Trading hours extension and intraday price behavior

Abstract

Although studies argue that periodic market closure induces the well-known intraday price overreaction, namely, a negative association between intraday returns and overnight returns, no study examines how the overreaction phenomenon is affected by extending trading hours. This study empirically examines it by investigating two Japanese stock futures whose trading hours have been continuously and asynchronously extended. Surprisingly, the overreaction is stronger when the extended-hours session is longer, and trading activity during the session is higher. The result indicates that the extension can worsen the overreaction phenomenon, highlighting the existence of the negative impact of trading hours extension on price efficiency.

Keywords: price overreaction; stock futures; opening price; trading hours

1. Introduction

Most financial markets are closed overnight. Studies such as the ones conducted by Glosten and Milgrom (1985), Kyle (1985), Foster and Viswanathan (1990), and Easlay and O’Hara (1992) argue that public and private information accumulates overnight, and thus market closures result in a high level of uncertainty at the opening of the trading sessions, which disturb the efficient incorporation of information into opening prices. In sum, market closure affects price formation especially at the opening.

In accordance with this argument, several studies suggest that periodical market closures induce the well-known intraday overreaction phenomenon characterized by a negative association between an overnight return—a price change from closing price to the next day’s opening price—and a subsequent intraday return—a price change from opening price to closing price, by affecting price formation at market openings. 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), Grant et al. (2005), and Liu and Tse (2017) find highly significant intraday price reversals in U.S. and Hong Kong 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 the driver of these overreaction phenomena, studies (e.g., Ekman, 1992; Daigler, 1997; Corte et al., 2015) argue that the overreaction phenomenon is attributed to opening price distortions or concession, which is induced by a high level of uncertainty at the opening of the trading sessions[1]. In other words, the studies suggest that the intraday overreaction phenomenon is induced by periodic market closures.

Meanwhile, the extension of trading hours has increasingly been discussed in several markets (Osaki, 2014). In the NYSE and NASDAQ, pre-market and after-hours trading sessions have already been introduced, while the trading hours of stock futures (e.g., Nikkei 225 futures and TOPIX futures) have been significantly extended.

Introducing or expanding extended-hours sessions, that is, shortening the market closure, might reduce the level of uncertainty at the opening. Thus, it can be hypothesized that the intraday overreaction phenomenon, which could be induced by uncertainty at the opening, can be weakened by introducing or expanding extended-hours sessions.

However, competing arguments exist for the effect of the extension. The simulation-based analysis of Miwa and Ueda (2017) shows that an extension of trading hours occasionally lowers price efficiency at market openings because prices fail to incorporate information efficiently during an extended-hours session. In fact, some assets

[1] The overreaction of opening prices might persist during regular trading hours, since Chen (2013) shows that the first 5-minute returns of the Taiwan Stock Index Futures persist toward the close of the market.

are 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 uncertainty might strengthen investor's sentiment effect and thus might induce erroneous pricing during the session (Gao et al. 2019), which lowers price efficiency at the opening of the subsequent regular session. Therefore, we can also set the hypothesis that the intraday overreaction phenomenon can be intensified by the extension of trading hours.

Hence, it is uncertain whether and how trading hours extension has an influence on price formation at market openings; particularly, it is uncertain whether the extension weakens or intensifies the intraday overreaction phenomenon. Since the extension of trading hours has increasingly been discussed in several markets, an empirical analysis regarding the effect of the extension is becoming increasingly important. However, to the best of our knowledge, no study successfully provides robust empirical evidence about the effect.

This study empirically analyzes whether the extension can reduce or intensify the price overreaction phenomenon. The analysis can enhance the understanding of not only the overreaction phenomenon but also the effect of market closures and trading hours extension on price formation (especially at market openings).

The difficulty of conducting empirical analyzes on the effect of the extension is that there are few suitable samples. While no study analyzes the effect of extending trading hours on the intraday overreaction phenomenon, some studies examine the effect on price volatility, trading volume, and daily-based short-term reversal. For example, Houston and Ryngaert (1992) find that reductions in NYSE trading hours had a negligible effect on return volatility and trading volume during the week in which the reductions occurred. Further, Fan and Lai (2006) report that an extension of the trading session of the Taiwan Stock Exchange by 1.5 hours did not lead to a significant change in the intraday pattern of return volatility and trading volume. Conversely, Lee et al. (2009) analyze whether and how the 15-minute extension of the opening session of futures markets affects the stock price behavior. They report that the daily-based short-term reversal of the stock market was weakened by the extension of the trading hours of the corresponding stock futures. In this way, previous studies show mixed results regarding the effect of trading hours extension. Since each study analyzes a specific one-time extension of trading hours, the mixed result of each of these studies might be attributed to the varied market conditions around the day of the extension.

However, recently, the trading hours of the two representative futures of the Japanese stock market, namely, the Nikkei 225 futures and the TOPIX futures has been significantly and continuously extended. In fact, the trading hours has been extended by 11 hours through the implementation and multiple extensions of an extended-hours session (called the “night session”). These significant and continuous extensions enabled us to perform time-series (before and after) comparisons of the price overreaction phenomenon. Furthermore, both extensions were not synchronously introduced. There was a period during which the extended-hours session of the Nikkei 225 futures was significantly longer than that of the TOPIX futures. This circumstance enabled us to perform a cross-sectional comparison—a comparison of stock futures with different durations of an extended-hours session. The result of the cross-sectional comparison is much less influenced by changing market conditions than the result of the time-series analysis. Finally, as claimed by Yarovaya et al. (2016), an analysis of stock index futures data is more practically significant for investors. Thus, the Japanese sample is considered to be, by far, the most suitable sample for examining the effect of trading hours extension.

In this study, we perform both time-series and cross-sectional comparisons on these Japanese stock futures to provide empirical evidence regarding the effect of trading hours extension on the intraday return patterns. Surprisingly, the results reveal that trading hours extension carries a risk of intensifying the intraday price overreaction phenomenon, indicating that the extension could increase uncertainty or price inefficiency at market openings. The findings can be summarized as follows.

First, the time-series analysis shows that a longer night session intensifies the negative association between overnight returns and the subsequent intraday returns, implying that the implementation and extension of a night session worsen the price overreaction phenomenon. For a robustness check, we examine whether several factors explain our results. High uncertainty during the financial crisis can result in a strong intraday overreaction phenomenon; a change in the market-wide uncertainty, represented by a change in the volatility index, adds explanatory power for the intraday overreaction phenomenon (Corte et al., 2015). Additionally, the intraday overreaction phenomenon is more likely to occur as a result of the bid–ask bounce (Corwin and Schultz, 2012). However, the result clearly denies the possibility that our results are subsumed by the high uncertainty during the financial crisis, the change in market-wide uncertainty, and the bid–ask bounce.

