Market Interaction Analysis: The Role of Time Difference

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We study the feature of market interaction: Even-linked interaction and direct market interaction. The event-linked interaction represents the connection between the triggering events and the market responses; and the direct market interaction is the market response to the other market's fluctuation. Since the existence of the event-linked interaction prevents the detection of the direct interaction, we propose a framework to analyze market interaction using time difference technique, and this in turn will help us to identify the direct interaction otherwise impossible to detect. To test our proposed framework, we conduct an empirical examination on the Chinese and U.S. stock markets.

INTRODUCTION

In the past few decades there has been an increase in economic integration across economies. As larger flows of capital are traded across countries, the capital markets exert enormous impact on the world economy, (e.g. today's total derivatives market has been more than ten times the size of the entire world economy). In view of the increased integration of the global economy, it may lead to higher correlation of equity markets across countries. There has been much empirical work that examines the international financial market linkages - for example, studies of international stock return co-movement (see Bekeart et al., 2009; Karolyi and Stulz , 1996; Brooks and Negro, 2004; Kaplanis, 1988; Bing et al., 2010; Chow and Lawler, 2008), and studies of correlation of international markets (see Solnik et al., 1996; Longin and Solnik, 2001; Longin and Solnik, 1995; Campbell and Hamao, 1992). This study proposes a framework that has not been used previously to the best of our knowledge to analyze market interaction.

We consider a change in a stock market to be a quick response to all triggering events (for the concept of efficient market hypothesis, see Fama, 1970). To study the feature of market interaction, we construct two cases as shown in Fig. 1. The first case depicts two independent markets linked only through the triggering event as shown in Fig.1(a). The second case illustrates that in addition to the links between the markets and the event, the two markets also have a direct interaction with each other, as shown in Fig. 1(b).

FIGURE 1
THE FEATURE OF MARKET INTERACTION

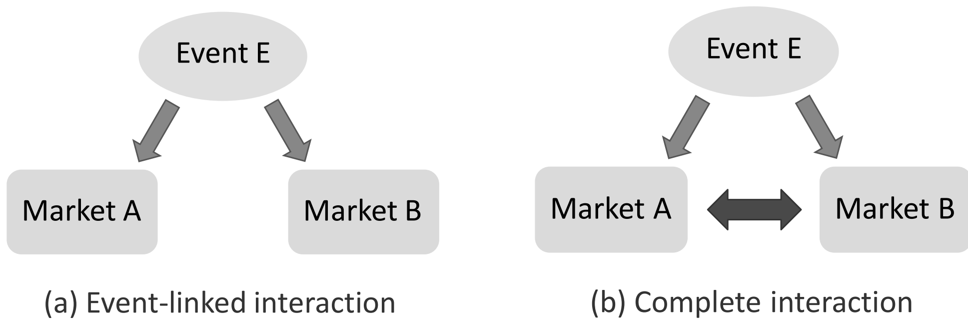

FIGURE 1. Figure (a) depicts two independent markets, A and B, linked only through the triggering event E. Figure (b) illustrates that in addition to the links between the markets and the event E, market A and B also have a direct interaction with each other.

How can we know whether direct interaction exists between the highly correlated two markets? Since it is difficult to observe its existence, direct market interaction has largely been ignored in literature. Considering the importance of stock market integration for research and practice in international finance, we develop a novel framework to analyze market interaction using time difference technique, and this in turn will help us to identify the direct interaction otherwise impossible to detect.

Finally, we apply an empirical example to our proposed framework by examining correlations between Chinese and U.S. stock markets. As we know, Chinese and U.S. stock markets have distinct time difference--they never open at the same time, so they are a perfect example of two markets with time difference. The results suggest that U.S. and Chinese markets have a direct interaction. We also find that the U.S. market has greater influence on the Chinese market than the Chinese market has on the U.S. market.

The paper is organized as follows. The next section presents a theoretical framework regarding market interaction. Section 3 describes the role of time difference in market interaction. Section 4 presents empirical results of interactions between Chinese and U.S. stock markets, followed by our conclusions in Section 5.

MARKET INTERACTION THEORY

We consider market fluctuation to be the result of market responses to particular events thus, we establish an association between the triggering event and the market response as shown in Fig. 1. Two cases are offered to help us understand market interaction. The first case is a relatively simple one called "the event-linked interaction" in this study. As illustrated in Fig. 1(a), we consider the two markets, A and B, to be mutually independent (meaning that there is no trading and/or economic dependence between these two markets). When an event E happens, both markets are affected by this event. Because they respond to the same event, these two markets may be correlated through the event E.

