SHOCKS FROM THE SUB-PRIME CRISIS TO BOND INDICES IN THE U.S., THE EU AND EMERGING MARKETS VIA CDS INDICES

Hao FANG[1]
Chung-Hua SHEN[2]
Hwey-Yun YAU[3]
Chien-Ping CHUNG[4]
Yen-Hsien LEE[5]

Abstract

Extending Longstaff's (2010) approach, this study uses the pre-, occurrence and persistent-periods of sub-prime crises in order to examine changes in global impulse responses, variance decompositions and contagion effects from the direct indices (i.e., ABX indices) of collateralised debt obligation (CDO), one kind of risky asset-backed securities (ABS), to the indices of credit default swaps (CDS). We then examine the similar approaches from CDS indices to associated bond indices. This paper is the first study to analyse the effects of shocks of financial crises on global bond markets through financial markets of risky ABS and CDS, simultaneously. These approaches are valuable because an investor buying a risky ABS tends to purchase a CDS to hedge the risks of the ABS, which then this CDS will transmit credit risks to capital markets.

Our findings show significant impulse responses and contagion effects from lower-rated ABX index returns to associated CDS index returns, as opposed to higher-rated ABX index returns after a crisis occurs. During the outbreak of a crisis, a sharp increase in impulse responses from CDS index returns to bond index returns in emerging markets has been observed, as well as a larger rise in the variance ratio from CDS indices to Asian and Non-Asian emerging market bond indices, as opposed to developed market bond indices. Thus,

[1] *School of Economics, Qufu Normal University. No. 80, North Road, Yantai, Rizhao City, Shandong, 276800, China.*
[2] *Department of Finance and Banking, College of Management, Shih Chien University. No. 70, Dazhi Street, Taipei 10462, Taiwan, R.O.C.*
[3] *Department of Accounting and Information, National Taipei University of Business. No. 321, Sec.1, Jinan Rd., Zhong Zheng District, Taipei, Taiwan 10051, R.O.C. E-mail: yauhy2006@gmail.com. Corresponding author.*
[4] *College of Management, National Taiwan University of Science and Technology. No.43, Keelung Rd., Sec.4, Da'an Dist., Taipei City 10607, Taiwan, R.O.C.*
[5] *Department of Finance, Chung Yuan Christian University. No. 200, Chung Pei Rd., Chungli 32023, Taiwan, R.O.C.*

developed countries should stop rebalancing losses through securitization and recapitalization in emerging markets, in order to prevent a severe global financial crisis. Moreover, following the onset of the sub-prime crisis, there were more significant contagion effects from CDS indices in Asian emerging market bond indices, as opposed to developed markets. In the early stage of a crisis, credit risks significantly increase in Asian emerging market bond index returns. Hence, financial authorities in Asian emerging markets should avoid the risks of large investments in fixed income securities for investors after a crisis occurs.

Keywords: sub-prime crisis; risky asset-backed securities; CDS index; bond index; contagion effects; impulse response; variance decomposition

JEL Classification: C32, F65, G01, G11, G12, G15

1. Introduction

Through financial innovations, financial institutions have repackaged mortgage-backed securities (MBS) and collateralised debt obligations (CDO) in the form of derivatives sold to investors. Both MBS and CDO belong in classes of risky asset-backed securities (ABS). The asymmetry of information between risky ABS and leveraged recapitalizations led to the sub-prime mortgage crisis. In addition to considerable losses borne by financial institutions, the ensuing shocks spilled across the housing and financial markets all over the world.

An ABX index, used to measure CDO returns and potential losses, consists of daily closing values for home-equity CDO of diverse credit ratings from respective dealers.[6] A credit default swap (CDS) refers to a credit derivative used to disperse default risks, which isolates the credit risks of bonds or loans. A CDS index measures credit and liquidity risks in financial environments, and CDS returns also measure the default probability of all corporate bonds and the risk for counterparties. A CDS index includes the North American CDS index, the emerging markets CDS index, and the Europe, Asia, and Australia iTraxx indices. An investor buying a CDO tends to purchase a CDS to hedge against CDO risks, and the changes in the CDS returns indicate the level of financial shocks.

Following this, the leading position of the CDS market in the stock market is in doubt.[7] However, related studies indicate that the CDS market performs the function of *price discovery* in the bond market. The findings of Longstaff, Mithal and Neis (2003) show that CDS and stock returns are ahead of corporate bond yields. Zhu (2004) identified CDS returns as being ahead of bond yields, and Blanco, Brennan and Marsh (2005) demonstrated that the CDS index is ahead of bond indices. Thus, a CDS index can be a leading indicator of its associated bond index.

Longstaff (2010) focused on the contagion effects of ABX indices with diverse ratings on stock and bond markets. However, an investor buying a risky CDO tends to purchase a CDS to hedge the risks of the risky CDO, and then the CDS will transmit credit risks to capital markets. It is necessary to analyse the effects of shocks from financial crises on global bond markets through financial markets of risky ABS and credit derivatives. *The 2007 sub-prime crisis provides an ideal opportunity to study the effects of* impulse responses, variance decomposition and *contagion in these corresponding indices of risky ABS, CDS and bond*

[6] *ABX indices with 5 ratings of AAA, AA, A, BBB and BBB- refer to the indicators for market quotations of a specific basket of CDO of diverse credit ratings.*

[7] *Norden and Weber (2004) discovered the leading position of the CDS market in the stock market. Forte and Pena (2009) addressed the leading position of the stock market in relation to the CDS market.*

markets. Thus, this study uses the pre-, occurrence and persistent- periods of a sub-prime crisis to further investigate the relation between the ABX and CDS indices, as well as that between the CDS and bond indices. This paper is organised as follows: In part 1, we present impulse responses, variance decompositions and contagion effects of the ABX indices on CDS indices. In part 2, we explore financial spread using similar techniques, in relation to the effects of CDS indices on bond indices, in various regions. Identifying these effects of severe financial shocks helps to avoid a serious subsequent global financial storm.

