Global Financial Crisis and Stock Market Integration:

The Case of Northeast Asia and Europe

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Abstract

This study examines the effect of global financial crisis on the level of stock market integration. In particular, we investigated the movements of two regional stock markets, Northeast Asia and Europe during the period between January 1, 2000 and December 30, 2012, with particular attention placed on the global financial crisis initiated from the US. For this purpose, the paper employs various approaches including DCC, Risk Decomposition, GVAR, and CCOR models to ensure the robustness of empirical findings. The findings of this study are as follows. First, Northeast Asian market remains independent from the international stock market movements except a temporary increase in integration with the international market during the crisis period. Second, European market shows an increasing trend of joint integration with the U.S. market since the crisis. Third, a significant decline in the unsystematic risks of both European and U.S. markets is found to be possible by adding Northeast Asian market to the existing portfolios. Finally, European market shows an increased level of integration with the Northeast Asian market during the crisis period. However, the level of integration falls again in the post-crisis era. In sum, the integration of stock market is a dynamic process and the global financial crisis seems to cause a shift in the pattern of integrating process.

Keywords: Market Integration, Risk Decomposition Model, Dynamic Conditional Correlation (DCC), GVAR, CCOR

JEL Codes: F36, G15

I. Introduction

Despite the recent global financial crisis, it has been convincingly suggested that the stock market integration led to the allocationally efficient financial market by increasing liquidity and reducing transaction costs. Therefore, an integrated stock market is believed to contribute to the market stabilization by reducing the market volatility by sharing the macroeconomic risks. In addition, advancement in information technology, rise of multi-national corporations, and the relief of traditional trade barriers since the formation of WTO have also facilitated to the creation of regional economic cooperation such as the European Union (EU), North American Free Trade Agreement (NAFTA), Asia Pacific Economic Council (APEC), and etc.

For Europe, one of the main reasons for the creation of the European Economic and Monetary Union (EMU) was to integrate the capital market of European countries. Today, it is generally accepted that this effort led to a convergence of European economies and stimulated the growth of corporations in the Eurozone area. Moreover, the broadening of investment opportunities in this area benefited both investors and corporations. In turn, the union has gained both political and economic strengths. However, recently, financial integration has been severely affected by the crisis. The effect is pervasive and tenacious. The problem is far from solved in spite of various efforts made by the ECB's measures targeted at financial market. Hence, further action is needed to stabilize the market. One of these actions might diversify EU market by increasing its economic ties with a more economically dynamic region such as Northeast Asia.

In fact, the economic ties between Europe and Northeast Asia have been increasing. According to the data from IMF and European Commission (2012), China, Japan, and Korea are the European Union's second, seventh, and tenth largest trading partner, covering 13.8, 3.6, and 2.1 percent of EU trade, respectively. Among the several reasons why the economic ties between EU and Northeast Asia have been increasing, there are two clear explanations. First, China is now the global power. In financial perspective, China's financial decisions are central to the global concerns. In fact, their financial policies and performance strongly affect the world economic markets nowadays. Second, the European Union (EU) has been negotiating the bilateral Free Trade Agreement (FTA) with the Northeast Asian countries. For instance, Korea became EU's tenth largest trading partner since the FTA between European Union and Korea went into effect in 2011.

Recently, the three main Northeast Asian countries – China, Japan, and Korea have recognized the importance of the integrated capital market and started to negotiate three nations Free Trade Agreement (FTA). If the three nations FTA reaches an agreement, the integrated market of China, Japan, and Korea would become a powerful economic forces with the combined Gross Domestic Product (GDP) of $15.4 trillion USD which is the second biggest market following the NAFTA ($18.6 trillion USD), and bigger than the EU ($12.1 trillion USD) as of 2012. However, studies regarding the level of stock market integration in these two big regional markets are still in its early stages and lack any detailed research or empirical analysis at this point in time. In this paper, we investigate the dynamic pattern of stock market integration in Northeast Asia and Europe with a particular attention focused on the effect of the recent global financial crisis. This paper contributes to the literature by comprehensively assessing the effect of financial crisis on integration by investigating dynamic pattern of stock market movements in Northeast Asian and European stock markets, and examining whether integration has progressed over time.

The sequence of this paper is as follows. The next section briefly reviews the literature. In Section III, the empirical framework is discussed. Section IV explains the data and sample statistics. Section V presents the empirical results. The last section gives the summary and conclusions.

II. Literature Review

There have been numerous studies on market integration and interdependence. Early works in this area analyzes the correlation coefficients across markets over certain time period. If the correlation is high, it is regarded that integration exists between the two markets. Using data from seven major European countries from 1970 to 1990, Longin and Solnik (1995) found that cross-country stock market correlations increase over time. Karolyi and Stulz (1996) analyzed the daily return co-movements between the Japanese and U.S. stocks from 1988 to 1992 and found evidence that correlations are high when there are significant market movements. Palac-McMiken (1997) used the monthly ASEAN market indices (Indonesia, Malaysia, the Philippines, Singapore, and Thailand) between 1987 and 1995 and found that, with the exception of Indonesia, all markets are linked with each other. He argued that there is still room for diversification across those markets despite the evidence of interdependence among ASEAN stock markets. Masih and Masih (1999) found high levels of interdependence among markets in Thailand, Malaysia, the U.S., Japan, Hong Kong, and Singapore from 1992 to 1997. Johnson and Soenen (2002) studied the equity market integration between the Japanese stock market and the other twelve equity markets in Asia. They found that the equity markets of Australia, China, HongKong, Malaysia, New Zealand, and Singapore are highly integrated with the stock market in Japan. They also found evidence that a higher import share as well as a greater differential in inflation rates, real interest rates, and GDP growth rates has negative effects on the stock market co-movements between countries. Regarding the problem of using correlation analysis, Forbes and Rigobon (2002) showed that unadjusted cross-market correlation coefficients are conditional on market volatility and therefore it is not appropriate either to measure the degree of integration or to distinguish it from contagion. However, Corsetti et al. (2002) raised a contrary argument, suggesting that the results of Forbes and Rigobon (2002) are dependent on the specification of idiosyncratic shocks, and the contagion would significant during the Asian crisis if those shocks were included in the analysis, even if correlation measures are flawed. A study done by Chelley-Steeley (2005) picked up correlation analysis again to address integration, where the study models the movement of bivariate equity market correlations as a smooth transition trend to check how rapidly several equity markets of Eastern Europe are moving away from market segmentation.