Second, the cross-sectional analysis shows that the price overreaction phenomenon is weaker for the Nikkei 225 futures than for the TOPIX futures when there is no difference in trading hours between the futures. However, when trading hours (a night session) is significantly longer for the Nikkei 225 futures than for the TOPIX futures, the overreaction for the Nikkei 225 futures emerges as strong as that for the TOPIX futures. This result also supports the view that a longer extended-hours session results in the stronger price overreaction phenomenon.

Additionally, we perform two additional analyses to further understand the effect of trading hours extension. Specifically, we examine whether transactions during an extended-hours (night) session worsen the intraday overreaction. To this end, first, we analyze the effect of trading activity during the night session on the overreaction. Second, the study analyzes whether price movements during the night session are negatively associated with subsequent intraday returns.

The analyses reveal that trading activity during the night session has additional predictive power for the price overreaction phenomenon; higher trading activity during the night session induces more negative associations between overnight returns and subsequent intraday returns. Additionally, night session returns are negatively associated with subsequent intraday returns. Both results indicate that transactions during the night session fail to reduce the price overreaction phenomenon.

These results support the view that implementing and extending the extended-hours session (the night session) can increase the intraday price overreaction phenomenon, which might indicate higher uncertainty or lower price efficiency at the opening of the trading session. The study contributes to existing studies by providing strong empirical evidence that trading hours extension carries a risk of increasing the intraday price overreaction phenomenon[2].

The remainder of this paper is organized as follows. Section 2 presents the sample, methodologies, and results. Section 3 elaborates on the robustness check, and Section 4 presents an additional analysis of the effect of extending trading hours. Finally, Section 5 summarizes the findings.

[2] Since we focus on Japanese sample, our analysis cannot be considered strong enough to suggest that the extension always has a negative impact on efficient price formation. However, our evidence is enough to suggest that trading hours extension carries a risk of lowering price efficiency.

2. Empirical evidence

2.1. Sample construction

The TOPIX futures contracts and the Nikkei 225 futures contracts traded on the Osaka Stock Exchange are utilized to test the intraday price overreaction. The sample spans over the period from January 2002 to December 2015. We use transaction prices instead of the bid-ask prices because bid and ask prices are sometimes not updated at the same pace at which the trading prices move. The futures market successfully supplies maximal immediacy of order execution at its opening (Grossman and Miller, 1988); this keeps the transaction costs low.

The last trading days for the TOPIX and Nikkei 225 futures are scheduled on a quarterly basis, that is, the business day preceding the second Friday of March, June, September, and December. The futures are cash-settled contracts, with multiple contracts traded simultaneously on any given day. We utilize the values of the closest contract, which is usually the most heavily traded.

The SQ (special quotation) fixation day (the business day following the last trading day) and the first trading day of each calendar year are excluded from the analysis. The SQ fixation days are excluded as the opening prices of the spot market are highly volatile because of the special quotation (SQ) events (SQs for expired contracts are calculated), and the latter is excluded as there is no extended-hours session for the prior (year-end day's) trading session.

The regular trading session for these futures runs from 9:00 to 15:10 (it was changed to 15:15 after July 20, 2010). The extended-hours sessions (night sessions)[3] for the Nikkei 225 futures and the TOPIX futures were introduced on September 18, 2007 and June 16,

[3] At first, the extended-hours session was called "the evening session."

2008, respectively. Subsequently, the extended-hours sessions were extended, as shown in panel (a) of Table 1.

[Table 1]

2.2. Research methodology

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

The opening prices and closing prices of the regular session are defined by futures value at 9:00 ($P_{i,t}^{9:00}$) and futures value at 15:10 ($P_{i,t}^{15:10}$), respectively. 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 ($P_{i,t-1}^{15:10}$)[4]. Thus:

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

Concerning intraday returns, there is a tendency for the overnight returns to be reversed, especially during the trading hours of the corresponding spot market. The trading hours of the Tokyo Stock Exchange includes a morning session and an afternoon session. The morning session runs from 9:00 to 11:00 (it was changed to 11:30 after November 21, 2011) and the afternoon session runs from 12:30 to 15:00. Specifically, we focus on return reversal during the morning session, namely, intraday futures returns from 9:00 to 11:00[5]. An intraday return, $R_{i,t}^{Intraday}$, is defined as:

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

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

[4] On July 20, 2010, the regular market closing time was changed to 15:15. However, we utilize the price at 15:10 to maintain the consistency of the definition of overnight returns. Even if we utilize prices at 15:15 for calculating the overnight returns after July 20, 2010, the implication of the result remains unchanged.

[5] We also analyze the return reversal during the afternoon session, which is defined by the association between overnight returns and intraday returns during the subsequent afternoon session. The result is shown in Section 4.1.

I evaluate the degree of the intraday overreaction phenomenon 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 the night session mitigates or worsens the intraday overreaction phenomenon, we perform a time-series comparison for each futures contract and conduct a cross-sectional comparison between the Nikkei 225 futures and the TOPIX futures.

2.2.1. Time-series comparison

Since the night sessions for the Nikkei 225 and TOPIX futures were introduced and extended significantly and continuously, we could analyze the effect of the implementation of the night sessions through the time-series comparison. Thus, we examine whether the association between overnight returns and subsequent intraday returns is affected by the implementation and extension of night sessions. If trading during the night session weakens (intensifies) the intraday overreaction phenomenon, then a long night session would induce a weaker (stronger) negative association. Thus, we run the following regression:

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

where $T_{i,t}^{Night}$ denotes the length (hours) of the night session on day *t*, which is shown in panel (b) of Table 1.[6] Note that, since an overnight return of day *t* ($R_{i,t}^{Overnight}$) is defined as a change from the closing value of day *t*-1 to the opening price of day *t*, $T_{i,t}^{Night}$ is defined as the length (hours) of the night session between closing of the regular hours session of day *t*-1 to the market opening of day *t*. Thus, if the implementation or extension of trading-hours is launched on day t, the variable of the length of the night session

[6] Although the market is closed from the end of the regular trading session until 16:30, we define $T_{i,t}^{Night}$ as the time that spans from the end of the previous day's regular trading session to the end of the night session because the news between the end of the regular trading session and 16:30 is expected to be incorporated into prices during the subsequent night session.

($T_{i,t}^{Night}$) increases on the next business day (t+1). If transactions during the night session mitigate (worsen) the intraday overreaction phenomenon, a longer $T_{i,t}^{Night}$ would induce a weaker (stronger) negative relationship between $R_{i,t}^{Intraday}$ and $R_{i,t-1}^{Overnight}$; consequently, the coefficient of $T_{i,t}^{Night} * R_{i,t}^{Overnight}$ (b_{2i}) would be positive (negative).

