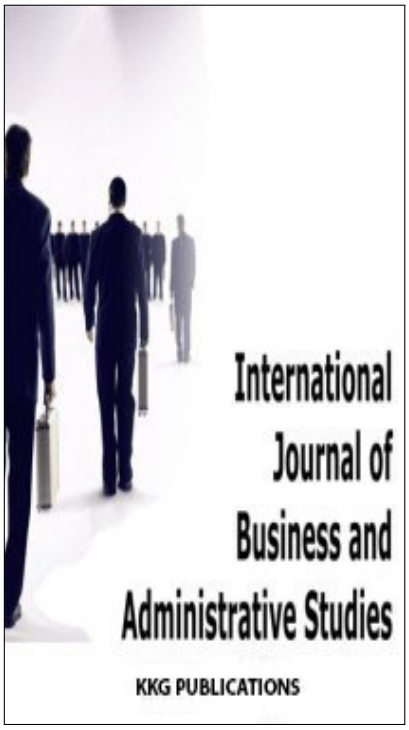

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VOLATILITY CONTAGION IN SELECTED SIX ASIAN COUNTRIES: EVIDENCE FROM COUNTRY DEBT RISK AND DETERMINANT INDICATORS

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Abstract. Volatility contagion has become a trend of financial crisis research ever since the outbreak of 2007 Sub-prime crisis in the US. Existing contagion studies are either too sector-based, or focus on specific financial product so there is a lack of comprehensive study to incorporate multiple indicators driving the volatility contagion. This study analysed multiple sources that can be associated with volatility contagion, comprising both the financial and non-financial sectors, market information, macroeconomic financial variables, country debt risks and external factors (S&P 500) combined together as variety types of indicators driving the volatility contagion. A generalised VAR-GARCH with multivariate BEKK-GARCH approach is employed to analyse volatility contagion of daily sectorial indices of six Asian countries from 1990 until 2015. When AIC criterion information was analysed, it showed that the VAR (1)-GARCH(1,1) model benchmark was robust. This covers two financial crises: Asian Financial Crisis (1997) and the Sub-prime Mortgage Crisis (2007). The research design is partitioned into three stages. The first stage is to analyse the structure of volatility contagion within the selected six Asia countries. In the start of financial crisis, strong interconnection exists between bank credit risk and sovereign credit risk. However, there is no literature providing empirical evidence of the country debt risk on volatility contagion. Hence, in the second stage, this study measures country risk with a Two-limit Tobit model to explore whether the volatility contagion is driven by country risk fluctuation. And lastly is to identify the fourteen major indicators from different sectors driving the volatility contagion, country risk is one of them. The results documented statistical evidence that the volatility contagion was not caused by a single factor. Rather, all volatility contagion has multiple indicators. Country debt risk is one of the important indicators driving volatility contagion. This is contrary to previous studies which focused only on specific sectors or products.

INTRODUCTION

For many decades, different types of economic and financial crisis involving an increase of huge amount of cost expenditures had taken place, and they are still occurring until today especially in the less developed countries. For example, the 2007-09 melt down produced a huge downshift in the path of economic output, consumption and financial wealth. The US nation as well as global has borne additional costs arising from psychological consequences, skill atrophy from extended unemployment, a reduced set of economic opportunities and increased government intervention in the economy.

When a large region experiences a crisis, it will inevitably transmit over to other countries through financial markets, business trade and other cross-country investment linkages. As financial integration remains to increase linkages around the world, this will create links from various countries that are close to each other through periods of strengths as well as weaknesses. However, there are instances whereby other countries that have no financial or economic ties are also affected. It is due to this that volatility contagion test of each financial stock market between regions should be studied in depth.

To diminish and avoid all these issues, it is important to find out the root of the problem as well as explore the indicators of volatility contagion to support investors, bankers, brokers and government to construct their asset management, risk management and portfolio allocation to make it resistant to shock and avoid slipping into contagion circumstance.

Many previous studies on contagion have made great strides in recent years; however, the overall linkages of variety types of indicators driving the volatility contagion are still poorly understood. In particular, there is still a lack of information on variety types of indicators driving the volatility contagion that occurs from both the financial and non-financial channels and other determinant variables. Majority of the studies (Haworth, Reisinger & Shaw, 2006; Jorion & Zhang, 2007; Anderson, 2011) have considered a particular or specific financial product (e.g. CDs) and financial sector intermediaries in investigat-

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ing contagion while in fact, all the financial institutions, non-financial institutions and other determinant variables are highly connected in different aspects, and any impact would definitely affect the efficiency of the global market.

Especially there is no literature providing empirical evidence of the country debt risk on volatility contagion, even though in the start of the financial crisis, strong interconnection exists between bank credit risk and sovereign credit risk. And, a high country debt risk will lead to instability of economy in a country and slip into contagion circumstances. Hence this study explores multiple indicators from different sectors: financial sector, non-financial sector, market information, macro-financial variable, country debt risk and S&P 500 on the volatility contagion testing.

At the stage of empirical testing, this article employs a statistical model recently developed by Ling & McAleer (2003) vector autoregressive-generalized autoregressive conditional heteroscedasticity (VAR-GARCH). This model provides meaningful exploration of the conditional volatility dynamics of the series considered as well as the conditional cross effects and volatility spillover between series. It also offers possibility estimates of the models parameters with fewer computational complications than several other multivariate GARCH specifications, for example the full-factor GARCH model. Furthermore, the findings can be employed to analyse the multiple indicators driving the volatility contagion in selected six Asia countries.

Generally, this study finds significant evidence of volatility contagion across the selected six Asia countries during two crisis periods. On the other hand, the result reveals that the country debt risk had increased for all the countries during and after six financial crises and it is one of the important indicators driving volatility contagion. Furthermore, our findings revealed that the volatility contagion was not caused by a single factor. Rather, all volatility contagion has multiple indicators. This is contrary to previous studies which focused only on specific sectors or products.

The remainder of the study is structured as follows: Section 2 introduces the empirical methodology. Section 3 presents data and preliminary analysis. Section 4 reports and discusses the empirical findings. Section 5 makes concluding remarks.

METHODOLOGY

Country Debt Risk Assessment Model

After filtering down the possible indicators of volatility contagion, this study has identified fourteen major indicators from different sectors. Country debt risk is one of them. So, in stage one, this study adopted Tobit model used by Gur (2001) and Lee, Cheng, Hooy and Taufiq (2016) to measure the country debt risk fluctuation for exploring the new indicator driving the volatility contagion.

This study utilizes the Two-limit Tobit model to determine debt rescheduling for selected six Asia countries up to thirty-three years, over the period of 1980 to 2013. After defining the fundamental debt ratios and macroeconomic variables affecting the debt re-compensation ability and debt restructuring of the sample developing countries in Asia, the estimated debt restructuring ratios are used to determine the percentage growth of Asian countries' debt risks. The model is investigated for its forecast-ability of the external debt crisis quarterly in advance with special emphasis given to the six economy crashes (Crisis of 1982, Japanese Asset Price Bubble 1989, the Savings and Loan Crisis (early 1990s), the Asian Financial Crisis (1997), Internet Bubble Bursting (2002) and the Mortgage Crisis (2007) and their predictability). The model uses the studies of Gur (2001) where the debt restructures to the total external debt stock ratio (restructuring ratio) which is employed as an endogenous variable in order to employ the relative amount of debt rescheduling over total debt.

Indicators of the Country Debt Risk Assessment Model

The applicable statistical approach to investigate the country debt risk is Two-limit Tobit approach which employs max likelihood to combine the probit & regression components of the log-likelihood function.

A country debt risk assessment model, Central Bank Review 1, 49-68. Similar to previous empirical studies, this research also selected the view that the demand for debt restructuring performs a debt servicing difficulty for a country and, therefore, poses a risk for lenders. This study attempted to investigate a country default risk by using a country debt restructuring risk as a proxy since country defaults no longer exist. In other words, debt restructuring is substituted in the estimation of debt servicing capacity, since country default is not an observable variable. Place (1989) had highlighted some crucial issues. First, debt repayment problem needs no result in a restructuring agreement. Next, we may face hidden information since some restructuring agreements are not made public. Third, between the announcement of a restructuring agreement and the problem of debt servicing there may be a considerable length of period. Nevertheless, debt rescheduling iillustrates that a country is experiencing severe repayment difficulties in its external debt. As a result, rating sovereign borrowers, according to their debt restructuring burden makes sense for lenders who do not want to be involved in the extremely long painful process of debt restructuring.

TABLE 1
Variables and Definitions of Country Debt Risk Estimation

Variables	Definitions	Expected Coefficient Sign
RR_{t+1} to EDT ratio	Debt Stock Restructured (a quarterly-ahead) to External Debt Stock	NIL
INT to XGS ratio	Total Interest Payment to Exports of Goods & Services	+
C to EDT ratio	Concessional loans to Total Debt Stock	-
RES to EDT ratio	International reserves to External Debt Stock	-
EDT to GDP ratio	External Debt to Gross Domestic Productivity	+
PRV to EDT ratio	Private sector LDOD to Total Debt Stock	-
RR to EDT ratio	Debt Stock Restructured to Total Debt Stock	+

As this study mentioned earlier, the dependent variable used in this study is a quarterly-ahead of total amount of debt restructuring to total amount of external debt ratio, TR (+1Q)EDT. It is normally called as the rescheduling ratio.

To determine a country's restructuring risk in external debt, this study selected a total of six economic Asia indicators to define the factors responsible for debt rescheduling. These six indicators are represented in table 1 and their expected signs are listed in table 8.

The first indicator is a classical indicator of creditworthiness, which is employed in variety country debt risk applications. The interest payment over export of goods and services ratio, (INT XGS).

The second variable is the total concessional loans over total debt stock ratio, (C EDT). To investigate the debt capacity of sovereign borrowers or country rescheduling risk, concessional long-term loans with a grant element of 25 percent or more are represented by the World Bank as loans.

The third variable is to define ratio of the total reserves over total debt, (RES EDT).

The fourth variable is used to test restructured behaviour in the model. The ratio of total debt stock over gross domestic product, (EDT GDP).

The fifth variable of the study is the ratio of private debt over total debt, (PRV EDT). A country with a well-established private sector and high private debt to total debt ratio is less likely to experience debt rescheduling or default than otherwise. This indicator has a negative expected sign.

The last indicator is the total debt rescheduling over total external debt ratio, (TR EDT). To determine the one-period lagged endogenous variable.

