Impact of information build-up on international stock market opening volatility

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ABSTRACT

This study examines the impacts of the length of trading hours and the timing of market opening on return volatilities in international stock markets. Using the absolute log return as a measure for market volatility, both Open-to-Close (OC) and Close-to-Open (CO) returns, are calculated for each market. The overnight volatilities (CO returns), are investigated across six Asian markets. Because information events presumably occur 24 hours a day, this implies more information must be absorbed at opening by markets with longer non-trading hours, causing greater volatility. However, the results do not show a clear relationship between the length of non-trading hours and overnight volatilities. In fact, the results show that markets with longer non-trading hours tend to instead have smaller overnight volatilities. In regard to the timing of opening hour, a market that opens first in the region has a higher overnight volatility and a market that opens last in the region has a lower overnight volatility.

Keywords: International stock markets, non-trading hours, return volatility

1. INTRODUCTION

This study is to examine whether the length of trading and non-trading hours and the timing of market opening will impact the return volatilities in international stock markets. In financial markets, information drives prices. However, no market is running on a 24-hour schedule. Different markets open and close at different times. Some open early while others open late, making the total trading hours also vary from market to market. Even though the level of information during non-trading hours is usually lower than trading hours, the occurrences of information events do not stop when a market is closed. Therefore, the amount of information being built up during the non-trading hours should be reflected at the opening of the market.

Over the years, many stock exchanges changed their trading hours. Some cited reasons are to better compete with other markets, to improve liquidity, and to provide a market for traders. For example, in August 2016, Korean Stock Exchange (KRX) extended its close hour to 3:30 p.m. from 3 p.m. "The KRX also wanted its trading hours to overlap by an additional 30 minutes with those of China's Shanghai and Shenzhen stock markets, taking into consideration the one-hour time difference. It said the move would help some securities here, such as exchange-traded funds that follow Chinese market indices, "better reflect information about Chinese markets."" [1]

Two major hypotheses that explain market volatilities include public information hypothesis and private information hypothesis. According to the public information hypothesis, both the trading-hours and non-trading hours volatilities should be affected since information is running on a 24-hours schedule. According to the private information hypothesis, trading-hours volatility will be higher than non-trading-hours volatility since private investors reveal information through trading. In literature, several studies investigate the stock market return volatilities due to information. For example, Andersen, Bollerslev and Cai (2000) find double U-shape patterns on the opening and closing returns of Nikkei 225 Index. They argue that the daily initial return reflects the overnight information accumulation. George and Hwang (2001) show that the level of information flow during trading hours is significantly higher than off hours. French and Roll (1986) attribute the cause of high volatility during trading hours to private information. Barclay, Litzenberger, and Warner (1990) compare the return volatilities between trading and non-trading hours using the US stocks traded on Tokyo Stock Exchange which opened three Saturdays for trading each month. Their findings show that regardless of whether or not a market is open on Saturday, the weekly volatility stays roughly the same. Their results imply that the information-driven volatility can be absorbed by longer trading hours and longer trading hours don't translate to higher volatility. Cliff, Cooper, and Gulen (2008) study S&P 500 from 1993 to 2006 and find that night returns are positive and significantly higher than day returns. Guner and Onder (2002) study the volatility of stock returns during trading and non-trading hours on Istanbul Stock Exchange. Their results show that opening prices calculate higher daily return volatility than closing prices. They attribute the findings to the long non-trading hours before opening. Chang, Rhee, and Tawarangkoon (1997) study the impact of the extended trading hours (i.e., shorter non-trading hours) in Thailand Stock Exchange and find an increased return variance during trading hours and a decreased return variance during non-trading hours. Huang, et al. (2000) show proof of private information hypothesis by finding higher return variances during trading hours than non-trading hours in Taiwan Stock Exchange.

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[1] "KRX feels heat from calls to cut trading hours", The Korea Herald, (http://www.koreaherald.com/view.php?ud=20181009000123&mod=skb)

Amihud and Mendelson (1991) find a higher open-to-open return volatility in the morning session in Tokyo Stock Exchange. They attribute the finding to the long overnight non-trading hours.