The other case fits more with real markets. It is named "complete interaction" in this study. A sketch of this kind of interaction is shown in Fig. 1(b). In addition to the links between the market and the event, both markets also have direct interactions between each other as the two-way arrow indicates. The response of one market is not only affected by the event, but also by the other market. While a connection of this kind may be assumed, the direct interaction cannot be easily detected. The existence of the event-linked interaction prevents the detection of the direct-interaction. For example, when the two markets are highly correlated, how can we know whether direct interaction exists between the two markets?

TIME DIFFERENCE IN MARKET INTERACTION

In the above section, we discussed market interactions in two different cases (see Fig. 1) leaving one question unsolved. If the market A and B in Fig. 1 are correlated, how do we know if there is any direct interaction between the two markets? It is hard to directly answer the question because the correlation itself does not tell whether it is due to the direct interaction or due to triggering events.

Let us introduce the framework that includes the time difference. If a market opens at 9 A.M. and closes at 4 P.M., the net change of the daily market (the closing price minus the previous closing price) essentially reflects the effects of all events that happened between 4 P.M. yesterday and 4 P.M. today, as in the effective market hypothesis. Let us assume two markets A and B have a time difference, which means they are not open at the same time. When an event E happens, it may first affect one market (for example, Market A), and then the other one (Market B). If the event-linked interaction is the only interaction (i.e., there is no existence of direct interaction) as in the case depicted in Fig. 1(a), both markets respond to the event only. The sequence of the market response will have no effect. In other words, whether the Event E affects Market A or Market B first, their market responses will not change.

FIGURE 2
TIME DIFFERENCE IN MARKET INTERACTION WHEN THE TWO MARKETS HAVE A DIRECT INTERACTION

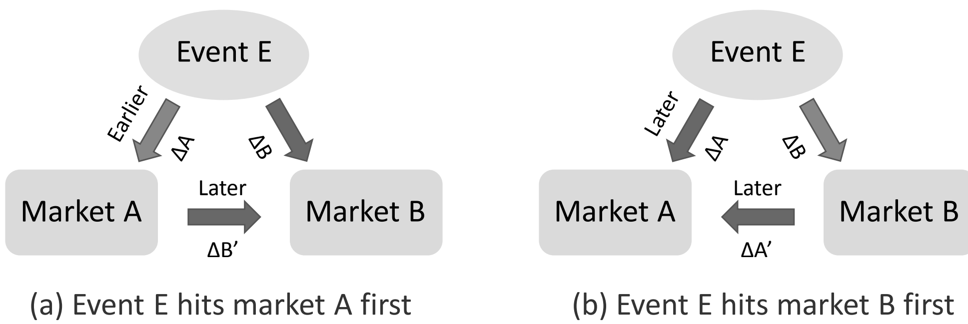

FIGURE 2. Figure (a) shows that market A has a change of ΔA when the even E affects market A first. Later when market A closes and market B opens, market B is affected by both the event E and the change of market A, ΔB+ΔB'. Figure (b) shows that the market A has a change of ΔA+ΔA' when the event E affects market B first.

However, if two markets have a direct interaction as shown in the case of Fig. 1(b), the earlier market's response to event E may influence the later market. Then, the time sequence of the event E on markets A and B may affect the market responses. Fig. 2 illustrates the case of Fig. 1(b) market interactions (complete-interaction scenario) with the time difference. Here we assume that when one market opens, the other market closes due to the time difference. In Fig.2 (a), the event E affects Market A first, and Market A will have a change of ΔA. Later, Market A closes and Market B opens. Besides the effect of the event E, the change of Market A plays an additional interaction on Market B. Thus, Market B will have a change of ΔB+ΔB', where ΔB' is from the direct interaction of Market A. Similarly, in Fig. 2(b), when event E affects Market B first, Market A will have a change of ΔA+ΔA', while Market B will have a change of ΔB. Thus, when time difference is involved we expect a different correlation between the two markets.

In the above, we discussed how time difference changes the market correlation when only one event is involved (e.g., event E in our example). Because the market responds to macroscopic events, as well, we need to treat all events from a statistical perspective. If we assume that numerous events happened during the specified time, then we may argue that affect-Market A-first events and affect-Market B-first events will have the same macroscopic effect on the market. This is similar to throwing a very large number of coins--they will come up with 50 percent heads and 50 percent tails. Thus, we maintain the symmetry of the events when we divide events into two groups: affect-Market A-first events and affect-Market B-first events. Then it is statistically reasonable to compare market correlations to disclose the characteristics of market interaction.