More recent papers have tried to capture the benefits of correlation coefficients within a GARCH framework which explicitly deals with volatility issues. Lucey and Voronkova (2007) used Dynamic Conditional Correlation (DCC) derived from multivariate GARCH framework to make inferences about short-term interdependence between Russian equity market and developed markets. Lahrech and Sylwester (2011) used DCC multivariate GARCH model and track how the correlations evolve over time using a smooth transition model between Latin American stock markets and the United States stock market. They found that the co-movements between two those markets have increased although the magnitude and the speed vary across markets. H.G. Min and Y.S. Hwang (2012), using DCC approach, analyzed the daily stock returns of four OECD countries with that of U.S. for the period between 2006 and 2010. They found contagion effects during the global financial crisis for U.K., Australia and Switzerland, whereas the impact of the global financial crisis on Japan was limited.

Another group of papers made use of asset pricing models. Bekaert and Harvey (1995) applied an asset pricing technique to study time-varying integration, with a conditional regime-switching two-factor model. Barari (2004) used a risk decomposition model to investigate the degree of integration for the Latin American countries. He found a trend towards increased regional integration relative to global integration until the mid-1990s and faster global integration versus regional integration during the second half of the 1990s in the region. Bekaert, Harvey and Ng (2005) proposed a two-factor (global and regional) model to examine the equity market contagion during both the Mexican and Asian crisis of 1990s. De Jong and De Rong (2005) developed a factor asset pricing model and found that emerging stock markets have become less segmented from world stock markets and the integration with the world significantly reduced the cost of capital. Hunter (2006) used a multivariate GARCH-in-Mean asset-pricing model on three Latin American markets: Argentina, Chile and Mexico. He found that those markets have not become integrated into the world equity market in the decade after liberalization. Tai (2007) estimated a dynamic international CAPM using a parsimonious multivariate GARCH-in-Mean (MGARCH-M) approach and found that emerging Asian stock markets became integrated after they liberalize their equity markets.

Several studies have investigated the effect of structural changes in the economy on the dynamic linkage of stock returns. Shamsuddin and Kim (2003) found that the presence of a stable long run relationship among the Australian, U.S. and Japanese markets existed prior to the Asian crisis and disappeared in the post-Asian crisis period. Fujii (2005) reported that the causal linkages among several emerging stock markets varied considerably during the time of rapid growth and major upheaval from 1990 in Asia and Latin America. Westermann (2004) empirically showed that the introduction of the Euro shifted the linkage across the Euro zone stock markets, and Kim et al. (2005) found that increased stability and higher levels of integration have emerged in the post-euro era. The observed shifts in the post-euro period may have reflected the fact that an overall macroeconomic convergence process associated with the single currency has emerged. For the transition economies, Chelley-Steeley (2005) found a movement towards increased equity market integration by analyzing a smooth transition.

III. Methodologies

In this study, we employ various approaches to analyze stock market integration. Each approach is discussed in the following sections.

1. Risk Decomposition Model

We followed the basic framework of a risk decomposition model to measure a differential degree of market integration across different capital markets. The rationale for developing an easily obtainable measure of country equity market segmentation lies in the importance of such a tool in country selection for portfolio diversification purposes. The proposed measure of equity market integration is a country's systematic risk contribution to the global and the regional benchmark market portfolios; more contribution implying a greater integration of the market with the benchmark. The degree of integration is measured by integration score. Integration score is calculated as a fraction of systematic risk in total country risk. This paper uses the risk decomposition methodology suggested by Akdogan (1996, 1997) and Barari (2004). For the time-varying evolution of stock market linkages, this methodology is based on computing the individual countries' contribution to the global and regional systematic risks.

Consider the following single index Return-generating model of the i^{th} country,

$$R_i = a + b_r q_r + b_w R_w + \varepsilon_i \tag{1}$$

where R_i and R_w are returns on the i^{th} country index and on a benchmark index, respectively. q_r is orthogonal to R_w and is obtained as residuals from the following regression:

$$R_r = a + b_r R_w + q_r \tag{2}$$

In equations (1) and (2) above, R_i is the rate of return on the i^{th} country, R_r and R_w are the rates of return on the benchmark regional and world portfolios respectively. Barari (2004) points out that by utilizing the above model we effectively break down the rate of return on the i^{th} country into three components: (1) a component that is perfectly correlated with the rate of return on the regional market, (2) a component of the international market rate of return that is uncorrelated with the rate of return on the regional market, and (3) a third component that is uncorrelated with either the first or the second component. The variance of R_i can then be decomposed by dividing both sides by $\mathrm{var}(R_i)$. We express the risk arguments on the right-hand side as fractions of total risk of investing in the i^{th} country portfolio down into the following components.

$$a_i = \frac{b_{ir}^2 var(q_r)}{var(R_i)},$$

$$b_i = \frac{b_{iw}^2 var(R_w)}{var(R_i)},$$

$$c_i = \frac{var(\varepsilon)}{var(R_i)}$$

a_i, b_i, and c_i represent the regional systematic risk, world systematic risk, and unsystematic risk, respectively. For instance, a_i is a relevant measure of the i^{th} country regional integration, implying that if the country's contribution to the regional systematic risk rises, it is becoming more integrated with the regional market. Likewise, b_i is a relevant measure of the i^{th} country international integration, implying that if the country's contribution to the world systematic risk rises, it is becoming more integrated with the world market. In turn, if the regional market is becoming increasingly integrated with the world market, a_i will be larger than b_i while the regional market's segmentation from the rest of the world will be shown by a_i larger than b_i. Thus, by taking the ratio of by a_i to b_i, the i^{th} country's regional versus world integration can be observed. c_i measures the country's unsystematic risk.

