# Contagion Effects in CDS Markets

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## ABSTRACT

This article examines contagion effects of a large idiosyncratic shock in credit default swap market. The credit contagion has been considered as one of the major reasons why the corporate defaults cluster in time. We analyze the structural change in a shock transmission mechanism and test CDS spreads co-move excessively beyond interdependence during the turmoil periods compared to the tranquil periods. We cannot find any evidence that supports the contagion effects in CDS spreads in the investigation into global corporate CDS data. The default probabilities implied in CDS spreads do not show the excessive co-movement after a large shock.

**JEL classification: G01, G15**

**Keywords:** *contagion; interdependence; CDS spreads; default probability.*

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## I. Introduction

In recession, a lot of firms are faced with financial distress simultaneously. Das et. al. (2007) expresses these phenomena as a term of "common failings" in their paper. So far, many researchers have found that corporate defaults cluster in time and tried to explain the empirical findings in various ways. They commonly documented the failings of small number of firms had a market-wide impact. One of the most persuasive explanations is that the conditional default probabilities are affected by common or correlated risk factors, which lead to positive default correlation. The conditional default probabilities of the firms exposed to common risk factors, such as industrial or regional factors, would be positively correlated and co-move. In several studies, however, it is documented that the default clustering effects observed in corporate bond market cannot be fully explained by the default correlation implied in the historical co-movement of credit spreads. For example, Das et. al. (2007) shows that time-clustering of default events of the U.S. firms is not explained by the doubly stochastic model using 4 factors; distance-to-default, 1-year stock return, 3-month T-bill rate, and 1-year S&P 500 return. Another empirical result that shows the defaults clustering in time is documented by Longstaff and Rajan (2008). They estimated a portfolio credit model using the prices of standard tranches on the CDX credit index and found the price implies a relatively frequent occurrence of large losses of portfolio. According to their result, the excessive default clustering effect is priced in the CDX spreads. (See also Collin-Dufresne et. al. (2003) and Zhang (2004))

To explain the excessive default clustering, Duffie et. al. (2008), Colline-Dufresne et. al. (2003), and Giesecke (2004) suggest the model in that people can learn the frailties from one firm's default. Alternatively, David and Lo (2001) and Jarrow and Yu (2001) explore the models which incorporate the counterparty risk to capture the strong default correlations. This literature implies the default event of a firm has contagious effects which might induce cross-firm defaults.

This article analyzes how the conditional default probabilities of firms are correlated globally. Especially, we are interested in how a large idiosyncratic shock in default probability affects other firms' default probabilities. If the shock leads to the excessive increase in other related firm's default probability beyond interdependence, the shock is considered to be contagious to other firms. This study examines whether the contagion effects are observed, so that the change in the conditional default probability affected by other firm's shock can explain the excessive default clustering effects. To understand how the default probabilities are correlated is important for investment and risk management of corporate bond portfolio. In addition, rating of the structured credit products, such as CDOs or multi-name credit derivatives, is crucially determined by the default correlations.

In this article, we examine the contagion effects in the credit default swap (henceforth CDS) markets. The CDS spread is a direct measure of firm's default probability. Jorion and Zhang (2007) used the CDS spreads to analyze contagion and competition effects of credit events, such as filings for the reorganization of Chapter 11 or the liquidation of Chapter 7. They listed several merits of usage of CDS spreads instead of corporate bond prices in credit risk analysis. This study also shares the merits: (1) CDS spread provides a direct measure of credit risk for the reference firm; (2) CDS market is still more liquid than corporate bond market; (3) Spreads between corporate and treasury bond yields are affected by tax difference or arbitrary choice of risk-free rate; and (4) CDS market leads the bond market in terms of price recovery. (See Blanco et. al. ( 2005) and Zhu( 2006))

Even though the contagion is widely documented in many financial markets, it can be defined in various ways. Originally, the contagion was extensively studied issue in the international stock market. Worldbank defines the contagion of international market as "the transmission of shocks to other countries or the cross country correlation, beyond any fundamental link among the countries and beyond common shocks." (See www.worldbank.org) Very restrictively, contagion means excessive co-movement during turmoil period relative to during tranquil period.

We define the contagion as a significant increase in market co-movement after a large shock. With this narrow definition, we explore whether the correlation of conditional default probabilities during turmoil period increases significantly and whether there is structural break in the transmission mechanism of financial shocks. This definition is adopted by many related researches in the international financial markets. Forbes and Rigobon (2002), Caporale et. al. (2005) and Corsetti et. al. (2005) examined the structural change in correlation structure of cross-country stock returns during the financial crisis, such as Hong Kong stock market crisis in 1997. Bae et. al. (2003) also suggested an approach to test the coincidence of extreme events across financial markets.

We use the empirical methodology which is broadly applied in the literature of contagion effects in international stock markets. Our analysis is also mainly based on the literature testing the change in correlation coefficients and structural break in transmission mechanism. This approach is first introduced by King and Wadhwani (1990), who test for significant increase in cross stock market correlation after the crash in 1987. Ronn (1998) found the conditional correlation coefficients are biased if the volatilities are time-varying and there is heteroskedasticity in market. Boyer et. al. (1999), Loretan and English (2000), Forbes and Rigobon (2002), and Corsetti et. al. (2005) suggested the statistical method to correct the bias in correlation coefficients. In addition, a very simple way to test for stability of linear shock transmission models is developed by Rigobon (2000) and applied to the contagion analysis of international stock market crisis in Rigobon (2003). This method considers latent factors and endogenous variable problems, which might affect the bias (See Forbes and Rigobon(2002)), as well as heterockedasticity problem. In this paper, we use this simple method to test for the structural break in shock transmission system of corporate CDS markets.

This article addresses some empirical results that it is doubtful whether the contagion effects exist in CDS spreads. The tests for the change in correlation coefficients do not show the significant increase in correlations after a large shock. In addition, the simple regression tests that examine the change in coefficients during turmoil periods do not show any evidence which supports the co-movements become stronger during the turmoil periods, either.

