# Do Indian Economic Activities Impact ASEAN-5 Stock Markets?

## (Adakah Aktiviti Ekonomi India Memberi Impak ke atas Pasaran Saham ASEAN-5?)

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*ABSTRACT*

*This study examines the dynamic linkages of ASEAN-5 with India based on a multivariate framework. DCC-MGARCH model was used to assess the presence of contagion effects and herding behaviour, indicated by the dynamic conditional correlations. The VAR-Granger causality test was employed to capture the direction of dynamic volatility transmission at the short run. Findings showed that the dynamic correlation of ASEAN-5 stock markets with Indian economy is in par with the U.S. and Japan. The simultaneous sudden spike in Dynamic Conditional Correlation between India and ASEAN-5 and followed by immediate reversal to decreasing Dynamic Conditional Correlation in 2009 indicate a contagion effect and herding behaviour which coincided with European sovereign debt crisis. The immediate reversal back to decreasing Dynamic Conditional Correlation suggests that both countries are hardly contagious by external crisis. In the short run, there is no volatility spillover from Indian economic activities to ASEAN-5 stock markets but there is volatility spillover from stock markets of Indonesia and Singapore to Indian economic activities. Trade policies, economic crises and economic liberalisation play significant roles in shaping the structure of the dynamic volatility correlations between the studied markets. This study reveals that ASEAN-5 has become preferred markets for the diversification of stock portfolio for India in the short run.*

*Keywords: Contagion effect; volatility spillover; ASEAN-5 stock markets; Indian economic activities*

*ABSTRAK*

*Kajian ini meneliti hubungan dinamik ASEAN-5 dengan India berdasarkan rangka kerja multivariat. Model DCC-MGARCH digunakan untuk menilai kewujudan kesan penjalaran dan tingkah laku berkelompok berasaskan korelasi volatiliti dinamik. Ujian VAR-Granger causality digunakan untuk memperoleh hala tuju transmisi korelasi volatiliti dinamik dalam jangka masa pendek. Dapatan kajian menunjukkan korelasi dinamik antara pasaran saham ASEAN-5 dengan ekonomi India adalah setara dengan ekonomi Amerika Syarikat dan Jepun. Peningkatan DCC yang serta merta secara serentak antara India dan ASEAN-5 dan seterusnya diikuti oleh pengurangan DCC dalam tahun 2009 menunjukkan kewujudan kesan penjalaran dan tingkah laku berkelompok berketetapan dengan krisis hutang kerajaan Eropah. Pengalihan semula yang cepat ke pengurangan DCC mencadangkan krisis luaran tidak mudah menjalari kedua-dua negara ini. Dalam jangka masa pendek, tiada limpahan volatiliti dari aktiviti ekonomi India ke pasaran saham ASEAN-5 tetapi wujud limpahan volatiliti daripada pasaran saham Indonesia dan Singapura ke atas aktiviti ekonomi India. Dasar perdagangan, krisis ekonomi dan liberalisasi ekonomi memainkan peranan penting dalam pembentukan struktur korelasi volatiliti dinamik antara pasaran yang dikaji. Kajian ini memperlihatkan ASEAN-5 sebagai pasaran pilihan untuk mempelbagaikan portfolio saham bagi India dalam jangka masa pendek.*

*Kata kunci: Kesan penjalaran; limpahan volatiliti, pasaran saham ASEAN-5; aktiviti ekonomi India*

## INTRODUCTION

India is one of the fastest growing economies in the world and the third largest economy in Asia, after Japan and China. The ASEAN nations are now Indian fourth largest trading partner. The percentage share of total FDI equity inflows from ASEAN to India has also increased gradually with Singapore being the major contributor.