2. Literature Review

2.1 Impulse Response and Variance Decomposition between Financial Markets

The empirical results of Longstaff (2010), using the VAR framework, found that the lagged ABX indices in the pre-crisis period provided little forecasting for bond indices, while the lagged ABX returns during the 2007 sub-prime crisis period gave rise to significant forecasting power on one-year and 10-year Treasury yields.[8] On the one hand, an investor buying a risky CDO tends to purchase a CDS as a hedge against CDO risk. On the other hand, as addressed by Zhu (2004) and Blanco, and Brennan and Marsh (2005), a CDS index is a leading indicator of a bond index. Because a leading financial market index leads to higher impulse and effect in a lag financial market index during a financial crisis period as opposed to a non-crisis period, the impulse response analysis and variance decomposition are used to catch the corresponding impulse and effect between these different financial markets. Sims (1980) proposed the use of impulse response analysis to build a dynamic structure via direct data assays on no need of prior theory, in order to resolve the identification of the framework. Also, Kutan (2007) said that an advantage of using the variance decomposition procedure was that the endogeneity problem in the local and foreign returns might be determined simultaneously.[9] The declaration of bankruptcy by Lehman Brothers on 15 September 2008 was the most severe corporate bankruptcy during the crisis period, and shocked investors all over the world with its associated impact on financial trading. Thus, this study analyses the impact of ABX indices on the associated CDS indices, and of CDS indices on the associated bond indices via impulse response analysis and variance decomposition in the outburst period after the above date. We analyse these impacts so as to compare the possible differences between the pre-crisis and crisis outburst period. We take the U.S. and the EU developed regions and the Asian and non-Asian emerging markets as our samples to examine the possible increase in global credit risks (*i.e., H_1*), and the further effects in capital markets during the short-term financial crisis (*i.e., H_2*). Hence, this study establishes the following two test hypotheses:

H_1: In terms of impulse response and variance decomposition, the ABX indices of different ratings have a more significant impact on the associated CDS indices in the crisis outburst period than in the pre-crisis period.

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[8] *Also, following the sub-prime crisis, all of the significant coefficients for the ABX returns are positive, indicating that negative shocks lead to a drop in bond yields and a rise in bond prices. Additionally, a lagged ABX index has significant and positive forecasting ability in the case of the S&P 500 index.*

[9] *The reason for this is that the variance decomposition approach is based on a vector autoregressive (VAR) model, which allows us to control for structural relationships in the data (Dornbusch, Park, and Classens, 2000).*

H_2: The impulse response and variance decomposition ratios of CDS indices to the associated bond indices are significantly greater in the crisis outburst period as opposed to the pre-crisis period.

2.2 Contagion Effects between Financial Markets

The contagion effect is used to analyse significant changes in the correlations between the different financial markets. Dornbusch, Park and Classens (2000) and Forbes and Rigobon (2002) proposed that contagion effects refer to a situation in which shocks in one market of a state/region lead to a significant rise in co-movements between the indices in financial markets. However, in addition to the positive drive towards a significant rise, such a narrow definition may overlook the negative drive towards a significant drop.[10] This study follows the definition of financial contagion proposed by Kaminsky, Reinhart and Vegh (2003), and Bae, Karolyi and Stulz (2003) as well as many others, which posits that after a shock occurs in one market, there is a significant increase in cross-market linkages, possibly due to a significant rise or drop in co-movement between the indices in financial markets.[11] There are many empirical studies that identify cross-market contagion effects, including the following: cross-market correlation coefficients analyses by Lee and Kim (1993), and Calvo and Reinhart (1995); the GARCH models of Hamao, Masulis and Ng (1990), Edwards (1998), and Edwards and Susmel (2001); the cointegration analysis by Chou, Ng and Pi (1994) and Longin and Slonik (1995); and the vector autoregression (VAR) of Longstaff (2010).

Similarly, a leading financial market index provides higher contagion effect for a lag financial market index during a financial crisis period, as opposed to a non-crisis period. Also, the timeline is divided from the beginning of 2007, which is known as the onset of the sub-prime crisis, into the pre-crisis period and the crisis period (according to Longstaff, 2010), in order to explore the contagion effect of ABX indices on the associated CDS indices. Thus, we establish test hypothesis 3 as follows:

H_3: In terms of the contagion effects between the CDO and CDS markets, the correlation between the ABX indices of different ratings and the CDS indices in respective regions significantly increases after the onset of a crisis.

The CDOs with lower-rated ABX indices have larger credit risks, so these CDOs are assumed to spill over larger credit risks to the associated CDS indices than the CDOs with higher-rated ABX indices during the sub-prime crisis period. Thus, test hypothesis 4 is established:

H_4: The contagion effects of lower-rated ABX indices on the associated bond indices are more pronounced than those of higher-rated ABX indices in the initial crisis period.

Similarly, the CDS indices are assumed to spill over larger credit risks to the associated bond indices during the financial crisis period as opposed to the non-crisis period. Thus, test hypothesis 5 is established:

H_5: In terms of the contagion effects between the CDS and bond markets, the correlation between the CDS indices and the associated bond indices significantly increase after the onset of the crisis.

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[10] *Both the positive and negative impacts triggered a "flight to quality" during the crisis period, thereby giving rise to cross-market multiple equilibria.*

[11] *The statistics from low to high values refer to the cross-market contagion effects, whereas those maintaining high values represent interdependence.*

Moreover, the contagion effect in developing markets may be more severe than in developed markets, since developing markets gradually implement liberalization in financial markets. However, a market opening in an emerging financial market serves only to accelerate the impact of a financial crisis (see Kim and Ying, 2007). Also, Bae, Karolyi and Stulz (2003) have proposed that emerging markets are more vulnerable to the impacts of international financial crises, rather than developed markets. Hence, test hypothesis 6 is established:

H_6 : The contagion effects of the CDS indices on the bond indices in Asian and non-Asian developing markets are more pronounced than those on the bond indices in the U.S. and EU developed markets in the sub-prime crisis period.

3. Variables, Data Range, Data Analysis and Methodology

3.1 Variables

(1) ABX Index

The data on the ABX indices are obtained from the daily closing values of ABX.HE 1, ABX.HE 2, ABX.HE 3 and ABX.HE 4, as disclosed by Reuters.[12] In order to integrate these four ABX indices into an overall ABX index, this study formulates an exclusive estimate, which discloses a specific value by rolling these four ABX indices for each half-year as used by Longstaff (2010).

(2) CDS index

The major corporate bond-related CDS index is used. The representative CDS index in the U.S. refers to the best investment-grade North-American CDX index, while that in non-Asian emerging markets refers to the CDX index in the emerging market of Latin America and Europe, the Middle East and Africa (EMEA), with those in Europe and Asia referring to the iTraxx Europe index and the iTraxx Asia index, respectively.[13] Because the proportion of corporate bond-related CDS indices to total CDS indices is highest, the changes in corporate bond-related CDS indices are used to find out how the world has suffered under the impact of the sub-prime mortgage credit risks and liquidity risks. The data have been obtained from the daily closing values, available from Bloomberg.

(3) Bond Indices

The data on bond markets in the U.S., Europe, and the Asian and non-Asian emerging markets are obtained from the daily closing values of government bond indices. Among them, the Europe bond index refers to one-year government bonds, which includes 11 countries. The Asian bond index refers to one-year Hong Kong government bonds, and the non-Asian bond index refers to one-year government bonds from the emerging markets in Latin America and EMEA.

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12 The data for ABX.HE 1 are based on the five credit ratings of AAA, AA, A, BBB and BBB-, which refer to the daily closing values of the ABX indices from 1/19/2006 to 6/30/2009. The data for ABX.HE 2, ABX.HE 3 and ABX.HE 4 are based on those from 7/19/2006 to 6/30/2009, 1/19/2007 to 6/30/2009 and 7/19/2006 to 6/30/2009, respectively.

