Lead-lag relationship between the CDS and the stock market and informed trading: Evidence from the Japanese CDS market

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(Abstract)

This paper investigates the dynamic relationship between CDS and stock market whether informed trading occurs in Japanese market. We find that the lead-lag relationship between CDS and stock market is not stable and that CDS market's contribution to the price discovery process is much higher in times of crisis. In addition, the unconditional information flow from CDS to stock market exists, but primarily for *keiretsu*-affiliated firms. Furthermore, the flow of information from CDS market to stock market, which is conditional on there being a bad credit event ahead, exists only in times of crisis and only for *keiretsu*-affiliated firms.

Keywords: Credit risk, CDS (credit default swap), Lead-lag relationship, Information flow, Informed trading

1. INTRODUCTION

Credit derivatives markets have experienced substantial growth over the past decade. The most popular instrument in these markets is the credit default swap (CDS), which allows investors to trade credit protection. The periodic payment (known as the CDS spread), which is expressed as a percentage (in basis points) of the bond's notional value, is expected to provide a measure of the reference entities' credit risk.

Credit risk of firms concerns almost all financial activities, and should be reflected by the market prices of financial claims on these firms, such as bonds, stocks and CDS. In efficient capital markets, credit risk changes should be reflected in both equity and debt claims of the firm simultaneously. However, in reality, different claims may incorporate information at different speeds if markets differ in the characteristics of traders, the liquidity, the transaction

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Journal of East Asian Studies, No.17, 2019.3. (pp.41-59)

cost, and the ability to short (Qiu and Yu, 2012; Bittlingmayer et al., 2013). It is important to know if information transfer, which is also called the lead-lag relationship between the stock and the CDS markets is observable since this would help to understand information flows between financial markets and the mechanism of pricing discovery process in CDS market.

Early studies examine the lead-lag relationship across CDS spread changes, corporate bond spreads, and stock returns. These empirical studies provide evidence that the stock market leads the CDS and bond markets (Norden and Weber, 2009; Forte and Peña, 2009) and that the CDS market leads the corporate bond market (Longstaff et al., 2005; Blanco et al., 2005; Zhu, 2006; Norden and Weber, 2009; Forte and Peña, 2009).

However, regarding the lead-lag relationship between the CDS and the stock market, conflicting opinions continue to exist. First, the CDS and stock markets have different investor compositions. The main participants in the CDS market are banks, hedge funds, and major institutional traders. Due to the possibility that these selected groups of investors may participate in informed trading of CDS, it has been argued that information discovery might be more efficient in the CDS market (Angelopouos and Glamouridis, 2012). In addition, the privacy provided in the CDS market as well as no restriction on short position reinforce the likelihood that the CDS market reveals new information ahead of the stock market (Qiu and Yu, 2012; Bittlingmayer et al., 2013). On the other hand, Hilscher et al. (2011) argue against the opinion that the CDS market reflects information ahead of the stock market. In order to maximize the expected profits an informed investor chooses a market with low transaction costs and a high proportion of uninformed traders. In fact, CDS bid-ask spreads are much higher than those of equities, and the proportion of uninformed traders in the CDS market are very low relative to the equity market. These empirical evidence on the lead-lag relationship between the CDS and the stock market documents that on average, stocks lead quotes in the CDS market whereas the CDS barely leads stocks. However, these studies are based on a cross-sectional analysis, providing an unconditional relationship between the CDS and the stock market.

More recent studies are concerned with the conditional relationship between the CDS and the stock market by investigating a time-varying behavior of price discovery. These studies provide evidence for an asymmetric information spillover between the CDS and the stock market. For instance, Forte and Lovreta (2015) document that the stock market's informational dominance reported in previous studies holds in times of financial crisis whereas the CDS market's contribution to price discovery tends to be higher during tranquil times.

Another group of studies are motivated by the possibility of information-based trading in the CDS market. Their underlying reasoning is as follows: the main participants in the CDS market, such as banks, hedge funds, and major institutional traders, are typically better informed than retail investors; thus, they may participate in informed trading of CDS in order to exploit their (insider) knowledge, causing a significant incremental information revelation in the CDS market. They also argue that this type of insider trading tends to take place

prior to severe credit deterioration, suggesting that incremental information revelation in the CDS market is asymmetric between good and bad credit events (Acharya and Johnson, 2007; Acharya and Johnson , 2008; Qiu and Yu, 2012).[1]

Given this literature on the dynamic relationship between the CDS and stock market, we notice that most previous empirical studies have focused on a sample of North American and European companies.[2] However, for the following reasons, the Japanese CDS market could not be neglected by academicians as well as practitioners.

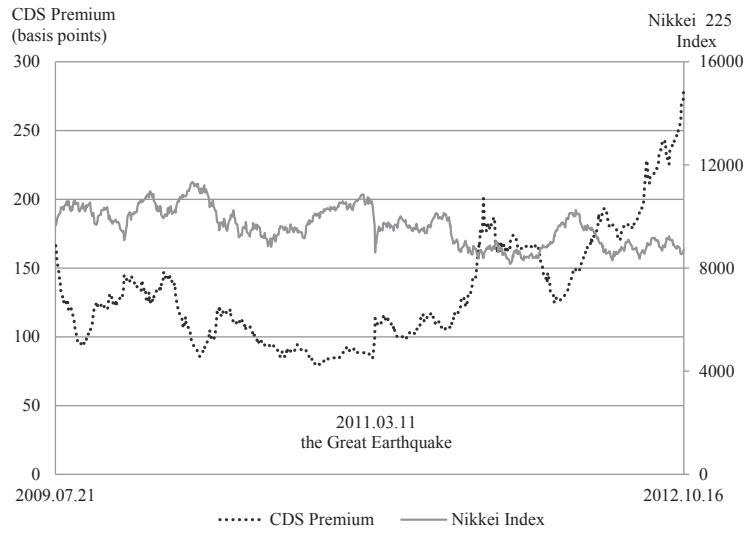
First of all, in terms of market size and liquidity of CDS for major Japanese firms, it is worth investigating whether prior empirical evidence on the lead-lag relationship between the CDS and the stock market, which is primarily based on U.S. and European data, still holds for the sample of Japanese CDS.