FIGURE 3
FOUR TIME INTERVALS OF DAILY EVENTS BETWEEN U.S. AND CHINESE STOCK MARKETS

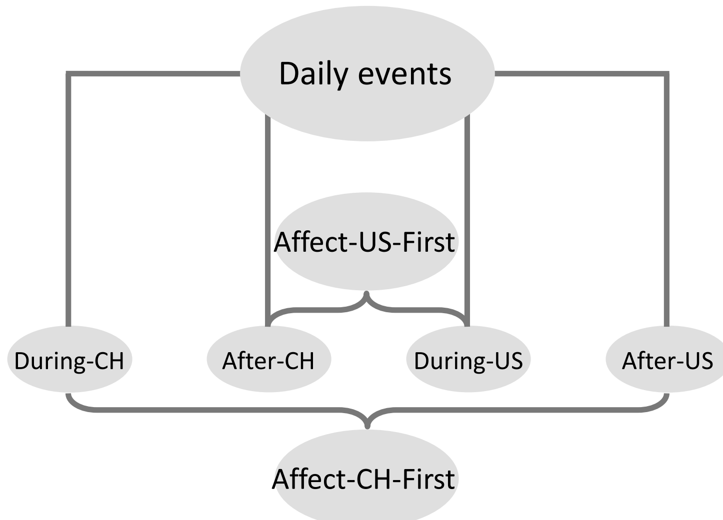

FIGURE 3. This figure shows that we divide daily events that happened within twenty four hours into four time intervals. "During-CH" includes all events that happened when the Chinese market opens; "After-CH" includes all events that happened after the Chinese market was closed and before the U.S. market was open; "During-US" include all events that happened when the U.S. market was open; "After-US" includes all events that happened after the U.S. market was closed and before the Chinese market was open.

EMPIRICAL ANALYSIS OF MARKET INTERACTIONS

In the following we examine correlations between the Chinese and U.S. stock markets to analyze market interaction. The opening times distinctly differ for the two markets. When one market opens, the other market closes. Thus we divide daily events that happened within twenty four hours into four time intervals as shown in Fig. 3. The time interval of “During-CH” includes all events that happened when the Chinese market was open; “After-CH” includes all events that happened after the Chinese market closed and before the U.S. market opens; “During-US” includes all events that happened when the U.S. market was open; “After-US” includes all events that happened after the U.S. market closed and before the Chinese market was open. Events that happened During-CH and After-US are considered as Affect-CH-First events, and events that happened After-CH and During-US are considered as Affect-US-First events. Figure 3 illustrates the concept of “earlier market” and “later market” for the specified Chinese and U.S. markets within the framework of time difference. Therefore, the Chinese market will be the earlier market for Affect-CH-First events, and the U.S. market will be the earlier market for Affect-US-First events.

Data

For statistical purposes, we focus on the Shanghai Shenzhen CS1300 index (0003000.SS)--jointly compiled by the Shanghai Stock Exchange and the Shenzhen Stock Exchange for the Chinese stock market, and the Standard and Poor's 500 index (S&P) for the U.S. stock market.

FIGURE 4
DATA SELECTION PROCESS

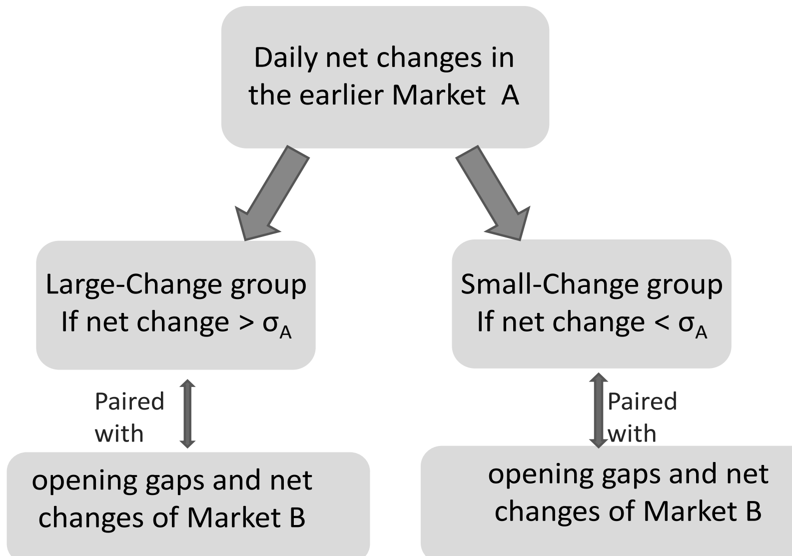

FIGURE 4. This figure demonstrates how a daily change of Market A matched with a daily change and an opening gap of Market B. First, daily changes in Market A are categorized into two groups: the Large-Change group vs. the Small-Change group. When the absolute value of a daily change in Market A is larger than the standard deviation of Market A (σ_A), it is classified within the Large-Change group; otherwise, it is classified within the Small-Change group. Every daily change in the market A is paired with a daily change and an opening gap in Market B according to the time sequence.
*In this figure, Market A is assumed as the earlier market and Market B the later market.