Singapore was the second highest investing country for FDI equity inflows for the years 2012-13. India received 12.6% of the cumulative FDI equity inflows from ASEAN during 2000-2014.[1]

India is actively strengthening its economic ties with ASEAN-5 since early 2000s.[2] India signed the Comprehensive Economic Cooperation Agreement (CECA) with Thailand in October 2003, followed by

Singapore in June 2005. The India-ASEAN FTA and CECA between India and Indonesia came into force in 2010; while the India-Malaysia CECA only came into effect in July 2011. Today, the influence of Indian economy in the region is on the rise. Hence, it is worth to explore the contagious impacts of Indian economic activities on ASEAN-5 stock markets.

Decision to diversify is made based on the evaluation of stock markets and economic conditions of the targeted countries. However, many researchers tend to focus on contagion effect amongst stock markets and ignore the linkages between economic activities and stock market's condition. In fact, both economic activities and stock market's condition play a significant role in determining the direction of portfolio diversification which is especially true during recession (Henry, Ólan, Olekalns & Thong 2004). Moreover, stock markets of countries that are economically integrated tend to respond in similar manners to global economic shocks (Morona, 2008). Hence, whether stock diversification by investors from India into ASEAN-5 stock markets has become more important is still ambiguous.

Theoretically, innovations in macroeconomic variables such as industrial production index, and real GDP growth rates have systematic effect on stock market returns (Che, Roll & Ross 1986; Schwert 1989; Hamilton and Gang 1996; Tang, Habibullah, and Puah 2007; Tsouma 2009; Franses and Mees 2011; Narayan and Narayan 2012; Yang and Hamori 2014 and Donadelli 2014). The existing empirical analyses on the fluctuation in Indian economic activities and its impact on the stock markets in the Asian countries are still limited. Teng, Yen and Chua (2013b) found that Indian economic growth rate cycle was marginally concordant with ASEAN-5 stock markets' cycles. This finding did not literally prove whether the movement is just a coincident or a contagion effect.

India is well known for its insulation from global economic crisis. (Fidrmuc & Korhonen 2010; Nikkinen, Saleem & Martikainen 2013). These are related to its successful stabilization policies, capital control regime and lack of economic integration with the crisis-hit countries (Dua and Sinha 2007). However, the validity of the invulnerability of Indian economy to withstand against economic crisis has raised doubts when Ghosh and Chandrasekhar (2009) found that the economy will no longer be insulated from crisis.

All of the facts mentioned above also mean that the possibility of economic fluctuation in India could potentially threaten ASEAN-5 stock markets. In order to address all the above mentioned issues, first, this paper examines the contagion effect of Indian economic activities into ASEAN-5 stock markets which reveals the diversification benefits from the standpoint of an investor from India. Second, it identifies the direction of volatility spillover amongst the studied markets, in order to reveal whether economic fluctuation in India, caused volatility

in ASEAN-5 stock markets or vice versa by using the U.S. and Japanese economic movements as robustness check. Dynamic Conditional Correlation Multivariate GARCH (DCC-MGARCH) model (Engle 2002) was adopted to estimate the presence of contagious while Granger causality test in Vector Autoregression (VAR) model was used to assess the direction of spill over effect.

This paper contributes to the existing literature by including the direction of causality effects between the countries' conditional volatilities generated by the multivariate DCC-GARCH model.[3] Thus, this paper offers more accurate information on the future direction of portfolio investment. It is proven that contagion does depend on conditional stock return volatility and it is predictable (Bae, Karolyi & Stulz 2003). Another contribution of this paper is to test the relevance of fluctuation in Indian economic activities on ASEAN-5 stock markets' movement which was not being examined by existing literature after the Indian economy boom in 1990s. Since volatility spillover amongst countries is not a constant phenomenon, thus this approach also allows the identification of economic events that explain the correlations between volatilities in economic activities of one economy and stock market of another economy. This paper also attempts to fill the gap by examining the impact of volatility in Indian economy and how it is transmitted to ASEAN-5 as compared to most literature that investigated the impact of the rest of the world on Indian economy and its stock market.