The rest of this article is organized as follows. Section II describes data used in this examination and data sampling procedure. And unconditional correlations between firms' CDS spreads are reported. Section III explains the statistical method to test the contagion effects and shows the test results which support the interdependence hypothesis. Finally, section IV concludes this article briefly.

## II. Default Correlations in CDS Market

### 1. CDS Spreads and Intensity Model

The CDS is a contract between a protection buyer and a protection seller, like any other credit derivatives. According to the contracts, protection buyer pays premiums to protection seller periodically in return for receiving loss amounts from the protection seller when the reference firm defaults. The premium which the protection buyer pays is the CDS spread. The CDS spread is determined by equating the value of the premium legs with the value of the protection legs for the CDS contract.

The values of the premium legs and protection legs are affected by the default probability of the reference firm. To show the relation between CDS spreads and default probabilities, we will illustrate a 5-year quarterly-pay CDS contract as an example.

The Default event can be modeled by the fist jump of a Poisson process with intensity $\lambda$. (See Duffie and Singleton (1999)) Denote that $\lambda_s$ is the deterministic default intensity at time s under the risk-neutral probability measure. In this model, the hazard function is $\Lambda(T) = \int_0^T \lambda_s ds$ and the survival probability at time T is $\exp[-\Lambda(T)] = \exp\left[-\int_0^T \lambda_s ds\right]$. If we denote $\bar{\lambda}(0,T) = \frac{1}{T}\int_0^T \lambda_s ds$, which implies the average default intensity from 0 to T, the survival probability is reduced to $\exp[-\bar{\lambda}T]$.

In this model, the value of the premium legs and the protection legs for the 5-year quarterly-pay CDS contract are calculated as follows, under the constant default intensity assumption.

The value of the premium legs = $\frac{s}{4}\sum_{t=1}^{20} D\left(\frac{t}{4}\right)\exp\left(-\bar{\lambda}\frac{t}{4}\right)$

The value of the protection legs = $LGD\int_0^5 D(s)\bar{\lambda}\exp\left(-\bar{\lambda}s\right)ds \cong \frac{LGD}{4}\sum_{t=1}^{20} D\left(\frac{t}{4}\right)\bar{\lambda}\exp\left(-\bar{\lambda}\frac{t}{4}\right)$

In the above equations, s denotes the CDS spread and LGD means the loss given default parameter. And D(t) is the function of riskless discount factors. The CDS spread equating the equations is $s = \bar{\lambda} \cdot LGD$. If the loss given default does not change in time, the CDS spread can be interpreted as the risk-neutral default intensity.

**2. Data Sampling Procedures**

We collected the corporate CDS spreads from the Markit CDS database. The sample period covers from January 1, 2006 through July 31, 2008. During the sample period, there were several important credit events affecting the corporate default probabilities, such as sub-prime mortgage defaults.

We use the spreads for 5-year CDS contracts since they are most liquid and constitute over 85% of the entire CDS market. We include the spreads for CDS contracts denominated in USD with modified restructuring (“MR”) clause for senior unsecured debt (“SNRFOR”) in our data sample. Modified restructuring has become common practice in North America. The Markit database provides not only the CDS spreads but the regions and sectors which the reference firms are belonged to. We restrict the region of the reference firms to only 5 regions, which are Asia, Europe, Latin America, North America, and Oceania. And we classify the firms into 11 sectors using the same categorization of the Markit database.

The CDS spreads quoted on every Wednesday are sampled. If the quote on Wednesday does not exist, the most recent quote within 1-week replaces. The firm with no quotes over 1-week is eliminated from our data set to prevent the bias generated by non-synchronous quotes. We use the weekly data to consider time lag while the quoted spreads reflect the news, which is attributable to infrequent trades. In addition, we can mitigate the lagging problem by using weekly data. 135 weeks are included in our sample period.

Finally, the CDS spreads for 1045 reference firms are sampled. Table 1 shows the number of reference firms included in our dataset. The number of firms which are belonged to each subgroup classified by 5 regions and 11 sectors is also reported. 632 firms in North America are included and form about 60% of total number of firms. The number of firms in financial sector is greater than in any other sectors.

[Insert Table 1 Here]

### 3. Unconditional Correlation Coefficients

We can expect that CDS spreads are positively correlated and co-move since the conditional default probabilities are affected by market-wide common factors or covariates. For instance, the CDS spreads for the financial firms in Asia are illustrated in Figure 1. The spreads for 36 firms are plotted simultaneously. This example shows the CDS spreads co-move and the co-movement seems to be conspicuous since the summer of 2007. In this figure, we can divide the sample period into a stable or tranquil period and a turmoil or crisis period by a large shock which induces a volatility spillover effect.

[Insert Figure 1 Here]

In this article, we are interested in whether there is a structural change in a shock transmission mechanism when the economy enters upon a turmoil phase from a stable phase. Before analyzing the stability of a shock transmission model, we examined overall co-movements of the CDS spreads.

To know how strongly the CDS spreads are correlated, we calculated the correlation coefficients between the weekly changes in spreads. Table 2 present the summary of pair-wise Pearson correlation coefficients during the whole sample period. The mean value of the correlation coefficients between the changes in CDS spreads of the two firms belonged to the same region and sector is reported for each subgroup. Since the correlation coefficients are calculated pair-wisely, the number of coefficients averaged in each subgroup would be $n(n-1)$, where $n$ is the number of firms in the subgroup.

[Insert Table 2 Here]

As reported in the Table 2, the changes in CDS spreads are positively correlated on average for all subgroups. In general, except for North America, the averages of the correlation coefficients are greater than 0.5 and the spreads are strongly correlated to each other. The correlations between firms in North America are lower than in any other regions over all. Though only intra-group correlations are presented in this table, correlations between firms in different subgroups are also positive on average. The averages of inter-group correlations are smaller than those of intra-group, but the differences between two are not large.