It is important to note that the Chinese CS1300 Index was created in the middle of 2005. Thus, we have collected data for daily percentage changes (the percentage change of the previous closing price and the current closing price) and the percentage changes of opening gaps (the difference between the previous closing price and the current opening price) of the Chinese (CS1300) and the U.S. (S&P 500) markets starting from the first trading day of 2006 to the last trading day of 2011. Furthermore, we also use the Shanghai Composite Index (SCI) 000001.SS data, in place from 1990 to the middle of 2005, to serve as a robustness test for the period from 2000-2005.

Methodology

In order to identify direct market interaction, we need to focus on relatively large market fluctuation of the earlier market, since a small fluctuation of one market may have little influence on the other market. We have categorized the data of daily changes of the earlier market into two groups: the Large-Change group and the Small-Change group. When the absolute value of a daily change in the earlier market is larger than the standard deviation of the market, it is classified within the Large-Change group. If the absolute value of a daily change is smaller than the standard deviation, then it is classified within the Small-Change group.

Every daily change in the earlier market is paired with data (an opening gap and a daily change) in the later market according to the time sequence. Fig. 4 demonstrates the grouping and paring process, assuming Market A is the earlier market and Market B is the later market. If the paired opening gap and net change of the later market does not exist due to the holidays, etc., then the observation has been dropped from the sample.

TABLE 1
SUMMARY STATISTICS FOR U.S. AND CHINESE STOCK MARKETS DATA (2006-2011)

Variable (%)	Obs. (n)	Mean	Std. Dev.	Min	Max	Large-Change group (n)
CH Absolute Daily Change	1,414	1.494	1.4215	0	9.3418	555
US Absolute Daily Change	1,415	1.003	1.1817	0	11.58	398
CH Daily Change	1,414	0.084	2.0612	-9.24	9.3418	364
US Daily Change	1,415	0.013	1.55	-9.035	11.58	277

This table reports the statistics of the daily percentage changes of U.S. S&P 500 Index and Chinese CSI 300 Index for the sample period January 1, 2006 through December 31, 2011. Daily percentage change is the difference between the closing index and the previous closing index divided by the previous closing index. Daily changes in both absolute value and signed value are reported. The data of daily changes are categorized into two groups: the Large-Change group and the Small-Change group. The last column reports the numbers of observations of the Large-Change group when the daily change is greater than standard deviation (>σ).

Correlation Test

Table 1 provides the sample statistics. There are 1,414 observations of daily net changes of CSI300 Index from 2006 to 2011 when the Chinese stock market is treated as the earlier market, and 1415 observations of daily changes of S&P 500 Index in the same period when the U.S. market is the earlier market. Table 1 reports the statistics of both daily changes and absolute daily changes of both markets. The absolute daily changes provide unidirectional amplitude of market fluctuation, while the daily changes provide the directional market fluctuation. Examining correlations on absolute daily changes between the U.S. and Chinese markets reveal the transmission of volatility between these markets; and examining correlation on daily changes between U.S. and Chinese markets help us characterize the market interaction and further identify the direct market interaction. The standard deviation of *absolute* daily changes in CSI 300 Index is 1.422%, while the standard deviation of *absolute* daily changes in the S&P 500 index is 1.182%. The standard deviation of daily changes in the CSI 300 Index is 2.06%, while the standard deviation of daily changes in S&P 500 index is 1.55%. There are 555 observations included in the Large-Change group that have *absolute* daily changes larger than the standard deviation in the Chinese market, and 398 *absolute* daily changes in the U.S. market included in the Large-Change group. Regarding total daily changes, there are 364 total daily changes in the Chinese market classified in the Large-Change group, and 277 total daily changes in the U.S. market classified in the Large-Change group.

We propose that if the earlier market has a large fluctuation it may lead to a bigger fluctuation in the later market. In Table 2, we analyze the magnitude of the daily net change; thus, only the absolute values of changes are used. Panel A of Table 2 reports the results when the Chinese market is treated as the earlier market. For each daily change of the Chinese market, a subsequent daily change and opening gap of the U.S. market in the next trading day are collected. When the Chinese market is treated as the earlier market, there are 555 absolute daily changes classified into the Large-Change group of the Chinese market as reported in Table 1, that are paired with daily changes and opening gaps of the U.S. market in time sequence. As Panel A of Table 2 shows, the mean of opening gaps and daily changes of the U.S. market corresponding to the Chinese Large-Change group are 0.13% and 1.12%, respectively. Similarly for 859 observations in the Small-Change group of the Chinese market, we find that the average opening gap and daily change of the paired US market are 0.09% and 0.92%. The T-test shows that the average opening gap of the U.S. market corresponding to China's Large-Change group is significantly higher than that of the U.S. market corresponding to China's Small-Change group at P<0.001. We further find that the daily net change of the U.S. market for Large-Change group is also significantly higher than that of the U.S. market for the Small-Change group at P=0.002. The significant difference between the two groups verifies that a large volatility in the Chinese market is more likely to lead to bigger volatility in the U.S. market. Also, the t-value of the opening gap is larger than that of daily change between the two groups, as we expected, since the opening gap of the later market (U.S. market) does not reflect During-US events that happened when the later market was open.

