19/2010</td><td>16:30～20:00</td></tr>
<tr><td>7/20/2010-7/18/2011</td><td>16:30～23:30</td></tr>
<tr><td>7/19/2011-11/20/2011</td><td rowspan="3">16:30～03:00</td></tr>
<tr><td>11/21/2011-3/23/2014</td><td>16:30～23:30</td></tr>
<tr><td>3/24/2014-</td><td>16:30～03:00</td></tr>
</table>

2.2. Research methodology

The intraday price overreaction, namely, intraday price reversals following price changes at the market open, can be identified by a negative association between overnight returns and subsequent intraday returns (Grant, 2005; Corte et al., 2015)..

At the start of each trading day, *t*, the opening price (futures value at 9:00: $P_{i,t}^{9:00}$) and the closing price of the prior trading day's regular session (futures value at 15:10 on day *t*-1: $P_{i,t-1}^{15:10}$) are immediately available. An overnight return (denoted as $R_{i,t}^{Overnight}$) is defined as the natural logarithm of the division of the opening price ($P_{i,t}^{9:00}$) by the prior day's closing value ($P_{i,t-1}^{15:10}$). Thus:

$$R_{i,t}^{Overnight} = \log(P_{i,t}^{9:00}/P_{i,t-1}^{15:10})$$

In terms of intraday returns, overnight returns are supposed to be reversed, especially when the corresponding spot market opens. The trading hours of the Tokyo Stock Exchange consist of a morning session and afternoon session. The morning session is from 9:00 to 11:00 (11:30 after Nov. 21, 2011) and the afternoon session is from 12:30 to 3:00. I specifically focus on return reversal during the morning session, namely, intraday future returns from 9:00 to 11:00. An intraday return, $R_{i,t}^{Intraday}$, is defined as:

$$R_{i,t}^{Intraday} = \log\left(\frac{P_{i,t}^{11:00}}{P_{i,t}^{9:00}}\right)$$

where $P_{i,t}^{11:00}$ is the latest transaction price at 11:00; *i*=1 means Nikkei 225 futures; and *i*=2 means TOPIX futures.

I evaluate the degree of the intraday overreaction phenomenon, namely intraday price reversals following price changes at the market open, by examining the association between the overnight return ($R_{i,t}^{Overnight}$) and the subsequent intraday return ($R_{i,t}^{Intraday}$). In order to examine whether the implementation of a night session mitigates or worsens the intraday overreaction phenomenon, I perform a time-series comparison for each futures and cross-sectional comparison between Nikkei 225 futures and TOPIX futures.

2.2.1. Time-series comparison

Because the night sessions for Nikkei 225 and TOPIX futures were introduced and extended significantly, I can analyze the effect of the implementation of the night sessions through time-series

comparison. I examine whether the association between overnight returns and subsequent intraday returns is affected by the implementation and extension of night sessions. If trading during a night session weakens (worsens) the intraday overreaction phenomenon, a longer night session should induce a weaker (stronger) negative association. Thus, I run the following regression:

$$R_{i,t}^{Intraday} = a_i + b_i^1 R_{i,t}^{Overnight} + b_i^2 T_{i,t-1}^{Night} * R_{i,t}^{Overnight} + b_i^3 T_{i,t-1}^{Night} + \mathrm{e}_{i,t} \quad (1)$$

where $T_{i,t}^{Night}$ denotes the length (hours) of a night session on day *t*, which is shown in Table 1, panel (b). If the transactions during a night session mitigate (worsen) the intraday overreaction phenomenon, a longer $T_{i,t-1}^{Night}$ should induce a weaker (stronger) negative relation between $R_{i,t}^{Intraday}$ and $R_{i,t-1}^{Overnight}$. Thus, the coefficient of $T_{i,t-1}^{Night} * R_{i,t}^{Overnight}$ (b_i^2) should be positive (negative).

In order to achieve greater understanding, I split the investigated period into three periods, on the basis of the length of the studied night sessions, and analyze the intraday overreaction phenomenon, namely the association between $R_{i,t}^{Intraday}$ and $R_{i,t}^{Overnight}$, for each period. As shown in Table 1, panel (b), when $T_{i,t-1}^{Night}$=0, time *t* is included in period 1, which is called the "no night-session period"; when $7 \geq T_{i,t-1}^{Night} > 0$, time *t* is included in period 2, which is called the "short night-session period"; and when $T_{i,t-1}^{Night}$>7, time *t* is included in period 3, which is called the "long night-session period."