To make the model serve as forecast of country debt riskiness, this study is using one-quarterly lagged values of the independent variables. As a result of such setup, the investigation of restructuring ratio for the next quarter (t+1) is obtained by utilizing values of the independent variables in the present quarter (t). In other words, the model is aimed to forecast coming debt servicing capacity of the selected Asian countries a-quarter in advance.

The Tobit Model: Censored and Truncated Regression Models

This section illustrates the Tobit model (the censored regression model). Suppose this study considers a sample size 'n' and records only those values of the dependent variable greater than a constant 'c'. The resulting sample based on such criterion is called a censored sample. However, if the sample is truncated before actual selection is made, then a sample from this truncated normal distribution is called a truncated sample. Amemiya (1984) surveyed the Tobit models by partitioning them into five basic types according to the form of the likelihood function, and stated that basic estimation methods can be applied to any of the five types with slight modifications. In the next section, Two-limit Tobit model is reviewed. The two-limit Tobit model is used rather than the standard Tobit model, if endogenous variable is subject to both an upper limit and a lower limit.

Two-Limit Tobit (Probit) Model

In the next section of the country debt risk estimation, the debt restructuring ratios are investigated with use of alternative models. In analyzing the debt repayment crises, this study measures the relative size of debt restructuring and the debt restructuring ratio which is bound with one and zero as an endogenous variable. In the cases that economic variables are restricted by an upper and lower limit but are continuous between the two limits, the Two-limit Tobit is the most robust framework. The Two-limit Tobit (Probit) regression model and its estimation method is given in Rosett & Nelson (1975). According to the statistic approach, the endogenous variable Y is determined by:

$$Y_t = L_{t1} \text{ when } Y_t^* - e_t \leq L_{1t},$$
$$Y_t = L_{t2} \text{ when } Y_t^* - e_t \leq L_{2t},$$
$$Y_t = Y_t^* - e \text{ when } L_{t1} \leq Y_t^* - e_t \leq L_{2t}, \quad (10)$$

where Y_t^* is a linear function of the exogenous variables X_t . The aim is to estimate the unknown parameters,

$Y_t^* = \sum_{i=1}^{k} \beta_i X_{it}$

where the subscript, t, distinguishes observations and its application to the limits l_1 and l_2 means that these limits are permitted to change among observations. The random variable is assumed to be normally distributed with a zero mean and standard deviation σ. If the non-limit values are known, the maximum likelihood estimates can be obtained from the following likelihood function:

$$L = \Pi_{S1} Q\left[\frac{Y^*-L_1}{\sigma}\right].\Pi_{S2} P\left[\frac{Y^*-L_2}{\sigma}\right].\Pi_{S3} \frac{1}{\sigma} Z\left[\frac{Y^*-Y}{\sigma}\right] \quad (11)$$

where P is the normal cumulative probability distribution, Q = 1-P, and Z is the normal density function. The sample has been categorised into three parts, S1 (lower limit), S2 (upper limit) and S3 (non-limit observations). After some simplifications, the likelihood function becomes:

$$L = \Pi_{S1} Q(I^* + \alpha_0 L_1).\Pi_{S2} P(I^* + \alpha_0 L_2).\Pi_{S3} P(-\alpha_0 Z(I^* + \alpha_0 Y_1)) \quad (12)$$

where

$\alpha_i = \beta_i \sigma$,

$\alpha = \frac{-1}{\sigma}$,

$I^* = \frac{Y^*}{\sigma}$

Taking the natural log of L gives

$$\phi = \sum_{S1} InQ(I * + \alpha_0 L_1) + \sum_{S2} InP(I * + \alpha_0 L_2) + \sum_{S3}\left[In(-\alpha_0) - \frac{1}{2} In 2\Pi - \frac{1}{2}(I* + \alpha_0 Y)^2\right] \quad (13)$$

and by maximization of this function the unknown parameter can be obtained.

The solutions for the estimates are not obtainable since this likelihood function yields non-linear normal equations. Consequently, some iterative maximization procedure must be employed. The ordinary least square (OLS) estimates may bring adequate initial values where the values of "Y" for the non-limit observations are known. In previous studies, applying the OLS to just non-limit observations yields better estimates. Alternatively, Tobin (1958) suggests a process to linearizing the normal equations.

This study uses STATA software to run the Two-limit Tobit model and diagnostic test for country debt risk measurement.

Lastly, to measure the country debt risk fluctuation, this study follows the table shown as below:

$$RR_{t+1}toEDT = \beta_1 INTtoXGS_t + \beta_2 CtoEDT_t + \beta_3 REStoEDT_t + \beta_4 EDTtoGDP_t + \beta_5 PRVtoEDT_t + \beta_6 RRtoEDT_t \quad (14)$$

The country debt risk is obtained by multiplying the total ratio variables to total coefficient of the indicators. Whereas, the fluctuation of country debt risk is obtained by dividing recent value (t) minus previous value (t-1) to previous value. The fluctuation of country debt risks is graphically shown in figure 1 and 2.

The Models Applied Indicators of the Volatility Contagion

In the second stage, this study deals with the issue of volatility modelling and predicting of commodities' prices. This study adopts the GARCH econometric approach which has acknowledged a special interest from almost all previous studies. While the objective is to explore transmission mechanisms and volatility interdependence among various time-series, multivariate settings such as the CCC-MGARCH model of Bollerslev (1990), the BEKK-MGARCH model of Engle and Kroner (1995) or the DCC-MGARCH model of Engle (2002) are more relevant than the univariate models. Empirical evidences reported in Hassan and Malik (2007), Kang, Kang and Yoon (2009), Agnolucci (2009) and Arouri, Jouini and Nguyen (2011) among others, confirmed that the stylized fact of the commodity-price conditional volatility and the dynamics of volatility interaction are satisfactorily captured by these robustness and superiority statistical approaches.

The earlier mentioned approaches are naturally applicable to answer our research question and to investigate the stock market volatility spillover in Asian countries. However, they often encounter convergence issue and excessive parameters during estimation processes especially when the conditional mean and variance equations are popularized by additional exogenous variables. For these reasons, Ling and McAleer (2003) contributes an interesting alternative method, the multivariate VAR(k)-GARCH(p,q) approach. Compared to other volatility spillover models, the main superiority is that it is flexible enough to deal with the volatility transmission and conditional cross effects between the series under consideration with less computational complexities. In particular, Chang, Jiang and Lu (2009) by recent research had confirmed that the strength of the VAR(1)-GARCH(1,1) model is the specification to capture cross-market volatility interaction.

In this study, by respectively selecting the best model (i.e., VAR-GARCH model and BEKK-GARCH model) for each pair of volatility contagion, this study used the AIC information criteria. Similar to findings of previous research, our study also selected one lag for both conditional variances and mean equation for all the thirty market pairs. Therefore, this study decided to opt for the bivariate framework of the VAR-GARCH model to compare the results across thirty stock market pairs in selected six Asian countries. In what follows, this study presents the bivariate VAR-GARCH model and competing

model (diagonal BEKK-GARCH). The former is considered as our benchmark model, and the latter is used especially to measure the indicators of volatility contagion.

Bivariate VAR(1)-GARCH(1,1) Model

The bivariate VAR(1)-GARCH(1,1) model of Ling and McAleer (2003) for each pair of stock market returns has the following specifications for the conditional mean:

$$\begin{cases} R_t = m + jR_{t-1} + e_t \\ e_t = H_t^{1/2} h_t \end{cases} \quad (1)$$

where $R_t = (rt^s, rt^0)'$ is the vector of returns on the pair of stock market index. Φ refers to a (2 X 2) matrix of coefficients of the form $\phi = \begin{Bmatrix} \phi & 0 \\ 0 & \phi \end{Bmatrix}$. $\epsilon = (\epsilon_t^s, \epsilon_t^0)'$ is the vector of the error terms of the conditional mean equations for pairs of stock returns. $\eta = (\eta_t^s, \eta_t^0)'$ refers to a sequence of independently and identically distributed (i.i.d) random errors; $H_t = \begin{Bmatrix} h_t^s & h_t^{so} \\ h_t^{so} & h_t^o \end{Bmatrix}$, is the conditional variances matrix of all pairs of stock returns. $h_t^s, h_t^o and h_t^{so}$ are specified as follows:

$$h_t^s = C_S^2 + b_{S1}^2 \times h_{t-1}^s + a_{S1}^2 \times (e_{t-1}^s)^2 + b_{S2}^2 \times h_{t-1}^0 \times a_{S1}^2 \times (e_{t-1}^s)^2 \quad (2)$$

$$h_t^s = C_0^2 + b_{01}^2 \times h_{t-1}^0 + a_{01}^2 \times (e_{t-1}^0)^2 + b_{02}^2 \times h_{t-1}^S \times a_{01}^2 \times (e_{t-1}^s)^2 \quad (3)$$

Obviously, Eqs. (2) and (3) assume that positive and negative shocks of equal magnitude have identical effects on conditional variances. The cross stock markets' volatility transmissions over time are governed through the cross values of error terms, $(\varepsilon_{t-1}^0)^2$ and $(\varepsilon_{t-1}^S)^2$, which capture the impact of direct effects of shock transmissions, as well as those of lagged conditional volatilities, h_{t-1}^0 and h_{t-1}^S, which directly account for the transfer of risk between markets. To guarantee stationarity, the roots of the equation $|I_2 - AL - BL| = 0$ must be outside the unit circle, where L is a lag polynomial, I_2 is a (2×2) identity matrix, and

$$A = \begin{pmatrix} \alpha_{S1}^2 & \alpha_{S2}^2 \\ \alpha_{02}^2 & \alpha_{01}^2 \end{pmatrix} \text{ and } B = \begin{pmatrix} \beta_{S1}^2 & \beta_{S2}^2 \\ \beta_{02}^2 & \beta_{01}^2 \end{pmatrix}$$

Let ρ be the constant conditional correlation (CCC); the conditional covariance between stock returns is modelled as:

$$h_t^{s0} = r \times \sqrt{h_t^s} \times \sqrt{h_t^0} \quad (4)$$

As specified previously, our empirical approach simultaneously allows long-run volatility persistence as well as volatility and shock transmissions between the stock markets under consideration. Of course, the assumption of CCC-GARCH model may be viewed as restrictive given changing economic conditions, but the statistical properties of a VAR-GARCH model accounting for DCC-GARCH model have not yet been theoretically analysed. The parameters of the above bivariate model are obtained by Quasi-Maximum Likelihood Estimation (QMLE), which is robust to any departure from normality conditions (Ling & McAleer, 2003).