TABLE 2
ASSOCIATION IN VOLATILITY BETWEEN U.S. AND CHINESE STOCK MARKETS (2006-2011)

Panel A – Chinese market is the earlier market				
	Mean		t- Stat	p
	Large-Change Group	Small-Change Group		
U.S. Opening Gap (%)	0.13	0.09	4.07	0.000***
U.S. Daily Change (%)	1.12	0.92	2.93	0.002***
n	555	859		
Panel B – U.S. market is the earlier market				
	Mean		t- Stat	p
	Large-Change Group	Small-Change Group		
CH Opening Gap (%)	0.95	0.4	10.55	0.000***
CH Daily Change (%)	1.68	1.42	3	0.001***
n	398	1,117		

This table uses the Small-Change group as the control group and the Large-Change group as the testing group to examine the association in volatility between the two groups in both Chinese and U.S. markets. All data are in absolute value. Panel A reports that when the Chinese market is treated as the earlier market, the means of daily changes and opening gaps of the U.S. market paired with the Large-Change group in Chinese market are significantly higher than those of the U.S. market paired with the Small-Change group in Chinese market. Penal B reports the results when the U.S. market is the earlier market.
*, **, *** Indicate significant at 10%, 5%, and 1%, respectively.

Similarly, Panel B of Table 2 summarizes the results when the U.S. market is the earlier market. Corresponding to the Large-Change group in the U.S. market, the paired opening gaps and daily changes of the Chinese market have a mean value of 0.95% and 1.68%. In contrast, the paired opening gaps and daily changes of the Chinese market to the Small-Change group of the U.S. market have a mean value of 0.4% and 1.42%. Again, both the opening gap and the daily change of the Chinese market that are paired for the Large-Change group of the U.S. market are significantly higher than those of the Chinese market paired for the Small-Change group of the U.S. market. The significant difference between the two groups further suggests the positive volatility correlation between Chinese and U.S. markets from 2006 to 2011.

In Table 2, we use the Small-Change group as the control group and the Large-Change group as the testing group. The significant differences between the two groups suggest that there is strong association in volatility between Chinese and U.S. markets. Next we examine whether there is significant correlation between these two markets, and how these two markets are related. Based on the results of the volatility test, we find that the Large-Change group may have higher correlation, and we predict intuitively that a less volatile market has little influence on the other market. So we focus only on correlations in the Large-Change group when we perform the correlation test. Unlike the volatility test, the correlation test is directional. Thus in Table 3, instead of absolute values, signed values are used in the correlation analysis.

We first assume that the Chinese market is the earlier market. Daily changes of the Chinese CSI300 Index from 2006 to 2011 are classified into a Large-Change group and a Small-Change group based on the method elaborated above (refer to Fig. 4). With the same matching procedure, each daily change of a Large-Change group in a Chinese market is matched with a daily change and an opening gap of the U.S. market. Panel A of Table 3 reports the correlations between observations of the large-Change group in the earlier market (China) and paired observations in later market (U.S.). Then, we assume that the U.S. market is the earlier market compared to the Chinese market. Similarly, all daily changes of the U.S. market S&P 500 Index are classified within Large-Change group and Small-Change group. Within the data of the Large-Change group in the U.S. market, each daily change is paired with a daily change and an opening gap of the Chinese market. Panel B of Table 3 reports the results when the U.S. market is the earlier market.

TABLE 3
CORRELATION BETWEEN U.S. AND CHINESE STOCK MARKETS (2006-2011)

Panel A – Chinese market is the earlier market					
	Mean	Std. Dev.	r with CH	t- Stat	p
Opening Gap (%) (n=1,414 pairs)	-0.0193	0.2467	0.2432	4.77	0.000***
Daily Change (%) (n=1,414 pairs)	-0.00385	1.91	0.1144	2.19	0.03**
Panel B – U.S. market is the earlier market					
	Mean	Std. Dev.	r with US	t-Stat	P
Opening Gap (%) (n=1,415 pairs)	-0.186	1.572	0.742	18.4	0.000***
Daily Change (%) (n=1,415 pairs)	-0.183	2.38	0.278	4.81	0.000**

This table reports the correlation between the U.S. and the Chinese markets. Signed values are used in this correlation analysis. Panel A reports the correlations between the observations of the earlier market (China) and the paired observation in later market (U.S.). Panel B reports the results when the U.S. market is the earlier market.
*, **, *** Indicate significant at 10%, 5%, and 1%, respectively.