2. Dynamic Conditional Correlation (DCC-VAR-GJR-MGARCH)

This study uses Dynamic Conditional Correlation (DCC-MGARCH) to investigate market interdependence. DCC allows stock market correlations to be time-varying.[1] We use a multivariate GARCH (DCC-MGARCH) model to capture a dynamic correlation pattern and volatility spillover effect. This approach demonstrates a more direct indication of interdependence between stock markets, where the dynamics of correlation are modeled together with those of the volatility of the series. By accounting for the time-varying volatility behavior of data series, a major advantage of using this is the detection of possible changes in conditional correlations over time when the state of the economy changes. In addition, we also use GJR-GARCH[2] model with VAR for the mean equation. The models are specified as follows:

$$\text{Conditional Mean: } r_{i,t} = \beta_{i,0} + \sum_{j=1}^{3} \beta_{i,j} r_{j,t-1} + \varepsilon_{i,t} \tag{3}$$

$$\text{Conditional Variance: } \sigma_{i,t}^2 = \alpha_{i,0} + \sum_{j=1}^{3} \alpha_{i,j}\, \varepsilon_{j,t-1}^2 + \delta_i \sigma_{i,t-1}^2 + \gamma_i \sigma_{i,t-1}^2 I \tag{4}$$

$$\text{Conditional Covariance: } \sigma_{ij,t} = \rho_{ij,t} \sigma_{i,t} \sigma_{j,t} \tag{5}$$

$r_{i,t}$: $i^{th}\ return\ at\ time\ t, \quad i = 1,2,3\ (1 = \text{Northeast Asia}, 2 = \text{EU}, 3 = \text{U.S.})$

$I = 1\ if\ \varepsilon_{t-1} < 0, \qquad 0\ if\ \varepsilon_{t-1} \geq 0$

Eq. (3) represents Vector Autoregression (VAR), and significant coefficient indicates that market *j* leads market *i*. In Eq. (4), volatility spillover effect among markets is estimated by $\alpha_{i,j}$. δ_i represents the persistence of volatility, and γ_i represents the asymmetric volatility. The

[1] See Engle (2002) for a detailed discussion.

[2] See Glosten, Jaganathan and Runkle (1993)

positive coefficient indicates that the bad news lead to a higher volatility than that of the good news. In Eq. (5), the conditional covariance is estimated by $\rho_{ij,t}$, and by $\sigma_{i,t}$ and $\sigma_{j,t}$ from an Eq. (4), and then we can classify, discussed in the following section, the Constant Conditional Correlation (CCC) and Dynamic Conditional Correlation (DCC) from the assumption of $\rho_{ij,t}$. In order to estimate coefficients in the model, the model assumes that residuals have conditional normal distribution as follows:

$$\varepsilon_t | F_{t-1} \sim N(0, H_t) \tag{6}$$

ε_t is 3 by 1 vector of conditional residuals at time t from 3 by 1 vector of expected return, r_t, when the historical information, F_{t-1} is given. The variance-covariance matrix (3 by 3), H_t, is normally distributed, and is as follows:

$$H_t = D_t R_t D_t, \qquad D_t = diag\left[\sigma_{1,t}, \cdots, \sigma_{3,t}\right] \tag{7}$$

R_t (3 by 3) is a conditional correlation matrix, D_t(3 by 3) is a diagonal matrix of conditional standard deviation. Vector of residuals, ε_t, can be generalized as follows:

$$Z_t = D_t^{-1} \varepsilon_t \tag{8}$$

Z_t (3 by 1) is a vector of generalized residuals with mean 0 vector (3 by 1) and with 3 by 3 variance-covariance matrix. The estimation methods, Constant Conditional Correlation (CCC) and Dynamic Conditional Correlation (DCC), of GARCH-M model have relatively few parameters to estimate, and they separately estimate conditional variance and conditional correlation.

Bollerslev (1990) have suggested CCC model that fixes conditional correlation as constant, and H_t is as follows:

$$H_t = D_t R D_t = [\rho_{i,j}\sigma_{i,t}\sigma_{j,t}], \qquad D_t = diag[\sigma_{1,t}, \cdots, \sigma_{3,t}] \tag{9}$$

$\sigma_{i,t}$ is a conditional standard deviation of i^{th} market at time t, and can be estimated by univariate GARCH model. $\mathrm{R} = [\rho_{i,j}]$ is 1 and has a constant $\rho_{i,j}$. Therefore, H_t is determined only by the changes of that conditional standard deviation. This Constant Conditional Correlation model, CCC, has overcome the difficulties of estimating the parameters by assuming that the conditional correlation matrix is not time-varying. However, this assumption is not convincing as it stands when we consider the real market time-series data. Therefore, Engle (2002) suggested the Dynamic Conditional Correlation model, DCC, considering the time-varying conditional correlations. The model is as follows:

$$H_t = D_t R_t D_t = [\rho_{ij,t}\sigma_{i,t}\sigma_{j,t}] \tag{10}$$

$$R_t(i,j) = \rho_{ij,t} = \frac{E_{t-1}(z_{i,t}z_{j,t})}{\sqrt{E_{t-1}(z_{i,t}^2)E_{t-1}(z_{j,t}^2)}} = \frac{q_{ij,t}}{\sqrt{q_{ii,t}q_{jj,t}}} \tag{11}$$

$$\begin{aligned} q_{ij,t} &= \overline{q_{\iota,J}} + a\left(z_{i,t-1}z_{j,t-1} - \overline{q_{\iota J}}\right) + b\left(q_{ij,t-1} - \overline{q_{\iota J}}\right) \\ &= (1 - \mathrm{a} - \mathrm{b})\overline{q_{\iota J}} + a\left(z_{i,t-1}z_{j,t-1}\right) + bq_{ij,t-1} \end{aligned} \tag{12}$$

$$Q_t = (1 - a - b)\bar{Q} + az_t z_t' + bQ_{t-1} \tag{13}$$

$$R_t = diag\left(q_{ii,t}^{-\frac{1}{2}}\right) Q_t diag\left(q_{ii,t}^{-\frac{1}{2}}\right) \tag{14}$$

An i^{th} column, j^{th} row element of a matrix Q (3 by 3), $q_{i,t}$, is a covariance of generalized residuals, $z_{i,t}\ and\ z_{j,t}$, and an Eq. (16) is estimated by GARCH(1,1) model of $q_{i,t}$. The estimated parameters a and b are positive values restricted to $\mathrm{a} + \mathrm{b} < 1$, and by using these values, we can estimate the conditional correlation, $\rho_{ij,t}$. The estimated conditional correlation matrix, R_t, estimated by DCC model, indicates the time-varying correlations between markets.