This paper investigates the overnight volatilities (i.e., volatilities from market close to market open) across several Asian markets. This is the first study to consider the effect of opening and closing hours across markets on overnight return volatilities. Three hypotheses are examined in this study. The first one is the impact of differences in the length of non-trading hours on overnight return volatilities of international stock markets. Where the non-trading hours are longer, a higher level of information will need to be absorbed when a market is opened since information events will not stop during non-trading hours. Therefore, a positive relationship between the length of non-trading hours and the overnight return volatility should be observed. The second one is the impact of the opening and closing timings on the overnight return volatility. The return correlations across international markets have been well documented. Therefore, the timing of a market's opening and closing compared to that of other adjacent markets could affect the amount of absorbance of overnight information on the opening prices. Over the years, markets adjusted their opening and closing hours. Some markets extend the opening hours to compete with other markets in the region, while some markets open earlier than others and some markets close later than others. During the time when some markets are open and the other markets are closed, news occurrences during non-trading hours would be reflected in the markets that are open first causing a higher level of opening volatility which results in a higher level of overnight volatility. Therefore, a market that opens first in a region would experience a high level of overnight volatility. The third one is the effect of information overlapping across markets. During the time when only a single or a few markets are open, the level of market volatility would be higher than when more markets are concurrently open. Therefore, for a market that opens last, most of the information has already been absorbed in other markets and, therefore, would experience a lower level of overnight volatility.

The remainder of the paper is structured into the following sections. Section 2 discusses the hypotheses and methodology. Section 3 describes the data. Section 4 reports the results. Section 5 concludes.

2. HYPOTHESES AND METHODOLOGY

2.1 Hypotheses

This study examines the impact of the length of non-trading hours and opening timing to the market overnight volatility. Specifically, the following three hypotheses are being proposed.

Hypothesis 1

Null Hypothesis:

H_0: Market overnight volatility is unrelated to the length of non-trading hours.

Alternative hypothesis:

H_A: A market with a longer length of non-trading hours will result in a higher degree of market overnight volatility.

Hypothesis 2

Null Hypothesis:

H_0: A market's overnight volatility is the same regardless of the opening hour of a market

Alternative hypothesis:

H_A: A market that opens first will experience a higher level of overnight volatility.

Hypothesis 3

Null Hypothesis:

H_0: A market's overnight volatility is the same regardless of the opening hour of a market

Alternative hypothesis:

H_A: A market that opens last will experience a lower level of overnight volatility.

Every market has a different opening hour and closing hour resulting in a different length of trading and non-trading hours. According to the first hypothesis, more information is accumulated overnight when the length of non-trading hours is longer since information can only be processed when a market is open, thereby making the overnight volatility higher. The second and third hypotheses relate the opening timing to overnight volatility. The international markets are intercorrelated. Therefore, the second alternative hypothesis states that for markets that are in the same region, the overnight volatility will be higher for the first opened market because a higher level of information will be reflected first when the market is opened. The third alternative hypothesis is related to the second one. For the market that opens last in a region, the overnight volatility should be lower since other markets have already been opened and processed the information.

2.2 Methodology

To investigate the effect of non-trading hours and opening timing on overnight volatility, the absolute log return is used a measure for market volatility. For each market, both the Open-to-Close (OC) and Close-to-Open (CO) returns are calculated. Since different markets have different total trading and non-trading hours, the hourly OC and CO returns are also provided.

- $OC_t=|\ln(Close_t)-\ln(Open_t)|$ (1)
  Where OC_t is the Open-to-Close volatility on day t, $Close_t$ is the closing price on day t, and $Open_t$ is the opening price on day t.
- $CO_t=|\ln(Open_{t+1})-\ln(Close_t)|$ (2)
  Where CO_t is the Close-to-Open volatility on day t, $Open_{t+1}$ is the opening price on day t+1, $Close_t$ is the closing price on day t.
- $OCH_t=|\ln(Close_t)-\ln(Open_t)|/Hour$ (3)
  Where OCH_t is the hourly Open-to-Close volatility on day t, $Close_t$ is the closing price on day t, $Open_t$ is the opening price on day t, and Hour is the total trading hours from open to close excluding lunch hours.
- $COH_t=|\ln(Open_{t+1})-\ln(Close_t)|/Hour$ (4)
  Where COH_t is the hourly Close-to-Open volatility on day t, $Open_{t+1}$ is the opening price on day t+1, $Close_t$ is the closing price on day t, and Hour is the total non-trading hours from close to open.