Meanwhile, relatively less shock is observed in the Japanese stock market, except for a sharp decline in stock prices and increase in CDS spread just after "Great East Japan Earthquake" on March 11, 2011 (Figure 1).[3] These dramatically contrasting periods (tranquil vs. chaotic) divided by the Great Earthquake provide us with a unique opportunity to test whether the lead-lag relationship between the CDS and the stock market is stable over time and whether, depending on the market conditions (tranquil vs. chaotic), the leading role in the price discovery process is different between the CDS market and the stock market. In addition, by focusing on the difference in the results between the tranquil and chaotic periods divided by the Great Earthquake, we may examine whether informed trading in the CDS market tends to take place prior to severe credit deterioration.

Furthermore, some institutional features specific to the Japanese CDS market may lead to some different results from those evidenced by prior research, which has focused on the U.S. and European CDS markets. Japanese corporate bonds are illiquid due to the buy-and-hold behavior of Japanese bond investors as well as the inactive repo (repurchase agreements) market for corporate bonds (Baba and Inada, 2007). Accordingly, trading activity related to firms' credit risk takes place mainly on the CDS market, and CDS spreads reflect the credit risks of Japanese firms more sensitively compared to bond spreads.[4] Therefore, the CDS market plays a critical role in the credit market in Japan as compared with the U.S. and European countries, where secondary bond markets are well established.[5] Ever since the beginning of CDS trading in the Japanese market in early 1998, main protection buyers of Japanese CDS are Japanese banks while foreign securities companies and hedge funds participate as protection sellers. One of the unique governance structures of Japanese firms is the keiretsu, a group of closely related companies with interlocking business relationship and ownership.[6] Because a core bank is centered on the keiretsu, the main bank maintains a special relationship with the keiretsu-affiliated firms, and thus retains insider information.[7] These unique institutional features in Japan provide us with an opportunity to investigate whether insider trading in the CDS market occurs in entities which subsequently experience adverse

credit events and furthermore, this phenomenon is more distinct as banking relationships increase. In particular, due to the fact that Japanese banks participate in the CDS market usually as protection buyers, they may take buying positions for the CDS of firms that are expected to subsequently experience severe credit deterioration.

Figure 1: Trend of average CDS premium and Nikkei index for the period from July 21, 2009 to October 16, 2012 surrounding the Great Earthquake



Given these motivations, this paper analyzes the dynamic relationship between credit default swaps (CDS) and stock markets for a sample of Japanese companies during the period from July 21, 2009 to October 16, 2012, which includes 797 trading days surrounding the "Great East Japan Earthquake" on March 11, 2011. The empirical analysis is largely divided into two part. In the first part, focusing on the difference in the results between the two (tranquil vs. chaotic) periods divided by the Great Earthquake, we investigate the intertemporal lead-lag relationship between the CDS and the stock market. In the second part, this paper investigates whether informed trading occurs in the Japanese CDS market similar to insider trading in the U.S. CDS market, which is empirically evidenced by Acharya and Johnson (2007) and Qiu and Yu (2012). Furthermore, this paper investigates whether informed trading patterns in the Japanese CDS market is different between firms that are *keiretsu*-affiliated or not.

The remainder of the paper is organized as follows. Section 2 describes the data and research methodology used in this paper. Section 3 provides evidence of a time-varying relationship between Japanese CDS spreads and stock returns, and analyzes the relative informational dominance of the CDS and stock market in tranquil vs. turmoil periods. In section 4, by focusing on any differences in informed trading patterns between the tranquil and chaotic periods we examine informed trading in the Japanese CDS market. Section 5 presents the

summary and conclusions.

2. DATA AND METHOLOGY

2.1. Data collection and sample composition

Our Japanese CDS data, which are based on the daily closing prices of the dealers' book of records, come from Quick Corp., a financial information service provider in Japan. As a sample of this study, we use 5-year single-name CDS contracts on senior unsecured obligations, which are the most liquid among a variety of CDS maturities and are used as samples in most prior studies. Because one of our main interests in this research is to examine the time-varying lead-lag relationship between the CDS and the stock market and different informed trading patterns between the tranquil and chaotic periods, the sample period is selected from July 21, 2009 to October 16, 2012 surrounding the Great Earthquake on March 11, 2011. This sample period is divided into two sub-periods, which includes 401 and 396 trading days before and after the Great Earthquake, respectively.

One of the major concerns in using CDS data is stale price quotes.[8] Thus, all the prior studies using daily CDS data apply a filter rule in order to minimize the problem of illiquidity of their CDS sample.[9] In this study, we also control for the Japanese CDS with stale price quotes by excluding companies with more than 30% of the daily observations unchanged from the previous day in any of the two sub-periods.[10] As a result, our sample of Japanese CDS consists of 82 firms for the period from July 21, 2009 to October 16, 2012 (see Appendix A). It includes most major Japanese firms, which constitute more than 80% of the market value of the Tokyo Stock Exchange (TSE).[11]

2.2. Summary statistics

Table 1 presents the summary statistics of firms and their CDS included in our final sample. For 82 Japanese companies in the sample, the mean of the average CDS level is 103.84 for the pre-earthquake period, and it significantly increases to 154.61 for the post-earthquake period, indicating that the Great Earthquake caused credit deterioration for many Japanese firms.[12] The median is 69.27 and 124.23 for the pre-earthquake and post- earthquake periods, respectively, suggesting that the distribution of the CDS premium is positively skewed. The increase in the mean and median for the average daily CDS changes as well as the increase in the volatility from the pre-earthquake to post- earthquake period also suggests a shock in the Japanese credit market by the Great Earthquake. To a lesser extent, a similar shock is observed in the Japanese stocks in our sample. In addition, we find that firms included in our sample are mostly large ones with positive skewness.