Bivariate AR(1)-GARCH(1,1) Model

Let us define here again the vector of the returns on pairs of stock market index, $R_t = (r_t^s, r_t^0)'$ and let $H_t = \left[h_t^{ij}\right], i, j = S, O$ be the conditional variance-covariance matrix of the returns which follows a bivariate GARCH(1,1) process, the conditional mean of the bivariate AR(1)-GARCH(1,1) can be specified as:

$$\begin{cases} R_t = \mu + \phi R_{t-1} + \varepsilon_t \\ \varepsilon_t = H_t^{1/2} \eta_t \end{cases} \quad (5)$$

where $H_t^{1/2}\eta_t$ is a (2×2) symmetric positive definite matrix and $\eta_t = (\eta_t^s, \eta_t^0)'$ is the victor of i.i.d. random errors with $\mathrm{E}(\eta_t) = 0$ and $\mathrm{Var}(\eta_t) = I_N$. The matrix of coefficients in the mean equations is defined as in the VAR-GARCH model, i.e., $\phi = \begin{Bmatrix} \phi_1 & 0 \\ 0 & \phi_2 \end{Bmatrix}$., , to permit the comparison across the benchmark and competing models. Different specifications for H_t thus lead to different multivariate GARCH-type models.

Engle and Kroner (1995) developed the diagonal BEKK-GARCH(1,1), in which the parameters of the covariance equations $(h_t^{ij}, i \neq j)$ are the products of the parameters of the variance equations (h_t^{ii}) that is defined as follows:

$$H_t = C'C + A'_{\varepsilon t-1} A + B_{Ht-1} B \quad (6)$$

where C, A, and B are (2×2) matrices of parameters, C is upper triangular and A & B are diagonal. Accordingly, the conditional variance and covariance processes take the following forms:

$$\begin{cases} h_t^s = C_s + \alpha_s^2 (\varepsilon_{t-1}^s)^2 + \beta_s^2 h_{t-1}^s \\ h_t^o = C_o + \alpha_o^2 (\varepsilon_{t-1}^o)^2 + \beta_o^2 h_{t-1}^o \\ h_t^{so} = C_{so} + \alpha_s \alpha_0 \varepsilon_{t-1}^s \varepsilon_{t-1}^0 + \beta_s \beta_o h_{t-1}^{so} \end{cases} \quad (7)$$

where h_t^s and h_t^0 are the conditional variances of r_t^s and r_t^0. Eq. (7) thus shows that direct volatility transmission between stock returns is not possible since the conditional volatility of each market depends only on its own shocks and its long-run persistence. This volatility model is covariance stationary when $\alpha_S^2 + \beta_S^2 < 1, \alpha_0^2 + \beta_0^2$ and $|\alpha_S \alpha_0 + \beta_S \beta_0| < 1$. We now shift our attention to another class of GARCH processes that model the conditional correlations rather than the conditional covariance matrix H_t. The economic rationale for doing so is to obtain the intuitive and meaningful interpretations of the correlation coefficients. The most well-known and commonly

used specification is the CCC-GARCH model produced by Bollerslev (1990).

The bivariate CCC-GARCH(1,1) is defined as follows:

$$H_t = D_t P D_t \quad (8)$$

where D_t = diag $\left(\sqrt{h_t^s}, \sqrt{h_t^0}\right)$ and p= ρ_{ij} is the (2×2) matrix containing the constant conditional correlations ρ_{ij} with $\rho_{ii} = 1, \forall i = S, O$. The conditional variances and covariance are given by:

$$\begin{cases} h_t^S = C_S + \alpha_S (\varepsilon_{t-1}^S)^2 + \beta_S h_{t-1}^S \\ h_t^0 = C_0 + \alpha_0 (\varepsilon_{t-1}^0)^2 + \beta_0 h_{t-1}^0 \\ h_t^{S0} = \rho \sqrt{h_t^S} \sqrt{h_t^0} \end{cases} \quad (9)$$

Bollerslev (1990) shows that it is not necessary to get a positive definite matrix P with the positivity of the ARCH and GARCH coefficients. This process is covariance stationary when the roots of det $(I_2 - \lambda A - \lambda B = 0)$ are outside the unit circle of the complex plan, where I_2 identity matrix and

$$A = \begin{pmatrix} \alpha_{S1} & 0 \\ 0 & \alpha_0 \end{pmatrix} \text{ and } B = \begin{pmatrix} \beta_S & 0 \\ 0 & \beta_0 \end{pmatrix}$$

On the whole, compared to the VAR-GARCH model the bivariate GARCH approaches presented above do not explicitly allow for the cross-sectional dependency of conditional volatilities between stock markets.

Regression Analysis

After filtering down the possible indicators of volatility contagion, this study has identified fourteen major indicators from different sectors: financial sector, non-financial sector, market information, macro-financial variables, country debt risk and external factor (S&P 500). In stage three, this study used regression models to analyse the correlation of fourteen indicators with volatility contagion. That is done to test whether the fourteen indicators play a role in driving the volatility contagion. To define the relationship between fourteen indicators and volatility contagion, the dependent variables and independent variables are listed as below:

$$VC_{a-b,t} = \alpha + b_1 R_{country\_debt\_risk,i,t} + b_2 R_{financial\_sectors,i,t} + b_3 R_{non-financial sectors,i,t} + b_4 R_{market\_information,i,t} + b_5 R_{macro-financial\_variables,i,t} + b_6 R_{S\&P500,i,t} + e_{i,t}$$

where

$VC_{a-b,t}$

= Volatility contagion of country a to b at time t

= $VC_{a-b,t} X Share Price a, t$

$R_{country\_debt\_risk,i,t}$

= Country debt risk of country i at time t

$R_{financial\_sector\_i,t}$

= aggregate financial stock index return of country i at time t (bank sector, real estate sector and insurance sector indices)

$R_{non\_financial\_sector\_i,t}$

= aggregate non-financial stock index return of country i at time t (telecom-media -IT sector, utilities sector and industrial sector indices)

$R_{market\_information\_i,t}$

= market information of country i at time t (money supply, treasury bills rate and exchange rate)

$R_{macro\_financial\_variables\_i,t}$

= macro financial variable of country i at time t (money market rate, gold price and crude oil price)

$RS\&P500, t$

= Stock Market Return S&P 500 at time t

$e_{i,t}$

= residual at time t

The regression models as above aim to:

- evaluate the relationship between country debt risk and volatility contagion;
- define the correlation between financial sectors (bank sector, real estate sector and insurance sector) and volatility contagion;
- analyse the relationship between non-financial sectors (telecom-media-IT sector, utilities sector and industrial sector) and volatility contagion;
- investigate the relationship between market information (money supply, treasury bills and exchange rate) and volatility contagion.;
- identify the relationship between macro financial variables (money market rate, gold price and crude oil price) and volatility contagion; and
- define the relationship between external factor (S&P 500) and volatility contagion.

DATA AND PRELIMINARY ANALYSIS

This study covers six Asian stock indices (the daily stock returns of the KLCI Composite index in Malaysia, Nikkei 225 in Japan, Bangkok S.E.T in Thailand, PSEi in the Philippines and KOSPI in South Korea and IDX Composite in Indonesia) to investigate each pair of volatility contagion. To measure the volatility contagion, this study used own currency to avoid exchange rate noise. Besides that, our sample data cover fourteen sectors in Indonesia, Japan, Malaysia, South Korea, Thailand and the Philippines: Banks, Real Estate, Insurances, Telecommunications-Media-IT, Utilities, Industrial, Money Supply, Treasury-Bills, Exchange Rate, Money Market Interest Rate, Gold Prices, Crude Oil Prices, Country Debt Risk fluctuation and S&P 500 index. Majority of the listed

companies come from banks, real estate and insurance sector; hence the selection of these three major sectors as the benchmark for financial sector was done. Telecom-Media-IT, Utilities and Industrial sectors have been chosen as the benchmark for non-financial sector as three of them are mostly industrial. Since 1957, S&P 500 index was widely viewed as the outstanding benchmark of the US stock markets. The S&P 500 index is actually partitioned into ten sectors, referring to the Global Industry Classification Standard. Altogether, fourteen sectors were used to analyse the correlation with each pair of volatility contagion. All compatible data are collected from the Data-stream International database and World Bank.

However, this study used the Brent crude oil price which was taken from the Energy Information Administration (EIA) database. The source of Brent crude from the North Sea is usually refined in north western Europe, and it is used to price about two-thirds of the worlds internationally traded crude oil currently. For assessment of the country debt risk, the sample Asian countries chosen have been borrowing significant amount of external loans from commercial banks, international institutions, private and governments sources throughout the years. The first principle for choosing a country was the availability of data for significantly long period of time. The next reference point was the level of external borrowing from commercial banks and the total amount of external debt stock. The database of this country debt risk measurement consists of 5586 observations. There are 136 rescheduling observations or 2.43% of total observations. This performs a relatively rich data set on country debt risk assessment in terms of country debt rescheduling. All of the selected countries have experienced debt rescheduling from 1980 to 2013 which would cover both the tranquil and turbulent periods. Quarterly data are used in this study to measure the country debt risk. The currency/ US dollar exchange rate from the Data-stream International database was used to perform any conversion to the US dollar while investigating a country debt risk.

As usual, all the data (e.g. six stock markets, six sector indices, three markets' information, three macro-financial variables, country debt risk and S&P (500) are computed by taking the natural log. The sample period covered is shown in the table below:

TABLE 2
The Sample Period of the Study

Name of the Crisis	Country	The "PEAK" Crisis Period
Crisis of 1982	Chile (South America)	1982
Japanese Asset Price Bubble 1989	Southeast Asia but primarily Japan	Oct 1987 - Mar 1988
Savings & Loan Crisis	US	Aug 1990 - Jan 1991
Asian Financial Crisis	East Asian	July 1997 - Dec 1998
The Internet Bubble Bursting	Asian, Europe, US and Canada	2002
Sub-prime Mortgage Crisis	US	Sept 2008 - Feb 2009

Table 2 shows the sample period of the study. The range of the periods was covered from first of the month until end of the month. The structure of volatility contagion estimation would cover the two crisis periods: Asian Financial Crisis and Sub-prime Mortgage Crisis. Whereas, the country debt risk estimation covered six crisis periods from year 1982 until 2009.