3. Generalized Variance and Collective Correlation

Variance and covariance of number of k countries are defined by symmetric matrix ($\mathrm{k\ by\ k}$), Σ, consists of number of k variances and number of $\mathrm{k(k-1)/2}$ covariances. Wilks (1932) defined the Generalized Variance of the population (GVAR) as a determinant of a matrix, $|\Sigma|$, that the overall variance is expressed with a scalar value. The squared root of GVAR is a Generalized Standard Deviation, GSD. We can find the overall variance and standard deviation of various markets through GVAR and GSD.

$$\mathrm{GVAR} = |\Sigma| = (\lambda_1 \lambda_2 \cdots \lambda_k), \qquad \mathrm{GSD} = \sqrt{GVAR} \tag{15}$$

However, in case we compare the variance with portfolios that have different size of stocks, it is hard to compare the variance directly because the GVAR increases as the number of stocks in a portfolio increases. Pena and Rodriquez (2003) suggested the Effective Variance, EVAR. The squared root of EVAR is an Effective Standard Deviation, ESD.

$$\mathrm{EVAR} = |\Sigma|^{1/k} = (\lambda_1 \lambda_2 \cdots \lambda_k)^{1/k}, \qquad \mathrm{ESD} = \sqrt{EVAR} \tag{16}$$

As the variance-covariance matrix, Σ, indicates the variance of overall market, the correlation matrix, R, indicates the linear independency of overall market. In contrast, Collective Correlation, CCOR, measures linear dependency of the overall market.

$$|R| = \frac{|\Sigma|}{\sigma_1^2 \cdots \sigma_k^2} \tag{17}$$

$$\text{CCOR} = 1 - |R| = (\lambda_1 \lambda_2 \cdots \lambda_k), \qquad \text{ECOR} = 1 - |R|^{1/k} = 1 - (\lambda_1 \lambda_2 \cdots \lambda_k)^{1/k} \tag{18}$$

As we discussed the difficulties of comparing GVAR with different size of portfolios, Pena and Rodriquez (2003) also suggested the effective correlation, ECOR, as there is a difficulty of comparing matrices with different dimensions.

By using these GVAR, EVAR, CCOR, and ECOR, we can signify the overall information of volatility and dependency of portfolios with a number (scalar). Kim and Bera (2007) showed that GVAR and CCOR explain the overall market's volatility and dependency.

IV. Data and Sample Statistics

We use daily close price indices of [1] Northeast Asia, which is an average of Korea Stock Composite (KOSPI), Shanghai Composite, and Nikkei 225, [2] Europe, Stoxx EU 600, and [3] United States, S&P500 from January 2000 to December 2012 as the basis for our data. Returns are calculated as continuously compounding rates of returns. All data was collected from Yahoo Finance (finance.yahoo.com). Since there is a time lag between U.S. and Northeast Asian market, we adjusted the date of S&P500 data by deferring one day (e.g., 2000/01/01 data of S&P500 is deferred to 2000/01/02). Table 1 reports basic descriptive statistics for the data. U.S. market displays the highest mean return and it is also rather volatile, with 10.92% and 13.18% higher standard deviation than that of Northeast Asia and Europe, respectively. The Jarque-Bera test-statistics reject the hypothesis of normality for each market. Furthermore, the mean return for each market is equal to zero, and Anova F-test statistic indicates that the mean return of a particular market is not different from the other markets. These results from the simple hypothesis tests for the mean return indicate that the markets are efficient.

<Table 1> Descriptive Statistics of Daily Returns (%), 2000-2012

obs:2871	Mean	Max.	Min.	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
N.E.Asia	-0.0142	8.5870	-10.6397	1.1523	-0.8393	11.9386	9891.58
EU	-0.0133	8.0088	-7.8091	1.1293	-0.1996	8.2033	3256.72
U.S.	0.0163	10.4236	-9.4695	1.2781	-0.1339	13.1252	12268.30

Jarque-Bera test-statistics rejects the normality under 1% significance level.

	Hypothesis Testing for Return: N.E.Asia, EU, U.S.		
H_0: Mean=0	N.E.Asia	EU	U.S.
t-statistic	-0.66	-0.63	0.68
Anova F-test	t-statistic: 0.61		

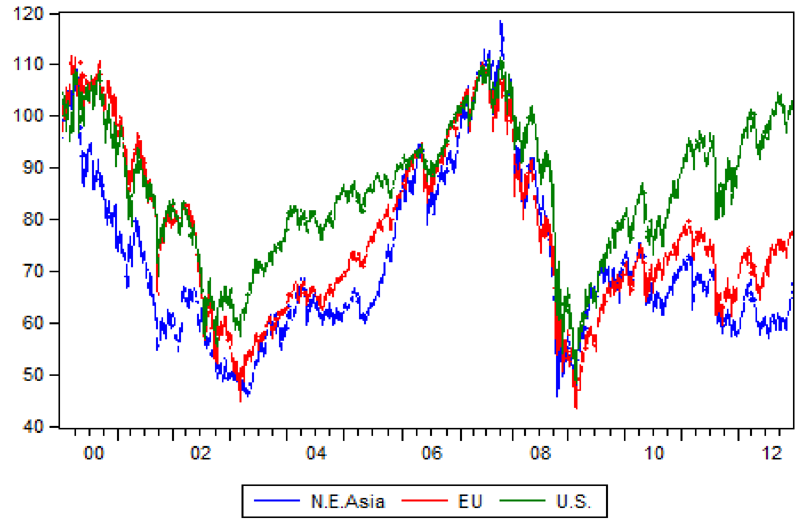
Table 2 shows the unconditional correlation relationship between markets. The correlations over the sample period range from 0.2607 for Europe and United States to 0.4629 for Northeast Asia and United States. The European market is more correlated with Northeast Asian market than with American market, and American market is also more correlated with the Northeast Asian market than with the European market. Daily index during the sample period are plotted in Figure 1, and it shows that among the three regions, Northeast Asia has still not fully recovered from the shock of the recent global financial crisis. Furthermore yearly correlations are plotted in Figure 2, and it confirms that the Northeast Asian market is highly correlated with European and U.S. Market. The important implication we found here is that the increased correlation during the global financial crisis is recently declining again during the post-crisis era.