Table 1: Summary statistics of 82 companies and their CDS in the sample

Panel A: Pre-earthquake period (2009.7.21- 2011.3.11)					
	Mean	Std.dev	Median	Min	Max
Avg. CDS premium level (b.p)	103.84	116.39	69.27	24.64	874.44
Avg. daily CDS changes (%)	-0.11	0.12	-0.11	-0.48	0.16
Volatility of CDS changes (%)	3.07	0.48	3.05	2.20	5.02
Avg. daily stock returns (%)	0.04	0.07	0.03	-0.12	0.22
Volatility of stock returns (%)	1.83	0.51	1.91	0.80	3.96
Firm's market value (¥ billion)	1,203	1,601	727	22	10,758
Firm's total asset (¥ billion)	6,348	17,150	2,773	429	152,723
Firm's leverage (%)	0.71	0.14	0.74	0.25	0.97
Panel B: Post-earthquake period (2011.3.14- 2012.10.16)					
	Mean	Std.dev	Median	Min	Max
Avg. CDS premium level (b.p)	154.61	116.68	124.23	48.53	692.44
Avg. daily CDS changes (%)	0.22	0.21	0.14	-0.13	1.15
Volatility of CDS changes (%)	3.10	1.17	2.88	1.50	10.41
Avg. daily stock returns (%)	-0.06	0.11	-0.04	-0.51	0.20
Volatility of stock returns (%)	2.17	0.69	2.09	0.92	6.33
Firm's market value (¥ billion)	1,383	1,720	805	37	11,551
Firm's total asset (¥ billion)	6,888	18,266	2,858	310	160,812
Firm's leverage (%)	0.69	0.14	0.71	0.28	0.96

Note: The firm market value, asset and leverage are based on the data as of the fiscal year end of 2009 for the pre-earthquake period and the fiscal year end of 2011 for the post-earthquake period.

2.3. Research methodology

In this paper, three research models are mainly utilized. First, a firm-specific VAR model (vector autoregressive) is used to analyze the daily lead-lag relationship between the Japanese CDS and stock markets. Second, the GARCH model is used to investigate the transmission mechanism of mean and variance between the CDS and the stock market. Third, in order to investigate informed trading in the Japanese CDS market we utilize the methodology employed by Acharya and Johnson (2007) and Qiu and Yu (2012).

The vector autoregressive (VAR) model is a multivariate time series model, in which the interaction between several variables is used to forecast each variable. The VAR analysis is a useful methodology for estimating the dynamic responses of each variable to the innovations in other variables in the system. The VAR model treats all the variables in a system as endogenous. The VAR model estimates the parameters in a dynamic system without imposing any a priori restrictions on the presence of variables in an equation. Therefore, the relationships among the variables are determined by the data themselves.

This paper estimates a firm-specific VAR model, which is composed of the daily changes in the CDS premium and stock returns. The estimation is conducted for each 82 firms in the sample for the period from July 21, 2009 to March 10, 2011 (401 trading days) and the period from March 11, 2011 to October 16, 2012 (396 trading days). Each VAR model is expressed as:

$$\Delta CDS_t = \alpha_1 + \sum_{k=1}^{p} \beta_{1k} \Delta CDS_{t-k} + \sum_{k=1}^{p} \gamma_{1k} Ret_{t-k} + \varepsilon_{1t} \quad (1)$$

$$Ret_t = \alpha_1 + \sum_{k=1}^{p} \beta_{2k} \Delta CDS_{t-k} + \sum_{k=1}^{p} \gamma_{2k} Ret_{t-k} + \varepsilon_{2t} \quad (2)$$

where, ΔCDS_t is the daily % change in CDS premium at day t, Ret_t is the daily stock return at day t, p is the number of lags, and ε_t is the disturbance term in t. Using Akaike' s minimum final prediction error (FPE) criterion and Schwartz's information criterion, we determine order 5 as an optimal lag in this paper.[13]

In the VAR model, the F-statistics refer to the null hypothesis that all of the lagged coefficients are jointly equal to zero. In this sense we test whether Granger causality or a lead-lag relationship exists among the variables in the VAR model (Granger, 1969). For example, we test whether a change in the CDS premium 'causes' or leads a stock return of the corresponding firm by means of the Wald test for $\gamma_{11}=\gamma_{12}=\cdots=\gamma_{1p}$. In addition, the VAR model provides the decomposition of forecast error variance, which measures the overall relative importance of individual variables in the system in generating the fluctuation of their own and other variables. Given a variable's forecast, an expected forecast error exists. This forecast error can be accounted for by its own innovations and the innovations of other variables in the system. The effects that the variables in the system have on each other over time can be measured by decomposing this forecast error variance. For example, by measuring the forecast error of the CDS spread changes and stock returns for each company in the sample, we may determine the contribution percentage of each innovation.

Once the causality between change in CDS premium (ΔCDS_t) and stock return (Ret_t) is identified, this paper employs the following GARCH model to investigate the transmission mechanism of mean and variance between ΔCDS_t and Ret_t.[14]

$$\begin{aligned} Y_t &= \alpha + \beta X_t + \varepsilon_t + \theta\varepsilon_{t-1},\ \varepsilon_t \mid \Omega_{t-1} \sim N(0,h_t) \\ h_t &= a + b\varepsilon_{t-1}^2 + ch_{t-1} + \delta\varepsilon_{X_t}^2 \end{aligned} \quad (3)$$

In this equation X_t and Y_t can be either ΔCDS_t or Ret_t, depending on the direction of the causality between ΔCDS_t and Ret_t. That is, X_t and Y_t are ΔCDS_t and Ret_t, respectively if the causality exists from CDS to stock return whereas X_t and Y_t are Ret_t and ΔCDS_t, respectively if the causality exists from stock return to CDS. In this equation the coefficients, β and δ, measure the transmission effects of mean and variance, respectively. In other words, the significance of these coefficients indicates that information occurring at variable X_t influences the mean and variance of variable Y_t.