TABLE 3
Descriptive Statistics of Each Variable in Ratio of Country Debt Risk Estimation

Variable	TR(+1) EDT	INT/XGS	C/EDT	RES/EDT	EDT/GDP	PRV/EDT	TR/EDT
				MALAYSIA			
Obs	133	133	133	133	133	133	133
Mean	0.0025	0.0340	0.0691	0.6993	0.4917	0.2258	0.0025
Max	0.0831	0.0956	0.1486	1.2114	0.7991	0.4344	0.0833
Min	0	0.0071	0.0108	0.2375	0.2178	0.0845	0
Std. Dev.	0.0117	0.0263	0.0339	0.2585	0.1117	0.0854	0.0118
Skewness	5.0973	1.0771	0.5461	-0.0133	0.5525	0.5756	5.0989
Kurtosis	29.343	2.7527	2.7595	2.2892	2.9997	2.4787	29.366

Variable	TR(+1) EDT	INT/XGS	C/EDT	RES/EDT	EDT/GDP	PRV/EDT	TR/EDT
INDONESIA							
Obs	133	133	133	133	133	133	133
Mean	0.0054	0.0915	0.2491	0.2273	0.5398	0.2290	0.0054
Max	0.0393	0.173	0.3647	0.5000	2.3231	0.3676	0.0396
Min	0	0.0265	0.1355	0.1128	0.2505	0.0871	0
Std. Dev.	0.0104	0.0446	0.0422	0.1124	0.2851	0.0903	0.0104
Skewness	1.7443	-0.025	-0.084	0.9807	2.7212	-0.153	1.743
Kurtosis	4.6447	1.67	3.704	2.8279	15.251	1.523	4.643
PHILIPPINES							
Obs	133	133	133	133	133	133	133
Mean	0.0235	0.1220	0.1906	0.3346	0.5765	0.1720	0.0233
Max	0.1984	0.3264	0.2843	1.3729	0.8522	0.3630	0.1958
Min	0	0.0386	0.0514	0.0346	0.2227	0.0399	0
Std. Dev.	0.0482	0.0793	0.0695	0.3602	0.1655	0.0957	0.0478
Skewness	2.2974	0.9934	-0.9538	1.7706	-0.5494	0.4349	2.2892
Kurtosis	7.4902	2.7077	2.5789	5.0430	2.3560	1.8245	7.4308
THAILAND							
Obs	133	133	133	133	133	133	133
Mean	0.0054	0.0614	0.1067	0.6511	0.4297	0.3255	0.0050
Max	0.0782	0.1506	0.1675	1.7079	0.9387	0.4777	0.0781
Min	0	0.0063	0.0342	0.1716	0.2443	0.1390	0
Std. Dev.	0.0152	0.0450	0.0351	0.486	0.1566	0.1059	0.0145
Skewness	3.3889	0.3931	0.0431	1.0445	1.4127	-0.2833	3.6362
Kurtosis	13.6855	2.0365	2.1161	2.6478	4.2685	1.6946	15.6113
JAPAN							
Obs	133	133	133	133	133	133	133
Mean	0.0005	0.0224	1.06E-05	0.0850	0.9601	2.610	0.0004
Max	0.0115	0.0462	0.000193	0.1457	2.107	4.476	0.0114
Min	0	-0.0016	0	0.0441	0.3664	0.8111	0
Std. Dev.	0.0021	0.0121	3.89E-05	0.0278	0.5583	1.254	0.001984
Skewness	4.206	-0.236	3.647	0.4383	0.6868	-0.1945	4.648
Kurtosis	19.323	2.393	14.914	1.874	1.917	1.455	23.394
SOUTH KOREA							
Obs	133	133	133	133	133	133	133
Mean	0.0522	0.0417	0.1593	3.678	0.2155	5.936	0.0359
Max	2.471	0.1300	0.7878	14.163	0.4501	25.33	1.647
Min	0	0.0056	0.0000	0.6814	0.0416	2.675	0
Std. Dev.	0.2843	0.0330	0.2573	3.541	0.1302	4.509	0.1860
Skewness	6.6324	1.203	1.303	1.6907	0.2974	2.553	6.4011
Kurtosis	50.146	3.199	3.0866	5.1372	1.707	9.687	48.69

The table 3 reports the basic statistics of ratio of each variable, including mean (Mean), maximum (Max), minimum (Min), standard deviations (Std.dev.), skewness (Skew.) and kurtosis (Kurt.). It also shows selected descriptive statistics for all variables used to investigate country debt risk. The PRVEDT in South Korea has the highest ratio in mean (5.94%) compared to others countries. Whereas, TREDT and TR(+1) EDT have the lowest ratio for all the countries (0.00%).

TABLE 4
Descriptive Statistics of Return Series

Variable	Obs	Mean(%)	Max(%)	Min(%)	Std. Dev. (%)	Skew.	Kurt.	Jarque-Bera
KLCI	523	6.477	7.004	5.571	0.3349	-0.386	2.083	31.3***
SET	523	6.013	6.525	5.334	0.2897	-0.4128	2.523	19.8***
NIKKEI 225	523	9.54	9.932	8.877	0.2803	-0.9927	2.737	87.4***
KOSPI	523	6.357	7.314	5.635	0.4893	0.4117	1.903	41***
PSEi	523	7.56	7.943	6.987	0.1931	-0.666	3.802	52.68***
IDX	523	6.39	7.68	5.548	0.5422	0.8033	2.351	65.41***

The table 4 reports the basic statistics of return series. Jarque-Bera is the empirical statistics test for normality based on skewness and excess kurtosis. The *, **, *** indicate the rejection of the null hypothesis of associated statistical tests at the 10%, 5% and 1% levels respectively. It also shows selected descriptive statistics for log return series. The Nikkei 225 stock index experienced higher returns (9.54%) than the other five countries. On the other hand, SET experienced the lowest returns (6.01%). One reasonable explanation for the poor performance of the Thailand stock market is that the selected two crises had threatened Thailand's recovery. As a result, the Jarque-Bera test statistics (JB) clearly confirm the normality for all return series with the rejection of the null hypothesis.

TABLE 5
Descriptive Statistics of Volatility Contagion Estimation

Variable	Obs	Mean(%)	Max(%)	Min(%)	Std. Dev. (%)	Skew.	Kurt.	JB
MALAYSIA								
MY-TH	523	6.236	6.968	5.550	0.3279	0.4031	2.087	32.32***
MY-ID	523	6.299	7.048	5.630	0.3460	0.3265	1.983	31.82***
MY-SK	523	6.094	6.715	5.296	0.2709	-0.0698	2.965	0.451
MY-PH	523	6.474	7.215	5.796	0.3358	0.3713	2.036	32.27***
MY-JP	523	6.830	7.779	5.755	0.6242	-0.5798	1.997	51.22***
INDONESIA								
ID-MY	523	6.345	8.466	5.228	1	1.052	2.341	105.9***
ID-TH	523	6.074	7.663	5.134	0.7035	0.9433	2.339	87.06***
ID-JP	523	6.810	7.413	6.195	0.2371	-0.0674	3.118	0.6979
ID-PH	523	6.417	7.614	5.605	0.4940	0.7358	2.363	56.04***
ID-SK	523	5.636	7.603	4.570	0.9137	1.0307	2.340	102.1***
PHILIPPINES								
PH-MY	523	7.279	8.523	6.414	0.5783	0.8692	2.353	74.99***
PH-TH	523	7.081	7.828	6.381	0.3215	0.2463	2.639	8.128**
PH-JP	523	7.602	8.100	7.138	0.2484	-0.2017	1.960	27.13***
PH-ID	523	7.103	7.727	6.444	0.2674	-0.1061	2.949	1.036
PH-SK	523	6.393	7.927	5.433	0.7377	0.9826	2.339	93.67***
THAILAND								
TH-MY	523	6.139	7.248	5.260	0.5118	0.3685	2.159	27.23***
TH-JP	523	6.455	7.120	5.929	0.3339	0.1746	1.837	32.14***
TH-ID	523	5.969	6.482	5.291	0.2895	-0.4118	2.524	19.71***
TH-SK	523	6.010	6.609	5.300	0.3097	-0.4317	2.436	23.18***
TH-PH	523	6.215	6.848	5.657	0.3064	0.2146	1.961	27.53***

Variable	Obs	Mean(%)	Max(%)	Min(%)	Std. Dev. (%)	Skew.	Kurt.	JB
JAPAN								
JP-MY	523	8.930	10.06	8.452	0.4624	1.138	2.677	115.1***
JP-TH	523	8.282	9.360	7.823	0.4305	1.135	2.729	113.8***
JP-ID	523	8.885	9.292	8.648	0.124	0.9535	4.058	103.6***
JP-PH	523	8.545	9.581	8.099	0.4078	1.132	2.774	112.8***
JP-SK	523	8.693	9.518	8.318	0.294	1.115	3.174	109.1***
SOUTH KOREA								
SK-MY	523	6.309	7.636	5.464	0.679	0.7422	2.089	66.1***
SK-TH	523	6.17	6.888	5.523	0.381	0.0630	1.759	33.9***
SK-JP	523	7.005	7.681	6.366	0.351	0.2639	1.996	28.04***
SK-ID	523	6.204	7.046	5.519	0.435	0.2543	1.828	35.56***
SK-PH	523	6.200	6.984	5.534	0.409	0.1645	1.792	34.16***

The table 5 reports the basic statistics of volatility contagion between stock market returns. The *, **, *** indicate the rejection of the null hypothesis of associated statistical tests at the 10%, 5% and 1% levels respectively. MY is Malaysia, TH is Thailand, ID is Indonesia, SK is South Korea, JP is Japan and PH is Philippines. It also shows selected descriptive statistics for each pair of volatility contagion log series. The volatility contagion from Japan to Malaysia (8.93%) achieved the highest compared to the others. The volatility contagion from Japan to Indonesia (8.89%) achieved the second highest. The third highest is the volatility contagion from Japan to South Korea (8.69%). The results are not surprising since for years, Japan was Asia's richest and most powerful economy so the default of Japan definitely spreads strongly to other countries.

The volatility contagion from Indonesia to South Korea (5.64%), however, experienced the least volatility in our study period. The Jarque-Bera test statistics (JB) are significant, confirming the rejection of the null hypothesis of normality for all pairs of volatility contagion except volatility contagion from the MY-SK, ID-JP and PH-ID.