## III. Tests for Contagion Effects in CDS Spreads

### 1. Credit Events and Turmoil Periods

To examine the contagion effects, we test for the structural break in co-movement of the CDS spreads. As mentioned in the previous section, the contagion is defined as an excessive co-movement during the turmoil period beyond any fundamental links or interdependence. If a large idiosyncratic shock is contagious to other firms, the correlation will increase after the shock. Testing for changes in the correlation coefficients after a shock would be the simple and intuitional method identifying the contagion. Many researchers have studied the contagion effects through testing the change in correlation coefficients during the crisis period. As well as the analysis of correlations, the stability of a linear shock transmission model can be tested to identify the contagion effects. If the contagion occurs during a turmoil period, the values of parameters in the model would be changed after a shock.

For the analysis, the turmoil period should be defined. First, we define the credit event which can be considered as a large shock. In this article, a large jump in the CDS spread is regarded as a credit event. The events that CDS spread jumps up more than twice or three-times within a week are considered as large shocks in the conditional default probabilities. Jorion and Zhang (2007) also regard the large jump in CDS spreads as one of the important credit events. Then, we regard the period covering from one week prior to the event to six weeks after the event as the turmoil period. As a result, the length of turmoil period is 8 weeks including the event week. The length of turmoil period was determined arbitrarily, but we found the results are not seriously affected by the choice of turmoil period.

Table 3 presents the number of events and the number of firms which underwent the events in parenthesis for each subgroup. The numbers of jumping up twice are reported in Panel A. Overall, there were 152 times those the CDS spreads of the firms in our dataset jumped twice within a week and 134 firms experienced that their CDS spreads doubled during the sample period. Panel B reports the cases of jumping up three-times. We found 19 events and 18 firms. All events of triple jump are observed only in Europe and North America.

[Insert Table 3 Here]

In addition, the Appendix reports the event firms and the dates of events. This table includes the event firm's region, country and sector, as well.

## 2. Naïve Tests for the Change in Correlation Coefficients

We test for the change in correlation coefficients during the turmoil periods. The correlation coefficients during tranquil and turmoil periods are estimated respectively and the change in the coefficients is examined. The correlation between event firm and other firms which are supposed to be affected by the shock on event firm is classified into intra and inter groups. We test for the change using Fisher's z-transformation[1]. Before presenting the results, the change in correlation coefficients should be interpreted carefully. As addressed in Ronn (1998), Forbes and Rigobon (2000), and many other papers, the conditional correlation coefficients are biased by the variability of variables. If volatility increases, the conditional correlation coefficients are biased upwardly. This means the conditional correlation coefficients will increase during crisis periods even if there is no structural break in the system because the volatility increases during the periods. Nevertheless, we examine the change in conditional correlation coefficients first in order to see the outlook for results.

Table 4 reports the changes in correlations and the test results. The mean and standard deviation values of pairwise correlation coefficients are presented for both tranquil and turmoil periods. As opposed to expectation, the mean values of correlation coefficients decrease for both intra and inter group. This means the overall co-movement was weaken after large shocks. Especially for the events of a triple jump, the mean value decreases more sharply.

[Insert Table 4 Here]

The ratios of the pairs, which reject the null hypothesis that the correlation coefficient is not increased or decreased at 5% significance level, are reported in the table. The ratios of significant increase in correlation are less than 10% and the ratio for the events of triple jump and inter-group correlations is less than 5%. The ratios which are greater than the significance level of 5% can be evidence for some contagion, of course. However, considering upward bias implied in the correlation coefficients in the turmoil period, these results are not enough to support contagion effects.

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[1] The formula for the Fisher's z transformation is z = 0.5[ln(1+r) - ln(1-r)]. And z has a normal distribution with a known standard error of $\sqrt{\frac{1}{n-3}}$ , where n is the numbers of pairs. Then, a confidence interval for the difference between correlation coefficients is constructed based on the general formula for a confidence interval where the statistic is $z_1$-$z_2$, and the standard error of the statistic is $\sqrt{\frac{1}{n_1-3}+\frac{1}{n_2-3}}$ .

A lot of remedies dealing with the heteroskedasticity problem have been suggested. Among them, Rigobon (2000) proposed a simple test method which considers both endogeneity and omitted variable problems, as well as heteroskedasticity problem. Forbes and Rigobon (2002) addressed the endogenous and latent variables in the model can affect the bias caused by heteroskedasticity.

### 3. Simple Regression Tests

The change in a shock transmission mechanism can be tested simply using a regression model. The correlation coefficient is equal to the slope coefficient of a simple regression equation when the dependent and independent variables are normalized to have unit standard deviations. We can identify the change in correlations by examining the change in slope coefficients in regression equations. The test equation is as follows. In this model, it is assumed that firm 1 denotes the event firm and firm 2 denotes the firm which is affected by the shock on firm 1.

$$\Delta y_{2,t} = \alpha + \beta_1 \Delta y_{1,t} + \beta_2 \Delta y_{1,t} D_t^* + \varepsilon_t$$

where $D^*$ is a dummy variable having value 1 during the turmoil period. $\Delta y_1$ and $\Delta y_2$ denote the normalized changes in CDS spreads of firm 1 and firm 2, respectively.

In this test, the significant increase in correlation is captured by the slope coefficient, $\beta_2$. If the shocks on the firm 1 affect CDS spreads of firm 2 more during turmoil periods than during tranquil period, $\beta_2$ will have a positive value. Thus, we are able to examine the contagion effects by testing whether $\beta_2$ is significantly greater than zero.

Table 5 reports the results for the regression tests. The equations are estimated pairwisely and the values of mean and standard deviation of estimated coefficients are presented in this table. Amazingly, the $\beta_2$'s are negative on average for both intra and inter groups. This result means that the links between conditional default probabilities are weakened after a large idiosyncratic shock.