Panel A of Table 3 reports a correlation coefficient of 0.24 between the daily changes of the earlier Chinese market and the following opening gaps of the later U.S. market, and a correlation coefficient of 0.11 between the daily changes of the earlier Chinese market and the following daily net changes of the later U.S. market. To test the significance of the correlation coefficients, we use the formula $t = r\sqrt{(n-2)/(1-r^2)}$, where n is the sample size and n-2 is the degree of freedom. T-test shows that the Chinese market has a highly significant positive correlation ($P<0.001$) to the U.S. market when the Chinese market has a relatively large fluctuation. As expected, the opening gap of the U.S. market shows a larger association with the earlier Chinese market than the daily change of the U.S. market does.

Similar calculations are performed when the U.S. market is treated as the earlier market as reported in Panel B of Table 3. Both the opening gaps and daily changes of the later Chinese market are highly associated with the earlier U.S. market, with correlation coefficients of 0.742 and 0.278, respectively. The t-tests of both correlations are highly significant at $P<0.001$. The correlation test verifies a strong positive correlation between Chinese and U.S. markets. We notice that t values in Panel A are much higher than the t values in Panel B, as well as noting the statistical significance indicated by p value. These results suggest that the U.S. market has a larger influence on the Chinese market than the Chinese market has on the U.S. market.

Test of Direct Interaction

The results reported in Tables 2 and 3 provide us enough evidence to acknowledge the existence of interactions between Chinese and U.S. markets. We now move to identify the existence of the direct market interactions which are directly caused by the market fluctuations. A visualized form of direct market interactions can be described as ΔB' and ΔA' in Fig. 2. As we discussed in the "Time difference" section, if two markets do not have direct interaction but are only event-linked interactions, we should not expect the time difference effect on the two markets because the change of one market does not influence the other market.

TABLE 4
DIRECT INTERACTION BETWEEN U.S. AND CHINESE STOCK MARKETS (2006-2011)

	r (US-CH)	r (CH-US)	z (US-CH)	z (CH-US)	Diff. z	P
Opening gap (%)	0.742	0.2432	0.955	0.2482	8.821	0.000***
Daily change (%)	0.278	0.1144	0.286	0.1149	2.13	0.033**

This table reports the differences between the correlation of CH-US (when Chinese market is the earlier market) and the correlation of US-CH (when U.S. market is the earlier market). z reports z score of Fisher's transformation for sample correlation coefficient r. the differences in z score indicate that the correlation coefficients between U.S. and Chinese stock markets are statistically different when U.S. market is the earlier market vs. when Chinese is the earlier market.
*, **, *** Indicate significant at 10%, 5%, and 1%, respectively.

In other words, if two markets with time difference have direct interactions, we expect a different correlation between the two markets--there will be different interactions depending on which market is the earlier market compared to the other market. Column 1 of Table 4 reports the results when the Chinese market is the earlier market and the U.S. market is the later market for the time intervals of After-US and During-CH. Events that happened during these two time intervals will be defined as Affect-CH-First events (see Fig. 3). Column 1 reports the CH-US correlation coefficients between the earlier Chinese market and the following opening gaps, as well as daily changes of the U.S. market, 0.243 and 0.114, as reported in Panel A of Table 3. Similarly, Column 2 of Table 4 reports the results when the U.S. market is the earlier market and the Chinese market is the later market for the time intervals of After-CH and During-U.S. Events that happened when the U.S. market is the earlier market will be Affect-US-First events. When the U.S. market is the earlier market, the US-CH correlation coefficients of opening gaps and daily net changes between the U.S. market and the Chinese market are 0.742 and 0.278, as reported in Panel B of Table 3.

To examine whether the correlations of CH-US and US-CH are statistically different, we use the Fisher transformation, which was developed by Fisher to transform the correlation distribution to approximate normal distribution, and extensively applied to test the difference in correlation coefficients (Fisher (1915) and Fisher (1921)). The transformation is defined by $Z = ln\left(\frac{1+r}{1-r}\right)/2$ for each correlation coefficient and the Z score thus is $Z = \frac{Z_1-Z_2}{\sqrt{\frac{1}{N_1-3}+\frac{1}{N_2-3}}}$, where Z_1 is the transformation of US-CH correlation coefficient and Z_2 is the transformation of CH-US correlation coefficient in this case. The results are summarized in column 3 and 4 of Table 4. The two-tailed z test is used to test the significance. The result shows a very large difference in the opening gap between US-CH and CH-US at p=0.000, and a significant difference in the daily net change at p=0.03. The difference of the correlation coefficients indicates the existence of the direct interactions between U.S. and Chinese markets since 2006. The difference is related to the intrinsic differences of the two markets, as well as the association between the earlier market and the triggering events. The statistical significances indicate that there are direct market interactions between the Chinese market and the U.S. market, in addition to event-linked interactions.