13 We refer to the North-American CDX index as the CDX-US index and the emerging markets CDX index as the CDX-EM index. In addition, we refer to the iTraxx Europe index as the iTraxx-EU index and the iTraxx Asia index as the iTraxx-Asia index.

3.2 Data Range

Data on the ABX indices became available on 19 January 2006, and the sub-prime crisis came to an end at the end of the first half of 2009. Therefore, the period for which data was collected extends from 19 January 2006 to 30 June 30 2009. Since the sub-prime mortgage crisis began in 2007, the time before 2007 is referred to as the pre-crisis period and the time after the beginning of 2007 refers to the crisis period. Since the Lehman Brothers' bankruptcy took place on 15 September 2008, the timeline is divided into two parts: the early stage, or the initial period (4 January 2007 to 12 September 2008), and the outbreak stage or the crisis period (15 September 2008 to 30 June 2009).

3.3 Data Analysis

We can see in Table 1 that the ABX index returns of various ratings experienced larger negative returns in the crisis period than in the pre-crisis period, and their largest negative returns occurred in the crisis outburst period. The respective CDS index returns also experienced larger negative returns in the crisis outburst period than in the pre-crisis period. The volatilities of ABX index returns and CDS index returns were significantly higher in the crisis period than in the pre-crisis period, and their highest volatilities occurred in the outburst period. These findings imply that there could be larger impulse response and variance decomposition in the onset of the outburst period, as opposed to the pre-crisis period. Next, the absolute value of the average correlation between different ABX index returns and CDS index returns significantly increased from the pre-crisis period to the initial period. These results imply that there could be larger contagion effect in the initial crisis period than in the pre-crisis period.

3.4 Methodology - Contagion Effects via an AR-GJR-GARCH Model

Extending Longstaff's (2010)'s approach, this study uses an autoregressive (AR) and a residual GJR-GARCH model to examine whether there are contagion effects from ABX index returns of certain credit ratings on CDS index returns across the four regions studied during the initial sub-prime crisis. We then investigate whether there are contagion effects from CDS index returns on associated bond index returns.[14] This study integrates a GJR-GARCH model into an AR approach's residual in order to avoid the heterogeneity of daily residual's volatility and capture asymmetric volatility from negative news of the crisis. In discussing contagion effects, we focus on the coefficients of dummy variables before and after the crisis to differentiate the impact of the ABX indices of various ratings on the CDS indices in a specific region, and that of the CDS indices on associated bond indices before and after the onset of the crisis. These models are estimated as follows:

(1) Are there contagion effects from ABX indices to CDS indices in specific regions?[15]

$$\begin{aligned}
&\Delta CDS_{n,t} = \alpha_0 + \sum_{i=1}^{q} \alpha_{1,i} \Delta CDS_{n,t-i} + \alpha_{2,i} I_{pre} \Delta ABX_{t-i} + \alpha_{3,i} I_{post} \Delta ABX_{t-i} + \varepsilon_{n,t} \\
&h_{n,t} = \phi_0 + \phi_1 \varepsilon^2_{n,t-1} + \phi_2 h_{n,t-1} + \phi_3 \varepsilon^2_{n,t-1} I_{n,t-1} \\
&\begin{cases} I_{n,t-1} = 1, if\ \varepsilon_{n,t-1} < 0 \\ I_{n,t-1} = 0, if\ \varepsilon_{n,t-1} \geq 0, \end{cases} \qquad h_{n,t} = E\left[\varepsilon^2_{n,t} \middle| \varepsilon_{n,t-1}, \varepsilon_{n,t-2}, \ldots \right]
\end{aligned} \tag{1}$$

[14] *We use an AR model as there was only one CDS index in a specific region.*

[15] *In (3.2.1), ΔCDS_t^n represents CDS index returns in a specific region n, and ΔABX_t represents the ABX index returns. I_{pre} is a dummy variable with a value of 1 before Jan, 4, 2007 and 0 otherwise. I_{post} is a dummy variable with the value of 1 after Jan, 4, 2007 and 0 otherwise.*

(2) Are there contagion effects from the CDS indices to the associated bond indices?[16]

$$\Delta P_{n,t} = \beta_0 + \sum_{i=1}^{q} \beta_{1,i}\Delta P_{n,t-i} + \beta_{2,i} I_{pre}\Delta CDS_{n,t-i} + \beta_{3,i} I_{post}\Delta CDS_{n,t-i} + \varepsilon_{n,t}$$

$$h_{n,t} = \gamma_1 + \gamma_2 \varepsilon^2_{n,t-1} + \gamma_2 h_{n,t-1} + \gamma_3 \varepsilon^2_{n,t-1} I_{n,t-1}$$

$$\begin{cases} I_{n,t-1} = 1, if \ \ \varepsilon_{n,t-1} < 0 \\ I_{n,t-1} = 0, if \ \ \varepsilon_{n,t-1} \geq 0, \end{cases} \qquad h_{n,t} = E\left[\varepsilon^2_{n,t} \middle| \varepsilon_{n,t-1}, \varepsilon_{n,t-2}, \ldots\right] \tag{2}$$

In equation 1, we use a different ABX index each time.[17] If there are contagion effects between various ABX index returns (CDS index returns) and CDS index returns (the associated bond index returns) during the sub-prime crisis, we anticipate that the correlation will become significantly higher after the crisis as opposed to before the crisis. To analyse whether there is a significant difference in the correlation between various ABX index returns (CDS index returns) and CDS index returns (the associated bond index returns) during the crisis period, compared with the pre-crisis period, we not only determine whether the t-values on the respective coefficients $\alpha_{3,i}$ and $\beta_{3,i}$ are significantly different from zero, but also examine whether the F-values of the coefficients $\alpha_{3,1}$ and $\alpha_{3,2}$ ($\beta_{3,1}$ and $\beta_{3,2}$) are jointly and significantly different from zero.

4. Empirical Findings

4.1 Vector Autoregression-Impulse Response Analysis and Variance Decomposition

First, this study uses the Granger causality test to estimate whether there is transmission from CDS indices to related bond indices during the crisis period. The results of the Granger causality test are summarized rather than shown, because of space limitations.[18] After the onset of the sub-prime crisis, the CDX-US and iTraxx-Asia indices exhibited significant leading relationships over the U.S. and Asian emerging market bond indices. As well, there are significant and increasing two-way influences between non-Asian emerging market bonds and the CDX-EM indices. The above findings indicate that there is more causal transmission from the CDS to bond indices in specific regions during the crisis period, as opposed to the pre-crisis period.

Then, by means of a multivariate VAR model using impulse response analysis, we separately compare the differences in the cumulative impulse response effects of ABX index returns on CDS index returns in the studied regions, and those of CDS index returns on the associated bond index returns before and after the financial crisis. Meanwhile, we use the percentage of forecasting error variance decomposition under a multivariate VAR model to explain the impacts of each variable as well as other variables from the ABX index returns to the CDS index returns. Similarly, we use this approach to explain these impacts from the CDS index returns to the associated bond index returns.