TABLE 6
Descriptive Statistics of Fourteen Indicators Driving the Volatility Contagion During Two Chosen Crisis Periods

Variable	Obs	Mean(%)	Max(%)	Min(%)	Std. Dev. (%)	Skew.	Kurt.	JB
MALAYSIA								
Bank	523	5.868	6.657	4.906	0.4973	-0.0386	1.657	39.44***
Real Estate	523	5.23	6.055	4.288	0.367	-0.0936	2.766	1.953
Insurance	523	6.171	7.232	5.219	0.617	0.4441	1.73	52.36***
Telecom, Media&IT	523	5.107	5.476	4.328	0.2348	-0.6863	2.51	46.28***
Utilities	523	7.211	7.556	6.35	0.2314	-0.4480	2.834	18.09***
Industrials	523	5.682	6.296	4.833	0.2815	-0.1143	3.161	1.702
Money Supply	523	12.84	13.73	12.46	0.5001	1.152	2.349	124.8***
Interest Rate	523	1.715	2.308	0.642	0.3772	-0.8691	2.72	67.54***
Exchange Rate	523	4.592	4.857	4.456	0.0891	1.6732	5.433	373***
Money Market Rate	523	1.847	2.437	0.884	0.4489	-0.6028	2.113	48.81***
Gold Price	523	5.96	6.897	5.611	0.4445	1.1655	2.445	125.1***
Crude Oil Price	523	2.999	4.732	2.208	0.6297	1.1391	3.15	113.5***
Country Debt Risk	523	-0.0204	0.001	-0.0455	0.0157	-0.4027	1.739	48.78***
S&P 500	523	6.914	7.157	6.6	0.1126	-0.1014	2.355	9.971***

Variable	Obs	Mean(%)	Max(%)	Min(%)	Std. Dev. (%)	Skew.	Kurt.	JB
INDONESIA								
Bank	523	7.742	9.758	5.935	1.107	-0.0396	2.229	13.1***
Real Estate	523	3.099	4.823	1.468	1.106	0.1431	1.52	49.53***
Insurance	523	3.845	5.096	2.919	0.4337	-0.029	3.004	0.0738
Telecom, Media&IT	523	5.156	6.358	3.942	0.5901	0.6555	2.322	47.47***
Utilities	523	6.329	8.181	4.96	0.9251	0.9684	2.288	92.81***
Indusitrials	523	7.287	8.864	5.735	0.8399	-0.3475	2.253	22.69***
Money Supply	523	13.36	14.46	12.67	0.6476	0.8654	2.161	80.6***
Interest Rate	523	3.17	4.073	2.242	0.5643	-0.0911	1.637	41.21***
Exchange Rate	523	4.886	5.950	4.336	0.516	0.9592	2.435	87.17***
Money Market Rate	523	3.532	4.395	2.14	0.821	-0.7737	1.866	80.2***
Gold Price	523	5.96	6.897	5.611	0.4445	1.165	2.445	125.1***
Crude Oil Price	523	2.999	4.732	2.208	0.6297	1.139	3.15	113.6***
Country Debt Risk	523	-0.005	0.042	-0.049	0.03	0.0501	1.883	27.41***
S&P 500	523	6.914	7.157	6.6	0.1126	-0.1014	2.355	9.971***
PHILIPPINES								
Bank	523	4.562	5.345	3.332	0.672	-0.8209	2.134	75.09***
Real Estate	523	4.643	5.178	4.008	0.2354	-0.1511	2.626	5.031*
Insurance	523	9.015	10.1	8.572	0.5877	1.133	2.386	120***
Telecom, Media&IT	523	6.839	7.592	6.352	0.3261	1.01	2.568	93.02***
Utilities	523	6.317	6.741	5.78	0.2278	-0.7412	2.292	58.81***
Industrials	523	4.756	5.255	3.79	0.2741	-1.354	5.37	282.2***
Money Supply	523	14.14	15.08	13.77	0.51	1.148	2.352	123.9***
Interest Rate	523	2.454	2.95	1.457	0.4558	-1.061	2.507	103.4***
Exchange Rate	523	4.856	5.167	4.583	0.1708	-0.335	2.227	22.82***
Money Market Rate	523	2.489	3.523	1.656	0.4967	-0.3611	2.564	15.5***
Gold Price	523	5.96	6.897	5.611	0.4445	1.165	2.445	125.1***
Crude Oil Price	523	2.999	4.732	2.208	0.6297	1.139	3.15	113.6***
Country Debt Risk	523	-0.005	0.042	-0.049	0.03	0.0501	1.883	27.41***
S&P 500	523	6.914	7.157	6.6	0.1126	-0.1014	2.355	9.971***
THAILAND								
Bank	523	6.921	8.018	5.95	0.6555	-0.0215	1.506	48.66***
Real Estate	523	4.224	4.763	3.599	0.2204	-0.035	2.685	2.275
Insurance	523	4.105	6.943	2.325	1.45	1.072	2.338	109.6***
Telecom,Media&IT	523	5.569	6.136	4.827	0.3204	-0.3881	1.994	35.17***
Utilities	523	4.673	5.055	4.167	0.2153	-0.1891	2.14	19.24***
Industrials	523	5.9	6.586	5.45	0.2258	0.6223	2.83	34.38***
Money Supply	523	15.43	15.85	15.21	0.2205	1.066	2.351	108.2***
Interest Rate	523	2.243	2.869	0.3492	0.7728	-1.191	2.861	123.9***
Exchange Rate	523	4.529	4.694	4.247	0.0881	-1.343	5.767	324.2***
Money Market Rate	523	2.186	3.173	0.5653	0.8808	-0.4560	1.576	62.28***
Gold Price	523	5.96	6.897	5.611	0.4448	1.166	2.447	125.1***
Crude Oil Price	523	2.999	4.732	2.208	0.6297	1.139	3.15	113.6***
Country Debt Risk	523	0.0082	0.254	-0.167	0.1549	0.4915	1.488	70.88***
S&P 500	523	6.914	7.157	6.6	0.1126	-0.1014	2.355	9.971***

Variable	Obs	Mean(%)	Max(%)	Min(%)	Std. Dev. (%)	Skew.	Kurt.	JB
JAPAN								
Bank	523	6.484	6.844	5.363	0.425	-1.257	2.828	138.4***
Real Estate	523	5.362	5.731	4.884	0.2026	-0.0905	2.043	20.66***
Insurance	523	6.554	6.93	6.286	0.1229	0.5314	3.499	30.05***
Telecom,Media&IT	523	6.273	6.617	5.698	0.2491	-0.9202	2.483	79.62***
Utilities	523	5.943	6.185	5.803	0.0953	0.657	2.271	49.2***
Industrials	523	5.811	6.122	5.455	0.1381	0.0151	2.56	4.236*
Money Supply	523	13.34	13.53	13.26	0.1013	1.079	2.295	112.3***
Interest Rate	523	-1.095	-0.447	-1.743	0.3537	-0.5345	2.925	25.03***
Exchange Rate	523	4.386	4.62	4.242	0.1096	1.048	2.935	95.78***
Money Market Rate	523	-1.054	-0.697	-2.303	0.4295	-1.414	3.981	195.3***
Gold Price	523	5.96	6.897	5.611	0.4445	1.165	2.445	125.1***
Crude Oil Price	523	2.999	4.732	2.208	0.6297	1.139	3.15	113.6***
Country Debt Risk	523	-0.0211	0.035	-0.092	0.0406	-0.5818	2.146	45.4***
S&P 500	523	6.914	7.157	6.6	0.1126	-0.1014	2.355	9.971***
SOUTH KOREA								
Bank	523	4.971	5.869	3.724	0.5472	-0.6298	2.378	43***
Real Estate	523	5.849	7.54	4.328	0.9649	0.0269	1.664	38.99***
Insurance	523	7.107	8.842	6.042	0.8866	1.016	2.294	100.9***
Telecom,Media&IT	523	7.9	8.674	7.303	0.4039	0.6084	2.069	51.16***
Utilities	523	4.554	5.094	4.053	0.2776	0.0891	1.83	30.52***
Industrials	523	5.401	7.336	4.429	0.9554	1.053	2.334	106.3***
Money Supply	523	13.47	14.2	13.08	0.4125	1.015	2.25	101.9***
Interest Rate	523	2.354	3.219	0.9123	0.6016	-0.6057	2.539	36.61***
Exchange Rate	523	4.659	5.016	4.414	0.1869	0.7553	2.428	56.85***
Money Market Rate	523	2.269	3.244	0.7227	0.712	-0.5615	2.34	36.96***
Gold Price	523	5.96	6.897	5.611	0.4445	1.165	2.445	125.1***
Crude Oil Price	523	2.999	4.732	2.208	0.6297	1.139	3.15	113.6***
Country Debt Risk	523	-0.5006	0.1957	-1.975	0.7122	-1.112	2.731	109.4***
S&P 500	523	6.914	7.157	6.6	0.1126	-0.1014	2.355	9.971***

The table 6 reports the basic statistic indices of banks, real estates, insurances, telecommunication-media-IT, utilities, industrial, money supply, interest rate (t-bills), exchange rate, money market interest, gold prices, crude oil prices, country debt risks and S&P 500. It shows selected descriptive statistics for fourteen independent variables which were used to investigate the correlation with each pair of volatility contagion. Money supply in all six selected countries posts the highest volatility sector returns compared to the other thirteen sectors in all countries. The exchange rate of the Thailand (5.767%) has kurtosis coefficient significantly greater than other sectors. Skewness coefficients are different significantly among cases. The Jarque-Bera test statistics (JB) are significant, confirming the rejection of the null hypothesis of normality for all fourteen stocks, except Real Estate and Industrial return sectors from the Malaysia, Insurance return sector from Indonesia and Real Estate return sector from Thailand.

RESULTS

Country Debt Risk Measurement

TABLE 7

Parameter Estimates and Expected Coefficient Signs of Debt Restructuring Risk

Indicators	Malaysia	Indonesia	Philippines	Thailand	Japan	South Korea
INTXGS	-46.34**	-.2092***	-.4563***	-1.019***	2.322***	-41.21***
CEDT	11.16	-0.0815**	-0.411***	-0.0496	84.9***	.8135*
RESEDT	-4.346**	-.0766***	0.0215	-0.0109	0.6466***	-0.8502***
EDTGDP	1.949***	.00776**	.2228***	.07466**	.009796	5.093***
PRVEDT	1.917	-0.0031	-0.4937***	-0.0412	-0.2895***	0.2557***
TREDT	1.53***	1.123***	0.6801***	0.791***	-0.00173	1.155***
Constant	1.426*	0.0447**	0.0533	0.0245	0.1176**	0.1882
Sigma	0.0086	0.0043	0.0153	0.007	0.0012	0.0724
Observation	133	133	133	133	133	133
Log -likelihood	118.06	120.86	112.46	112.56	112.36	105.21

*** Significant at the 1% levels, ** Significant at the 5% levels, * Significant at the 10% levels

Table 7 shows the parameter estimates of debt rescheduling risk under the Two-limit Tobit model. The significant variables are different among the countries. For South Korea, six out of six variables are significant at 1% and 10%. Majority of the variables are highly significant. This means that these six variables have high coefficient values that indicate effectiveness for predicting the total rescheduling of one quarter lag for South Korea. For Indonesia and the Philippines, five out of six variables are significant. For Malaysia and Japan four out of six variables are significant. However, for Thailand, only three out of six variables are significant.