Extended Tests

We extend our analysis for the period from 2000 to 2005. Because Shanghai Shenzhen CSI 300 index was created in the middle of 2005, Shanghai Composite index, 000001.SS, is used as the typical index for the Chinese stock market before 2006. At that time the Chinese market and its economy were in a fast-developing stage but with a much smaller size and impact to the world economy. Its liberalization and integration were much less than today. So we expect that there was much less interaction between the Chinese market and the U.S. market during this period.

TABLE 5
CORRELATION BETWEEN U.S. AND CHINESE STOCK MARKETS (2000-2005)

Panel A – Chinese market is the earlier market				
	Mean	Std. Dev.	r with CH	t-Stat
Opening Gap (%) (1=1,391 pairs)	-0.000264	0.005	0.0238	0.436
Daily Net Change (%) (1=1,391 pairs)	-0.0868	1.183	-0.0333	-0.61
Panel B – U.S. market is the earlier market				
	Mean	Std. Dev.	r with US	t-Stat
Opening Gap (%) (1=1,391 pairs)	0.0766	0.723	-0.012	-0.22
Daily Net Change (%) (1=1,391 pairs)	0.02	1.495	0.01	0.185

This table reports the directional correlation between the U.S. and the Chinese markets. Panel A reports the correlations between the observations of the earlier market (China) and the paired observation in later market (U.S.). Panel B reports the results when the U.S. market is the earlier market.

There are 1391 observations included for daily changes of both the Chinese market and the U.S. market from 2000 to 2005 (to save space, the table of the basic statistic is not provided here). The standard deviation of absolute changes in the Chinese market (1.367) is greater than the standard deviation of the U.S. market (1.196). Panel A and B of Table 5 report the results of correlation coefficients between these two markets when the Chinese market is the earlier market and when the U.S. market is the earlier market, respectively. There are no statistical significances reported on any correlation coefficients. The lack of statistical significance suggests that there is no significant interaction between the two markets no matter which market is the earlier market.

Finally, we present a yearly correlation graph in Fig. 5 showing (a) CH-US and (b) US-CH market interactions from 2000 to 2011, a twelve year period. From the graph, we can clearly observe the recent trend of strengthened interactions. Also Fig. 5 shows the noticeable difference between CH-US and US-CH interactions. The U.S. market has a larger influence on the Chinese market than the Chinese market has on the U.S. market, consistent with the results reported in the above tables.