The structure of this paper is as follows: Section 2 gives a brief literature review, followed by Section 3 which describes the data used in this study. The empirical methods are presented in Section 4. Section 5 discusses the results. Conclusion is in Section 6.

## LITERATURE REVIEW

There has been vast literature on contagion effect and volatility spillover. These two terms have been used interchangeably in the empirical literature. The contagion or volatility spillover in the financial markets is sometimes referred to as the 'domino effect'. It is a chain reaction of an event whereby one trivial change in a country leads to a comparable change in a neighbouring country, which then continues to pass over to another neighbouring country. Forbes and Rigobon (2002) and Vo and Daly (2005) defined contagion as a noticeable rise in stock markets cross-country or cross-region correlations after experiencing an external shock. Bekaert, Harvey and Ng (2005) described contagion as an excess in stock market correlation responding to high level of uncertainties during turbulence periods. Baele and Inghelbrecht (2010) defined contagion as a substantial rise in cross-market correlations following a shock to one country or a group of countries. Kenourgios Samitas and Paltalidis (2011) defined contagion as the transmission

of financial turbulence from one country to another. Contagion effect is different from herding behaviour. Herding behaviour is referred to as a significant rise in the cross-market correlation whereby investors across different markets react simultaneously to systematic risk, such as a particular shocks or news (Chiang, Jeon & Li 2007). Hirshleifer and Teoh (2003) defined herding as a convergence occurrence toward an unexpected change of investor sentiment. This implies that herding behaviour of investors happened when the crisis becomes public news and creates widespread panic.

Contagion effects and herding behaviour have significant bearing for investors who seek to reduce their overall portfolio risk by diversifying into countries which are less correlated to their own countries' volatilities. The pattern of movements in cross-countries' volatility correlations shows gradual changes in the trend of market integration. The estimation of short-run dynamic conditional correlation between the two markets is using both markets' volatilities (Engle 2002). When the time-varying correlation increases positively, it indicates increase in the cross-country volatility transmission in the short run, which implies the existence of a contagion effect (Chiang et al. 2007; Kasch and Caporin 2013). The opportunity for diversification between markets is reduced when their conditional correlation is rising and there is a significant volatility spillover from one country to another.

Empirical findings on contagion effect in the emerging markets are mixed. Kenourgios et al. (2011) found that financial turmoil tends to be contagious in emerging markets (Brazil, Russia, India and the PRC (BRICs)) especially when the root-cause of the crisis is the U.S.'s stock market. These emerging markets are less likely to be affected by crisis coming from emerging countries.[4] A similar finding was observed by Mensi, Hammoudeh, Reboredo and Nguyen (2014). They found that global factors impact the BRICs' stock markets, particularly the onset of the recent global financial crisis. This shows that the BRICs have become more internationally integrated after the U.S.'s global financial crisis (Bekiros 2014). Conversely, Samarakoon (2011) observed that there is no contagion from the U.S. to emerging markets except for Latin America but surprisingly, there is contagion from emerging markets to the U.S. The source of contagion in emerging markets is the shock from emerging market while for the frontier markets contagion is from the U.S.'s shocks. However, Bordo and Murshid (2006) found that the transmission of shocks is stronger amongst the developed economies compared to transmission from developed economies to emerging economies. A study conducted by Beirne, Caporale, Schulze-Ghattas and Spagnolo (2009) also produced similar results.

As for East Asian stock markets, it becomes less responsive to the U.S.'s shocks after the 2007–2009 global financial crisis; but East Asian stock markets become more integrated after the crisis which is similar to the BRICs' stock markets (Wang 2014; Bekiros 2014). However, Donadelli (2014) revealed that Asian stock markets' performances experienced a short-run plunge in response to the U.S.'s shock after the subprime crisis.