Observing Figures 1 to 4, there is a significant impulse response from the higher-rated (AAA, AA) ABX index returns to the four CDS index returns in the studied regions in the pre-crisis

[16] *In (3.2.2), $\Delta P_{n,t}$ represents the bond index returns in the specific region n, and $\Delta CDS^{n}_{n,t-i}$ represents CDS index return of the previous i period in the region n. The statement regarding the dummy variables is the same as that in footnote 22.*

[17] *The Akaike information criterion (AIC) is used in the selection of lags.*

[18] *These data are available upon request.*

period, whereas there is a significant impulse response from the lower-rated (AA, BBB, BBB-) ABX index returns to the four CDS index returns during the crisis period. Thus, in terms of impulse response, the lower-rated ABX indices have a more significant impact on the associated CDS indices in the crisis outburst period as opposed to those in the pre-crisis period, which partially supports hypothesis H_1, for the lower-rated ABX indices. In the crisis outburst period, lower-rated ABX indices have larger credit risks to give higher degrees of impulse responses in CDS indices than higher-rated ABX indices.

Table 2 shows that the variance ratio of CDX-EM index returns under their own impulse is highest in the pre-crisis period, while the percentage of variance decomposition for CDX-US, iTraxx-EU and iTraxx-Asia index returns under their own impulse in the pre-crisis period plummeted significantly. This shows that the impact of the pre-crisis ABX index returns on CDS index returns grew as time increased, and might reflect the origin of the sub-prime crisis in the U.S. and the EU. Furthermore, the ABX index returns impact CDX-EM (Non-Asian emerging market) index returns more in the crisis outburst period as opposed to the pre-crisis period; they do however impact CDX-US, iTraxx-EU and iTraxx-Asia index returns less in the crisis outburst period rather than in the pre-crisis period. The result partially supports hypothesis H_1 but only for the CDX-EM index.

One may see in Figures 5 to 8 that there is a steep impulse response from the four CDS index returns on the corresponding bond index returns in the crisis outburst period, as opposed to the pre-outburst period, which supports hypothesis H_2. Furthermore, the degree of impulse responses from the associated CDS returns to the Asian and non-Asian bond index returns rose more in the crisis period relative to the pre-crisis period, as compared to that from the associated CDS returns to the U.S. and EU bond index returns. This denotes that emerging markets suffer more critical shocks during financial crises, as opposed to developed markets.

Table 3 indicates that the percentage of variance decomposition for bond index returns affected by CDS index returns in the crisis outburst period increases in contrast to that in the pre-crisis period, which also supports hypothesis H_2. Moreover, the variance decomposition ratios of CDS indices to the associated bond indices in the Asian and non-Asian developing markets are significantly greater than those of the associated bond indices in the U.S. and EU developed markets in the outburst period.

4.2 Contagion Effects via an AR-GJR-GARCH Model

One may see in Tables 4 and 5 that the coefficients $\alpha_{3,i}$ ($\beta_{3,i}$) became highly significant once the crisis began, providing clear evidence of an obvious increase in cross-market linkages for the CDO and CDS markets (CDS and bond markets). The results show that the ABX indices (CDS indices), given their impact on the CDS indices (bond indices) have significant forecasting power.

Observing Table 4, F-tests for the ABX indices of respective ratings and specific CDS indices during the early stage as compared with the pre-crisis period show a majority of the acceptance of the null hypothesis $\alpha_{2,i}=0$, and the rejection of the null hypothesis $\alpha_{3,i}=0$, which identify contagion effects from the ABX indices to specific CDS indices during the early stages of the crisis.[19] The larger t-statistics for the first and second lagged values of the five

[19] *According to AIC, the largest lagged number is 2.*

ABX indices on the CDS indices in the initial crisis period as opposed to those in the non-crisis period show that there is stronger evidence to exist significant contagion effects between asset-backed CDO and CDS markets in the specific regions in the early stages of a crisis. This finding supports hypothesis H_3. Moreover, due to the rising credit risks of the lower-rated ABX indices of BBB and BBB- against the higher-rated ABX indices of AAA, AA and A in the early stages, lower-rated ABX indices spread more credit risks to CDS indices as opposed to higher-rated ABX indices in the initial crisis period. This finding supports hypothesis H_4. The lower-rated ABX indices of BBB and BBB- have stronger predictability for CDX-US, iTraxx-Asia and CDX-EM indices than for iTraxx -EU indices.

Observing Table 5, F-tests for the CDS and related bond indices show the acceptance of H: $\beta_{2,i} = 0$ in the pre-crisis period, and the rejection of H: $\beta_{3,i} = 0$ in the early stages of the crisis for the lagged CDX-US on the US bond indices and for the lagged iTraxx-Asia on Asian emerging market bond indices. Also, the t-statistics for the first lagged values of the CDX-US and iTraxx-Asia on the U.S and Asian emerging market bond indices are significant in the initial crisis period. These evidences indicate significant contagion effects from CDS markets in the U.S. and Asian emerging markets to associated bond markets in the early stages of the crisis, which partially supports hypothesis *H5*. We further find a more significant contagion effect in Asian emerging markets than in the U.S. and EU, which partially supports hypothesis *H6*. This phenomenon results from the fact that the U.S. translates the losses dispersed by the financial crisis into emerging markets by engaging in securitization.

5. Conclusions and Implications

5.1 Conclusions

This paper examines changes in global impulse response, variance decomposition and contagion effects from ABX indices of CDO (*i.e.,* one kind of risky ABS) to the CDS indices, and from the CDS indices to connected bond indices during the pre-, occurrence- and persistent-periods of sub-prime crisis. Our contribution to studies regarding the transmission of credit risks in financial markets during a crisis, is to analyse the effects of shocks from financial crisis on global bond markets through financial markets of risky ABS and credit derivatives, simultaneously. This approach is close to reality because an investor buying a risky ABS tends to purchase a CDS to hedge the risks of the risky ABS, which then this CDS transmits credit risks to capital markets.

There was a major increase in the impulse responses from the ABX to the CDS indices following the bankruptcy of Lehman Brothers. After the outburst of the sub-prime crisis, there was a larger impulse response from the lower-rated ABX index returns to the CDS index returns, as opposed from the higher-rated ABX index returns. In addition, there was a larger explanatory variance from the ABX index returns to the CDX-EM index returns in non-Asian emerging markets as opposed to other CDS index returns. The contagion effects from ABX indices to CDS indices identify the increasing linkages across ABX indices and related CDS indices, so that there are significant contagion effects across CDO and CDS markets in the early stages of a crisis. There were more significant contagion effects from lower-rated ABX indices to CDS indices than from higher-rated indices.