<Table 2> Correlation Matrix for Equity Market Returns

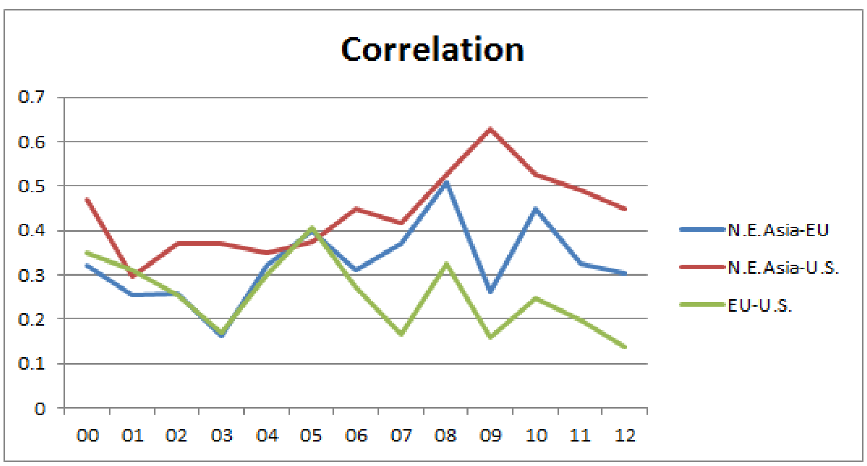
Correlation (t-Statistic)	N.E.Asia	EU	U.S.
N.E.Asia	1		
EU	**0.3510*** (20.08)**	1	
U.S.	**0.4629*** (27.96)**	**0.2607*** (14.46)**	1

***, ** and * represent the levels of significance of 1%, 5% and 10% respectively.

<Figure 1> Index Trends



<Figure 2> Correlation



V. Empirical Results

1. Risk Decomposition Analysis

Table 3 provides the estimated historical integration scores for two regional markets, Northeast Asia, and Europe. We divide the sample period into three sub-periods; pre-crisis, during-crisis, and post-crisis. Considering the fact that there is still no agreement over the date on which the global financial crisis set in, it is not easy to specify an exact date. By and large, some researchers (e.g., Gorton, 2009) consider the outburst of the financial crisis at New Century Financial Corp. as the beginning of the global financial crisis. Consequently, this risk decomposition analysis employs the date on which the trading of stocks of New Century Financial Corp. was terminated on the NYSE, i.e. March 13, 2007, as the breaking point[3] to secure more data observations. Thus, to fully investigate the dynamic pattern of integration based on before, during, and after the global financial crisis, the overall sample interval is partitioned into three non-overlapping sub periods: (i) pre-crisis period running from January 1, 2000 to December 30, 2007, (ii) during-crisis period extending from January 1, 2008 to December 30, 2010, and (iii) post-crisis period extending from January 1, 2011 to December 30, 2012.

The result implies that, for the pre-crisis period, the markets have low degree of integration with other markets. Rather, they have high degree of unsystematic region-specific risk, and for the during-crisis period, these markets generally have shown a tendency to shift towards global integration, thus, the systematic risks have sharply increased. However, in case of Northeast Asia for the post-crisis period, the increased degree of integration with regional (EU) market during the crisis period is recently declining, and shows relatively higher degree of integration with regional (EU) market than the world (U.S.) market. On the contrary in case of Europe for the post-crisis period, we found strong evidence that the market is being

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[3] Using the collapse date of Lehman Brothers (September, 2008) as the breaking point of financial cris is does not significantly change the empirical results reported here. In DCC analysis, reported in the n ext section, we assumed the collapse date of Lehman Brother as the breaking point since we divide t he sample period into two sub-periods.

integrated with the world market rather than the Northeast Asian market.

<Table 3> Integration Scores

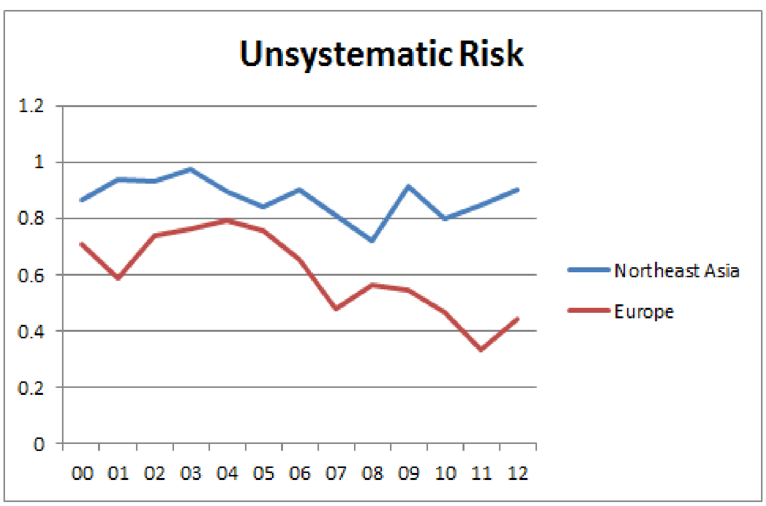
	Northeast Asia			Europe		
	a	b	c	a	b	c
2000	0.1316	0.0006	0.8678	0.1075	0.1836	0.7089
2001	0.0353	0.0293	0.9354	0.0222	0.3891	0.5887
2002	0.0551	0.0119	0.9330	0.0435	0.2206	0.7360
2003	0.0237	0.0033	0.9731	0.0185	0.2200	0.7615
2004	0.0825	0.0219	0.8956	0.0729	0.1353	0.7918
2005	0.1517	0.0097	0.8386	0.1372	0.1044	0.7584
2006	0.0795	0.0177	0.9029	0.0576	0.2886	0.6538
2007	0.1855	0.0042	0.8103	0.1091	0.4145	0.4764
2008	0.2670	0.0125	0.7205	0.2083	0.2295	0.5621
2009	0.0841	0.0034	0.9125	0.0500	0.4076	0.5424
2010	0.1131	0.0878	0.7991	0.0661	0.4673	0.4666
2011	0.1356	0.0147	0.8497	0.0530	0.6152	0.3319
2012	0.0632	0.0328	0.9040	0.0308	0.5286	0.4406
ALL-Period	0.1186	0.0138	0.8676	0.0836	0.3045	0.6119
Pre-Crisis	0.0698	0.0098	0.9204	0.0531	0.2465	0.7004
During-Crisis	0.2030	0.0172	0.7798	0.1443	0.3013	0.5544
Post-Crisis	0.1109	0.0189	0.8701	0.0467	0.5871	0.3662

The results of table 4 confirm that Northeast Asian market and the European market are being segmented from each other's market, whereas both markets are being integrated with the U.S. market. In addition, the recent global financial crisis initiated from the U.S. seems to cause a shift in the pattern of integrating process. In fact, as shown in figure 3, the international market is recently showing the trend of decoupling. Overall, the integrated market of three Northeast Asian countries, China, Japan, and Korea, remains independent from the international stock market movements except a temporary increase in integration with the international market during the crisis period.