In the second part of this paper, another research methodology is used in order to investigate the informed trading in the Japanese CDS market. Acharya and Johnson (2007)

propose a standard approach for isolating credit market specific information, which is also used in Berndt and Ostrovnaya (2008), Qiu and Yu (2012), and Angelopouos and Glamouridis (2012). Following Acharya and Johnson (2007), we extract information unique to the CDS market at day *t* by running the time-series regression for each firm in the sample as follows:

$$\Delta CDS_{it} = \alpha_i + \sum_{k=0}^{5}\left(\beta_{ik} + \frac{\gamma_{it}}{CDS_{it}}\right) Ret_{i,t-k} + \sum_{k=0}^{5}\delta_{ik}\Delta CDS_{i,t-k} + u_{it} \quad (4)$$

where, ΔCDS_{it} is the daily % change in the CDS premium for firm *i* at day *t*, CDS_{it} is the CDS premium level for firm i at day t, $Ret_{i,t-k}$ is the stock return for firm i at day *t-k*, and u_{it} is the residual term for firm *i* at day *t*. The interaction terms of stock returns and the inverse of the CDS spread are included to account for the non-linear dependence between the CDS changes and stock returns. In this specification of the model, the residual term, u_{it}, refers to the independent news arriving in the CDS market for firm *i* at day *t*, which is termed as '*CDS innovations*' in Acharya and Johnson (2007).

Then, following Acharya and Johnson (2007) and Qiu and Yu (2012), we use the panel regression shown below, and investigate whether *CDS innovation*, which is the residual term obtained from the estimation of equation (3), is relevant for future stock returns.

$$Ret_{it} = a + \sum_{k=1}^{5}(b_k + b_k^D(\text{Credit condition dummy})_{it}) \times (\text{CDS innovation})_{i,t-k} + \sum_{k=1}^{5}(c_k + c_k^D(\text{Credit condition dummy})_{it}) \times Ret_{i,t-k} + \varepsilon_{it} \quad (5)$$

In particular, $(\text{Credit condition dummy})_{it}$ is included in equation (4) as a conditional term, which identifies the occurrence of a credit event for firm *i*. According to Acharya and Johnson (2007), insider trading in the CDS market tends to take place prior to severe credit deterioration. If this argument holds for the Japanese CDS market, we may observe significant value of the coefficient, $\Sigma_{k=1}^{5} b_k^D$, which measures the incremental information flow from the CDS market to the stock market conditional on there being some bad credit events ahead. Since $\Sigma_{k=1}^{5} b_k$ measures the unconditional information flow from the CDS market to the stock market, the coefficient $\Sigma_{k=1}^{5}(b_k + b_k^D)$ represents the flow of information from the CDS market to the stock market conditional on there being a bad credit event ahead. In this paper we assume more than a 10% jump in the daily CDS spread changes as a bad credit event, and assign a value of 1 to $(\text{Credit condition dummy})_{it}$ for periods up to ten days prior to the credit events.[15]

3. LEAD-LAG RELATIONSHIP BETWEEN JAPANESE CDS AND STOCK MARKETS

Before we analyze the dynamic lead-lag relationship between the CDS and the stock

market using a VAR model, we examine the contemporaneous association between the daily CDS premium changes and stock returns since the VAR model does not allow for a contemporaneous correlation. The stock returns and the CDS premium changes are affected by the credit information of the underlying firm in a way that negative (positive) credit news is related with an increase (decrease) in the reference entity's credit spread and a decrease (increase) in the corresponding stock price. In efficient capital markets, the credit news should be reflected in CDS and stock prices simultaneously, exhibiting a negative contemporaneous correlation between the daily CDS premium changes and stock returns.

Consistent with prior evidence that is primarily based on U.S. and European data, the contemporaneous correlation between daily CDS premium changes and stock returns are significantly negative in the Japanese market. All contemporaneous correlations for the 82 cases in our sample are significantly negative with a mean (median) value of -0.175 (-0.177) for the pre-earthquake period, and with an exception of only one case in the post-earthquake period the correlations are more negative with a mean (median) value of -0.258 (-0.276).[16] The magnitude of negative contemporaneous correlation is similar to that observed by prior studies using the U.S. and European data, suggesting that the credit risk is priced to generate a negative contemporaneous relationship between CDS premium changes and stock returns in the Japanese market as in the U.S. and European markets.

Even though credit related news is contemporaneously reflected in the CDS and stock markets, prior studies provide evidence of some lead-lag relationship between CDS premium changes and stock returns and predictability with a time lag.[17] However, since these results are primarily obtained from the analysis of U.S. and European data, this paper investigates the lead-lag relationship between Japanese CDS and stock markets. More importantly, more recent studies argue that the lead-lag relationship between the CDS and the stock market is time-varying depending on the market conditions (i.e., tranquil times vs. crisis). The dramatically contrasting periods (tranquil vs. chaotic) divided by the Great Earthquake in Japan provide us with a unique opportunity to analyze the time-varying lead-lag relationship between the CDS and the stock market.

In this paper, following Norden and Weber (2009), a firm-specific VAR model (vector autoregressive) is used to analyze the daily lead-lag relationship between Japanese CDS and stock markets. A VAR model implicitly assumes functional dependence among some or all of the variables.[18] In this sense we test whether Granger causality or a lead-lag relationship between daily CDS premium changes and stock returns exists. The F-statistic tests if all the coefficients of the lagged stock returns are jointly statistically significant and help in the explanation of the current CDS premium changes in the VAR model represented in equation (1), and vice versa in the VAR model represented in equation (2). The summary results of the Granger causality test conducted on each of the 82 Japanese companies in our sample are presented in Table 2.