INTXGS is the variable that is significant for all the six chosen countries. This means that INTXGS has higher coefficient value that indicates effectiveness on the following quarter-year restructuring behaviour and size. In addition, EDTGDP and TREDT are the variables that are significant for five out of six chosen countries.

CEDT and RESEDT have significant impact for four out of the selected six Asian countries. However, PRVEDT mostly has no significant effect on the majority of the chosen countries. This means that PRVEDT has very few coefficient values that indicate effectiveness for the oncoming quarter-year rescheduling behavior.

Some of the parameters' signs are not parallel with model predictions. The concessional loans, high degree of private sector and high international reserves establishment in debtor country are indicators that reduce debt restructuring likelihood and the sum of the proportion of restructured debt in the coming year by following the theory sign. On the contrary, accumulated debt burden over GDP, interest payment difficulties over exports of goods and services and previous debt repayment burden increase the likelihood of debt restructuring risk in the following year. Table 7 shows the signs of the parameters; some of the coefficient signs were different compared to the expected coefficient parameter signs for all the countries. Based on the result, all the EDTGDP coefficient signs of all the countries followed the expected coefficient parameter signs. All the TREDT coefficient signs followed the expected coefficient parameter signs except Japan.

FIGURE 1

The Percentage of Country Debt Risk Fluctuation in Malaysia, Indonesia and Thailand from 1Q1980 1Q2013

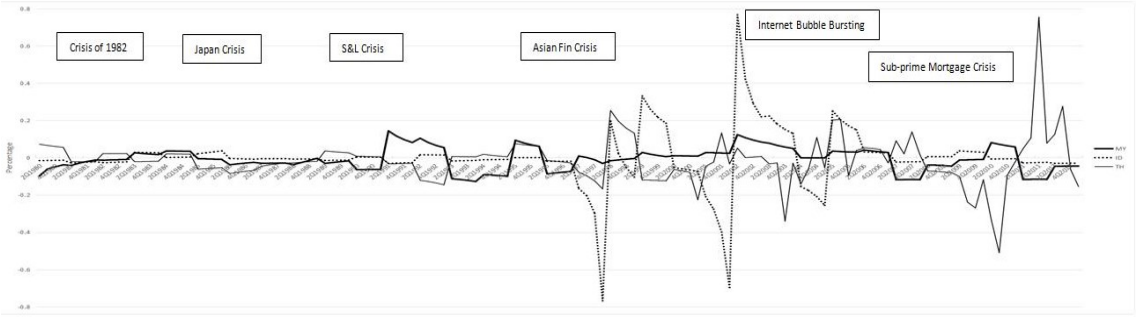
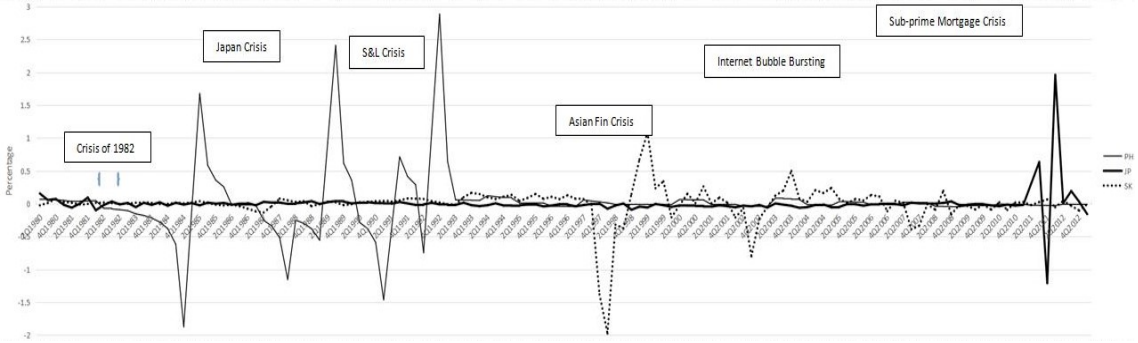


FIGURE 2
The Percentage of Country Debt Risk Fluctuation in Philippines, Japan and South Korea from 1Q1980 1Q2013



Figures 1 and 2 show the graphs of the percentage of country debt risk fluctuation. Based on the result, this study can conclude that the country debt risks did increase dramatically during and after the six crises.

In 2002, stock prices took a sharp downturn in stock markets across the United States, Canada, Asia, and Europe. For Malaysia, the country debt risk increased 0.14%, 0.12% and 0.08% during Savings and Loan Crisis, the Internet Bubble Bursting (2002) and after the Sub-prime Mortgage Crisis respectively. The financial turmoil spread to MY had affected post-recession economic imbalance, due to first country's weak fundamentals to confront the crisis. Second, highly negotiated to such international financial instruments. And third, high external debt.

Between June 1997 and January 1998 a financial crisis swept like a bush fire through the "tiger economies" of SE Asian, Indonesia did not escape. For the Asian Financial Crisis the country debt risk in Indonesia did increase sharply 0.197%, 0.33% and 0.26% at period over 1998_1Q to 1998_2Q, 1999_1Q to 1999_2Q and 1999_2Q to 1999_3Q respectively. And then, during the Internet Bubble Bursting (2002), the country debt risk increased at 0.767% and 0.42% from 2002_1Q until 2002_3Q. Uneven country debt risk fluctuation did happen during and after the crisis of 1997 and Internet Bubble Bursting since investors began to lose confidence in ID and started pulling money out of the country (refer to table A2).

Nevertheless, the country debt risk in South Korea did increase during and after Asian Financial Crisis. This means that the country was badly affected by the collapse. South Korea country debt risk did achieve 0.67% and 1.08% from 1998_4Q until 1999_4Q. South Korea experienced post-recession economic imbalance after the Asian Financial Crisis due to first, highly negotiated to such international financial instruments; second, the structural weaknesses of the economy; third, mismatch between the industrial structure and country's financial market structure; fourth, failing of governance in both the industrial and financial institutions; fifth, inefficiency of policy designing, in terms of financial regulation and the sequencing of market liberalisation; and sixth, the foreign short-term capital sudden ebbing away during the autumn of 1997 was certainly partly responsible for the near shock of the Korean economy at the end of 1997.

On the other hand, there was post-recession economic imbalance in the Philippines. The country debt risk did increase dramatically after the Crisis of 1982, and Savings and Loan Crisis. The Philippines country debt risk did score 1.678% and 2.88% at 1985_1Q to 1985_2Q and 1992_3Q to 1992_4Q respectively. However, during the Japanese asset price bubble 1989, the empirical result reveals that the country debt risk in the Philippines increased at 2.411%. The failure of Philippines policymakers to confront to the external collapse, by reacting heavily against devaluation through the issuance of forward and swap contracts, and by waiting so long to declare a moratorium have driven their own problems to become worse. Since the fundamental hardships have not been avoided through a more supportive external environment or better short-run macroeconomic governance. Thus during 1980s, the Philippines slipped into finance difficulties by failing to design fundamental resource allocation when external financing was available.

Besides that, the meltdown of the Sub-prime Mortgage Crisis did shock transmission to Asian countries. The post-recession economy took place in Thailand and Japan after 2010. The Thailand country debt risk scored 0.106% and 0.755% from 2011_2Q until 2011_4Q while Japan country debt risk scored 1.96% from 2011_4Q until 2012_1Q. Thailand experienced post-recession economic imbalance after the Subprime Mortgage Crisis (2008) due to first, Thai financial collapse driven by macroeconomic imbalance of the country, and the imbalance was an essential feature to the fault of the country's financial sector structure. As a result Thai bath was depressed by more than 50% at late of 1997. Second, country's weak fundamentals to confront the crisis. And third, the problem started when foreign investors began to lose confidence in Thailand. They started pulling money out of the country that triggered country

debt risk to decrease sharply at 0.11% (2011_2Q to 2011_3Q) and 0.76% (2011_3Q to 2011-4Q) after the subprime mortgage crisis (refer to table A2). Whereas, Japan experienced post-recession economic imbalance after the Sub-prime Mortgage Crisis due to highly negotiated to such international financial instruments and Earthquake and Tsunami disaster in 2011.

The country debt risk fluctuations from year 1980 until 2013 will then be taken as one of the fourteen indicators driving the volatility contagion.

Since based on previous crisis experienced, a high country debt risk did lead to instability of economy in a country and slipping into contagion circumstances. Hence, this study measured the fluctuations of country debt risk for exploring the role of country debt risk on volatility contagion. To define the country debt risk, this study modelled actual rescheduling ratios, since the size of debt rescheduling brings more information about the risk undertaken by sovereign borrowers. Based on previous studies, the rescheduling ratio is obviously found to be a better proxy than binary rescheduling values in the country debt risk estimation. As country debt risk fluctuates according to the amount of debt rescheduling. Therefore, the country debt risk fluctuation developed in this study reflects a more accurate scoring for the sample countries. The final results showed that all the countries have increased country debt risks during and after the selected two crisis periods and defined as one of the key indicators triggering the volatility contagion.

Volatility Contagion Assessment

This study first assessed the volatility contagion of selected six countries in Asia between 1990 and 2013. This study applied analytic approach in looking at the daily ranges of the stock markets within the six selected countries in Asia and US in order to investigate the structure of volatility contagion during the Asian Financial Crisis (1997) and Sub-prime Mortgage Crisis (2008-09) that began in 1990. Based on AIC information criteria, our benchmark VAR-GARCH model was selected. The results revealed that each pair of stock market returns has volatility contagion, significant at 1% level, during the selected two crisis periods.

The Significance of Fourteen Indicators Driving the Volatility Contagion During the Two Crisis Periods

Tables 8 to 9 show the estimates of variety types of indicators that drive the volatility contagion during the selected two crisis periods. The results revealed that the volatility contagion was not caused by a single factor. Rather, it was brewed in an environment that was highly susceptible to such a volatility contagion. This environment can be characterized by a combination of features such as financial sector, non-financial sector, market information, macro-financial variables and external factors (S&P 500). It is interesting to develop an understanding of how shocks can be transmitted between countries and the multiple causes of volatility contagion so that steps can be taken to reduce financial contagion for economic stability in order for a country to develop and grow. Majority of the fourteen factors did affect each pair of volatility contagion during the selected crisis periods. This evidence proved significantly that volatility contagion is driven by various types of indicators, not only specific or single sector or products as estimated by preceding studies.