There were fierce increases in impulse responses from the CDS markets to bond markets after the bankruptcy of Lehman Brothers. There was a steeper rise in the impulse responses and variance ratio from CDS indices to Asian and Non-Asian emerging market bond indices,

as opposed to the U.S. and EU bond indices during the outburst period. Moreover, there are significant contagion effects from the CDX-US and iTraxx-Asian indices to related U.S. and Asian bond indices. Furthermore, the bond indices of Asian developing countries suffered from corresponding CDS indices more distress, as opposed to those of U.S. and EU developed countries during the financial crisis.

5.2 Implications

Our empirical findings from the ABX indices to the CDS indices show that there were more significant impulse responses and contagion effects from the lower-rated ABX index returns to associated CDS index returns across the four regions, as opposed from the higher-rated ABX index returns following the onset of the sub-prime crisis. Accordingly, financial authorities should consider enhancing the management of lower-rated CDO securitizations to avoid negative impacts on the CDS markets after a financial crisis occurs.

In terms of the empirical findings of impulse response analysis and variance decomposition from the CDS indices on associated bond indices, there was a major increase in impulse responses from CDS index returns to associated bond index returns during the outburst period. Emerging markets suffered more distress than the developed markets. In addition, there was a major increase in variance decomposition from the CDS indices in the Asian and Non-Asian emerging market bond indices. This might have resulted from the developed countries rebalancing their losses in financial markets via securitization in emerging countries. Therefore, developed countries should stop rebalancing losses through securitization and recapitalization in emerging markets, in order to prevent another severe global financial storm.

In terms of empirical findings of contagion effects from CDS indices on associated bond indices, there were more significant contagion effects from CDS indices to Asian emerging market bond indices as opposed to developed markets following the onset of the sub-prime crisis. More specifically, credit risks significantly increased in Asian emerging market bond index returns, because negative shocks from a crisis on its stock markets are likely to cause investors to transfer market funds into fixed income securities. Consequently, the financial authorities of Asian emerging markets should seek a balance between the pursuit of financial market liberalization and the risks of large investments in fixed income securities for investors after a financial crisis occurs, in order to reduce the risk linkages across financial markets. In addition, investors may invest less in the short run in Asian emerging market bonds during the early stages of a financial crisis, in order to disperse portfolio losses. But this investment should be implemented before the outburst period of the crisis.

One possible limitation of our study is that the data on the ABX indices became available on 19 January 2006. Thus, our sample period only began from this time, and may be limited. Also, avenues for future research are suggested to explore the other possible effects of shocks from various financial crises in global stock markets through financial markets of different risky ABS and different credit derivatives.

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Annex: Tables and Figures

Table 1

Summary Statistics of the Daily ABX Index and CDS Index Returns

		Mean	Maximum	Minimum	Std. Dev.	Correlation								
						AAA	AA	A	BBB	BBB-	CD-US	CD-EM	iT-EU	iT-Asia
Pre-crisis START-2007/1/4	AAA	-0.001	0.050	-0.170	0.015	1.000								
	AA	0.000	0.209	-0.369	0.035	0.709	1.000							
	A	-0.004	0.171	-0.270	0.043	0.457	0.567	1.000						
	BBB	-0.015	0.539	-0.822	0.150	0.100	0.179	0.598	1.000					
	BBB-	-0.022	0.564	-1.162	0.180	0.124	0.172	0.609	0.822	1.000				
	CD-US	-0.035	13.407	-5.921	1.903	0.045	0.044	-0.017	-0.074	-0.150	1.000			
	CD-EM	-0.003	16.406	-20.076	2.804	-0.013	-0.012	0.009	0.096	0.093	-0.135	1.000		
	iT-EU	-0.199	7.603	-5.287	1.781	0.038	0.013	-0.065	-0.109	-0.198	0.525	-0.126	1.000	
	iT-Asia	-0.078	8.712	-5.408	1.668	0.013	-0.036	-0.060	-0.063	-0.090	-0.046	-0.165	0.163	1.000
Initial 2007/1/4-2008/9/15	AAA	-0.202	6.751	-10.352	1.595	1.000								
	AA	-0.584	10.207	-18.850	2.927	0.752	1.000							
	A	-0.656	17.667	-16.830	3.113	0.609	0.704	1.000						
	BBB	-0.642	17.672	-19.870	3.156	0.409	0.516	0.566	1.000					
	BBB-	-0.645	11.194	-15.628	3.096	0.326	0.459	0.493	0.848	1.000				
	CD-US	0.454	25.228	-20.587	4.483	-0.389	-0.287	-0.252	-0.391	-0.183	1.000			
	CD-EM	-0.013	2.479	-2.730	0.363	0.372	0.266	0.240	0.213	0.183	-0.659	1.000		
	iT-EU	0.455	27.690	-25.825	5.615	-0.404	-0.329	-0.324	-0.217	-0.171	0.664	-0.588	1.000	
	iT-Asia	0.546	29.305	-37.722	6.249	-0.262	-0.208	-0.384	-0.342	-0.109	0.589	-0.329	0.693	1.000
Outburst 2008/9/15-END	AAA	-0.382	17.271	-15.988	3.455	1.000								
	AA	-0.600	17.371	-27.187	3.656	0.706	1.000							
	A	-0.590	7.104	-19.075	2.600	0.527	0.762	1.000						
	BBB	-0.658	5.274	-12.573	1.925	0.498	0.711	0.638	1.000					

Table 2

Comparisons of Variance Decomposition for Specific CDS Index Returns in the Pre-crisis and Outburst Periods

(Unit: %)

AB / X index		AAA		AA		A		BBB		BBB-		own	
CDS index	day	pre-crisis	outburst	pre-crisis	outburst	pre-crisis	outburst	pre-crisis	outburst	pre-crisis	outburst	pre-crisis	outburst
CDX-US	2	3.620	1.741	0.012	0.377	4.581	0.215	0.158	0.082	1.302	0.505	90.327	97.080
	5	3.045	2.144	4.891	1.933	24.603	1.791	12.449	0.437	5.072	1.365	49.940	92.330
	10	3.956	2.145	6.663	2.292	20.095	1.948	20.160	0.797	17.323	1.771	31.803	91.048
CDX-EM	2	0.012	1.271	0.083	0.079	0.125	0.044	0.008	0.022	0.000	0.230	99.771	98.354
	5	0.065	2.551	0.208	2.969	0.193	1.137	0.057	0.888	0.157	0.483	99.320	91.972
	10	0.278	2.474	0.419	6.897	0.784	1.855	0.314	1.513	0.307	0.860	97.899	86.402
iTraxx-EU	2	0.548	0.953	6.928	0.027	19.796	0.019	0.210	0.385	7.533	0.024	64.985	98.592
	5	2.725	1.465	5.790	1.627	22.940	1.931	11.677	2.028	8.296	0.704	48.571	92.246
	10	3.799	1.585	4.289	2.335	18.065	2.005	31.156	4.586	18.738	1.800	23.953	87.689
iTraxx-Asia	2	0.118	1.617	4.430	0.113	4.942	1.387	4.673	0.426	21.324	0.511	64.513	95.946
	5	2.930	2.159	12.783	1.436	21.348	2.051	4.793	1.195	16.461	1.109	41.684	92.050
	10	8.466	4.019	13.378	2.431	13.983	3.398	22.972	2.791	19.655	1.533	21.547	85.828