Table 2: Number of Granger-causal cases

	Direction of Causality	Significant Level 0.01	0.05	0.10
Pre-earthquake Period	S→C	8	18	32
(2009.07.21-2011.03.11)	C→S	6	12	14
Post-earthquake Period	S→C	20	31	38
(2011.03.14-2012.10.16)	C→S	20	34	43

Note: 'S→C' refers to 'stock returns do Granger-cause CDS premium changes', while 'C→S' refers to 'CDS premium changes do Granger-cause stock returns'.

First, during the pre-earthquake period we observe more cases of causality from the stock to the CDS market than that from the CDS to the stock market. However, the proportion of causality from the stock to the CDS market (e.g., 18 of 82 at the 0.05 significance level) is much smaller as compared to the empirical results based on the U.S. and European data, which report 60-70% of cases with causality from the stock to the CDS market. For the same period, the proportion of causality from the CDS to the stock market (e.g., 12 of 82 at the 0.05 significance level) is similar to the evidence on U.S. and European markets. These results suggest that the stock market's leading role in the price discovery process is very weak in the Japanese market relative to the informational dominance of the stock market observed in the U.S. and European markets.

More interesting results are observed in the post-earthquake period. Though both causalities from the stock to the CDS market and from the CDS to the stock market increase, a more sizable increase is observed in the latter at all the significance levels. For example, at the 0.05 significance level cases of causality from the CDS to the stock market increase from 12 in the pre-earthquake period to 34 in the post-earthquake period, whereas those from the stock to the CDS market increase from 18 to 30. As a result, during the post-earthquake period we observe that the Japanese CDS market more often leads the stock market than vice versa.

This evident shift in the lead-lag relationship between the CDS and the stock market presents some important implications. First of all, this result suggests that the relationship is not stable over time. In particular, the significant increase in the CDS's leading role during the post-earthquake period suggests that the CDS market's contribution to the price discovery process is much higher in times of crisis. These empirical results based on the Japanese CDS data are consistent with the contention of Acharya and Johnson (2007) and Qiu and Yu (2012) that the information flow from the CDS market to the stock market becomes stronger in times of credit deterioration. However, our results observed in the Japanese CDS contradict the empirical evidence of Forte and Lovreta (2015), in which the stock market's informational dominance holds only in times of crisis whereas the CDS market's contribution to price discovery tends to be higher during tranquil times.

As a complement to the causality tests we also examine the decomposition of forecast

error variance. For a time horizon of 5 and 10 days we measure the forecast error of CDS premium changes and stock returns for each company in the sample, and determine the percentage that each innovation contributes. As shown in Table 3, for both pre-earthquake and post-earthquake periods a relatively large part of the forecast error variance of the stock returns is explained by innovations in the CDS premium changes, whereas the influence of innovations in the stock returns on CDS premium changes is slight. By contrast with the evidence based on the U.S. and European data, this result indicates the relative informational dominance of CDS premium changes in the price discovery process in the Japanese market. We may attribute this result to the unique features of the Japanese bond market, which is illiquid due to the buy-and-hold behavior of Japanese bond investors as well as the inactive repo (repurchase agreements) market for corporate bonds. Accordingly, trading activity related to firms' credit risk takes place mainly on the CDS market in Japan.

Table 3: Average (median) decomposition of forecast error variances

	Forecast Explained	Horizon Days	By Innovation in Stock		By Innovation in CDS	
Pre-earthquake Period (2009.07.21-2011.03.11)	Stock	5	94.91	(95.79)	5.09	(4.21)
		10	94.68	(95.50)	5.32	(4.50)
	CDS	5	1.79	(1.65)	98.21	(98.35)
		10	2.07	(1.85)	97.93	(98.15)
Post-earthquake Period (2011.03.14-2012.10.16)	Stock	5	88.97	(89.63)	11.03	(10.37)
		10	88.64	(89.24)	11.36	(10.76)
	CDS	5	2.60	(2.16)	97.40	(97.84)
		10	2.86	(2.50)	97.14	(97.50)

Note: Numbers in parenthesis indicate the median decomposition of forecast error variances for 82 firms in the sample.

More importantly, the leading role of the CDS market significantly increases in the post-earthquake period. For example, the proportion of stock returns' forecast errors explained by CDS premium changes for the horizon of 10 days exhibits a mean (median) of 11.36% (10.76%) during the post-earthquake period whereas its mean (median) is 5.32% (4.50%) during the pre-earthquake period. Thus, combined with the results of Granger causality tests shown in Table 2, this result confirms that the relative informational dominance of CDS premium changes in the price discovery becomes stronger during the times of crisis.

Next, using the GARCH model shown in equation (3), we investigate the transmission mechanism of mean and variance between change in CDS premium and stock return. Specifically, based on the results in Table 2, we identify the direction of causality between change in CDS premium (hereafter, "C") and stock return (hereafter, "S") for 82 Japanese firms. Then, at the 0.05 significance level we select 18 cases of causality from S to C and 12 cases of causality from C to S during the pre-earthquake period and 31 cases of causality from S to C

and 34 cases of causality from C to S during the post-earthquake period. Using these samples, we estimate GARCH model, where change in CDS premium is dependent variable while stock return is included as exogenous variable if causality exists from S to C, and vice versa if causality exists from C to S. As mentioned before, the coefficients, β and δ, in the GARCH model measure the transmission effects of mean and variance, respectively. The average of the coefficients, β and δ, is reported in Table 4.