The empirical finding revealed that the Telecom-Media-IT market index was strongly affected by the volatility contagion for each pair of stock returns during the two crisis periods. The result shows consistency with the reality that information technology has a larger impact on the financial crisis, since advances in information technology can lead to significant increase in productivity and efficiency globally. For example, the internet bubble bursting was mainly triggered by the IT sector because over-productivity of IT did lead to economic imbalance.

However, the industrial sector has become one of the highest factors triggering the volatility contagion in Asia. The result is not surprising, since industry sector is a key sector of production and labour in Asia. The automotive industry crisis of 2008-2010 played a crucial part in the global financial downturn.

Nevertheless, bank, real estate, insurance, utilities, crude oil and S&P 500 have complexity causing the volatility contagion too.

The Significance of Fourteen Indicators Driving the Volatility Contagion during Asian Financial Crisis

Table 8 shows the causes of volatility contagion on each pair of stock market returns during Asian Financial Crisis. The fluctuation of bank, industrial, money supply and exchange rate highly triggered the volatility contagion in Asia as thirty out of thirty pairs of volatility contagion are driven by these two factors. The findings revealed that the volatility contagion was not caused by a single factor. Rather caused by variety types of indicators from different sectors.

Nevertheless, the fluctuations of all the financial and non-financial sectors, market information, gold prices and country debt risk have complexity causing the volatility contagion too (Nishiyama, 2016).

TABLE 8

Estimates of Correlation between Fourteen Variables with Volatility Contagion during Asian Financial Crisis

Asian Financial Crisis															
	MY to TH	TH to MY	MY to ID	ID to MY	MY to SK.	SK to MY	MY to PH	PH to MY	MY to JP	JP to MY	TH to JP	JP to TH	TH to ID	ID to TH	TH to SK
Financial Sectors															
Bank	0.33***	0.23***	0.33***	0.04***	0.33***	0.17***	0.33***	-0.05***	0.33***	-0.09***	0.23***	-0.09***	0.23***	0.04***	0.23***
Real Estate	-0.06***	-0.008	-0.06***	0.11***	-0.06***	0.05***	-0.06***	0.43***	-0.06***	0.32***	-0.008	0.32***	-0.008	0.11***	-0.008
Insurance	0.02*	0.003	0.02*	0.01	0.02*	0.19***	0.02*	-0.09***	0.02*	0.11***	0.003	0.11***	0.003	0.01	0.003
Non-Financial Sectors															
Telecom, Media & IT	0.33***	0.32***	0.33***	1.13***	0.33***	-0.022	0.33***	0.32***	0.33***	-0.054	0.32***	-0.054	0.32***	1.13***	0.32***
Utilities	-0.03	0.11***	-0.0256	-0.61***	-0.0256	0.29***	-0.0256	014***	-0.0256	0.15***	0.11***	0.15***	0.11***	-0.61***	0.11***
Industrial	0.38***	0.11***	0.38***	0.08***	0.38***	0.3***	0.38***	0.15***	0.38***	0.61***	0.11***	0.61***	0.11***	0.08***	0.11***
Market Information															
Money Supply	-0.28**	-1.72***	-0.276**	0.13*	-0.28**	-0.37***	-0.28**	0.4***	-0.28**	0.55*	-1.72***	0.55*	-1.72***	0.13*	-1.72***
Treasury Bill Rate	0.09***	-0.09***	0.09***	0.14***	0.09***	-0.011	0.09***	-0.01	0.09***	-0.02*	-0.09***	-0.02*	-0.09***	0.14***	-0.09***
Exchange Rate	0.18***	-0.19***	0.18***	0.11***	0.18***	0.18***	0.18***	0.47***	0.18***	0.24***	-0.19***	0.24***	-0.19***	0.11***	-0.19***
Macro-Financial Variables															
Money Market Rate	0.03***	-0.006	0.03***	-0.03***	0.03***	-0.028	0.03***	0.01*	0.03***	0.016	-0.006	0.016	-0.006	-0.03***	-0.006
Gold Price	-0.14***	0.066	-0.14***	0.76***	-0.14***	-0.03	-0.14***	0.13***	-0.14***	-0.22***	0.066	-0.22***	0.066	0.76***	0.066
Crude Oil Price	-0.0068	-0.021	-0.0068	-0.17***	-0.0068	0.023	-0.0068	0	-0.0068	0.05***	-0.021	0.05***	-0.021	-0.17***	-0.021
Country Debt Risk	-1.08***	-0.024	-1.08***	-0.03***	-1.08***	-0.02***	-1.08***	-0.26*	-1.08***	-0.056	-0.024	-0.056	-0.024	-0.03***	-0.024
External Factor															
S&P 500	0.15***	0.29***	0.15***	-0.066	0.15***	-0.013	0.15***	-0.046	0.15***	-0.0135	0.29***	-0.0135	0.29***	-0.066	0.29***
	12/14	8/14	12/14	12/14	12/14	8/14	12/14	11/14	12/14	10/14	8/14	10/14	8/14	12/14	8/14

Asian Financial Crisis																
	SK to TH	TH to PH	PH to TH	JP to ID	ID to JP	JP to PH	PH to JP	JP to SK	SK to JP	ID to PH	PH to ID	ID to SK	SK to ID	SK to PH	PH to SK	
Financial Sectors																
Bank	0.17***	0.23***	-0.05***	-0.09***	0.04***	-0.09***	-0.05***	-0.09***	0.17***	0.04***	-0.05***	0.04***	0.17***	0.17***	-0.05***	30/30
Real Estate	0.05***	-0.008	0.43***	0.32***	0.11***	0.32***	0.43***	0.32***	0.05***	0.11***	0.43***	0.11***	0.05***	0.05***	0.43***	25/30
Insurance	0.19***	0.003	-0.09***	0.11***	0.01	0.11***	-0.09***	0.11***	0.19***	0.01	-0.09***	0.01	0.19***	0.19***	-0.09***	20/30
Non-Financial Sectors																
Telecom, Media & IT	-0.022	0.32***	0.32***	-0.054	1.13***	-0.054	0.32***	-0.054	-0.022	1.13***	0.32***	1.13***	-0.022	-0.022	0.32***	20/30
Utilities	0.29***	0.11***	014***	0.15***	-0.61***	0.15***	014***	0.15***	0.29***	-0.6***	014***	-0.6***	0.29***	0.29***	014***	25/30
Industrial	0.3***	0.11***	0.15***	0.61***	0.08***	0.61***	0.15***	0.61***	0.3***	0.08***	0.15***	0.08***	0.3***	0.3***	0.15***	30/30
Market Information																
Money Supply	-0.37***	-1.72***	0.4***	0.55*	0.13*	0.55*	0.4***	0.55*	-0.4***	0.13*	0.4***	0.13*	-0.4***	-0.4***	0.4***	30/30
Treasury Bill Rate	-0.011	-0.09***	-0.01	-0.02*	0.14***	-0.02*	-0.01	-0.02*	-0.011	0.14***	-0.01	0.14***	-0.011	-0.011	-0.01	20/30
Exchange Rate	0.18***	-0.19***	0.47***	0.24***	0.11***	0.24***	0.47***	0.24***	0.18***	0.11***	0.47***	0.11***	0.18***	0.18***	0.47***	30/30
Macro-Financial Variables																
Money Market Rate	-0.028	-0.006	0.01*	0.016	-0.03***	0.016	0.01*	0.016	-0.028	0***	0.01*	-0.03***	-0.028	-0.028	0.01*	15/30
Gold Price	-0.03	0.066	0.13***	-0.22***	0.76***	-0.22***	0.13***	-0.22***	-0.03	0.76***	0.13***	0.76***	-0.03	-0.03	0.13***	20/30
Crude Oil Price	0.023	-0.021	0	0.05***	-0.17***	0.05***	0	0.05***	0.023	-0.2***	0	-0.17***	0.023	0.023	0	10/30
Country Debt Risk	-0.02***	-0.024	-0.26*	-0.056	-0.03***	-0.056	-0.26*	-0.056	0***	0***	-0.26*	-0.03***	0***	0***	-0.26*	20/30
External Factor																
S&P 500	-0.013	0.29***	-0.046	-0.0135	-0.066	-0.0135	-0.046	-0.0135	-0.013	-0.066	-0.046	-0.066	-0.013	-0.013	-0.046	10/30
	8/14	8/14	11/14	10/14	12/14	10/14	11/14	10/14	8/14	12/14	11/14	12/14	8/14	8/14	11/14	

*** Significant at the 1% levels, ** Significant at the 5% levels, * Significant at the 10% levels

TABLE 9

Estimates of Correlation between Fourteen Variables with Volatility Contagion during Sub-Prime Mortgage Crisis

	Sub-Prime Mortgage Crisis														
	MY to TH	TH to MY	MY to ID	ID to MY	MY to SK.	SK to MY	MY to PH	PH to MY	MY to JP	JP to MY	TH to JP	JP to TH	TH to ID	ID to TH	TH to SK
Financial Sectors															
Bank	0.35***	0.23***	0.35***	0.046*	0.35***	0.11***	0.35***	0.009	0.35***	0.09***	0.23***	0.09***	0.23***	0.046*	0.23***
Real Estate	0.11***	0.16***	0.11***	0***	0.11***	-0.02*	0.11***	0.19***	0.11***	-0.004	0.16***	-0.004	0.16***	0***	0.16***
Insurance	0.04***	-0.05*	0.04***	0.1***	0.04***	0.07***	0.04***	-0.011	0.04***	0.014	-0.05*	0.014	-0.05*	0.1***	-0.05*
Non-Financial Sectors															
Telecom, Media & IT	0.07**	0.23***	0.07**	0.23***	0.07**	0.31***	0.07**	0.54***	0.07**	0.73***	0.23***	0.73***	0.23***	0.23***	0.23***
Utilities	0.16***	0.28***	0.16***	0.1***	0.16***	0.05***	0.16***	0.14***	0.16***	-0.1***	0.28***	-0.1***	0.28***	0.1***	0.28***
Industrial	0.41***	0.14***	0.41***	0.3***	0.41***	0.4***	0.41***	0.14***	0.41***	0.32***	0.14***	0.32***	0.14***	0.3***	0.14***
Market Information															
Money Supply	-0.24**	-0.07	-0.24**	-0.008	-0.24**	-0.158	-0.24**	-0.077*	-0.24**	6.59***	-0.07	6.59***	-0.07	-0.008	-0.07
Treasury Bill Rate	-0.009	-0.019	-0.009	0.07**	-0.009	0***	-0.009	0.03***	-0.009	0.08***	-0.019	0.08***	-0.019	0.07**	-0.019
Exchange Rate	-1.4***	-0.205	-1.4***	0.24***	-1.4***	-0.08	-1.4***	0.247	-1.4***	0.21***	-0.205	0.21***	-0.205	0.24***	-0.205
Macro-Financial Variables															
Money Market Rate	0.03***	0.054*	0.03***	-0.6***	0.03***	0.02*	0.03***	0.24***	0.03***	0.05**	0.054*	0.05**	0.054*	-0.6***	0.054*
Gold Price	-0.007	-0.1***	-0.007	-0.03	-0.007	0.05***	-0.007	-0.0045	-0.007	0.04**	-0.1***	0.04**	-0.1***	-0.03	-0.1***
Crude Oil Price	0***	0.08***	0***	0.09***	0***	-0.005	0***	0.0068	0***	0.006	0.08***	0.006	0.08***	0.09***	0.08***
Country Debt Risk	-0.641	-0.124	-0.641	1.42***	-0.641	0.027	-0.641	-0.7123	-0.641	-0.5***	-0.124	-0.5***	-0.124	1.42***	-0.124
External Factor															
S&P 500	0.06***	0.053*	0***	0.0069	0.06***	0.06***	0.06***	0.021*	0.06***	0.026	0.053*	0.026	0.053*	0.0069	0.053*
	11/14	10/14	11/14	11/14	11/14	10/14	11/14	8/14	11/14	10/14	10/14	10/14	10/14	11/14	10/14