<Table 4> Annual a/b Ratios

	Northeast Asia	Europe
2000	219.33	0.59
2001	1.20	0.06
2002	4.63	0.20
2003	7.18	0.08
2004	3.77	0.54
2005	15.64	1.31
2006	4.49	0.20
2007	44.17	0.26
2008	21.36	0.91
2009	24.74	0.12
2010	1.29	0.14
2011	9.22	0.09
2012	1.93	0.06

<Figure 3> Unsystematic Risk



2. Price and Volatility Spillover Effects

Table 5 shows the estimation results of the mean and variance equations measured by multivariate DCC-GJR-GARCH model that indicates the simultaneous price and volatility spillover effects among markets. The asymmetric volatility, γ_i, is significant in all three markets and the persistency, δ_i, of those asymmetric volatility are high (0.89 to 0.94). This result implies that the shock increases volatility more sharply in bad cases than in good cases, and that the increased volatility persists for some period of time. According to the Efficient Market Hypothesis (Fama, 1970), when price is decreased by a shock leading to a higher volatility, the market then should be instantaneously stabilized and normalized since that collapsed price becomes the fair price. However, such shocks somewhat causes panic in the market, and in turn, causes asymmetric volatility that shows high persistence.

In particular, of analysis from all periods without classifying the pre- and post-crisis periods, neither Northeast Asian market nor U.S. market affects the volatility of other markets. However, there is positive volatility spillover effect from European market to U.S. market. In case of price spillover effects, there are negative price spillover effects from U.S. market to Northeast Asian market and from Northeast Asian market to European market, and positive price spillover effects from European market to Northeast Asian market and from Northeast Asian market to U.S. Market.

<Table 5> DCC-GJR-MGARCH for All-Period

Conditional Mean: $r_{i,t} = \beta_{i,0} + \sum_{j=1}^{3} \beta_{i,j} r_{j,t-1} + \epsilon_{i,t}, \quad i,j = 1,2,3$ (N.E.Asia, EU, U.S.)				
	$\beta_{i,0}$	$\beta_{i,1}$	$\beta_{i,2}$	$\beta_{i,3}$
N.EA (i=1)	0.0049	**-0.1292*****	**0.3492*****	**-0.0361****
	(0.015)	**(0.016)**	**(0.017)**	**(0.014)**
EU (i=2)	0.0064	**-0.0281***	-0.0282	0.0103
	(0.013)	**(0.015)**	(0.020)	(0.015)
U.S. (i=3)	0.0228	**0.0337****	**0.5027*****	**-0.1749*****
	(0.013)	**(0.014)**	**(0.016)**	**(0.016)**

Conditional Variance: $\sigma_{i,t}^2 = \alpha_{i,0} + \sum_{j=1}^{3} \alpha_{i,j} \epsilon_{j,t-1}^2 + \delta_i \sigma_{i,t-1}^2 + \gamma_i \epsilon_{j,t-1}^2 I$						
	$\alpha_{i,0}$	$\alpha_{i,1}$	$\alpha_{i,2}$	$\alpha_{i,3}$	δ_i	γ_i
N.EA (i=1)	**0.0298*****	**0.0439*****	0.0120	0.0082	**0.8909*****	**0.0669*****
	(0.004)	**(0.004)**	(0.009)	(0.008)	**(0.007)**	**(0.008)**
EU (i=2)	**0.0122*****	-0.0074	**0.0125****	0.0066	**0.9285*****	**0.0959*****
	(0.002)	(0.005)	**(0.006)**	(0.006)	**(0.007)**	**(0.008)**
U.S. (i=3)	**0.0089*****	0.0048	**0.0145****	-0.0029	**0.9437*****	**0.0880*****
	(0.002)	(0.006)	**(0.006)**	(0.004)	**(0.006)**	**(0.011)**
DCC: $\mathbf{Q_t} = (1-a-b)\overline{\mathbf{Q}} + a\mathbf{z_t z_t'} + b\mathbf{Q_{t-1}}$						
a=0.0047*** (0.003), b=0.9940*** (0.000)						

***, ** and * represent the levels of significance of 1%, 5% and 10% respectively.
( ) represents the standard error.

We also partitioned the period by pre- and post-crisis in order to analyze the changes in spillover effects and correlations. Table 6 shows the results. In specific, the significant volatility spillover effect of Northeast Asian market to European and U.S. market has disappeared after the crisis. For European market, there is significant volatility spillover effect to U.S. market after the crisis, whereas Northeast Asian market is not significantly influenced by European market for volatility after the crisis.

In case of price spillover effects, the Northeast Asian market is negatively affected by U.S. market, and U.S. market is positively affected by European market. The price spillover effects from Northeast Asian market to U.S. market and from U.S. market to Northeast Asian market have disappeared in the post-crisis period.

<Table 6> DCC-GJR-MGARCH for Pre-, Post-Crisis

Conditional Mean: $r_{i,t} = \beta_{i,0} + \sum_{j=1}^{3} \beta_{i,j} r_{j,t-1} + \epsilon_{i,t},\ i,j = 1,2,3$ (N.E.Asia,EU,U.S.)