Table 4: Transmission effect of mean and variance

	Direction of Causality	Mean β	Variance δ
Pre-earthquake Period	S→C	-0.1810	0.2524
(2009.07.21-2011.03.11)	C→S	-0.1146	0.0116
Post-earthquake Period	S→C	-0.1520	0.1898
(2011.03.14-2012.10.16)	C→S	-0.1464	0.0253

Note: 'S→C' refers to 'stock returns do Granger-cause CDS premium changes', while 'C→S' refers to 'CDS premium changes do Granger-cause stock returns'.

We find that the coefficients, β, which measure the transmission effect of mean, are all negative, suggesting that CDS premium changes and stock returns influence in the opposite direction to each other. During the pre-earthquake period the magnitude of negative coefficients, β, is larger in absolute value for the case of causality from S to C. However, during the post-earthquake period the magnitude of negative coefficients, β, becomes close to each other. This result suggests that as compared to the pre-earthquake period the influence of stock return on CDS premium changes decreases during the post-earthquake period while the influence of CDS premium changes on stock return increases during the same time period.

In Table 4 we observe that the coefficients, δ, which measure the transmission effect of variance, are large and positive for the case of causality from S to C, implying that a volatility surprise in stock return affect the volatility of CDS premium changes. However, their magnitude declines during the post-earthquake period, implying that the volatility transmission effect from stock return to CDS premium changes weakens after the Great Earthquake in Japan. On the other hand, we find that the transmission effect of variance from CDS premium changes to stock return is very weak in the Japanese market.

4. INFORMED TRADING IN THE JAPANESE CDS MARKET

Given this evidence of the leading role of the CDS market in Japan, we are motivated to investigate the possibility of informed trading in the Japanese CDS market. Acharya and Johnson (2007) argue that though asymmetric information and insider trading problems potentially exist in most markets, the CDS market is especially vulnerable because the main

participants in the CDS market such as banks, hedge funds, and major institutional investors are typically informed traders. Thus, their informed trading of CDS may engender a significant incremental information revelation in the CDS market, yet insider trading occurs only for firms that are expected to experience credit deterioration. In their empirical investigation of insider trading for the sample of the U.S. CDS, Acharya and Johnson (2007) and Qiu and Yu (2012) provide evidence consistent with the above-mentioned argument.

In the Japanese CDS market the main protection buyers are Japanese banks while foreign securities companies and hedge funds participate as protection sellers. Considering the important role of the main banks in corporate governance in Japan,[19] Japanese banks may possess more inside information compared to the banks in the U.S., and take buying positions for the CDS of firms that are expected to subsequently experience severe credit deterioration. Therefore, following the same methodology as Acharya and Johnson (2007) and Qiu and Yu (2012), this paper investigates informed trading in the Japanese CDS market for the two (tranquil vs. chaotic) periods divided by the Great Earthquake. The results are reported in Table 5.

Table 5: Information flow from the CDS to Stock market for adverse credit conditions

	Pre-earthquake period (2009.07.21-2011.03.11)	Post-earthquake period (2011.03.14-2012.10.16)
a	0.020**	-0.049***
	(1.84)	(3.82)
$\Sigma_{k=1}^{5} b_k$	-0.038***	0.038***
	(-4.16)	(3.20)
$\Sigma_{k=1}^{5} b_k^D$	-0.018	-0.086***
	(-0.59)	(-3.34)
$\Sigma_{k=1}^{5} c_k$	-0.056***	0.035**
	(-4.13)	(2.49)
$\Sigma_{k=1}^{5} c_k^D$	-0.055	0.137***
	(-1.14)	(3.65)

Note: ***, **, * indicate a statistical significance at 1%, 5% and 10% respectively.

Of key importance in Table 5 are $\Sigma_{k=1}^{5} b_k$ and $\Sigma_{k=1}^{5} b_k^D$. For the pre-earthquake period we observe significantly negative $\Sigma_{k=1}^{5} b_k$, indicating the unconditional information flow from the CDS market to the stock market. However, $\Sigma_{k=1}^{5} b_k^D$ is not statistically significant, suggesting that there is no incremental information flow from the CDS to the stock market conditional on there being a bad credit event ahead. These results for the Japanese CDS are different from those of Acharya and Johnson (2007) and Qiu and Yu (2012), which present the existence of information flow from the CDS to the stock market only for firms that are expected to experience a bad credit event in the future.

However, for the post-earthquake period $\Sigma_{k=1}^{5} b_k^D$ is significantly negative, suggesting that the conditional information flow from the CDS to the stock exists in times of crisis. Although $\Sigma_{k=1}^{5} b_k$ is significantly positive, its magnitude is smaller than that of $\Sigma_{k=1}^{5} b_k^D$. By adding the two

terms we find that $\Sigma_{k=1}^{5}(b_k+b_k^D)$ = -0.048, which represents on average 4.8% transmission of information in CDS innovation to future stock returns for firms that are expected to experience a bad credit event within 10 trading days. These results are consistent with Qiu and Yu's (2012) finding that the conditional information flow from the CDS to the stock market becomes stronger during the global financial crisis, when the financial markets are volatile due to increased uncertainty.

As mentioned before, under the unique corporate governance system in Japan, the *keiretsu*, the main bank maintains a special relationship with *keiretsu*-affiliated firms, and thus retains insider information. These unique institutional features in Japan provide us with an opportunity to investigate whether insider trading in the CDS market is more distinct as the banking relationship increases. Thus, we classify firms in our sample as *keiretsu*-affiliated or non-*keiretsu*-affiliated firms, which consist of 52 and 30 firms, respectively. For each sample we repeat the same analysis as that of Table 5. The results are reported in Table 6.