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

2.2.2. Cross-sectional comparison

The trading hours for the Nikkei 225 futures and the TOPIX futures are extended asynchronously. As shown in panel (b) of Table 1, a length of the night session ($T_{i,t}^{Night}$) is significantly longer for the Nikkei 225 futures, from 7/21/2010 to 3/24/2014, than for the TOPIX futures (this period is denoted as "the different trading-hours period"). Meanwhile, there is no difference in $T_{i,t}^{Night}$ between these futures until 9/18/2007, from 6/17/2008 to 10/14/2008, and after 3/25/2014 (these periods are denoted as "the same trading-hours period"). We perform panel data analysis by applying panel regression models with fixed effects for the different and same trading-hours periods.

$$R_{i,t}^{Intraday} = a + b_1 R_{i,t}^{Overnight} + b_2 NK_i * R_{i,t}^{Overnight} + b_3 NK_i + \mathrm{e}_{i,t} \quad (2)$$

NK_i is a dummy variable that takes one for the Nikkei 225 futures and zero for the

[7] As a robustness test, we also apply several cut points. However, the result (available upon request) reveals that the implication of the regression analysis is invariant regardless of the cut point.

TOPIX futures. The coefficient b_2 (the coefficient of $NK_i * R_{i,t}^{Overnight}$) represents the difference in the intraday overreaction phenomenon between the TOPIX futures and the Nikkei 225 futures. Since an intense negative association between $R_{i,t}^{Intraday}$ and $R_{i,t}^{Overnight}$ implies a strong intraday overreaction phenomenon, a positive (negative) b_2 would imply that the overreaction is weaker (stronger) for the Nikkei 225 futures than for the TOPIX futures. If night-session trading mitigates the intraday overreaction phenomenon, then the coefficient b_2 would be higher during the different trading-hours period than during the same trading-hours period; this is because the night session of the Nikkei 225 futures is longer than that of the TOPIX futures during the different trading-hours period. Conversely, if night-session trading worsens the intraday overreaction phenomenon, then b_2 would be lower during the different trading-hours period than during the same trading-hours period.

The different trading-hours period consists of the following three separate periods. Thus, we also perform a panel analysis for the different trading-hours period by adding dummy variables:

$$R_{i,t}^{Intraday} = a + b_1 R_{i,t}^{Overnight} + b_2 NK_i * R_{i,t}^{Overnight} + b_3 T1_t * R_{i,t}^{Overnight} + b_4 T2_t * R_{i,t}^{Overnight} + b_5 NK_i + b_6 T1_t + b_7 T2_t + \mathrm{e}_{i,t} \quad (3)$$

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 the TOPIX futures were extended as of 11/21/2011 ($T_{i,t}^{Night}$ increased to 8.5 as of 11/22/2011). Thus, we also perform a panel analysis for the same trading-hours period by adding a dummy variable $T3_t$, which takes one if day *t* spans from 11/22/2011 to 3/24/2014:

$$R_{i,t}^{Intraday} = a + b_1 R_{i,t}^{Overnight} + b_2 NK_i * R_{i,t}^{Overnight} + b_3 T3_t * R_{i,t}^{Overnight} + b_4 NK_i + b_5 T3_t +$$

$e_{i,t}$ (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 a cross-sectional comparison—the cross-sectional difference in the overreaction between the Nikkei 225 futures and the TOPIX futures. Thus, these cross-sectional analyses can provide more robust evidence regarding the effect of trading hours extension 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 the weakest during the no night-session period. Furthermore, the negative association between $R_{i,t}^{Intraday}$ and $R_{i,t}^{Overnight}$ for the Nikkei 225 futures during this period is insignificant. However, after the introduction of the night session, a stronger negative association can be observed for the TOPIX and the Nikkei 225 futures.

[Table 2]

Panel (b) of Table 2 reveals that the intraday overreaction phenomenon—intraday price reversals following price changes at market openings—is observed for the TOPIX and Nikkei 225 futures. Concerning the effect of the length of the night session on the intraday overreaction phenomenon, the results for both futures reveal that the coefficient of $T_{i,t}^{Night} * R_{i,t}^{Overnight}$ is significantly negative, indicating that a longer night session (larger $T_{i,t}^{Night}$) induces a stronger negative relationship between an overnight return ($R_{i,t}^{Overnight}$) and a 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. Panel (a) of Table 3 reveals 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 is essentially weaker for the Nikkei 225 futures than for the TOPIX futures.

[Table 3]

The difference in the intraday overreaction phenomenon could be attributed to the difference in information uncertainty in the underlying spot market indexes of the 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 based on liquidity, market size, and visibility, while the constituents of the TOPIX index include 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, as shown in Table 4, the reciprocals of analyst coverage[8] and those of market values (billion yen), which are proxies of information uncertainty, are significantly higher for the TOPIX constituents than for the Nikkei 225 constituents. Additionally, the number of constituents is much larger for the TOPIX index (from 1500 to 2000) than for the Nikkei 225 index (essentially, 225); the larger number of constituents might induce higher information uncertainty inherent to the index. Thus, it is highly likely that information uncertainty is higher for the TOPIX futures than for the Nikkei 225 futures. Thus, the intraday overreaction phenomenon, which could be strengthened by information uncertainty, might be stronger for the TOPIX futures than for the Nikkei 225 futures.

[Table 4]

[8] Analyst coverage is defined by the number of earnings forecasts for the current fiscal year. We obtain a sample of analysts' earnings forecasts for Japanese firms from the Factset Estimates.

However, the results, shown in Panel (a) of Table 3, reveal that the coefficient b_2 (the coefficient of $NK_i * R_{i,t}^{Overnight}$), which represents the difference in the intraday overreaction phenomenon between the Nikkei 225 futures and the TOPIX futures, is insignificant during the different trading-hours period. Further, the coefficient b_2 is much smaller for the different trading-hours period than for the same trading-hours period. Although the intraday overreaction phenomenon is weaker for the Nikkei 225 futures than for the TOPIX futures during the same trading-hours period, the overreaction for the Nikkei 225 futures is as strong as that for the TOPIX futures when the length of the night session is longer for the Nikkei 225 futures than for the TOPIX futures.

As shown in Table 4, a difference in information uncertainty between the two futures is not smaller during the different trading-hours period when compared to the same trading-hours period. Therefore, the stronger overreaction phenomenon for the Nikkei 225 futures during the different trading-hours is not explained by the time-varying information uncertainty. Rather, it is likely that the stronger overreaction for Nikkei 225 is attributed to a longer night session for the Nikkei 225 futures. These results support this study's view that a longer night session results in the stronger intraday overreaction phenomenon.

3. Robustness analysis

High uncertainty during the financial crisis can result in a strong intraday overreaction phenomenon. Additionally, Corte et al. (2015) show that a change in market-wide uncertainty, represented by a change in the VIX index, adds explanatory power for the intraday overreaction phenomenon. Finally, the intraday overreaction phenomenon is more likely to occur as a result of the bid–ask bounce (Corwin and Schultz, 2012). Thus, for the robustness check, we examine whether our result is not subsumed by the high uncertainty during the financial crisis, the change in market-wide uncertainty, and the bid–ask bounce.