3. SAMPLE DESCRIPTION

There are six Asian markets under this study including Tokyo Stock Exchange (TSE), Korean Stock Exchange (KRX), Taiwan Stock Exchange (TWSE), Hong Kong Stock Exchange (HKEX), Shanghai Stock Exchange (SSE), and Indonesia Stock Exchange (IDX). The sample period is from 2016 to 2020. Each market opens and closes at different hours. Some markets have a lunch break while others do not. Because these markets are located in three different time zones, all of the hours in this paper are standardized in GMT (Greenwich Mean Time).

Table 1 (Appendix) lists market hours including the opening, closing, length of lunch break, total trading and non-trading hours for each market. TSE and KRX are in the same time zone; TWSE, SSE, and HKEX are in the same time zone; IDX is in a different time zone. In regard to the opening times, TSE and KRX open first, followed by TWSE, SSE, HKEX, and then IDX. KRX and TWSE do not have a lunch break while the other markets have lunch breaks with different length. Excluding the lunch hours, KRX has the longest trading hours of 6.5 hours while SSE has the shortest of 4 hours. In regards to the overnight non-trading hours, TWSE is the longest with 19.5 hours and IDX is the shortest with 17 hours.

The graph in Figure 1 (Appendix) shows clearly the opening and closing timing of the markets in the sample including their lunch hours. For example, among the markets, TSE and KRX open first at the same time at GMT 0. TSE closes at GMT 6 which is 30 minutes earlier than KRX. However, the total trading hour of TSE is 5 hours which is 1.5 hours shorter than that of KRX, because TSE has a one-hour lunch break from GMT 2:30 to 3:30, while KRX does not have a lunch break.

Figure 2 (Appendix) shows daily mean volatility in Panel A and hourly mean volatility in Panel B of each market for both the Open-to-Close (OC) and Close-to-Open (CO). In Panel A, the daily mean volatilities of most markets under study are higher during trading hours except TSE. In Panel B, the Open-to-Close hourly (OCH) volatilities do not include the lunch breaks. Since the length of non-trading hours is much longer than trading hours, the hourly mean volatilities are all smaller in non-trading hours. These results are consistent with previous studies.

4. RESULTS

Since the goal of this paper is to investigate the overnight information build-up, only overnight volatilities are focused in this section. Pairwise comparisons of the overnight market volatilities (Close-to-Open volatilities, or CO) across markets are first performed. The results are presented in Table 2 (Appendix). For each pair, the market with longer overnight non-trading hours is listed first. The number in paratheses is the length of overnight non-trading hours. For example, the first pair is TSE vs. KRX. TSE is closed for 18 hours, while KRX is closed for 17.5 hours. Therefore, the difference in overnight non-trading hours between TSE and KRX is 0.5 hours. The results show that the overnight volatilities for most markets are statistically different except between TSE and HKEX. For example, between TSE and KRX, TSE's Close-to-Open (CO) volatility is 0.12% higher than KRX's at the 1% significance level. According to the Hypothesis 1, the difference of overnight volatilities should be positive and statistically significant. However, a relationship between the length of non-trading hours and overnight volatilities is not clearly observed. Eight of fifteen pairs show that a market with longer non-trading hours has a lower level of overnight volatility, while six other pairs show the opposite. To further examine this relationship, multiple regressions are performed next.