Table 3

Comparisons of Variance Decomposition for Specific Bond Index Returns in the Pre-crisis and Outburst Periods (Unit: %)

CDS index / Bond Index	day	CDX-US		CDX-EM		iTraxx-EU		iTraxx-Asis		own	
		pre-crisis	outburst	pre-crisis	outburst	pre-crisis	outburst	pre-crisis	outburst	pre-crisis	outburst
U.S. bond index	2	1.929	1.075	0.114	0.807	1.120	0.599	0.877	0.463	95.960	97.055
	5	1.887	7.249	0.150	4.888	3.542	3.527	1.794	3.030	92.627	81.307
	10	2.312	8.243	0.160	5.166	4.634	5.868	2.508	3.105	90.387	77.618
EU bond index	2	3.354	3.130	0.076	0.436	3.381	0.475	0.264	3.446	92.926	92.512
	5	3.973	9.444	0.627	3.788	3.880	2.439	0.852	7.796	90.669	76.533
	10	4.567	10.292	0.843	3.855	4.552	2.904	0.844	9.528	89.194	73.421
Asia emerging market bond index	2	0.556	4.491	0.047	0.096	0.608	15.056	0.569	0.032	98.221	80.325
	5	1.758	5.388	0.137	0.586	0.911	22.914	0.732	3.045	96.461	68.067
	10	2.060	6.088	0.140	0.845	1.126	25.844	0.862	3.685	95.813	63.538
non-Asia emerging market bond index	2	4.986	0.172	1.961	0.992	3.034	0.040	0.212	2.125	89.807	96.672
	5	6.942	3.315	2.334	5.981	3.451	3.397	0.370	3.337	86.903	83.969
	10	8.587	7.632	2.598	6.560	4.635	9.811	0.607	3.078	83.573	72.918

Table 4

Results of Contagion Effects from the ABX Index Returns of Respective Ratings to Specific CDS Index Returns

CDS	ABX	$t(\alpha_{21})$	$t(\alpha_{22})$	$t(\alpha_{31})$	$t(\alpha_{32})$	$P(\alpha_2 = 0)$	$P(\alpha_3 = 0)$	$Q^2(12)$	Q(12)	X^2
CDX-US	AAA	-2.073	-0.017	1.354	-4.317	0.11371	0.00003***	15.401 [0.22021]	10.050 [0.61161]	1.731 [0.63015]
	AA	-1.024	-1.024	0.418	-4.156	0.54284	0.00012***	11.984 [0.44699]	9.868 [0.62751]	1.419 [0.70116]
	A	-0.617	-0.204	1.362	-6.209	0.78662	0.00000***	9.862 [0.62804]	12.284 [0.42318]	0.983 [0.80532]
	BBB	-1.784	0.297	-1.405	-8.843	0.20314	0.00000***	8.807 [0.71934]	7.312 [0.83635]	2.568 [0.46309]
	BBB-	-1.024	-0.224	-0.860	-8.286	0.44588	0.00000***	7.943 [0.78960]	7.403 [0.82990]	1.124 [0.77123]

CDS	ABX	$t(\alpha_{21})$	$t(\alpha_{22})$	$t(\alpha_{31})$	$t(\alpha_{32})$	$P(\alpha_2 = 0)$	$P(\alpha_3 = 0)$	$Q^2(12)$	Q(12)	X^2
CDX-EM	AAA	2.717	8.439	-2.973	3.121	0.00000***	0.00094***	20.963 [0.12856]	16.992 [0.19870]	3.385 [0.33594]
	AA	-1.055	0.367	-1.762	2.164	0.52737	0.06628***	17.359 [0.15884]	15.856 [0.21005]	0.738 [0.86417]
	A	-2.181	1.725	-2.971	3.548	0.10283	0.00019***	10.214 [0.39943]	14.633 [0.32764]	0.587 [0.89937]
	BBB	-4.658	2.824	-5.324	2.790	0.12002	0.00000***	15.184 [0.26438]	19.474 [0.19890]	0.238 [0.97121]
	BBB-	-4.040	2.173	-0.128	5.469	0.11028	0.00000***	18.451 [0.14332]	13.207 [0.28052]	0.294 [0.96110]
iTraxx-EU	AAA	0.727	0.080	-1.720	-1.235	0.76679	0.03769**	5.424 [0.94230]	5.479 [0.94004]	0.315 [0.95722]
	AA	-0.842	-2.379	-0.419	-2.057	0.05791***	0.03387***	4.781 [0.96491]	4.965 [0.95914]	0.428 [0.93446]
	A	-1.021	-0.433	-1.515	-1.803	0.49557	0.00569***	5.831 [0.92437]	5.398 [0.94334]	0.865 [0.83376]
	BBB	-1.183	1.005	-1.193	-1.374	0.36833	0.06623*	5.729 [0.92912]	5.612 [0.93437]	0.449 [0.92985]
	BBB-	-1.903	2.182	-0.824	-1.404	0.13917	0.04896***	6.518 [0.88777]	6.291 [0.90072]	0.556 [0.90640]
iTraxx-Asia	AAA	2.104	0.307	-5.012	0.148	0.09946***	0.00000***	6.435 [0.89259]	16.105 [0.18646]	0.536 [0.91088]
	AA	1.762	-0.253	-3.492	0.559	0.18186	0.00100***	6.257 [0.90259]	15.981 [0.19212]	0.210 [0.97592]
	A	-1.490	0.070	-5.329	1.730	0.31936	0.00000***	5.712 [0.92989]	15.950 [0.19353]	0.265 [0.96640]
	BBB	-0.847	-0.412	-5.027	-0.907	0.49262	0.00000***	5.589 [0.93539]	14.644 [0.26151]	0.341 [0.95218]
	BBB-	-1.075	-0.323	-3.849	-0.971	0.41455	0.00005***	4.979 [0.95866]	14.141 [0.29179]	0.123 [0.98890]

Notes: 1. $t(\alpha_{21})$*and* $t(\alpha_{22})$ *are the t-statistics of the* α_{21}*and* α_{22} *coefficients before the sub-prime crisis (2006.01.19-2006.12.29).*

2. $t(\alpha_{31})$ *and* $t(\alpha_{32})$ *are the t-statistics of the* α_{31} *and* α_{32} *coefficients in the early stage of the sub-prime crisis (2007.1.4-2008.9.12).*

3. $P(\alpha_2 = 0)$ *and* $P(\alpha_3 = 0)$ *are the p-values of the joint test of the F-statistics for the pre-crisis period and the early stage of the crisis, respectively. (*, ** and *** denote significance at the 10%, 5% and 1% levels, respectively).*