3.1. Adjustment for the financial crisis 2007–2008

The sample spans from January 2002 to December 2015. This period includes the financial crisis of 2007–2008. The high uncertainty during the financial crisis can lead to a strong intraday overreaction phenomenon. Thus, we include $D\_Crisis_t * R_{i,t}^{Overnight}$ (and D_Crisis_t) as control variables, where D_Crisis_t is the financial crisis dummy that is equal to 1 in 2007 or 2008, as follows:

$$R_{i,t}^{Intraday} = a_i + b_{1i} R_{i,t}^{Overnight} + b_{2i} T_{i,t}^{Night} * R_{i,t}^{Overnight} + b_{3i} T_{i,t}^{Night}$$
$$+ b_{4i} D\_Crisis_t * R_{i,t}^{Overnight} + b_{5i} D\_Crisis_t + \mathrm{e}_{i,t} \quad (5)$$

Subsequently, we examine whether the coefficient b_{2i} (the coefficient of $T_{i,t}^{Night} * R_{i,t}^{Overnight}$) is still negative. As shown in Table 5, the intraday overreaction of the TOPIX futures is significantly strong in 2007 and 2008 (the coefficient of $D\_Crisis_t * R_{i,t}^{Overnight}$ is significantly negative for the TOPIX futures). However, the coefficient of $T_{i,t}^{Night} * R_{i,t}^{Overnight}$ (b_{2i}) remains significantly negative for both futures, even after controlling for the effect of the financial crisis. Thus, the negative impact of night-session trading on the intraday overreaction phenomenon cannot be subsumed by the uncertainty that emerged during the financial crisis.

[Table 5]

3.2. Adjustment for bid-ask bounce and changes in market-wide uncertainty

In this section, in order to conduct an additional robustness check, we analyze the effect of trading hours extension on the intraday overreaction phenomenon after controlling for two effects—changes in market-wide uncertainty and bid-ask bounce.

Kyle (1985), Grossman and Miller (1988), and Nagel (2012) show that a short-term reversal strategy is positively associated with the proxy for market-wide uncertainty, namely, the VIX index. Specifically, Corte et al. (2015) show that a lagged daily change in the volatility index adds explanatory power for the intraday overreaction phenomenon in stock futures[9]; specifically, increased market volatility heightens the intraday overreaction in a subsequent period (the more negative association between $R_{i,t}^{Intraday}$ and $R_{i,t}^{Overnight}$). Thus, to control for the effect of a change in market volatility on the intraday overreaction, we include $\Delta VIX_{t-1} * R_{i,t}^{Overnight}$ (and ΔVIX_{t-1}) as control variables, where a daily change in the volatility index ($\Delta VIX_t = VIX_t - VIX_{t-1}$) is calculated by a change in official close values of the Nikkei stock average volatility index (because the sample comprises Japanese stock futures[10]):

$$R_{i,t}^{Intraday} = a_i + b_{1i}R_{i,t}^{Overnight} + b_{2i}T_{i,t}^{Night} * R_{i,t}^{Overnight} + b_{3i}T_{i,t}^{Night} + b_{4i}\Delta VIX_{t-1} * R_{i,t}^{Overnight} + b_{5i}\Delta VIX_{t-1} + \mathrm{e}_{i,t} \quad (6)$$

Additionally, we control for the effect of the bid-ask bounce. A price change from close to open might occur because of the bid-ask bounce than from an overnight change in the true value (Corwin and Schultz, 2012). Thus, it may be necessary to control for the effect of the bid-ask bounce on overnight returns. To this end, as a control variable, we add $Sign(R_{i,t}^{Overnight}) * \mathrm{bidask}_{i,t-1}$, where $\mathrm{bidask}_{i,t}$ is defined by the bid-ask spread divided by the transaction price at the end of the regular session on day *t*. The control variable $Sign(R_{i,t}^{Overnight}) * \mathrm{bidask}_{i,t-1}$ can be considered the overnight return that is attributable to the bid-ask bounce. We run the subsequent regression model as:

$$R_{i,t}^{Intraday} = a_i + b_{1i}R_{i,t}^{Overnight} + b_{2i}T_{i,t}^{Night} * R_{i,t}^{Overnight} + b_{3i}T_{i,t}^{Night} + b_{4i}Sign(R_{i,t}^{Overnight}) * \mathrm{bidask}_{i,t-1} + \mathrm{e}_{i,t} \quad (7)$$

Furthermore, we run the following regression model where both control variables are included:

$$R_{i,t}^{Intraday} = a_i + b_{1i}R_{i,t}^{Overnight} + b_{2i}T_{i,t}^{Night} * R_{i,t}^{Overnight} + b_{3i}T_{i,t}^{Night} + b_{4i}\Delta VIX_{t-1} * R_{i,t}^{Overnight} +$$

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9 Corte et al. (2015) also utilize the difference between the opening and prior close levels of the index. Considering that the historical opening value of the Nikkei stock average volatility index is not available, we analyze the interaction effect with daily changes in the volatility index.

10 Since the full historical values of volatility index for TOPIX are unavailable, we control for the Nikkei stock average volatility index when we analyze the intraday price overreaction of TOPIX futures.

$b_{5i}\Delta VIX_{t-1} + b_{6i}Sign(R_{i,t}^{Overnight}) * \text{bidask}_{i,t-1} + \text{e}_{i,t}$ (8)

Subsequently, we examine whether the coefficient b_{2i} (the coefficient of $T_{i,t}^{Night} * R_{i,t}^{Overnight}$) is still negative.

The results in Table 6 reveal that the coefficients of $\Delta VIX_{t-1} * R_{i,t}^{Overnight}$ are insignificant, indicating that there is no significant effect of the market-wide uncertainty on the intraday overreaction. The coefficient of $Sign(R_{i,t}^{Overnight}) * \text{bidask}_{i,t-1}$ is significant for the TOPIX futures, while it is insignificant for the Nikkei futures. The bid-ask bounce might induce the intraday overreaction for the TOPIX futures.

However, the coefficients of $T_{i,t}^{Night} * R_{i,t}^{Overnight}$ (b_{2i}) in model (6), (7), and (8) are still significantly negative, even after controlling for the effects of the market-wide uncertainty and bid-ask bounce. Thus, the results suggest that the impact of night-session trading on the intraday overreaction phenomenon cannot be subsumed by the effect of market-wide uncertainty and bid-ask bounce.