Equation 5 estimates the effect of total non-trading hours on overnight volatility. CO vol is the overnight (Close-to-Open) volatility, CO hours is the length of overnight non-trading hours. To control the effect of trading hours volatility on non-trading hours volatility, following Huang et al. (2000), we include the variable of Open-to-Close volatility (OC vol). Moreover, to control for the overall market volatility, we include S&P 500 volatility (SPY vol) from the previous trading day. Bagnoli, Clement, and Watts (2006) find that announcements made on Fridays tend to be negative compared to other days. To capture this effect, a dummy variable, Friday, is included, which equals 1 if overnight volatility is from the close of Friday to the open of Monday. Finally, year dummies are included to control the yearly effect.[2] Table 3 (Appendix) shows the results.

$$\text{COvol}_{i,t} = \alpha_0 + \alpha_1 \text{CO hours}_{i,t} + \alpha_2 \text{OC vol}_{i,t} + \alpha_3 \text{SPY vol}_{i,t} + \alpha_4 \text{Friday} + \alpha_5 \text{Year2017} + \alpha_6 \text{Year2018} + \alpha_7 \text{Year2019} + \alpha_8 \text{Year2020} + \varepsilon_{i,t} \quad (5)$$

In Model 1 of Table 3, the coefficient of CO hours is negative and statistically significant at the 1% level. It shows that if a market has longer non-trading hours, its overnight volatility tends to be smaller. Surprisingly, this result is different from the alternative hypothesis 1, which states a positive relationship between the length of non-trading hours and overnight volatility.[3] Two possible explanations are proposed to this result. First, a market with longer non-trading hours allows investors to better digest the overnight news before the market is opened resulting in a lower level of overnight volatility. Another possible reason is that a market with longer non-trading hours is the one that closes when other markets are still open, and, therefore, results in a lower level of overnight volatility. The coefficient of Friday is positive and statistically significant at the 1% level. Therefore, the weekend news accumulated over the weekend is reflected on the market opening on Monday, which makes the non-trading hours volatility higher.

To test the other hypotheses, two variables to Equation 5 are added including First Open and Last Open. Among the six markets in this study, First Open equals 1 if a market is the first one to open and Last Open equals 1 if a market is the last one to open. The hypothesis states that if a market is the first one to open, the overnight information will be reflected first when it opens. Therefore, its overnight volatility will be higher. Conversely, a market that opens last should experience a lower overnight volatility since most of the information has already been processed while all the other markets are open. The results are presented in Models 2 to 4 of Table 3. Model 2 includes First Open; Model 3 includes Last Open; and Model 4 includes both. The coefficient of First Open in Model 2 is positive and statistically significant at the 1% level. The result confirms the Alternative Hypothesis 2, which states that overnight volatility will be higher if a market is opened first. The coefficient of Last Open in Model 3 is negative and statistically significant at the 1% level. The result confirms the Alternative Hypothesis 3, which states that overnight volatility will be lower if a market is opened last. Finally, Model 4 includes all variables. All of the coefficients have the same signs and statistical significance levels as in the previous three models.

5. CONCLUSION

This paper investigates the effect of non-trading hours and opening timing on overnight volatility. When examining the cross-country volatilities, most markets have statistically

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[2] Yearly coefficients are not reported. They are available upon request.

[3] Among the six markets, TWSE has the longest non-trading hours (19.5 hours). Since Table 2 (Appendix) shows that TWSE tends to have a lower overnight volatility when compared with other markets. To prevent the possibility that the regression result is driven by TWSE, we rerun the model without TWSE and find similar results which are available upon request.

different overnight volatilities. Three hypotheses are tested. The first is the impact of the length of non-trading hours on overnight volatility. The second and third hypotheses examine the impact of the timing of market opening on overnight volatility. The result shows that a market with longer non-trading hours tends to have a smaller overnight volatility. This result is different from the hypothesis. One reason could be that longer non-trading hours allow a market to better digest the overnight information before a market is opened. Another possible reason is that a market with longer non-trading hours is the one that closes when other markets are still open and therefore results in a lower level of overnight volatility. In regard to the timing of opening hour, a market that opens first in the region has a higher overnight volatility because it is the first market to absorb the overnight information. A market that opens last in the region has a lower overnight volatility because other markets have already been opened and processed the information.

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Table 1 - Market Hours in GMT (Greenwich Mean Time)

Table 1 lists the market, open time, close time, lunch hours, total trading hours, total non-trading hours, and the local time. Because these markets are located in different time zone, all times are standardized in GMT (Greenwich Mean Time).