[Insert Table 5 Here]

In addition, the ratios of coefficients which are significantly positive or negative at 5% significance level are presented in the Table 5. More than 60% of the $\beta_1$ coefficients, which means the overall correlation, have significantly positive values. On the other hand, much less than 5% of the coefficients have negative values.

However, the $\beta_2$ coefficients have more significant negative values rather than positive values.

More than 30% of the coefficients have significantly negative values, while only less than 10% have significantly positive values. This evidence is against the contagion effect that a large idiosyncratic shock is transmitted to other firms beyond interdependence.

#### 4. Rigobon's DCC Tests

Rigobon (2000, 2003) developed a simple procedure to test for the stability of parameters when the data exhibits heteroskedasticity, endogeneity and omitted variable problem. We adopt his model to test for contagion effects in CDS market.

The model is the following linear simultaneous equations. The equations take into consideration reciprocities between variables and latent factors.

$$X_t A' = z_t \Gamma' + \varepsilon_t$$

$X_t$ is a T by N vector of endogenous variables given by $X_t \equiv (x_{1t}, \ldots, x_{Nt})$.

$z_t$ is a vector of K unobservable common factors, which are independent and have mean zero.

$\varepsilon_t$ is a vector of the idiosyncratic shocks, which are independent and have mean zero.

The covariance matrix of common factors and idiosyncratic shocks are given as follows.

$$E\left[\varepsilon_t{}' \varepsilon_t\right] = \Omega_t^{\varepsilon} \quad \text{and} \quad E\left[z_t{}' z_t\right] = \Omega_t^{z}$$

The A and Γ are coefficient matrices and the factor coefficients for the first variable are normalized to 1.

$$A = \begin{pmatrix} 1 & a_{12} & \cdots & a_{1N} \\ a_{21} & 1 & & \\ \vdots & & \ddots & \vdots \\ a_{N1} & & \cdots & 1 \end{pmatrix}, \text{ and } \Gamma = \begin{pmatrix} 1 & 1 & \cdots & 1 \\ \gamma_{21} & \gamma_{22} & & \gamma_{2k} \\ \vdots & & \ddots & \vdots \\ \gamma_{N1} & \gamma_{N2} & \cdots & \gamma_{Nk} \end{pmatrix}$$

We can calculate the covariance matrix of $X_t$ in the reduced from of the system.

$$\Omega_t = A^{-1}\Gamma\Omega_t^z\Gamma' A'^{-1} + A^{-1}\Omega_t^\varepsilon A'^{-1}$$

If the coefficients, A and Γ, are stable in time and $\Delta\Omega_t^\varepsilon$ has only one nonzero diagonal element, the determinant of change in covariance matrix will be zero.

$$\det(\Delta\Omega_t) = \det\left(A^{-1}\Gamma\Delta\Omega_t^z\Gamma' A'^{-1} + A^{-1}\Delta\Omega_t^\varepsilon A'^{-1}\right) = 0$$

The DCC method developed by Rigobon (2000) tests whether the determinant of the change in covariance matrix during the turmoil period is significantly different from zero. The change in the covariance matrix has determinant equal to zero, if the parameters are stable and the heteroskedasticity in some sub-sample is explained by the change in the variance of only one shock. This means the null hypothesis that the determinant of the change in covariance matrix is zero cannot be rejected if the shock transmission mechanism remains unchanged and the high volatility during the turmoil period is induced by an idiosyncratic shock. The confidence interval for the determinant can be obtained by statistical bootstrapping.

Sorry... The remainder is being in progress.

## IV. Conclusion

In this article, we examined the contagion effects in CDS spreads. An investigation of CDS market is useful to understand how the default probabilities are correlated since the CDS spreads can be directly interpreted as the reference firm's default intensity. Plenty of global firms are included in our analysis and the firms are classified into subgroups by their regions and sectors.

The contagion is defined as "excessive co-movement of CDS spreads beyond interdependence" and we test whether a large idiosyncratic shock is contagious and is excessively transmitted to other firms. For the purpose, the change in correlations during the turmoil period was analyzed. In addition, we estimated the simple regression model to test for the structural change in shock transmission mechanism.

We could not find any evidence that support the contagion effect in CDS spreads. As opposed to the contagion, we found the co-movement tends to be weakened after a large idiosyncratic shock, in the point of view that the correlation decreases after the shock. In conclusion, the contagion in CDS market cannot be an explanation to the question why the corporate defaults cluster in time.

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**Table 1. The number of firms in the dataset**

| | Asia | Europe | L.America | N.America | Oceania | Sum |
|---|---|---|---|---|---|---|
| Basic Materials | 4 | 16 | 2 | 49 | 2 | 73 |
| Consumer Goods | 17 | 33 | - | 85 | 3 | 138 |
| Consumer Service | 7 | 38 | 2 | 88 | 5 | 140 |
| Financials | 36 | 49 | - | 121 | 12 | 218 |
| Government | 18 | 9 | 15 | 2 | - | 44 |
| Health Care | - | 4 | - | 37 | 1 | 42 |
| Industrials | 20 | 31 | - | 86 | 4 | 141 |
| Oil & Gas | 5 | 6 | 1 | 50 | 1 | 63 |
| Technology | 7 | 4 | - | 28 | - | 39 |
| Telecommunication | 9 | 17 | - | 26 | 3 | 55 |
| Utilities | 10 | 21 | 1 | 60 | - | 92 |
| Sum | 133 | 228 | 21 | 632 | 31 | 1,045 |