Table 5

Results of Contagion Effects from the CDS Index Returns to Associated Bond Index Returns

Associated bond index	CDX- US	iTraxx-EU	CDX-EM	iTraxx-Asia
	U.S. bond index	EU bond index	Non-Asian emerging market bond index	Asian emerging market bond index
$t(\beta_{21})$	-0.14868	-1.13640	-2.87221***	-0.32414
$t(\beta_{22})$	1.78776*	2.94780***	0.03194	3.21533***
$t(\beta_{31})$	1.78883*	-0.52649	1.42638	-5.16725***
$t(\beta_{32})$	-0.62245	1.08711	-0.30541	-0.63078
$P(\beta_{2,i}=0)$	0.20007020	0.01029740**	0.01612742**	0.10539805
$P(\beta_{3,i}=0)$	0.09634719*	0.50823445	0.32717357	0.00000131***
$Q^2(12)$	12.323 [0.42012]	7.725 [0.80627]	17.438 [0.13385]	1.174 [0.99996]
$Q(12)$	7.686 [0.80918]	15.019 [0.24042]	4.815 [0.96387]	12.175 [0.43172]
X^2	1.682 [0.65413]	1.223 [0.74315]	0.992 [0.79058]	0.783 [0.81445]

Notes: 1. $t(\beta_{21})$ *and* $t(\beta_{22})$ *are the t-statistics of the* β_{21} *and* β_{22} *coefficients before the sub-prime crisis (2006.01.19-2006.12.29).*

2. $t(\beta_{31})$ *and* $t(\beta_{32})$ *are the t-statistics of the* β_{31} *and* β_{32} β_{32} *coefficients in the early stage of the sub-prime crisis (2007.1.4-2008.9.12).*

3. $P(\beta_{2,i}=0)$ *and* $P(\beta_{3,i}=0)$ *are the p-values of the joint test of the F-statistics for the pre-crisis period and the early stage of the crisis, respectively. (*, ** and *** denote significance at the 10%, 5% and 1% levels, respectively).*

Figure 1: The Impulse Response Figure from the ABX Index of Respective Ratings to the CDX-US Index in Pre-crisis and Crisis Outburst Periods

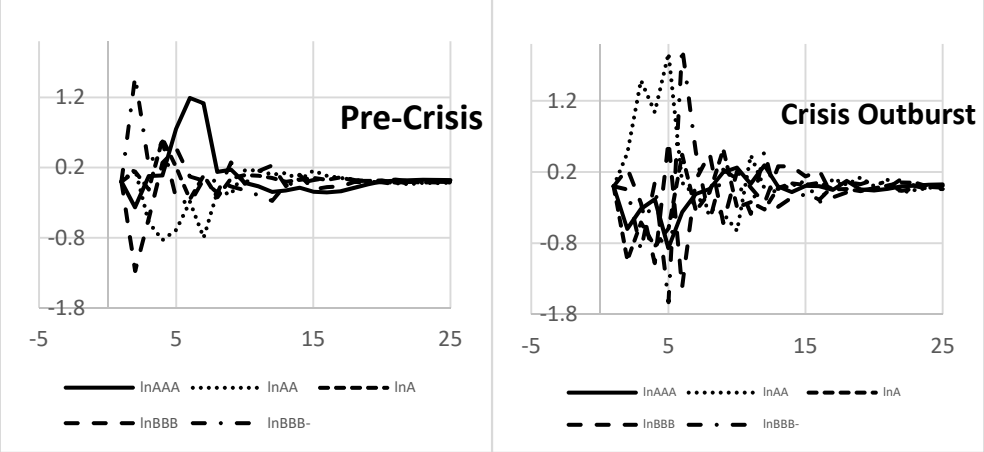

Figure 2: The Impulse Response Figure from the ABX Index of Respective Ratings to the iTraxx-EU Index in Pre-crisis and Crisis Outburst Periods

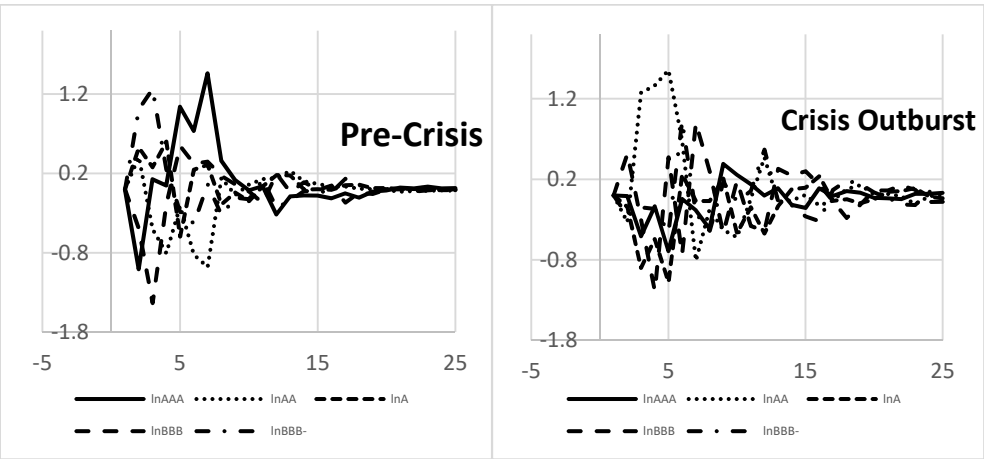

Figure 3: The Impulse Response Figure from the ABX Index of Respective Ratings to the CDX-EM Index in Pre-crisis and Crisis Outburst Periods

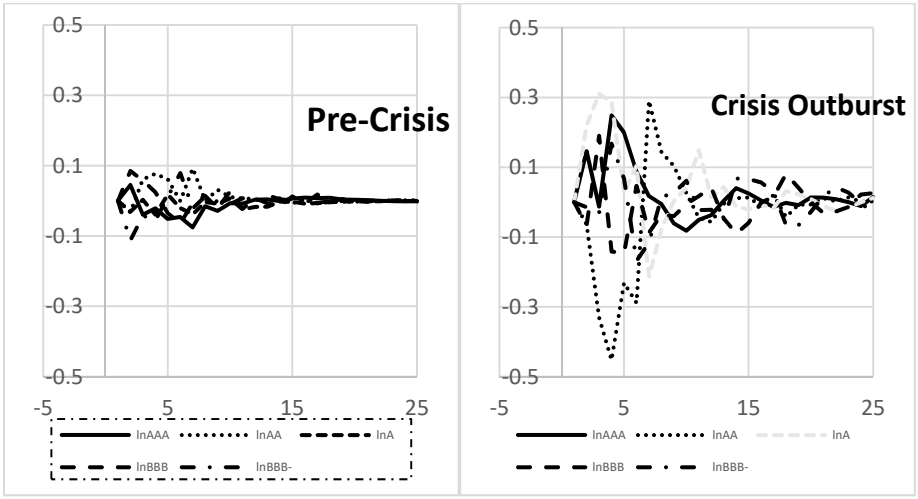

Figure 4: The Impulse Response Figure from the ABX Index of Respective Ratings to the iTraxx-Asia Index in Pre-crisis and Crisis Outburst Periods