2.2.2. Cross-sectional comparison

The trading hours for Nikkei 225 futures and TOPIX futures are extended asynchronously. As shown in Table 1, panel (b), the trading hours of a prior trading day ($T_{i,t-1}^{Night}$) are significantly longer for Nikkei 225 futures than for TOPIX futures from 7/20/2011 to 3/24/2014 (this period is denoted "the different trading-hours period"). However, there is no difference in $T_{i,t-1}^{Night}$ between them until 9/18/2007, from 6/17/2008 to 10/14/2008, and after 3/25/2014 (these periods are denoted overall as "the same trading-hours period"). I perform panel data analysis by conducting the following panel regression analysis for the different trading-hours period and the same trading-hours period.

$$R_{i,t}^{Intraday} = a + b^1 R_{i,t}^{Overnight} + b^2 NK_i * R_{i,t}^{Overnight} + b^3 NK_i + \mathrm{e}_{i,t} \quad (2)$$

NK_i is a dummy variable that takes one for Nikkei 225 futures and zero for TOPIX futures. The coefficient b^2 (the coefficient of $NK_i * R_{i,t}^{Overnight}$) represents the difference in the intraday overreaction phenomenon between TOPIX futures and Nikkei 225 futures. Since the more negative association between $R_{i,t}^{Intraday}$ and $R_{i,t}^{Overnight}$ means the stronger intraday overreaction phenomenon, positive (negative) b^2 means that the overreaction is weaker (stronger) for Nikkei 225 futures than for TOPIX futures. If night session trading mitigates the intraday overreaction phenomenon, the coefficient b^2 should be higher during the different trading-hours period than during the same trading-hours period because a night session of Nikkei 225 futures is longer than that of TOPIX futures during the different trading-hours period. However, if night session trading makes the intraday overreaction phenomenon worse, b^2 should be lower during the different trading-hours period than during the same trading-hours period.

The different trading-hours period consists of three separate periods; namely, the period from 1/4/2002 to 9/18/2007, from 6/17/2008 to 10/14/2008, and from 3/25/2014 to 12/30/2015. Thus, I also perform a panel analysis for the different trading-hours period by adding dummy variables for inclusion in these periods as control variables. Thus:

$$R_{i,t}^{Intraday} = a + b^1 R_{i,t}^{Overnight} + b^2 NK_i * R_{i,t}^{Overnight} + b^3 T1_t * R_{i,t}^{Overnight} + b^4 T2_t * R_{i,t}^{Overnight} + b^5 NK_i + b^6 T1_t + b^7 T2_t + \mathrm{e}_{i,t} \quad (3)$$

where $T1_t$ is a dummy variable that takes one if day *t* is between 6/17/2008 and 10/14/2008, and $T2_t$ is a dummy variable that takes one if day *t* is between 3/25/2014 and 12/30/2015.

During the same trading-hours period, the trading hours for TOPIX futures were extended as of 11/21/2011. Thus, I also perform a panel analysis for the same trading-hours period by adding a dummy variable $T3_t$, which takes one if day *t* is from 11/22/2011 to 3/25/2014, for inclusion as a control variable. Thus:

$$R_{i,t}^{Intraday} = a + b^1 R_{i,t}^{Overnight} + b^2 NK_i * R_{i,t}^{Overnight} + b^3 T3_t * R_{i,t}^{Overnight} + b^4 NK_i + b^5 T3_t + \mathrm{e}_{i,t} \quad (4)$$

While the result of the time-series analysis may be attributable to a time-varying macro event or other market structural change, the effect of these time-varying factors is less relevant for cross-sectional comparison; namely, the cross-sectional difference in the overreaction between Nikkei 225 futures and TOPIX futures. Thus, these cross-sectional analyses could provide more robust evidence regarding the effect of extended-hour session on the intraday overreaction phenomenon.

2.3. Results

2.3.1. Time-series comparison

Table 2 shows the results of the time-series analysis. First, panel (a) reveals that the intraday overreaction phenomenon, identified by the negative association between $R_{i,t}^{Intraday}$ and $R_{i,t}^{Overnight}$, is weakest during the no night-session period. Further, the negative association between $R_{i,t}^{Intraday}$ and $R_{i,t}^{Overnight}$ for Nikkei 225 futures during this period is insignificant. However, after the introduction of the night session, a stronger negative association can be observed for TOPIX and Nikkei 225 futures.

Table 2
Time-series comparison

(a) Intraday price overreaction for each period

	Nikkei 225 Futures	TOPIX Futures
Period 1	-0.022	-0.056 ***
(No night-session period)	(0.99)	(3.08)
Period 2	-0.069 ***	-0.165 ***
(Short night-session period)	(2.74)	(4.92)
Period 3	-0.093 ***	-0.122 ***
(Long night-session period)	(3.48)	(4.27)

(b) Overreaction and the length of the night sessions

	Nikkei 225 Futures	TOPIX Futures
Intercept	0.000	0.000 ***
	(1.41)	(3.08)
Overnight return	-0.037 **	-0.094 ***
	(2.01)	(3.13)
Extension	0.000 **	0.000 ***
	(2.29)	(3.43)
Overnight return x Extension	-0.005 **	-0.007 **
	(2.18)	(2.16)

Panel (b) of Table 2 reveals that the intraday overreaction phenomenon, namely intraday price reversals following price changes at the market open, is observed for TOPIX and Nikkei 225 futures. In terms of the effect of night-session trading on the intraday overreaction phenomenon, the result reveals that the coefficient of $T_{i,t-1}^{Night} * R_{i,t}^{Overnight}$ is significantly negative, indicating that a longer night session (higher $T_{i,t-1}^{Night}$) induces a stronger negative relation between an overnight return ($R_{i,t}^{Overnight}$) and the subsequent intraday return ($R_{i,t}^{Intraday}$). These results indicate that a longer night session induces the stronger intraday overreaction phenomenon.