Market	Open Time in GMT	Close Time in GMT	Lunch Hours	Total Trading Hours	Total Non-trading Hours	Local Time in GMT
Tokyo Stock Exchange	0:00	6:00	2:30 to 3:30	5	18	GMT+9
Korea Stock Exchange	0:00	6:30	n.a.	6.5	17.5	GMT+9
Taiwan Stock Exchange	1:00	5:30	n.a.	4.5	19.5	GMT+8
Shanghai Stock Exchange	1:30	7:00	3:30 to 5:00	4	18.5	GMT+8
Hong Kong Stock Exchange	1:30	8:00	4:00 to 5:00	5.5	17.5	GMT+8
Indonesia Stock Exchange	2:00	9:00	4:30 to 6:30	5	17	GMT+7

Table 2 – The mean overnight volatility difference between markets from Year 2016 to 2020

Table 2 provides the pairwise comparisons of Close-to-Open volatility differences between two markets. For each pair, the one with longer non-trading hours is listed first. The number in parentheses is the total non-trading hours for each market.

Paired markets (non-trading hours)	Difference in hours	Close-to-Open volatility difference
TSE (18) vs. KRX (17.5)	0.5	0.0012**
TWSE (19.5) vs. TSE (18)	1.5	-0.0023**
TSE (18) vs. IDX (17)	1	0.0025**
TSE (18) vs. HKEX (17.5)	0.5	-0.0001
TWSE (19.5) vs. KRX (17.5)	2	-0.0011**
IDX (17) vs. KRX (17.5)	0.5	-0.0013**
TWSE (19.5) vs. IDX (17)	2.5	0.0002*
TWSE (19.5) vs. HKEX (17.5)	2	-0.0024**
HKEX (17.5) vs. KRX (17.5)	0	0.0012**
HKEX (17.5) vs. IDX (17)	0.5	0.0026**
SSE (18.5) vs. TSE (18)	0.5	-0.0019**
SSE (18.5) vs. HKEX (17.5)	1	-0.0021**
SSE (18.5) vs. KRX (17.5)	1	-0.0008**
SSE (18.5) vs. IDX (17)	1.5	0.0006**
TWSE (19.5) vs. SSE (18.5)	1.5	-0.0004*

* $p<0.05$; ** $p<0.01$

Table 3 - Regression results

Table 3 reports OLS regression analysis. The independent variable Overnight Volatility is defined as $CO_t=|\ln(Open_{t+1})-\ln(Close_t)|$, where CO_t is the Close-to-Open volatility on day t, $Open_{t+1}$ is the opening price on day t+1, $Close_t$ is the closing price on day t. CO hours is the length of overnight non-trading hours. OC vol is the Open-to-Close volatility, defined as $OC_t=|\ln(Close_t)-\ln(Open_t)|$, where OC_t is the Open-to-Close volatility on day t, $Close_t$ is the closing price on day t, and $Open_t$ is the opening price on day t. SPY vol is S&P 500 volatility from the previous trading day. Friday equals 1 if overnight volatility is calculated from the close of Friday to the open of Monday. Yearly dummies are included but not reported in the table.

	Overnight Volatility			
	(1)	(2)	(3)	(4)
CO hours	-0.00002	-0.00002	-0.00002	-0.00002
	(3.10)**	(2.83)**	(3.58)**	(3.26)**
OC vol	0.0696	0.0781	0.0701	0.0762
	(3.89)**	(4.41)**	(3.92)**	(4.31)**
SPY vol	0.0520	0.0508	0.0519	0.0510
	(3.79)**	(3.74)**	(3.82)**	(3.78)**
Friday	0.0006	0.0006	0.0005	0.0005
	(3.67)**	(3.77)**	(3.63)**	(3.71)**
First Open		0.0011		0.0008
		(9.55)**		(6.40)**
Last Close			-0.0015	-0.0012
			(14.38)**	(9.84)**
Constant	0.0030	0.0026	0.0033	0.0029
	(13.83)**	(11.73)**	(15.21)**	(13.01)**
R^2	0.06	0.08	0.08	0.09
N	4,986	4,986	4,986	4,986

* p<0.05; ** p<0.01

Figure 1 – Trading hours

Figure 1 shows each market's total trading hours and lunch hours. It also shows the opening and closing hours in GMT (Greenwich Mean Time).