[Table 6]

4. Additional analyses

4.1. Price reversal during an afternoon session

In this study, we specifically focus on price reversal during a morning session. In this section, we examine whether the overnight return remains reversed during an afternoon session. We define the price reversal during an afternoon session based on the association between overnight returns and returns during the subsequent afternoon session. We utilize a return from 11:00 to 15:10, denoted as $R_{i,t}^{Afternoon}$. $R_{i,t}^{Afternoon}$ is defined as:

$$R_{i,t}^{Afternoon} = \log(P_{i,t}^{15:10}/P_{i,t}^{11:00})$$

I analyze the association between $R_{i,t}^{Overnight}$ and $R_{i,t}^{Afternoon}$ and examine whether the association is affected by the length of the night session ($T_{i,t}^{Night}$). To this end, we perform a time-series analysis for the association by running the following regression:

$$R_{i,t}^{Afternoon} = a_i + b_{1i}R_{i,t}^{Overnight} + b_{2i}T_{i,t}^{Night} * R_{i,t}^{Overnight} + b_{3i}T_{i,t}^{Night} + \mathrm{e}_{i,t} \tag{9}$$

Additionally, we conduct a cross-sectional comparison between the Nikkei 225 futures and the TOPIX futures by running the following panel analysis for the same trading-hours period and the different trading-hours period:

$$R_{i,t}^{Afternoon} = a + b_1R_{i,t}^{Overnight} + b_2NK_i * R_{i,t}^{Overnight} + b_3NK_i + \mathrm{e}_{i,t} \tag{10}$$

The results of the time-series analysis and cross-sectional analysis in Table 7 reveal that the coefficients of $R_{i,t}^{Overnight}$ are insignificant at a significance level of 0.05. This finding indicates that an intraday return during an afternoon session is not significantly associated with the latest overnight return.

[Table 7]

Additionally, the time-series analysis reveals that the coefficient of $T_{i,t}^{Night} * R_{i,t}^{Overnight}$ is insignificant. Furthermore, the cross-sectional analysis reveals that the coefficient $NK_i * R_{i,t}^{Overnight}$ is insignificant for the same trading-hours period and the different trading-hours period. These results indicate that the association between an overnight return and a return during an afternoon session is not affected by the length of the night session.

All these results suggest that the overnight return does not remain reversed during an afternoon session and the effect of a latest night-session trading is not observed for the subsequent afternoon session.

4.2. The level of trading activity during the night session

The level of trading activity during the night session is positively associated with the degree of the effect of extended-hours trading. If extended-hours transactions fail to lower information uncertainty and price inefficiency at market openings, then a higher level of trading activity during the extended-hours would result in greater intraday overreaction. In other words, high trading activity during an extended-hours session can intensify the negative association between intraday returns $R_{i,t}^{Intraday}$ and overnight returns $R_{i,t}^{Overnight}$.

Thus, in addition to analyzing the effect of the length of the night session on the intraday overreaction phenomenon, we analyze the effect of the level of trading activity during the night session on such an overreaction. To evaluate the level of trading activity, we utilize a turnover ratio, denoted as $OTURN_{i,t}^{Night}$; it is defined on the basis of the trading volume during the night session denominated by a 20-day moving median[11] of open interest (the total number of open or outstanding futures contracts). Open interest, which gauges market participation, is quite volatile, and there is long-term trend toward the last trading day (e.g., a gradual decrease in open interest near the last trading day). To reduce the effects of the fluctuations and trends, a median value within the short-term period, that is, a 20-day median value (one-month median), is used as the denominator. The trading activity tends to increase significantly from five days prior to the SQ because many investors roll forward a futures contract; additionally, trading activity prior to the SQ might be affected by settlement mechanisms (Hsieh and Ma, 2009). Thus, we control for these rolling-over demands by running the following regression for each futures:

$$OTURN_{i,t}^{Night} = \alpha_i + \sum_{s=1}^{5} \beta_i^s ET_{i,t}^s + \varepsilon_{i,t}$$

where $ET_{i,t}^s$ is a dummy variable that takes one when day *t* is *s*-days prior to the SQ date of the latest futures *i*. The adjusted turnover, $TURN_{i,t}^{Night}$, is defined as:

$$TURN_{i,t}^{Night} = OTURN_{i,t}^{Night} - \sum_{s=1}^{5} \beta_i^s ET_{i,t}^s$$

I analyze the effect of $TURN_{i,t}^{Night}$ on the association between $R_{i,t}^{Intraday}$ and

[11] In an untabulated analysis, we find that the result still holds, even if the other denominator (e.g., 10-day median value, 40-day median value, and 20-day average) is used.

$R_{i,t}^{Overnight}$ by running the following regression:

$$R_{i,t}^{Intraday} = a_i + b_{1i}R_{i,t}^{Overnight} + b_{2i}TURN_{i,t}^{Night} * R_{i,t}^{Overnight} + b_{3i}TURN_{i,t}^{Night} + \mathrm{e}_{i,t}$$

(11)

The negative b_{2i} (the negative coefficient of $TURN_{i,t}^{Night} * R_{i,t}^{Overnight}$) implies that higher trading activity during the night session results in the stronger intraday overreaction phenomenon.

The result in panel (a) of Table 8 reveals that the coefficient of $TURN_{i,t}^{Night} * R_{i,t}^{Overnight}$ (b_{2i}) is significantly negative, indicating that a negative relationship between the overnight return ($R_{i,t}^{Overnight}$) and the subsequent intraday return ($R_{i,t}^{Intraday}$) is intensified by higher trading activity during the night session. This result indicates that transactions during the night session intensify the intraday overreaction phenomenon.

[Table 8]

Compared to the effect of the length of the night session ($T_{i,t}^{Night} * R_{i,t}^{Overnight}$), $TURN_{i,t}^{Night} * R_{i,t}^{Overnight}$ seems to have a more robust predictive power for the degree of the intraday overreaction phenomenon. Thus, to test the incremental influence of $TURN_{i,t}^{Night}$, we run the following regression after controlling for $T_{i,t}^{Night} * R_{i,t}^{Overnight}$:

$$R_{i,t}^{Intraday} = a_i + b_{1i}R_{i,t}^{Overnight} + b_{2i}TURN_{i,t}^{Night} * R_{i,t}^{Overnight} + b_{3i}TURN_{i,t}^{Night} + b_{4i}T_{i,t}^{Night} * R_{i,t}^{Overnight} + b_{5i}T_{i,t}^{Night} + \mathrm{e}_{i,t} \quad (12)$$

As revealed in panel (b) of Table 8, the coefficient of $TURN_{i,t}^{Night} * R_{i,t}^{Overnight}$ (b_{2i}) continues to be significantly negative, indicating that $TURN_{i,t}^{Night} * R_{i,t}^{Overnight}$ has additional predictive power for the overreaction. Since a longer night session (larger $T_{i,t}^{Night}$) results in a higher $TURN_{i,t}^{Night}$, the $TURN_{i,t}^{Night}$ contains information regarding $T_{i,t}^{Night}$. Specifically, $TURN_{i,t}^{Night}$ reflects both $T_{i,t}^{Night}$ and the degree of trading activity per unit of time. Thus, the result suggests that the degree of trading activity per unit of time can have an additional predictive power for the overreaction. In other words, the overreaction phenomenon is also associated with the degree of trading activity during the session. The results in this section suggest that the overreaction phenomenon can worsen as a result of frequent trading during the extended-hours sessions.