Table 6: Information flow from the CDS to stock market for adverse credit conditions for the sample divided into Keiretsu and non-Keiretsu firms

	Pre-earthquake period (2009.07.21-2011.03.11)		Post-earthquake period (2011.03.14-2012.10.16)	
	Keiretsu	Non-***Keiretsu***	***Keiretsu***	Non-***Keiretsu***
a	0.021	0.018	-0.058***	-0.032
	(1.48)	(1.11)	(-3.62)	(-1.50)
$\Sigma_{k=1}^{5} b_k$	-0.046***	-0.025*	0.026*	0.061***
	(-4.22)	(1.85)	(1.73)	(3.23)
$\Sigma_{k=1}^{5} b_k^D$	-0.018	-0.023	-0.094***	-0.058
	(-0.45)	(-0.54)	(-3.00)	(-1.30)
$\Sigma_{k=1}^{5} c_k$	-0.049***	-0.072***	-0.010***	0.134***
	(-2.88)	(-3.19)	(-5.84)	(5.70)
$\Sigma_{k=1}^{5} c_k^D$	-0.006	-0.180**	0.166***	0.079
	(-0.10)	(-2.13)	(3.80)	(1.01)

Note: ***, **, * indicate a statistical significance at 1%, 5% and 10% respectively.

Interestingly, we observe fairly different results between *keiretsu*-affiliated and non-*keiretsu*-affiliated firms. For the pre-earthquake period, $\Sigma_{k=1}^{5} b_k$ is -0.046 and significant at the 0.01 level for *keiretsu*-affiliated firms, while it is -0.025 and marginally significant at 0.10 level for non- *keiretsu*-affiliated firms. This result suggests that the unconditional information flow from the CDS market to the stock market, which is observed in Table 5, tends to appear mainly in *keiretsu*-affiliated firms. More interestingly, the conditional information flow from the CDS to the stock market, which is observed in the post-earthquake period, exists only in *keiretsu*-affiliated firms. That is, $\Sigma_{k=1}^{5} b_k^D$ is -0.095 and significant at the 0.01 level for *keiretsu*-affiliated firms while it is insignificant for non- *keiretsu*-affiliated firms. As a result, $\Sigma_{k=1}^{5}(b_k+b_k^D)$ is -0.069 for *keiretsu*-affiliated firms, indicating 6.9% transmission of information in CDS innovation to future stock returns for *keiretsu*-affiliated firms conditional on a bad credit event ahead. On the other

hand, $\Sigma_{k=1}^{5}(b_k+b_k^D)$ is 0.003 for non-*keiretsu*-affiliated firms, suggesting that conditional information flow from the CDS market to the stock market does not exist for non- *keiretsu*-affiliated firms. Thus, we know that the result of $\Sigma_{k=1}^{5}b_k+b_k^D)$= -0.048 observed in Table 5 is mainly incurred by *keiretsu*-affiliated firms.

Collectively, these findings suggest that in the Japanese CDS market the unconditional information flow from the CDS market to the stock market exists mainly for *keiretsu*-affiliated firms. In addition, the flow of information from the CDS market to the stock market that is conditional on there being a bad credit event ahead exists only in times of crisis and moreover, only for *keiretsu*-affiliated firms. This result supports Acharya and Johnson's (2007) contention that insider trading in the CDS market occurs for entities that subsequently experience adverse credit events and that this phenomenon is more distinct as banking relationships increase.

5. SUMMARY AND CONCLUSIONS

This paper analyzes the dynamic relationship between the CDS and the stock market for a sample of Japanese companies during the period from July 21, 2009 to October 16, 2012. In particular, by focusing on the difference in the results between the two (tranquil vs. chaotic) periods divided by the Great Earthquake on March 11, 2011, we investigate the intertemporal lead-lag relationship between the CDS and the stock market. In addition, this paper investigates whether informed trading occurs in the Japanese CDS market similar to insider trading in the U.S. CDS market, which is empirically evidenced by Acharya and Johnson (2007) and Qiu and Yu (2012). Furthermore, this paper investigates whether informed trading patterns in the Japanese CDS market is different between firms that are *keiretsu*-affiliated or not.

The results are summarized as follows. First, consistent with prior evidence primarily based on the U.S. and European data, the contemporaneous correlation between daily CDS premium changes and stock returns are significantly negative in the Japanese market. Second, we find that the stock market's leading role in the price discovery process is very weak in the Japanese market relative to the informational dominance of the stock market observed in the U.S. and European markets. Third, we observe that the lead-lag relationship between the Japanese CDS and the stock market is not stable and that the CDS market's contribution to the price discovery process is much higher in times of crisis. Fourth, in the Japanese CDS market an unconditional information flow from the CDS market to the stock market exists, but primarily for *keiretsu*-affiliated firms. Fifth, the flow of information from the CDS market to the stock market that is conditional on there being a bad credit event ahead exists only in times of crisis and moreover, only for *keiretsu*-affiliated firms. This result supports Acharya and Johnson's (2007) contention that insider trading in the CDS market occurs for entities that subsequently experience adverse credit events and that this phenomenon is more distinct as

the banking relationship increases.

In conclusion, prior empirical evidence on the lead-lag relationship between the CDS and the stock market and informed trading in the CDS market, which is mainly based on U.S. and European data, generally holds for a sample of Japanese CDS. For example, similar evidence includes negative contemporaneous correlation between daily CDS premium changes and stock returns, the time-varying lead-lag relationship between the CDS and the stock market, occurrence of informed trading in the CDS market for entities that subsequently experience adverse credit events, etc. However, if we examine the details, some differences exist. First of all, the CDS market's leading role in the price discovery process is relatively strong in the Japanese market as compared to the informational dominance of the stock market observed in the U.S. and European markets. We may attribute this result to the unique features of the Japanese bond market, which is illiquid due to the buy-and-hold behavior of Japanese bond investors as well as the inactive repo (repurchase agreements) market for corporate bonds. Accordingly, in Japan, the trading activity related to firms' credit risk takes place mainly on the CDS market. More interestingly, this information flow from the CDS market to the stock market is mainly concentrated in *keiretsu*-affiliated firms. Under the unique corporate governance system (the keiretsu) in Japan, the main bank maintains a special relationship with *keiretsu*-affiliated firms, and thus retains insider information. Hence, this result suggests that informed trading in the CDS market is more distinct as banking relationship increases.