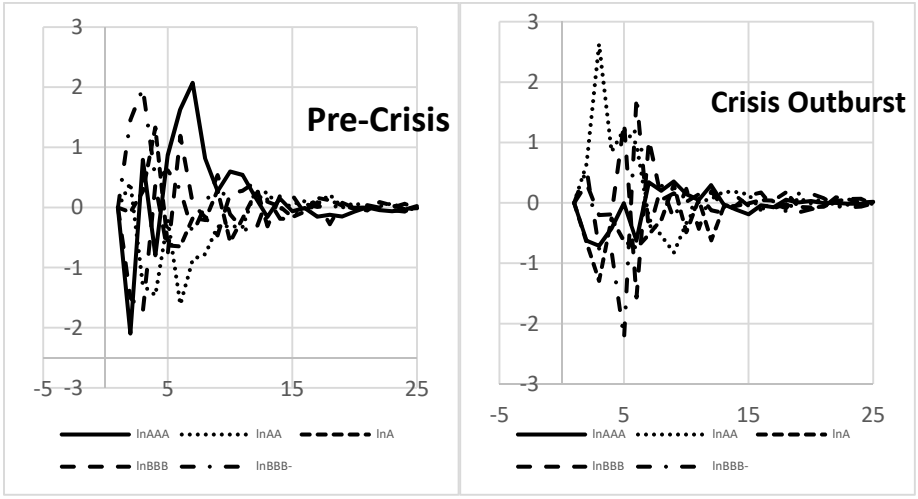

Figure 5: The Impulse Response Figure from the CDS Index in the Studied Region to the U.S. Bond Index in Pre-crisis and Crisis Outburst Periods

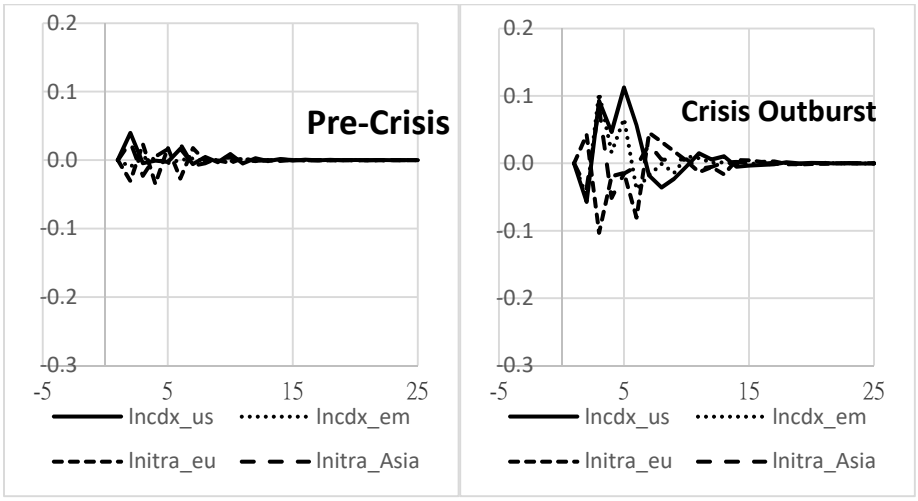

Figure 6: The Impulse Response Figure from the CDS Index in the Studied Region to the EU Bond Index in Pre-crisis and Crisis Outburst Periods

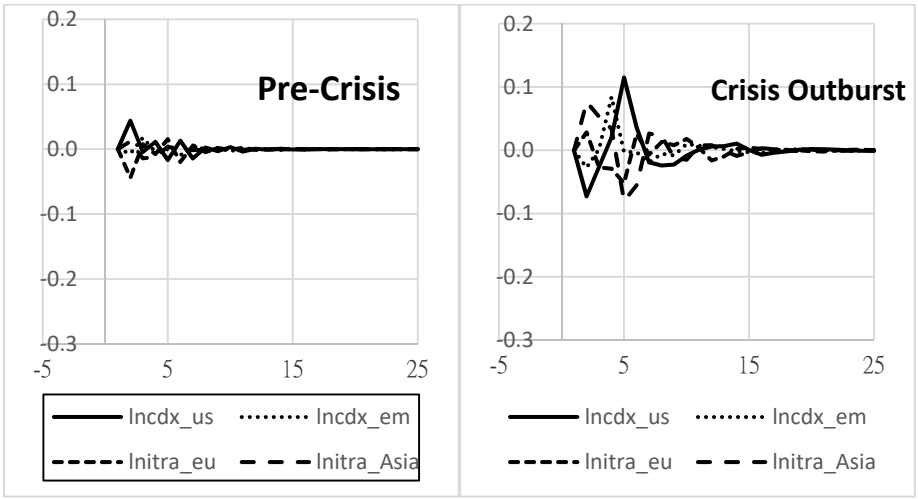

Figure 7: The Impulse Response Figure from the CDS Index in the Studied Region to the Asian Emerging Market Bond Index in Pre-crisis and Crisis Outburst Periods

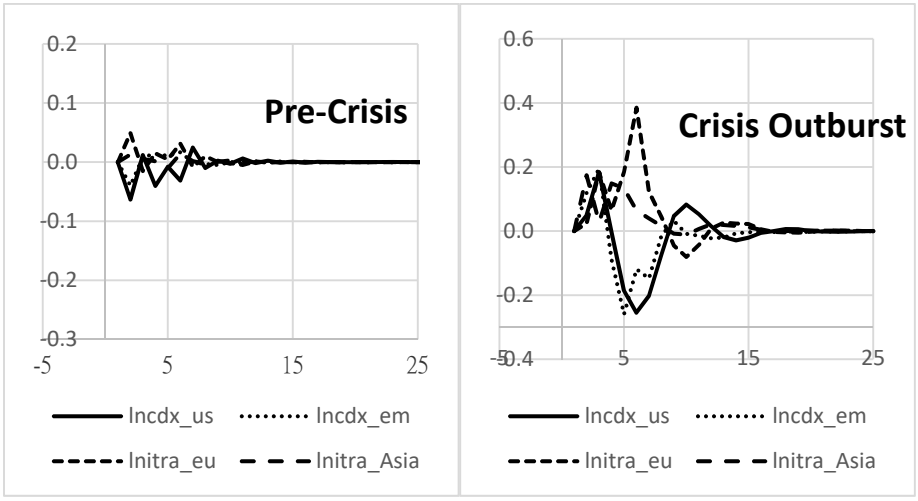

Figure 8: The Impulse Response Figure from the CDS Index in the Studied Region to the Non-Asian Emerging Market Bond Index in Pre-crisis and Crisis Outburst Periods