4.3. Price movement during the night session

In this section, we analyze price discovery during the night session by testing whether price movements during such a session mitigate the opening price overreaction by reducing uncertainty at the opening of a subsequent regular session. To this end, we analyze the association between returns during the night session and the subsequent intraday returns. Specifically, we analyze the relationship when a prior night session stays open until 3:00 (when futures have the longest night-session period). The investigated periods for the Nikkei 225 futures and the TOPIX futures range from 7/20/2011 to the end of 2015 and 3/25/2014 to the end of 2015, respectively. We decompose overnight returns, $R_{i,t}^{Overnight}$, into the night-session return, $R_{i,t}^{Night}$ and the opening return, $R_{i,t}^{Opening}$. The night-session and opening returns are defined as:

$$R_{i,t}^{Night} = \log(P_{i,t}^{3:00}/P_{i,t-1}^{15:10})$$

$$R_{i,t}^{Opening} = \log(P_{i,t}^{9:00}/P_{i,t}^{3:00})$$

where $P_{i,t}^{3:00}$ reflects the latest transaction prices at 3:00. We examine the association between $R_{i,t}^{Intraday}$ and $R_{i,t}^{Night}$ by running the following regression:

$$R_{i,t}^{Intraday} = a_i + b_{1i}R_{i,t}^{Night} + b_{2i}R_{i,t}^{Opening} + \mathrm{e}_{i,t} \quad (12)$$

Table 9 reports the results of the regression. $R_{i,t}^{Intraday}$ is negatively and significantly associated not only with $R_{i,t}^{Opening}$ but also with $R_{i,t}^{Night}$, indicating that price movements during the night session are reversed during the subsequent regular session. In other words, price movements during the night session intensify the overreaction of subsequent opening prices. The result, at least, suggests that price movements during the night session fail to reduce information uncertainty or pice inefficiency at market opening that induces the intraday overreaction.

[Table 9]

5. Conclusion

In this study, we provide empirical analysis regarding how and whether the intraday price overreaction, which could indicate a high uncertainty or price inefficiency at market openings, is affected by extending trading hours.

The study investigates the extension of two representative Japanese stock index futures contracts. The trading hours of these futures contracts have been extended continuously and asynchronously. The continuous extensions enable us to perform a time-series (before and after) comparison regarding the intraday price overreaction and the asynchronous extensions enable us to compare stock futures with different trading hours.

Time-series analysis shows that a longer extended-hours session (a longer night session) results in storonger price reversals following price changes at market openings. A cross-sectional analysis reveals that although the intraday price overreaction tends to be weaker for the Nikkei 225 futures than for the TOPIX futures during the same trading-hours period, the overreaction for the Nikkei 225 futures is as strong as that for the TOPIX futures when the night session of the Nikkei 225 futures is longer than that of the TOPIX futures. Additional analysis shows that not only the length of the night session but also the level of trading activity during the session have a positive association with the degree of the overreaction phenomenon; the higher level of trading activity also induces the stronger overreaction. Moreover, the results reveal that price movements during the night session are reversed during the subsequent regular session. These results indicate that transactions during the night session intensify the overreaction of subsequent opening prices.

Although the extension of trading hours has been increasingly discussed in several markets, most studies overlook the importance of providing empirical evidence on whether and how the extension of trading hours affects price formation. Specifically, there is no study that empirically clarifies the effect on the well-known intraday (opening price) overreaction, which is induced by market closure. We contribute to the existing study by providing empirical evidence that trading hours extension carries a risk of worsening the intraday overreaction phenomenon. The results suggest that the opening price overreaction is not easily and straightforwardly mitigated by extending trading hours. In other words, such evidence highlights the existence of the negative impact of trading hours extension on price efficiency and uncertainty at market openings.

This study also has practical importance. Considerable investors are averse to overnight risk; therefore, they reduce their exposure shortly before market closure and avoid trading at the opening (Lou et al., 2018). Since prices are considered to incorporate information efficiently during an extended-hours session, the extension of trading hours is expected to reduce overnight risk, and thus lowers the necessity to avoid an overnight risk. However, our result, which reveals that transactions during the night session fail to reflect information efficiently, suggests that overnight risk is not straightforwardly reduced by the extension of trading hours. The result suggests that the necessity of reducing the overnight exposure could remain intact even after trading hours is extended.

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Table 1

Trading hours of index futures

Panel (a) shows the trading hours of the extended-hours sessions (referred to as “night sessions”) for the Nikkei 225 futures and the TOPIX futures. Panel (b) shows the values of $T_{i,t}^{Night}$, which represent the length of the night sessions. Panel (c) shows the period categories, which are determined on the basis of the length of the night sessions.

(a) The extended sessions 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>9/18/2007–6/15/2008</td><td rowspan="2">16:30–19:00</td></tr>
<tr><td>6/16/2008–10/13/2008</td><td rowspan="4">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>

(b) Values of $T_{i,t}^{Night}$ [12]

<table>
<tr><th></th><th>Nikkei 225</th><th>TOPIX</th></tr>
<tr><td>-9/18/2007</td><td>0</td><td rowspan="2">0</td></tr>
<tr><td>9/19/2007-6/16/2008</td><td rowspan="2">4</td></tr>
<tr><td>6/17/2008-10/14/2008</td><td rowspan="4">4</td></tr>
<tr><td>10/15/2008-7/20/2010</td><td>5</td></tr>
<tr><td>7/21/2010-7/19/2011</td><td>8.5</td></tr>
<tr><td>7/20/2011-11/21/2011</td><td rowspan="3">12</td></tr>
<tr><td>11/22/2011-3/24/2014</td><td>8.5</td></tr>
<tr><td>3/25/2014-</td><td>12</td></tr>
</table>

(c) Period categories

<table>
<tr><th></th><th>Category (Nikkei 225)</th><th>Category (TOPIX)</th></tr>
<tr><td>-9/18/2007</td><td>Period 1</td><td rowspan="2">Period 1</td></tr>
<tr><td>9/19/2007-6/16/2008</td><td rowspan="2">Period 2</td></tr>
<tr><td>6/17/2008-7/20/2010</td><td rowspan="2">Period 2</td></tr>
<tr><td>7/21/2010-11/21/2011</td><td rowspan="2">Period 3</td></tr>
<tr><td>11/22/2011-</td><td>Period 3</td></tr>
</table>

[12] As explained in section 2, we define $T_{i,t}^{Night}$ as the time that spans from the end of the regular trading session to the end of the night session.