Note

1. In this paper, the definition of informed trading comes from Ahn et al. (2008), which means trading on information not yet reflected in claims price. Traders may have obtained this information from astute analysis of varied bits of publicly available information, newly disclosed public information yet to be incorporated into claims' price, or confidential information possessed by firm insiders or other entities. On the contrary, insider trading usually means trading on information that originate inside the company.
2. Norden and Weber (2009) and Forte and Lovreta (2015) include Japanese CDS data in their sample. However, the number of Japanese samples is limited to less than 10, and the sample period is covered for pre-2008.
3. On March 11, 2011, the earthquake had a little impact on the stock market because the main earthquake occurred at 14:46, just 14 minutes before the market closing at 15:00. On the following Monday, March 14, the Nikkei market index opened at 10,044.17 points and continued to drop to 9,620.49 points, which recorded -6.18% from the closing price of 10,254.43 points on the previous Friday. The Nikkei index marked the local minimum point at 8,227 on March 15, and then bounced back to over 9,000 points by the end of the week. In terms of individual firm level, however, depending on the nature of business or the location of factory, uncertainty continued to persist for a while. For example, the electric power industry, insurance firms, and social infra-related firms are more exposed to uncertainty. In particular, Tokyo Electric Power Co. (TEPCO) experienced an extremely difficult time due to accidents at the nuclear power plants and the radiation problem. Meanwhile, for our sample of 82 Japanese firms, the average (median) CDS premium is 103.84 (69.27) basis points during the period from July 21, 2009 until the day before the Great Earthquake on March 11, 2011, while the average (median) CDS premium is 154.61 (124.23) basis points during the period from the earthquake day to October 16, 2012. More

importantly, the average volatility, which is measured as the standard deviations of daily CDS premium changes of 82 sample firms, significantly increases from 28.98 in the pre-earthquake period to 60.16 in the post- earthquake period.

4. In the investigation of price discovery of credit spreads for Japanese Mega-banks, Baba and Inada (2007) find that the CDS spread plays a more dominant role in price discovery than the bond spread and that there is significant information spillover from the CDS to the bond spread.
5. Ito and Harada (2004) document that CDS is a good measure of the soundness of Japanese banks rather than the Japan premium, which is calculated as the interbank interest rate spread over the LIBOR (London Interbank Offered Rates)
6. Although recently the *keiretsu* is losing its grip, this unique corporate governance system in Japan has attracted numerous studies. However, some studies present a negative view on this system in terms of aggravation of agency costs (among them, e. g., Weinstein and Yafeh, 1998; Morck, 2000). In particular, as another pathology of the *keiretsu*, Hiraki and Ito (2009) report that keiretsu-affiliated money managers drive their portfolio decisions toward financially weak firms of their *keiretsu* at the expense of their client investors.
7. After major structural changes in the early 2000, there are three mega-banks in Japan such as the Bank of Tokyo-Mitsubishi UFJ, Sumitomo Mitsui Banking Corporation, and Mizuho Corporate Bank, which respectively belong to Mitsubishi, Mitsui, and Mizuho group. Ito and Harada (2004) mention that the main reference entities are these mega-banks in the Japanese CDS market.
8. For example, Bittlingmayer et al. (2013) observe that in the CDS data set from Markit Group, which is frequently used in CDS studies, 73.21% of the daily observations is unchanged from the previous day in 2001. This percentage of unchanged quotes decreases every year, declining to 5.75% in 2010.
9. For example, Norden and Weber (2009) select firms with at least 100 daily CDS quotes in each of the years 2000–2002. Forte and Lovreta (2015) exclude companies with quotes and trades available for less than 5% of the trading days in any of the years 2002-2008.
10. Given that no trading volume data are available in the CDS data set, prior studies conjecture the illiquidity of CDS contracts with slight price variation over a certain period of time.
11. Out of 82 sample firms 71 firms' stocks are included in the Nikkei 225 index. as of October 16, 2012.
12. Among 82 firms in our sample, only one company (ACOM Co., Ltd.) exhibits a decrease in its average CDS premium from the pre-earthquake to post- earthquake period.
13. Norden and Weber (2009) also use lag of order 5 in their VAR model for daily data.
14. This paper adopts GARCH(1,1) model by the results of AIC (Akaike's Information Criterion) and SBC(Schwartz Bayesian Criterion) tests.
15. In fact, the actual definition of a major credit event is critical in empirical studies on informed trading in CDS markets. For example, Acharya and Johnson (2007) define a credit event in three different specifications as when (i) the firm experiences a credit deterioration of more than 50 basis points between date t and the end of the sample; (ii) the firm's credit spread level remains at a level greater than 100 basis points between time t and end of the sample period; and (iii) the credit rating of the firm at time t is low, that is, A3/A- or worse. However, similar results are obtained from three different specifications. Qiu and Yu (2012) also provide similar results between two alternative definitions of a credit event when (i) an increase in the daily CDS spread increases by more than 50 basis points and (ii) the one-day increase in the CDS premium is greater than 4 standard deviations of the rolling 60-day period average percentage CDS change.
16. The detailed results are omitted in this paper, but are available upon request.
17. Hilscher et al. (2011) mention the transaction costs for CDS contracts and inattentive participants in the CDS market as reasons for the delay in the adjustment of CDS premiums to publicly available stock return data.
18. Because the VAR model is a reduced form model, it is not meaningful to interpret the coefficients, and for this reason they are not reported in this paper.
19. See, for example, Hoshi et al. (1993), Kaplan (1994), Kaplan and Minton (1994), Kang and Shivdasani (1995),

Kang and Shivdasani (1997), and Imai (2007).

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