2.3.2. Cross-sectional comparison

Table 3 shows the results of the cross-sectional comparison. The results reveal that the coefficient b^2 (the coefficient of $NK_i * R_{i,t}^{Overnight}$) for the same trading-hours period is significantly positive, indicating that the intraday overreaction phenomenon, namely intraday price reversals following price

changes at the market open, is essentially weaker for Nikkei 225 futures than for TOPIX futures.

The difference in the intraday overreaction phenomenon could be attributed to the difference in information uncertainty in the underlying spot market indexes of TOPIX and Nikkei 225 futures. The constituents of the Nikkei index are selected from stocks listed on the first section of the Tokyo Stock Exchange on the basis of liquidity, market size, visibility, and so on, while the constituents of the TOPIX index are all the stocks listed on the first section of the Tokyo Stock Exchange. Thus, the constituents of the Nikkei index consist of large and high visibility stocks, while the constituents of the TOPIX index include a considerable number of small and low visibility stocks. Actually, the reciprocals of analyst coverage and market values (billion yen), which are proxies of information uncertainty, are always higher for the TOPIX index than for the Nikkei 225 index. In addition, the number of constituents is much larger for the TOPIX index (from 1500 to 2000) than for the Nikkei 225 index (essentially, 225). Thus, it is highly likely that information uncertainty is higher for TOPIX futures than for Nikkei 225 futures. Thus, the intraday overreaction phenomenon, which could be strengthened by information uncertainty, could be stronger for TOPIX futures than for Nikkei 225 futures.

Table 3
Cross-sectional comparison

(a) The same trading-hours period

	Model (2)	Model (3)
Intercept	0.000	0.000 ***
	(1.08)	(2.83)
Overnight return	-0.114 ***	-0.087 ***
	(3.13)	(3.32)
NK	0.000	0.000
	(0.42)	(0.50)
Overnight return x NK	0.091 **	0.092 **
	(2.27)	(2.34)
T1		0.001
		(0.57)
Overnight return x T1		-0.055
		(0.99)
T2		0.001 ***
		(4.22)
Overnight return x T2		-0.056 *
		(1.68)

(b) The different trading-hours period

	Model (2)	Model (4)
Intercept	0.000	0.000
	(0.09)	(0.12)
Overnight return	-0.111 ***	-0.175 ***
	(4.64)	(4.00)
NK	0.000	0.000
	(0.63)	(0.63)
Overnight return x NK	0.006	0.006
	(0.15)	(0.16)
T3		0.000
		(0.00)
Overnight return x T3		0.090 *
		(1.78)

However, the results reveal that the coefficient b^2, which represents the difference in the intraday overreaction phenomenon between Nikkei 225 futures and TOPIX futures, is insignificant during the different trading-hours period. Further, the coefficient b^2 (the coefficient of $NK_i * R_{i,t}^{Overnight}$) is much smaller for the different trading-hours period than for the same trading-hours period. Although the intraday overreaction phenomenon is weaker for Nikkei 225 futures than for TOPIX futures during the same trading-hours period, the overreaction for Nikkei 225 futures is as strong as that for TOPIX futures when the length of the night session is longer for Nikkei 225 futures than for TOPIX futures.

These results essentially support this study's view that a longer night session results in the stronger intraday overreaction phenomenon.

3. Conclusion

Previous studies argue that periodic market closures induce the well-known intraday return pattern, namely, intraday price reversals following price changes at the market open. On the other hand, the extension of trading hours has increasingly been discussed in several markets. Although the effect of the extension of trading hours could be complex, there is no empirical study that examine whether and how the extension of trading hours affects the intraday return pattern which is caused by period market closures.

In this study, I provide empirical evidence by examining whether intraday price reversals following price changes at the market open is weaken or strengthened by extending trading hours.

I investigate the extension of two representative Japanese stock index futures contracts. These can

be considered the best sample for analyzing the effect of an extension for following reasons: the trading hours of these futures contracts have been extended significantly and asynchronously; the significant extensions enable us to perform a time-series (before and after) comparison regarding the intraday price reversals; and the asynchronous extensions enable us to perform comparisons of stock futures with different trading hours.

Time-series analysis (the before and after comparison) shows that a longer extended-hours session (a longer night session) results in larger intraday price reversals following price changes at the market open for Nikkei 225 and TOPIX futures contracts. Cross-sectional analysis reveals that, although the intraday price reversals tends to be weaker for Nikkei 225 futures than for TOPIX futures during the same trading-hours period, the reversal for Nikkei 225 futures is as strong as that for TOPIX futures when the length of the night session is significantly longer for Nikkei 225 futures..

All these findings support the view that night session trading could strengthen intraday price reversals during a subsequent regular session, namely, the intraday price overreaction. The results suggest that the intraday return patterns induced by periodic market closure are not easily and straightforwardly mitigated by an extension of trading hours. Such evidence highlights the existence of the negative impact of the extension of trading hours.

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