Table 2

Time-series comparison

Panel (a) shows the regression results regarding the association between the overnight returns ($R_{i,t}^{Overnight}$) and the intraday returns ($R_{i,t}^{Intraday}$) for period 1 (the no night-session period), period 2 (the short night-session period), and period 3 (the long night-session period). The results for the regressions in equation (1) in the text are shown in panel (b). The rows for “overnight return,” “extension,” and “overnight return x extension” show the coefficients of $R_{i,t}^{Overnight}$, $T_{i,t}^{Night}$, and $T_{i,t}^{Night} * R_{i,t}^{Overnight}$, respectively. The figures in parentheses are t-statistics based on the Newey-West standard errors. *, **, and, *** indicate the two-sided statistical significance at the 10%, 5%, and 1% levels, respectively.

(a) Opening price overreaction for each period

	Nikkei 225 futures	TOPIX futures
period 1	-0.02153	-0.05642 ***
(no night-session period)	(0.99)	(3.08)
period 2	-0.06902 ***	-0.16466 ***
(short night-session period)	(2.74)	(4.92)
period 3	-0.09250 ***	-0.12187 ***
(long night-session period)	(3.48)	(4.27)

(b) Overreaction and the length of the night sessions

	Nikkei 225 futures	TOPIX futures
intercept	-0.00021	-0.00041 ***
	(1.41)	(3.08)
overnight return	-0.03741 **	-0.09433 ***
	(2.01)	(3.13)
extension	0.00004 **	0.00006 ***
	(2.29)	(3.43)
overnight return x extension	-0.00512 **	-0.00652 **
	(2.18)	(2.16)

Table 3

Cross-sectional comparison

The results for the panel analyses in equations (2), (3), and (4) in the text are shown in the panels. Panels (a) and (b) show the results for the same and different trading-hours period, respectively. The rows for "overnight return," "NK," "overnight return x NK," "T1," "overnight return x T1," "T2," "overnight return x T2," "T3," and "overnight return x T3" show the coefficients of $R_{i,t}^{Overnight}$, NK_i, $NK_i * R_{i,t}^{Overnight}$, $T1_t$, $T1_t * R_{i,t}^{Overnight}$, $T2_t$, $T2_t * R_{i,t}^{Overnight}$, $T3_t$, and $T3_t * R_{i,t}^{Overnight}$, respectively. The figures in parentheses are t-statistics based on the Newey-West standard errors. *, **, and *** indicate the two-sided statistical significance at the 10%, 5%, and 1% levels, respectively.

(a) The same trading-hours period

	model (2)	model (3)
intercept	-0.00018	-0.00039 ***
	(1.08)	(2.83)
overnight return	-0.11353 ***	-0.08651 ***
	(3.13)	(3.32)
NK	0.00009	0.00010
	(0.42)	(0.50)
overnight return x NK	0.09101 **	0.09192 **
	(2.27)	(2.34)
T1		0.00056
		(0.57)
overnight return x T1		-0.05523
		(0.99)
T2		0.00072 ***
		(4.22)
overnight return x T2		-0.05556 *
		(1.68)

(b) The different trading-hours period

	model (2)	model (4)
intercept	-0.00001	-0.00003
	(0.09)	(0.12)
overnight return	-0.11141 ***	-0.17454 ***
	(4.64)	(4.00)
NK	0.00013	0.00014
	(0.63)	(0.63)
overnight return x NK	0.00610	0.00574
	(0.15)	(0.16)
T3		0.00000
		(0.00)
overnight return x T3		0.08957 *
		(1.78)

Table 4

Proxies of information uncertainty

This table shows averages of the following two information uncertainty indicators: reciprocals of analyst coverage and market values (billion yen). The columns headed “1/Coverage” and “1/MV” show the averages of the reciprocals of analyst coverage and market values, respectively. The table reports the values for TOPIX (the columns headed “TOPIX”), the Nikkei index (the columns headed “Nikkei”), and the difference between them (the columns headed “Difference”) at the end of each calendar year. The figures in parentheses are simple t-statistics. *, **, and *** indicate the two-sided statistical significance at the 10%, 5%, and 1% levels, respectively.

	1/Coverage			1/MV		
	TOPIX Futures	Nikkei Futures	Difference	TOPIX Futures	Nikkei Futures	Difference
2002	0.517	0.292	0.225 ***	0.062	0.010	0.051 ***
			(10.41)			(17.04)
2003	0.534	0.278	0.256 ***	0.071	0.010	0.061 ***
			(12.07)			(18.36)
2004	0.531	0.292	0.240 ***	0.044	0.005	0.039 ***
			(11.26)			(24.32)
2005	0.607	0.327	0.281 ***	0.034	0.004	0.030 ***
			(12.85)			(27.44)
2006	0.569	0.309	0.260 ***	0.023	0.002	0.021 ***
			(12.52)			(29.76)
2007	0.533	0.259	0.274 ***	0.030	0.002	0.027 ***
			(13.81)			(29.25)
2008	0.517	0.239	0.278 ***	0.040	0.003	0.037 ***
			(14.54)			(28.76)
2009	0.461	0.170	0.291 ***	0.069	0.005	0.064 ***
			(16.38)			(22.15)
2010	0.508	0.169	0.339 ***	0.059	0.004	0.055 ***
			(19.98)			(27.88)
2011	0.510	0.160	0.350 ***	0.058	0.004	0.054 ***
			(20.22)			(24.30)
2012	0.400	0.145	0.255 ***	0.061	0.005	0.056 ***
			(14.71)			(28.45)
2013	0.427	0.150	0.277 ***	0.053	0.004	0.049 ***
			(16.29)			(28.11)
2014	0.426	0.160	0.266 ***	0.040	0.003	0.037 ***
			(14.61)			(29.20)
2015	0.441	0.136	0.306 ***	0.039	0.003	0.036 ***
			(19.08)			(28.33)
2002-2015	0.499	0.220	0.278 ***	0.049	0.005	0.044 ***
			(21.36)			(29.81)

Table 5

Controlling for the financial crisis of 2007–2008

This table shows the result for the regressions in equations (5) in the text. The table shows the results for the Nikkei 225 futures and the TOPIX futures, respectively. The rows for "overnight return," "extension," "crisis," "overnight return x extension," and "overnight return x crisis" show the coefficients of $R_{i,t}^{Overnight}$, $T_{i,t}^{Night}$, D_Crisis_t, $T_{i,t}^{Night} * R_{i,t}^{Overnight}$, and $D\_Crisis_t * R_{i,t}^{Overnight}$, respectively. The figures in parentheses are t-statistics based on the Newey-West standard errors. *, **, and *** indicate the two-sided statistical significance at the 10%, 5%, and 1% levels, respectively.