		$\beta_{i,0}$	$\beta_{i,1}$	$\beta_{i,2}$	$\beta_{i,3}$
N.E.A (i =1)	Pre	0.0051	**-0.0679*** **	**0.3123*** **	**-0.0554*** **
		(0.018)	**(0.020)**	**(0.019)**	**(0.018)**
	Post	0.0205	**-0.2734*** **	**0.4137*** **	0.0292
		(0.023)	**(0.032)**	**(0.025)**	(0.026)
EU (i =2)	Pre	0.0030	-0.0227	**-0.0567** **	0.0212
		(0.016)	(0.018)	**(0.024)**	(0.020)
	Post	0.0240	-0.0254	0.0007	-0.0143
		(0.027)	(0.036)	(0.034)	(0.031)
U.S. (i =3)	Pre	0.0123	**0.0387** **	**0.4350*** **	**-0.1894*** **
		(0.012)	**(0.016)**	**(0.018)**	**(0.019)**
	Post	0.0559	-0.0073	**0.6098*** **	**-0.1361*** **
		(0.021)	(0.027)	**(0.026)**	**(0.027)**

Conditional Variance: $\sigma_{i,t}^2 = \alpha_{i,0} + \sum_{j=1}^{3} \alpha_{i,j} \epsilon_{j,t-1}^2 + \delta_i \sigma_{i,t-1}^2 + \gamma_i \epsilon_{j,t-1}^2 I$

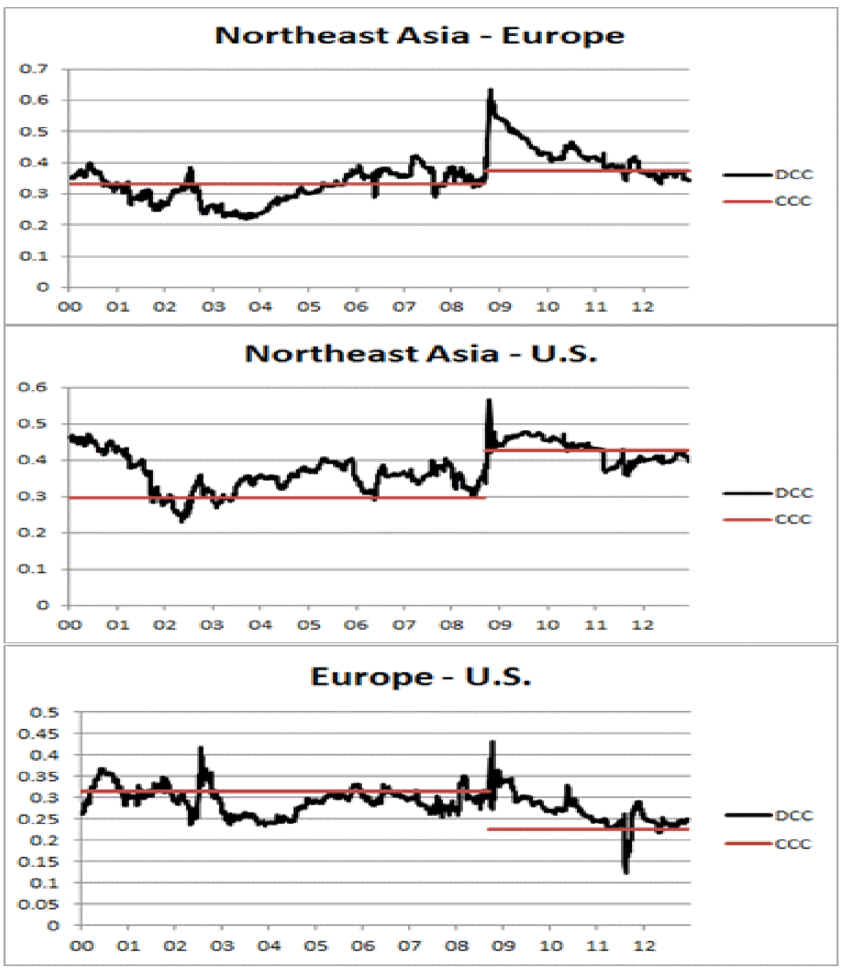
		$\alpha_{i,0}$	$\alpha_{i,1}$	$\alpha_{i,2}$	$\alpha_{i,3}$	δ_i	γ_i
N.E.A (i =1)	Pre	**0.0112*** **	**0.0374*** **	**0.0243*** **	-0.0084	**0.9329*** **	**0.0301*** **
		(0.002)	**(0.004)**	**(0.007)**	(0.005)	**(0.002)**	**(0.008)**
	Post	**0.0808*** **	0.0082	-0.0126	**0.0929*** **	**0.8204*** **	**0.1409*** **
		(0.009)	(0.025)	(0.023)	**(0.023)**	**(0.015)**	**(0.025)**
EU (i =2)	Pre	**0.0134*** **	**-0.0153* **	0.0042	0.0079	**0.9281*** **	**0.1058*** **
		(0.003)	**(0.008)**	(0.008)	(0.009)	**(0.009)**	**(0.014)**
	Post	**0.0307*** **	0.0061	**0.0215*** **	0.0227	**0.9043*** **	**0.0907*** **
		(0.005)	(0.018)	**(0.004)**	(0.015)	**(0.006)**	**(0.012)**
U.S. (i =3)	Pre	**0.0021** **	**0.0087** **	0.0064	**-0.0081** **	**0.9717*** **	**0.0608*** **
		(0.001)	**(0.004)**	(0.006)	**(0.003)**	**(0.005)**	**(0.009)**
	Post	**0.0209*** **	0.0311	**0.0442*** **	0.0057	**0.9074*** **	**0.0856*** **
		(0.004)	(0.025)	**(0.011)**	(0.018)	**(0.015)**	**(0.023)**

***, ** and * represent the levels of significance of 1%, 5% and 10% respectively.
( ) represents the standard error.

Overall, there were dominant agreements that the world market is highly correlated, that the volatility spillover effects are strongly significant, and that such trends tend to increase after the shock such as the global financial crisis. In fact, however, the results of dynamic conditional correlation analysis confirm the implication from the risk decomposition analysis in that the world markets are recently being segmented and that such trend or the degree of contagion effects from regional markets to one another is being weakened.

Figure 4 shows dynamic conditional correlation (DCC) and constant conditional correlation (CCC). CCC results indicate that the correlation coefficient increased after the crisis except the one between European market and U.S. market. But if we take a closer look at the DCC results, it is clear that the increased correlations have reverted back to of pre-crisis level, and that the trends of correlation relationship between markets are on the decreasing.