**Table 2. Unconditional correlation coefficients**

| | Asia | Europe | L.America | N.America | Oceania | Sector Average |
|---|---|---|---|---|---|---|
| Basic Materials | 69.7% | 52.5% | 43.3% | 31.3% | 71.5% | 33.5% |
| Consumer Goods | 64.2% | 62.8% | - | 32.6% | 88.9% | 37.4% |
| Consumer Service | 68.2% | 51.0% | 53.6% | 37.4% | 45.3% | 39.7% |
| Financials | 62.5% | 69.6% | - | 30.0% | 67.8% | 37.6% |
| Government | 59.1% | 57.0% | 54.0% | 99.4% | - | 57.2% |
| Health Care | - | 82.3% | - | 31.9% | - | 32.3% |
| Industrials | 62.4% | 59.2% | - | 31.0% | 67.6% | 35.5% |
| Oil & Gas | 64.9% | 74.1% | - | 47.6% | - | 48.1% |
| Technology | 64.1% | 65.3% | - | 32.0% | - | 34.1% |
| Telecommunication | 59.2% | 67.2% | - | 26.5% | 90.8% | 40.3% |
| Utilities | 62.1% | 53.6% | - | 36.1% | - | 38.5% |
| Region Average | 62.3% | 61.5% | 53.9% | 33.2% | 66.8% | 38.0% |

## Table 3. The number of credit events

A. Jumping up two times within a week

| | Asia | Europe | L.America | N.America | Oceania | Sum |
|---|---|---|---|---|---|---|
| Basic Materials | 1 ( 1 ) | - ( - ) | - ( - ) | 6 ( 5 ) | - ( - ) | 7 ( 6 ) |
| Consumer Goods | 5 ( 5 ) | 1 ( 1 ) | - ( - ) | 7 ( 7 ) | - ( - ) | 13 ( 13 ) |
| Consumer Service | 3 ( 3 ) | 3 ( 3 ) | - ( - ) | 7 ( 7 ) | - ( - ) | 13 ( 13 ) |
| Financials | 13 ( 9 ) | 9 ( 9 ) | - ( - ) | 38 ( 31 ) | 1 ( 1 ) | 61 ( 50 ) |
| Government | 3 ( 2 ) | 2 ( 2 ) | - ( - ) | - ( - ) | - ( - ) | 5 ( 4 ) |
| Health Care | - ( - ) | - ( - ) | - ( - ) | 2 ( 2 ) | - ( - ) | 2 ( 2 ) |
| Industrials | 3 ( 3 ) | 1 ( 1 ) | - ( - ) | 12 ( 11 ) | - ( - ) | 16 ( 15 ) |
| Oil & Gas | - ( - ) | 2 ( 2 ) | - ( - ) | 4 ( 4 ) | - ( - ) | 6 ( 6 ) |
| Technology | 2 ( 2 ) | - ( - ) | - ( - ) | 1 ( 1 ) | - ( - ) | 3 ( 3 ) |
| Telecommunication | 5 ( 4 ) | 1 ( 1 ) | - ( - ) | 3 ( 3 ) | - ( - ) | 9 ( 8 ) |
| Utilities | 4 ( 4 ) | 2 ( 2 ) | - ( - ) | 11 ( 8 ) | - ( - ) | 17 ( 14 ) |
| Sum | 39 ( 33 ) | 21 ( 21 ) | - ( - ) | 91 ( 79 ) | 1 ( 1 ) | 152( 134 ) |

B. Jumping up three times within a week

| | Asia | Europe | L.America | N.America | Oceania | Sum |
|---|---|---|---|---|---|---|
| Basic Materials | - ( - ) | - ( - ) | - ( - ) | 1 ( 1 ) | - ( - ) | 1 ( 1 ) |
| Consumer Goods | - ( - ) | - ( - ) | - ( - ) | 1 ( 1 ) | - ( - ) | 1 ( 1 ) |
| Consumer Service | - ( - ) | 2 ( 2 ) | - ( - ) | 1 ( 1 ) | - ( - ) | 3 ( 3 ) |
| Financials | - ( - ) | - ( - ) | - ( - ) | 5 ( 5 ) | - ( - ) | 5 ( 5 ) |
| Government | - ( - ) | - ( - ) | - ( - ) | - ( - ) | - ( - ) | - ( - ) |
| Health Care | - ( - ) | - ( - ) | - ( - ) | - ( - ) | - ( - ) | - ( - ) |
| Industrials | - ( - ) | 1 ( 1 ) | - ( - ) | 3 ( 3 ) | - ( - ) | 4 ( 4 ) |
| Oil & Gas | - ( - ) | - ( - ) | - ( - ) | - ( - ) | - ( - ) | - ( - ) |
| Technology | - ( - ) | - ( - ) | - ( - ) | 1 ( 1 ) | - ( - ) | 1 ( 1 ) |
| Telecommunication | - ( - ) | 1 ( 1 ) | - ( - ) | - ( - ) | - ( - ) | 1 ( 1 ) |
| Utilities | - ( - ) | - ( - ) | - ( - ) | 3 ( 2 ) | - ( - ) | 3 ( 2 ) |
| Sum | - ( - ) | 4 ( 4 ) | - ( - ) | 15 ( 14 ) | - ( - ) | 19 ( 18 ) |

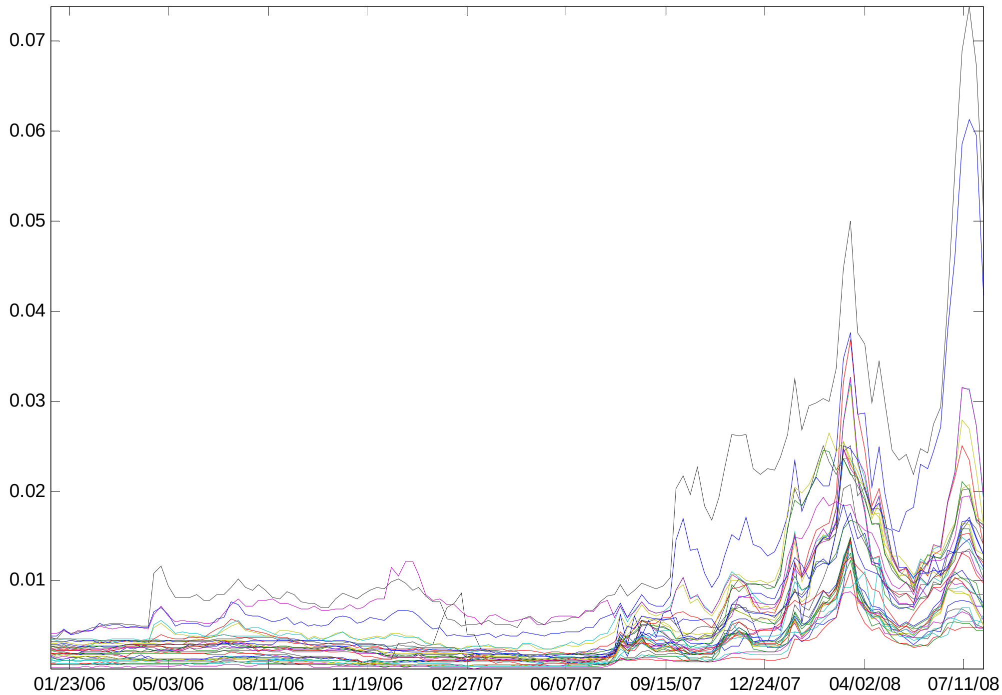
**Table 4. Correlation coefficient tests**