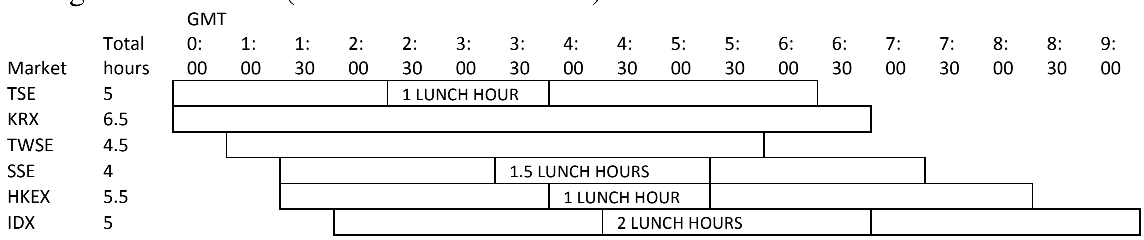
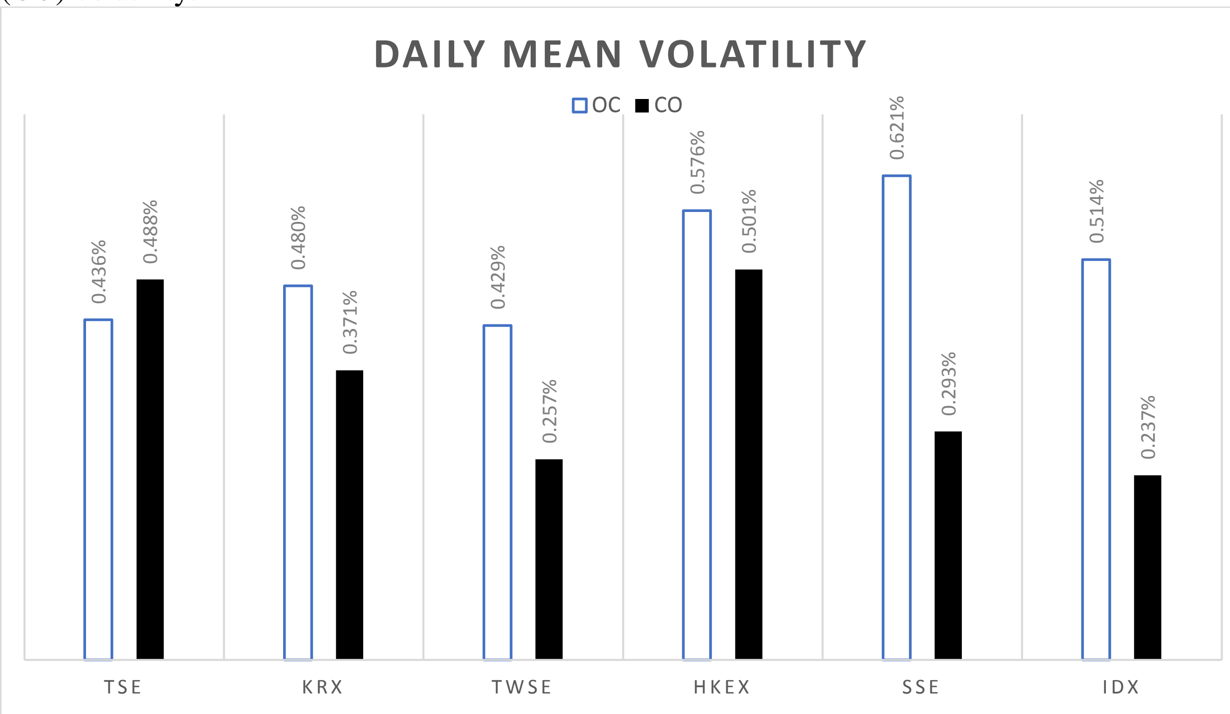


Figure 2 – Mean Volatility

Panel A: Daily Mean Volatility
In Panel A, Daily Mean Volatility includes Open-to-Close (OC) volatility and Close-to-Open (CO) volatility.



Panel B: Hourly Mean Volatility
In Panel B, Hourly Mean Volatility includes Hourly Open-to-Close (OCH) volatility and Hourly Close-to-Open (COH) volatility.