FIGURE 5
THE INTERACTION BETWEEN U.S. MARKET AND CHINESE MARKET FROM 2000 TO 2011

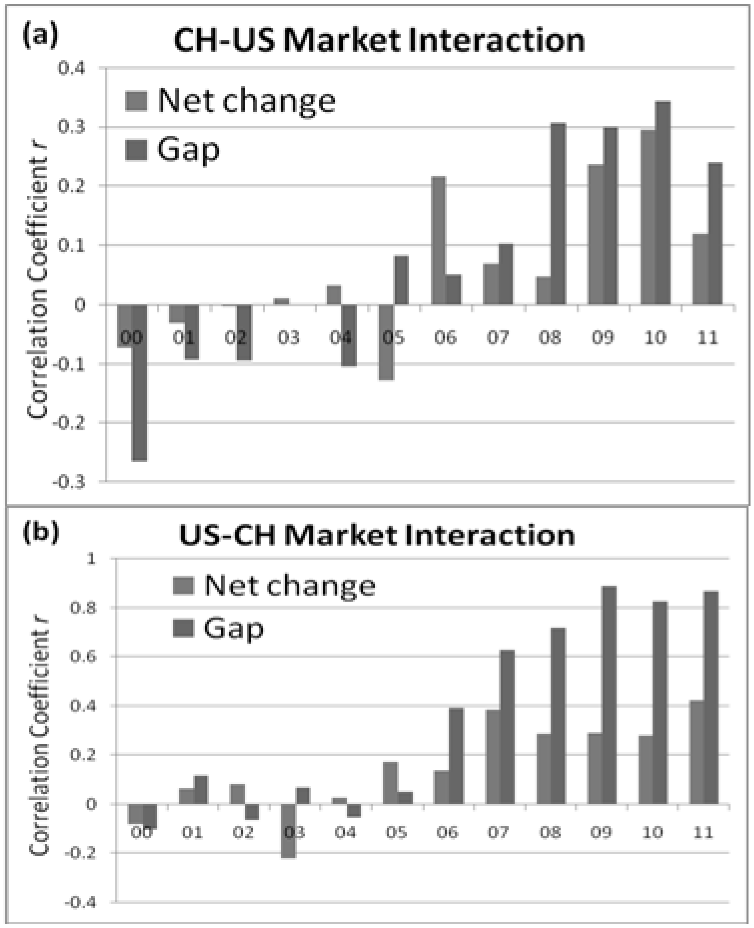

FIGURE 5. Figure (a) shows the two markets' interaction when Chinese market is the earlier market; and Figure (b) shows the interactions when U.S. Market is the earlier market.

CONCLUSIONS

In this study, we categorized two basic types of market interactions as event-linked interaction and direct market interaction. The event-linked interaction represents the connection between the triggering events and the market responses. The direct market interaction is the market response to the other market's fluctuation. One key problem of the interaction theory is to identify the existence of the direct market interaction, i.e., to determine the cause of the market fluctuation in an integrated market environment. Then we apply the role of time difference in the market interaction. We suggest that due to the time difference it is possible to detect the direct market interactions.

To apply our proposed framework we conducted an empirical examination in a time period between 2006 and 2011 on the Chinese market and the U.S. market because these two markets have distinct time differences. By dividing the market daily-change data into two groups, a Large-Change group and a Small-Change group, we find that if the earlier market had a relatively large fluctuation then it led to a bigger fluctuation in the later market. The results also support our prediction: If the earlier market has relatively small fluctuation, it has much less impact on the later market. This lets us focus on the Large-

Change group in the correlation test. The results show a highly significant correlation between the two markets between 2006 and 2011. Based on a significant difference between the correlation of CH-US (when Chinese market is the earlier market and the U.S. market is the later market) and the correlation of US-CH (when U.S. market is the earlier market and the Chinese is the later market), we further conclude that the two markets have a direct market interaction. The results also suggest that the U.S. market has a greater influence on the Chinese market than the Chinese market has on the U.S. market.

Finally we extend our examination in a time period of 2000 to 2005 when the Chinese stock market had much less influence and involvement to the world market and economy. The results clearly indicate that between 2000 and 2005 there was no significant correlation between the Chinese market and the U.S. market. Our study is possibly the first attempt to characterize the market interactions using time difference technique. We believe our findings may shed some light on both academic and practical research.

REFERENCES

Bekaert, G., Hodrick R.J., & Zhang X. (2009). International stock return comovements. *Journal of Finance* 64, 2591-2626.

Bing, Z., Zhizhen F., & Xindan L. (2010). Comovement between China and U.S.'s stock markets. *Economics Research* 11, 141-151.

Brooks, R., & Del Negro, M. (2004). The Rise in Comovement Across National Stock Markets: Market Integration or IT Bubble? *Journal of Empirical Finance* 11, 649–680.

Campbell, J.Y., & Hamao Y. (1992). Predictable Stock Returns in the United States and Japan: A Study of Long-term Capital Market Integration. *Journal of Finance* 47, 43-69.

Chow, G.C. & Lawler C.C. (2008). A Time Series Analysis for the Shanghai and New York Stock Price Indices. *Annals of Economics and* Finance 4, 17-35.

Fama, E. (1970). Efficient Capital Markets: A Review of Theory and Empirical Work. *Journal of Finance* 25, 383-417.

Fisher, R.A. (1915). Frequency distribution of the values of the correlation coefficient in samples of an indefinitely large population. *Biometrika* 10, 507–521.

Fisher, R.A. (1921). On the 'Probable Error' of a Coefficient of Correlation Deduced from a Small Sample. *Metron* 1, 3–32.

Kaplanis, E.C. (1988). Stability and Forecasting of the Comovement Measures of International Stock Market Returns. *Journal of International Money and Finance* 7, 63-75.

Karolyi, A.G., & Stulz, R.M. (1996). Why Do Markets Move Together? An Investigation of U.S.-Japan Stock Return Comovement. *Journal of Finance* 51, 951-986.

Longin, F., & Solnik B. (1995). Is the Correlation in International Equity Returns Constant: 1960–1990? *Journal of International Money and Finance* 14, 3–26.

Longin, F., & Solnik B. (2001). Extreme Correlation of International Equity Markets. *Journal of Finance* 56, 649-675.

Solnik, B., Boucrelle C., & Le Fur, Y. (1996). International Market Correlation and Volatility, *Financial Analysts Journal* 52, 17-34.