| turmoil event | stat | intra-group Tranquil | intra-group Turmoil | inter-group Tranquil | inter-group Turmoil |
|---|---|---|---|---|---|
| two times | mean | 0.308 | 0.263 | 0.302 | 0.239 |
| | std | 0.261 | 0.419 | 0.227 | 0.397 |
| | increase | | 8.6% | | 6.1% |
| | decrease | | 7.2% | | 7.4% |
| | pairs | 8,219 | 8,219 | 131,677 | 131,677 |
| three times | mean | 0.244 | 0.178 | 0.254 | 0.097 |
| | std | 0.251 | 0.470 | 0.230 | 0.423 |
| | increase | | 9.9% | | 3.6% |
| | decrease | | 10.8% | | 12.9% |
| | pairs | 1,339 | 1,339 | 17,453 | 17,453 |

**Table 5. Simple regression tests**

| | | intra-group | | inter-group | |
|---|---|---|---|---|---|
| turmoil event | stat | b1 | b2 | b1 | b2 |
| two times | mean | 0.384 | -0.210 | 0.367 | -0.166 |
| | std | 0.464 | 0.524 | 0.378 | 0.491 |
| | positive | 66.9% | 5.3% | 70.1% | 8.9% |
| | negative | 1.4% | 30.6% | 0.9% | 29.2% |
| | pairs | 8,219 | 8,219 | 131,677 | 131,677 |
| three times | mean | 0.241 | -0.156 | 0.317 | -0.263 |
| | std | 0.775 | 0.816 | 0.656 | 0.690 |
| | positive | 56.0% | 3.4% | 61.1% | 2.1% |
| | negative | 1.9% | 31.7% | 0.9% | 39.3% |
| | pairs | 1,339 | 1,339 | 17,453 | 17,453 |