	Nikkei 225 futures	TOPIX futures
intercept	-0.00027	-0.00053 ***
	(1.60)	(3.81)
overnight return	-0.01180	-0.03834
	(0.54)	(1.54)
extension	0.00004 **	0.00007 ***
	(2.33)	(3.61)
crisis	0.00018	0.00027
	(0.61)	(0.75)
overnight return x extension	-0.00660 ***	-0.01061 ***
	(2.66)	(2.86)
overnight return x crisis	-0.04378	-0.10339 **
	(1.53)	(2.09)

Table 6

Controlling for market uncertainty and the bid-ask bounce

The panels show the results for the regressions in equations (6), (7), and (8) in the text. Panels (a) and (b) show the results for the Nikkei 225 futures and the TOPIX futures, respectively. The rows for "overnight return," "extension," "VIX," "overnight return x extension," "overnight return x VIX," and "bid-ask" show the coefficients of $R_{i,t}^{Overnight}$, $T_{i,t}^{Night}$, ΔVIX_{t-1}, $T_{i,t}^{Night} * R_{i,t}^{Overnight}$, $\Delta VIX_{t-1} * R_{i,t}^{Overnight}$, and $Sign(R_{i,t}^{Overnight}) * \text{bidask}_{i,t-1}$, respectively. The figures in parentheses are t-statistics based on the Newey-West standard errors. *, **, and *** indicate the two-sided statistical significance at the 10%, 5%, and 1% levels, respectively.

(a) Nikkei 225 futures

	model (6)	model (7)	model (8)
intercept	-0.00020	-0.00022	-0.00021
	(1.34)	(1.47)	(1.39)
overnight return	-0.03552 *	-0.04828 *	-0.04407 *
	(1.92)	(1.95)	(1.75)
extension	0.00004 **	0.00004 **	0.00004 **
	(2.28)	(2.30)	(2.29)
VIX	0.00550 *		0.00546 *
	(1.95)		(1.93)
overnight return x extension	-0.00495 **	-0.00473 **	-0.00465 **
	(2.17)	(2.02)	(2.05)
overnight return x VIX	-0.25538		-0.24629
	(1.42)		(1.34)
bid-ask		0.11838	0.09189
		(0.90)	(0.69)

(b) TOPIX futures

	model (6)	model (7)	model (8)
intercept	-0.00041 ***	-0.00047 ***	-0.00047 ***
	(3.06)	(3.82)	(3.78)
overnight return	-0.09171 ***	-0.09920 ***	-0.09524 ***
	(3.16)	(4.00)	(3.84)
extension	0.00006 ***	0.00006 ***	0.00006 ***
	(3.46)	(3.27)	(3.33)
VIX	0.00914 ***		0.00770 ***
	(3.33)		(3.69)
overnight return x extension	-0.00571 **	-0.00700 **	-0.00642 **
	(2.11)	(2.28)	(2.41)
overnight return x VIX	-0.32946		-0.20946
	(1.00)		(0.75)
bid-ask		0.28376 **	0.24843 **
		(2.42)	(2.12)

Table 7

Return reversal during afternoon sessions

Panel (a) shows the time-series analysis regarding the association between the overnight returns and the intraday returns during afternoon sessions (the results for the regression in equation (9)). The rows for "overnight return," "extension," and "overnight return x extension" show the coefficients of $R_{i,t}^{Overnight}$, $T_{i,t}^{Night}$, and $T_{i,t}^{Night} * R_{i,t}^{Overnight}$, respectively. Panel (b) shows the cross-sectional analysis regarding the association (the results for the regression in equation (10)). The rows for "overnight return," "NK," and "overnight return x NK" show the coefficients of $R_{i,t}^{Overnight}$, NK_i, and $NK_i * R_{i,t}^{Overnight}$, respectively. The figures in parentheses are t-statistics based on the Newey-West standard errors. *, **, and *** indicate the two-sided statistical significance at the 10%, 5%, and 1% levels, respectively.

(a) Time-series analysis

	Nikkei 225 futures	TOPIX futures
intercept	0.000	0.000
	(0.93)	(1.03)
overnight return	0.068	0.059 *
	(1.62)	(1.81)
extension	0.000	0.000
	(0.35)	(0.00)
overnight return x extension	0.003	0.006
	(0.60)	(1.05)

(b) Cross-sectional analysis

	The same trading-hours period	The different trading-hours period
intercept	0.000	0.000
	(0.67)	(0.83)
overnight return	0.068 *	0.067 *
	(1.73)	(1.81)
NK	0.000	0.000
	(0.08)	(0.53)
overnight return x NK	-0.010	0.022
	(0.17)	(0.38)

Table 8

Trading activity indicator

Panels (a) and (b) show the results for the regressions in equations (11) and (12), respectively. The rows for "overnight return," "extension," "turnover," "overnight return x extension," and "overnight return x turnover" show the coefficients of $R_{i,t}^{Overnight}$, $T_{i,t}^{Night}$, $TURN_{i,t}^{Night}$, $T_{i,t}^{Night} * R_{i,t}^{Overnight}$, and $TURN_{i,t}^{Night} * R_{i,t}^{Overnight}$, respectively. The figures in parentheses are t-statistics based on the Newey-West standard errors. *, **, and *** indicate the two-sided statistical significance at the 10%, 5%, and 1% levels, respectively.

(a) The effect on overreaction

	Nikkei 225 futures	TOPIX futures
intercept	0.000	0.000 ***
	(1.14)	(2.66)
overnight return	-0.030 *	-0.099 ***
	(1.78)	(3.70)
turnover	0.006 *	0.046 **
	(1.80)	(2.31)
overnight return x turnover	-0.924 ***	-4.664 ***
	(3.78)	(3.13)

(b) Incremental information of the indicator

	Nikkei 225 futures	TOPIX futures
intercept	0.000	0.000 **
	(1.32)	(2.55)
overnight return	-0.040 **	-0.110 ***
	(2.14)	(3.58)
turnover	0.003	0.037
	(0.56)	(1.18)
extension	0.000	0.000
	(0.69)	(0.46)
overnight return x turnover	-1.129 ***	-5.510 ***
	(3.65)	(3.09)
overnight return x extension	0.003	0.004
	(1.07)	(0.81)

Table 9

Night-session returns

This table shows the results for the regression in equation (12). The rows for “night-session return” and “opening return” show the coefficients of $R_{i,t}^{Night}$ and $R_{i,t}^{Opening}$, respectively. The figures in parentheses are t-statistics based on the Newey-West standard errors. *, **, and *** indicate the two-sided statistical significance at the 10%, 5%, and 1% levels, respectively.

	Nikkei 225 futures	TOPIX futures
intercept	0.000 *	0.000 *
	(1.83)	(1.81)
night-session return	-0.036 **	-0.098 **
	(2.17)	(2.08)
opening return	-0.142 ***	-0.256 ***
	(5.56)	(3.09)