<Figure 4> Conditional Correlations (DCC, CCC)

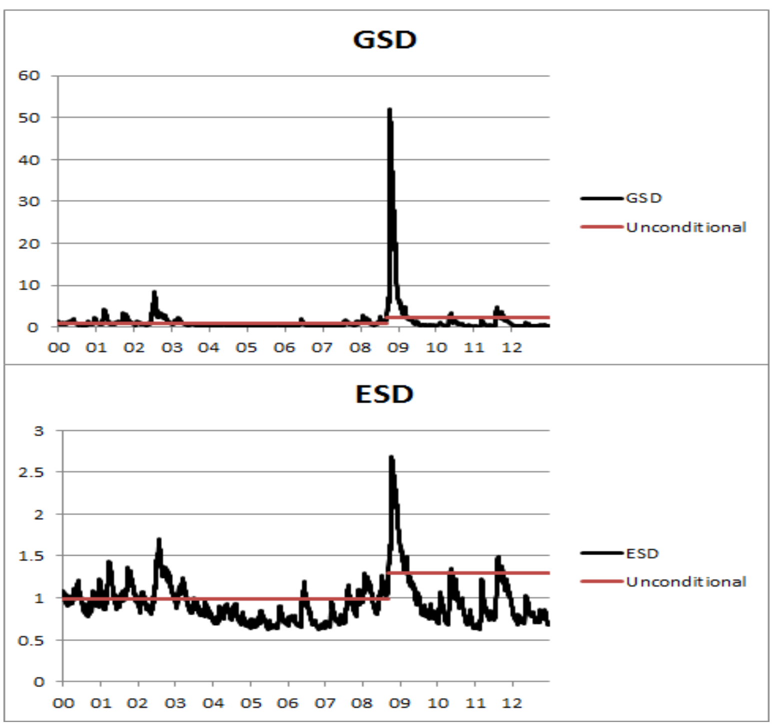


3. Overall Market Volatility and Correlation

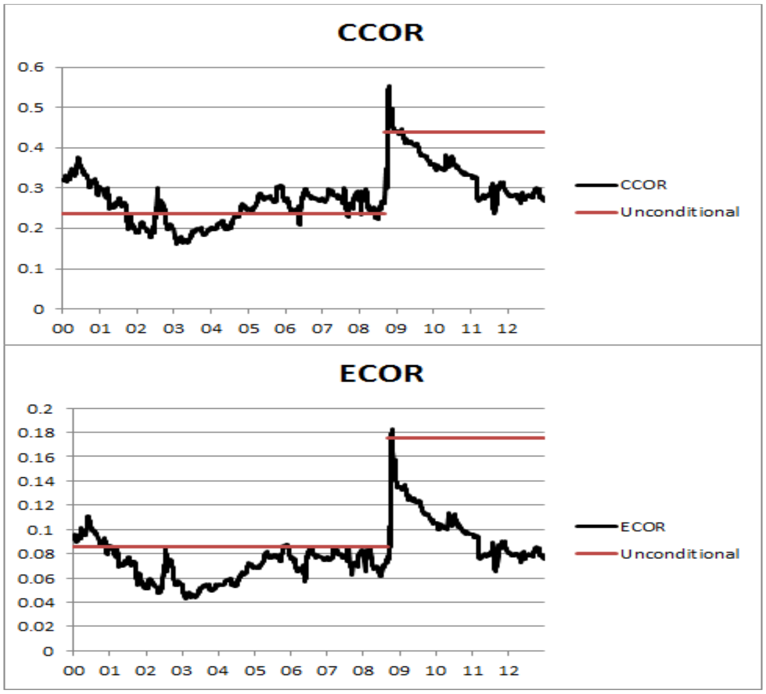
By using the methodology of generalized variance (GVAR) and collective correlation (CCOR), we can analyze the overall market volatility and correlation relationship. Figure 5 shows the generalized standard deviation (GSD) and effective standard deviation (ESD). The figure indicates that volatility sharply increased during the crisis and that the high volatility has persisted for a period of time. Additionally, as shown in figure 5, we can recognize the high volatility caused by shocks from 911 in 2001 and from the Chinese market bubble in 2006.

Figure 6 shows the collective correlation (CCOR) and effective correlation (ECOR). Likewise the result of dynamic conditional correlation analysis, CCOR and ECOR results indicate that the overall market correlation relationship has sharply increased during the crisis period, and reverted back to that of pre-crisis period.

<Figure 5> Generalized Standard Deviation & Effective Standard Deviation



<Figure 6> Collective Correlation & Effective Correlation



VI. Summary and Conclusions

In recognition of the importance of economic ties and integration in regional blocs, European countries integrate the regional market in Europe and create European Union. Today, it is generally accepted that this effort led to a convergence of European economies and stimulated the growth of corporations in the Eurozone area. However, the benefit of financial integration has been severely affected by the recent financial crisis. This adverse effect is pervasive and tenacious. One of the solutions to mitigate the problem is to diversify EU market by increasing its economic ties with a more economically dynamic region such as Northeast Asia. Three main Northeast Asian countries of China, Korea, and Japan are now in the process of negotiating Free Trade Agreement (FTA). There is no doubt that three nations' FTA would sustain and stimulate the economic growth of the region. In financial perspective, these three countries should pursue more capital and new investment opportunities in the region. However, studies regarding the level of stock market integration in these two big regional markets are still in its early stages and lack any detailed research or empirical analysis at this point in time. In this paper, we investigate the dynamic pattern of stock market integration in Northeast Asia and Europe with a particular attention focused on the effect of the recent global financial crisis. This paper assesses the effect of financial crisis on integration by investigating dynamic pattern of stock market movements in Northeast Asian and European stock markets, and examines whether integration has progressed over time. The findings of this study are as follows:

First, Northeast Asian market remains independent from the international stock market movements except a temporary increase in linkages with the international market during the crisis period. Second, European market shows an increasing trend of joint integration with the U.S. market since the crisis. Third, a significant decline in the unsystematic risks of both European and US markets is found to be possible by adding Northeast Asian market to the existing portfolios. Finally, the global financial crisis seems to cause a shift in the pattern of stock market integration. European market shows an increased level of integration with the Northeast Asian market during the crisis period. However, the level of integration falls again in the post-crisis era.

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