**Figure 1. CDS spreads for 36 financial firms in Asia**



## Appendix. List of Credit Events

| Ticker | Company | Sector | Region | Country | Event Dates | |
|---|---|---|---|---|---|---|
| | | | | | 2-times | 3-times |
| JARMAT | Jardine Matheson Hldg | Consumer Servic | Asia | Hong Kong | 20070801 | |
| KCRC | Kowloon Canton Rwy Co | Consumer Servic | Asia | Hong Kong | 20070801 | |
| CHINA-HK | Arpt Auth HKAA | Government | Asia | Hong Kong | 20071017 | |
| | | | | | 20071031 | |
| CTHK | City Telecom HK Ltd | Telecommunicati | Asia | Hong Kong | 20060621 | |
| NPG | Nippon Paper Group In | Basic Materials | Asia | Japan | 20080123 | |
| KIRIN | Kirin Brewery Co Ltd | Consumer Goods | Asia | Japan | 20080123 | |
| SEKCHE | Sekisui Chem Co Ltd | Consumer Goods | Asia | Japan | 20080123 | |
| SHARP | SHARP Corp | Consumer Goods | Asia | Japan | 20080123 | |
| KEIHIN | Keihin Elec Express R | Consumer Servic | Asia | Japan | 20080123 | |
| ACOM | ACOM CO LTD | Financials | Asia | Japan | 20060419 | |
| AIFUL | Aiful Corp | Financials | Asia | Japan | 20070725 | |
| | | | | | 20070815 | |
| LTCB | Shinsei Bk Ltd | Financials | Asia | Japan | 20080123 | |
| MUFJ-BTM | Bk of Tokyo Mitsubish | Financials | Asia | Japan | 20061220 | |
| SUMITR | Sumitomo Tr & Bkg Co | Financials | Asia | Japan | 20071107 | |
| TOKIO | Millea Hldgs Inc | Financials | Asia | Japan | 20071114 | |
| | | | | | 20080123 | |
| ZESHBK | Shinkin Cen Bk | Financials | Asia | Japan | 20080312 | |
| SHOCHU | Shoko Chukin Bk | Government | Asia | Japan | 20080312 | |
| KAWHI | Kawasaki Heavy Inds L | Industrials | Asia | Japan | 20080123 | |
| ADVANT | Advantest Corp | Technology | Asia | Japan | 20080123 | |
| NECORP-E | Nec Electrs Corp | Technology | Asia | Japan | 20080123 | |
| CRLY-Wil | WILLCOM Inc | Telecommunicati | Asia | Japan | 20080123 | |
| DDI | KDDI Corp | Telecommunicati | Asia | Japan | 20080123 | |
| NTT | Nippon Telegraph & Te | Telecommunicati | Asia | Japan | 20070801 | |
| | | | | | 20080123 | |
| CHUBEP | CHUBU Elec Pwr Co Inc | Utilities | Asia | Japan | 20080123 | |
| KYUSEL | Kyushu Elec Pwr Co In | Utilities | Asia | Japan | 20080123 | |
| OSAKAG | Osaka Gas Co Ltd | Utilities | Asia | Japan | 20080123 | |
| TOKELP | Tokyo Elec Pwr Co Inc | Utilities | Asia | Japan | 20080123 | |
| HYNMTR-K | Kia Mtrs Corp | Consumer Goods | Asia | Korea (Republic of) | 20060215 | |
| HANABK | Hana Bank | Financials | Asia | Korea (Republic of) | 20070801 | |
| | | | | | 20070815 | |
| KORELE-K | Korea Southern Pwr Co | Government | Asia | Korea (Republic of) | 20080220 | |
| KOWACO | Korea Water Res Corp | Utilities | Asia | Korea (Republic of) | 20071121 | |
| BCHB-CIM | CIMB Bk BHD | Financials | Asia | Malaysia | 20070801 | |
| DBSSP-DB | DBS Bk Ltd | Financials | Asia | Singapore | 20070613 | |
| | | | | | 20080416 | |
| TFIFP | Societe Television Fr | Consumer Servic | Europe | France | 20080220 | |
| CRFON | Cr Foncier De France | Financials | Europe | France | 20080123 | |
| CHRBNG | Charbonnages de Franc | Government | Europe | France | 20070801 | |
| FRTR | French Rep | Government | Europe | France | 20070801 | |
| BOUY | BOUYGUES | Industrials | Europe | France | 20080227 | 20080227 |
| RBOSCH | Robert Bosch GmBH | Consumer Goods | Europe | Germany | 20080220 | |
| BYLAN | Bay Landbk Giroz | Financials | Europe | Germany | 20070801 | |
| TALANX-H | HDI Gerling Industrie | Financials | Europe | Germany | 20070725 | |
| MILANO | Bca Pop di Milano Soc | Financials | Europe | Italy | 20070801 | |
| FINMEC | Finmeccanica S p A | Industrials | Europe | Italy | 20071121 | |
| ENEL | ENEL S p A | Utilities | Europe | Italy | 20070801 | |
| AAB | ABN Amro Hldg N V | Financials | Europe | Netherlands | 20070801 | |
| TNT | TNT N.V. | Industrials | Europe | Netherlands | 20071121 | |
| BRISA | Brisa Auto Estradas d | Industrials | Europe | Portugal | 20060208 | 20060208 |
| ITV | ITV Plc | Consumer Servic | Europe | United Kingdom | 20080702 | 20080702 |
| RTRGRP | Reuters Gp PLC | Consumer Servic | Europe | United Kingdom | 20070207 | 20070207 |
| YELLLN-P | Yellow Pages Ltd | Consumer Servic | Europe | United Kingdom | 20070801 | |
| BRADBI | Bradford & Bingley PL | Financials | Europe | United Kingdom | 20071121 | |
| LAND | Ld Secs Gp plc | Financials | Europe | United Kingdom | 20070808 | |
| LAND-Sec | Ld Secs PLC | Financials | Europe | United Kingdom | 20070801 | |
| IPRLN | Intl Pwr PLC | Utilities | Europe | United Kingdom | 20071128 | |
| SINCH-HK | SINOCHEM HONG KONG Hl | Basic Materials | N.Amer | Bermuda | 20080312 | |
| CP | Cdn Pac Ltd | Industrials | N.Amer | Canada | 20070718 | |
| RYG | ROYAL GROUP Tech Ltd | Industrials | N.Amer | Canada | 20060125 | |
| ARMLL-Us | ArcelorMittal USA Inc | Basic Materials | N.Amer | United States | 20080716 | |
| DOMC | Domtar Corp | Basic Materials | N.Amer | United States | 20070228 | |
| EMN | Eastman Chem Co | Basic Materials | N.Amer | United States | 20080206 | |
| | | | | | 20080305 | |
| LYO | Lyondell Chem Co | Basic Materials | N.Amer | United States | 20080206 | |
| WLKCC | Westlake Chem Corp | Basic Materials | N.Amer | United States | 20080430 | 20080430 |
| BMW-USCa | BMW US Cap LLC | Consumer Goods | N.Amer | United States | 20061011 | |
| JCI | Johnson Ctls Inc | Consumer Goods | N.Amer | United States | 20060322 | |
| LEA | Lear Corp | Consumer Goods | N.Amer | United States | 20080319 | 20080319 |
| METALD | Metaldyne Corp | Consumer Goods | N.Amer | United States | 20060111 | |
| NESTLE-H | Nestle Hldgs Inc | Consumer Goods | N.Amer | United States | 20070110 | |
| SIMBED | Simmons Bedding Co | Consumer Goods | N.Amer | United States | 20061004 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| COST | Costco Whsl Corp | Consumer Servic | N.Amer | United States | 20070725 | |