	Sub-Prime Mortgage Crisis															
	SK to TH	TH to PH	PH to TH	JP to ID	ID to JP	JP to PH	PH to JP	JP to SK	SK to JP	ID to PH	PH to ID	ID to SK	SK to ID	SK to PH	PH to SK	
Financial Sectors																
Bank	0.11***	0.23***	0.009	0.09***	0.046*	0.1***	0.009	0.1***	0.11***	0.046*	0.009	0.046*	0.11***	0.11***	0.009	25/30
Real Estate	-0.02*	0.16***	0.19***	-0.004	0***	-0.004	0.2***	-0.004	-0.02*	0***	0.2***	0***	-0.02*	-0.02*	0.2***	25/30
Insurance	0.07***	-0.05*	-0.011	0.014	0.1***	0.014	-0.011	0.014	0.07***	0.1***	-0.011	0.1***	0.07***	0.07***	-0.011	20/30
Non-Financial Sectors																
Telecom, Media & IT	0.31***	0.23***	0.54***	0.73***	0.2***	0.7***	0.54***	0.73***	0.31***	0.2***	0.5***	0.2***	0.31***	0.3***	0.5***	30/30
Utilities	0.05***	0.28***	0.14***	-0.1***	0.1***	-0.1***	0.14***	-0.1***	0.05***	0.1***	0.14***	0.1***	0.05***	0.05***	0.14***	30/30
Industrial	0.4***	0.14***	0.14***	0.32***	0.3***	0.32***	0.14***	0.32***	0.4***	0.3***	0.14***	0.3***	0.4***	0.4***	0.14***	30/30
Market Information																
Money Supply	-0.158	-0.07	-0.08*	6.59***	-0.008	6.59***	-0.08*	6.59***	-0.158	-0.008	-0.08*	-0.008	-0.158	-0.158	-0.08*	15/30
Treasury Bill Rate	0***	-0.019	0.03***	0.08***	0.07**	0.08***	0.03***	0.08***	0***	0.07**	0.03***	0.07**	0***	0***	0.03***	20/30
Exchange Rate	-0.08	-0.205	0.247	0.21***	0.2***	0.21***	0.247	0.21***	-0.08	0.24***	0.247	0.24***	-0.08	-0.08	0.247	15/30
Macro-Financial Variables																
Money Market Rate	0.02*	0.054*	0.24***	0.05**	-0.6***	0.05**	0.24***	0.05**	0.02*	-0.6***	0.24***	-0.6***	0.02*	0.02*	0.24***	30/30
Gold Price	0.05***	-0.1***	-0.0045	0.04**	-0.03	0.04**	-0.0045	0.04**	0.05***	-0.03	-0.0045	-0.03	0.05***	0.05***	-0.0045	15/30
Crude Oil Price	-0.005	0.08***	0.0068	0.006	0.1***	0.006	0.0068	0.006	-0.005	0.09***	0.0068	0.09***	-0.005	-0.005	0.0068	15/30
Country Debt Risk	0.027	-0.124	-0.7123	-0.5***	1.4***	-0.5***	-0.7123	-0.5***	0.027	1.42***	-0.7123	1.42***	0.027	0.027	-0.7123	10/30
External Factor																
S&P 500	0.06***	0.053*	0.021*	0.026	0.0069	0.2963	0.021*	0.026	0***	0.8008	0.021*	0.8008	0***	0***	0.021*	20/30
	10/14	10/14	8/14	10/14	11/14	10/14	8/14	10/14	10/14	11/14	8/14	11/14	10/14	10/14	8/14	

*** Significant at the 1% levels ** Significant at the 5% levels * Significant at the 10% levels

Besides that, bank and real estate sectors did impact the volatility contagion in Asia during the Asian Financial Crisis. The result is not surprising since the high volatility of bank and real estate stock market returns can lead to volatility contagion, and large amount of money is poured into the economy (especially real estate sector) and construction activities expanded on a large scale during that period.

A World Bank publication that appeared in 2000 indicated that the percentage of firms unable to meet current debt repayment in 1999 was higher in the real estate sector than in any other sector in all four of the most affected countries: Indonesia, South Korea, Malaysia and Thailand. In Indonesia, in particular, 87 percent of real estate firms were unable to repay their debt. The percentage of debt repayment increasing sharply during 1997 is the main reason for the real estate stock market return to trigger the volatility contagion during the Asian Financial Crisis (refer to Appendix A, Table 10, page 26).

Whereas, the volatility of crude oil prices and S&P 500 had triggered least to each pair of volatility contagion during Asian Financial Crisis. The result is not surprising since the origin of Asian Financial Crisis is from countries in Asia and not from the United States.

Table 9 shows the channels of volatility contagion of each stock market return during Sub-prime Mortgage Crisis. Even though the origin of the Sub-prime Mortgage Crisis started from the United States, the results show that combined multiple internal and external factors had triggered volatility contagion between selected six Asian countries during the Sub-prime Mortgage Crisis. The fourteen factors consist of both financial and non-financial sectors, interest rate, money market rate and S&P 500. The rapid growth of the non-financial sector (especially Technology sector) had led the economy in Asia.

Besides that, the country debt risk fluctuation seems to trigger each pair of volatility contagion during the Sub-prime Mortgage Crisis.

In summary, the results in this study are totally different from the previous studies on specific products or sectors. This empirical study showed that the volatility contagion was triggered by a combination of features, such as financial sector, non-financial sector, market information, macro-financial variables and external factors (S&P 500). Majority of the fourteen factors did trigger volatility contagion during the selected crisis periods. The most affected indicators came from both the financial and non-financial sectors, market information and country debt risk during Asian Financial crisis. Whereas, during the Sub-prime Mortgage Crisis, all of the indicators had triggered the volatility contagion except country debt risk triggering least.

CONCLUSION

This study used VAR-GARCH, BEKK-GARCH and CCC-GARCH models to analyse volatility contagion. Empirical result presents that volatility contagion did occur in Indonesia, Japan, Malaysia, South Korea, Thailand and the Philippines stock markets during the selected two crisis periods, significant at 1% level.

Besides that, this study measures country debt risks for exploring the new indicator of volatility contagion that receives rare attention in the previous studies. The Two-limit Tobit model is used to investigate the country debt risks by using a panel data set from 1980 until 2013 for the selected six Asian nations. The results show that all the countries have increased country debt risks during and after the selected six crisis periods. In addition, the results also revealed that country debt risk fluctuation did partially trigger the volatility contagion between Asian regions during the selected two crisis periods.

Lastly, this study carried out an extensive study on indicators of a volatility contagion by employing regression model, and found evidence of volatility contagion is not totally caused by a single factor. Rather, it was triggered by a combination of features, such as financial sector, non-financial sector, market information, macro-financial variables, country debt risk and external factor (S&P 500). The empirical findings can bring advantage to investors, bankers, brokers, and government to design their portfolio allocation, policy plan and risk management to make it more resistant to shock as well as to avoid slipping into contagion circumstances.

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APPENDIX

TABLE 10

Percentage of Firms Unable to Meet Current Debt Repayment

					2nd Quarter 1999			
Country	**1995 (total)**	**1996 (total)**	**1997 (total)**	**1998 (total)**	**Total**	**Mfg**	**Svcs**	**RE**
ID	12.6	17.9	40.3	58.2	63.8	41.8	66.8	86.9
SK	8.5	11.2	24.3	33.8	26.7	19.6	28.1	43.9
MY	3.4	5.6	17.1	34.3	26.3	39.3	33.3	52.8
TH	6.7	10.4	32.6	30.4	28.3	21.8	29.4	46.9

Source: (World Bank, 2000)
Note Mfg: Manufacturing, Svcs: Services & RE: Real Estate

TABLE 11

Foreign Direct Investment of Thailand and Indonesia (million)

Year	Indonesia	Japan	South Korea	Malaysia	Philippines	Thailand
1982	225	440	69	1397	16	190
1983	292	410	68	1260	105	349
1984	222	-10	110	797	9	401
1985	310	637	233	694	12	163
1986	258	226	459	488	127	262
1987	385	1161	616	422	307	351
1988	576	-481	1014	719	936	1105
1989	682	-1038	1117	1667	563	1775
1990	1093	1777	788	2332	530	2443
1991	1482	1285	1179	3998	544	2013
1992	1777	2759	728	5183	228	2113
1993	2004	118	588	5005	1238	1804
1994	2109	911	809	4341	1591	1366
1995	4346	39	1775	4178	1478	2067
1996	6194	207	2325	5078	1517	2335
1997	4677	3200	2844	5136	1222	3894
1998	-240	3268	5412	2163	2287	7314
1999	-1865	12308	9333	3895	1247	6102
2000	-4550	8227	9283	3787	2240	3365
2001	-2977	6190	3527	553	195	5067
2002	145	9087	2392	3203	1542	3341
2003	-596	6238	3525	2473	491	5232
2004	1896	7806	9246	4624	688	5860
2005	8336	5459	13643	3924	1664	8222
2006	4914	-2396	9161	7690	2707	8926
2007	6928	21631	8826	9071	2918	8620
2008	9318	24624	11187	7572	1340	8566
2009	4877	12226	9021	114	2064	6427
2010	15292	7440	9497	10885	1070	14714
2011	20564	-850	9773	15119	2007	2468
2012	21200	546	9495	8895	3215	12894
2013	23281	7412	12766	11296	3737	15822