| HD | Home Depot Inc | Consumer Servic | N.Amer | United States | 20061004 | |
| HET | Harrahs Entmt Inc | Consumer Servic | N.Amer | United States | 20061004 | |
| HYATT | Hyatt Equities LLC | Consumer Servic | N.Amer | United States | 20080723 | |
| STN | Sta Casinos Inc | Consumer Servic | N.Amer | United States | 20061115 | |
| TRUVO-Su | TRUVO SUBSIDIARY CORP | Consumer Servic | N.Amer | United States | 20061213 | 20061213 |
| UNOR | Uno Restaurant Corp | Consumer Servic | N.Amer | United States | 20060510 | |
| ABK-Assu | Ambac Assurn Corp | Financials | N.Amer | United States | 20070725 | |
| | | | | | 20070801 | |
| | | | | | 20071031 | |
| | | | | | 20080123 | 20080123 |
| AFL | AFLAC Inc | Financials | N.Amer | United States | 20070725 | |
| AGO-AGUS | Assur Gty Us Hldgs In | Financials | N.Amer | United States | 20070801 | |
| AIG-Amge | Amern Gen Corp | Financials | N.Amer | United States | 20070801 | |
| AIG-Amge | Amern Gen Fin Corp | Financials | N.Amer | United States | 20070801 | |
| ALL-Life | Allstate Life Ins Co | Financials | N.Amer | United States | 20071219 | |
| | | | | | 20080206 | |
| AXP-Cred | Amern Express Cr Corp | Financials | N.Amer | United States | 20070801 | 20070801 |
| C | Citigroup Inc | Financials | N.Amer | United States | 20070801 | |
| | | | | | 20071128 | |
| CB | Chubb Corp | Financials | N.Amer | United States | 20070815 | |
| CCR | Ctrywde Finl Corp | Financials | N.Amer | United States | 20070815 | 20070815 |
| CINF | Cincinnati Finl Corp | Financials | N.Amer | United States | 20070815 | |
| COMET | Cap One Multi Asset E | Financials | N.Amer | United States | 20070801 | |
| DDR | Developers Diversifie | Financials | N.Amer | United States | 20071107 | |
| FNF | Fid Natl Finl Inc | Financials | N.Amer | United States | 20071205 | |
| GE-GNWTH | Genworth Finl Inc | Financials | N.Amer | United States | 20070801 | |
| HCPI | HCP, Inc. | Financials | N.Amer | United States | 20080213 | |
| HIW | Highwoods Pptys Inc | Financials | N.Amer | United States | 20080109 | |
| JACLIF | Jackson Natl Life Fdg | Financials | N.Amer | United States | 20080716 | 20080716 |
| JPM-Chas | JPMorgan Chase Bk Nat | Financials | N.Amer | United States | 20080312 | |
| | | | | | 20080625 | |
| LIBMUT | Liberty Mut Ins Co | Financials | N.Amer | United States | 20080319 | |
| LRY | Liberty Ppty Tr | Financials | N.Amer | United States | 20080227 | |
| LTR | Loews Corp | Financials | N.Amer | United States | 20080213 | |
| MET | MetLife Inc | Financials | N.Amer | United States | 20080220 | |
| PFGRQ | Prin Finl Group Inc | Financials | N.Amer | United States | 20070801 | |
| PRU-Fund | Prudential Fdg LLC | Financials | N.Amer | United States | 20080220 | |
| RA | Reckson Assoc Rlty Co | Financials | N.Amer | United States | 20071121 | |
| RDN | Radian Gp Inc | Financials | N.Amer | United States | 20070801 | |
| SAFC | SAFECO Corp | Financials | N.Amer | United States | 20070912 | |
| SKT-Prop | TANGER Pptys Ltd PART | Financials | N.Amer | United States | 20070418 | 20070418 |
| WILLIS | Willis North Amer Inc | Financials | N.Amer | United States | 20070815 | |
| | | | | | 20071107 | |
| WRE | WA Real Estate Invt T | Financials | N.Amer | United States | 20070808 | |
| BMY | Bristol Myers Squibb | Health Care | N.Amer | United States | 20070516 | |
| HB | Hillenbrand Inds Inc | Health Care | N.Amer | United States | 20060726 | |
| BLDGMT | Bldg Matls Corp Amer | Industrials | N.Amer | United States | 20080206 | |
| CAT | Caterpillar Inc | Industrials | N.Amer | United States | 20080109 | |
| DLX | Deluxe Corp | Industrials | N.Amer | United States | 20060809 | 20060809 |
| ETN | Eaton Corp | Industrials | N.Amer | United States | 20070404 | |
| GD | Gen Dynamics Corp | Industrials | N.Amer | United States | 20070801 | 20070801 |
| NOC | Northrop Grumman Corp | Industrials | N.Amer | United States | 20070808 | |
| PH | PARKER HANNIFIN Corp | Industrials | N.Amer | United States | 20070919 | 20070919 |
| | | | | | 20080102 | |
| ROK-Coll | Rockwell Collins Inc | Industrials | N.Amer | United States | 20080618 | |
| SLR | Solectron Corp | Industrials | N.Amer | United States | 20080312 | |
| BHI | Baker Hughes Inc | Oil & Gas | N.Amer | United States | 20080312 | |
| KMI | Kinder Morgan Inc | Oil & Gas | N.Amer | United States | 20060531 | |
| NI-FinCo | NiSource Fin Corp | Oil & Gas | N.Amer | United States | 20080402 | |
| TSO | Tesoro Corp | Oil & Gas | N.Amer | United States | 20080305 | |
| FICORP | Fair Isaac Corp | Technology | N.Amer | United States | 20060913 | 20060913 |
| TDS | Tel & Data Sys Inc | Telecommunicati | N.Amer | United States | 20061004 | |
| VZINC | Verizon Comms Inc | Telecommunicati | N.Amer | United States | 20080326 | |
| VZW | Verizon Wireless Inc | Telecommunicati | N.Amer | United States | 20080611 | |
| BRK-MidA | Midamerican Engy Hldg | Utilities | N.Amer | United States | 20070228 | |
| EFHC-Onc | Oncor Elec Delivery C | Utilities | N.Amer | United States | 20060628 | |
| | | | | | 20060927 | |
| | | | | | 20070321 | 20070321 |
| | | | | | 20070425 | 20070425 |
| EQT | EQUITABLE Res INC | Utilities | N.Amer | United States | 20071107 | 20071107 |
| EXC | Exelon Corp | Utilities | N.Amer | United States | 20070704 | |
| FE-Cleve | Cleveland Elec Illum | Utilities | N.Amer | United States | 20070829 | |
| KSE | KeySpan Corp | Utilities | N.Amer | United States | 20080220 | |
| PGL | PEOPLES ENERGY Corp | Utilities | N.Amer | United States | 20070801 | |
| TXU-Texa | TX Competitive Elec H | Utilities | N.Amer | United States | 20070228 | |
| LLC-LLFM | Lend Lease Fds Mgmt L | Financials | Oceania | Australia | 20070801 | |
| # of obs. | 134 | | | | 152 | 19 |