Empirical evidence indicates that macroeconomic variables changes have an impact on movement of stock market. This is proven by the study conducted by Achraf, Boujelbene and Issam (2013) on the significant dynamic correlation between the macroeconomic variables of the U.S. and developed countries (France, Germany, United Kingdom and Japan). Trade linkages emerged as the vital transmission mechanism for subprime crisis (Achraf et al. 2013). Similar finding was observed in the study by Calomiris, Love and Martínez Pería (2012) and Donadelli (2014). These studies suggested that the emerging markets' stock returns are more responsive to shocks related to changes in global trade conditions and global economic environment during the crisis period; such as U.S. industrial production uncertainty shocks and U.S. stock market volatility shocks. Yang and Hamori (2014) empirical study provides evidence that the influences of the changes in U.S. monetary policy did spillover to the ASEAN stock markets but only during the tranquil period.

## DATA

Monthly data from January 1991 to March 2013 were extracted from DataStream. The stock markets' movements are represented by stock market index with reference to their respective currencies while the economic activities' movements are represented by the industrial production index (IPI).[5,6] The IPI was selected as the economic activities indicator in this study for two reasons. First, for the selected countries in this paper, industrial growth is the most influential driver for their economic growth.[7] Second, the IPI indicates changes in economic activities that occurred in the countries, and reflects the real production output of a country (Hamilton and Gang 1996). It is pro-cyclical as it is positively correlated with business cycle (Artis, Marcellino & Proietti 2004).[8] An increasing trend of the IPI series indicates that the economy is doing well, and vice versa.

The list of indices of the selected countries are Jakarta Stock Exchange Composite Stock Price Index (JSE), the FTSE Kuala Lumpur Stock Exchange Composite Price Index (KLCI), the Philippine Stock Exchange Composite Price Index (PSE), the Straits Times Stock Exchange Index of Singapore (SSI), the Bangkok Stock Exchange Price Index (THSE), the Indian Industrial Production Index - Manufacturing (IN), the U.S. Industrial Production Index - Manufacturing (US) and the Japanese Industrial Production Index - Manufacturing (JP).[9]

TABLE 1. Diagnostics Tests Results for Return Series

| Panel B: | IN | US | JP | KLCI | JSE | PSE | SSI | THSE |
|---|---|---|---|---|---|---|---|---|
| Mean | 0.59% | 0.21% | -0.06% | 0.46% | 0.92% | 0.89% | 0.49% | 0.35% |
| Standard. Deviation. | 2.87% | 0.74% | 2.69% | 6.62% | 7.72% | 7.56% | 5.53% | 8.53% |
| Skewness | -0.7591*** | -1.3450*** | -1.1690*** | -0.0286 | -1.0328*** | 0.3487** | -0.0290 | -0.2267 |
| Excess Kurtosis | 10.783*** | 5.4586*** | 4.0855*** | 3.7840*** | 2.9249*** | 5.0375*** | 2.6793*** | 1.8083*** |
| Jarque-Bera | 1319.1470*** | 411.9807*** | 246.5113*** | 159.3312*** | 142.6389*** | 287.7192*** | 79.9003*** | 38.6515*** |
| Ljung-Box Q-Statistics Q(12) | 51.0508*** | 207.039*** | 70.1744*** | 60.6737*** | 33.4395*** | 13.0370 | 24.496** | 12.7588 |
| Engle ARCH Test Q²(12) | 9.2983*** | 7.1853*** | 3.0490*** | 11.527*** | 3.8493*** | 0.6813 | 3.8896*** | 4.3993*** |
| ADF test statistic (Level) | -2.1006 (14) | -2.2803 (3) | -0.4565 (15) | -2.2728 (2) | 0.1781 (0) | 0.2161(0) | -2.1982 (0) | -0.6721 (0) |
| ADF test statistic (1st dif) | -2.8946 (13)** | -4.5402 (2)*** | -5.7446 (14)*** | -9.2510 (1)*** | -6.9107 (2)*** | -15.6692 (0) *** | -14.6761 (0)*** | -15.7772 (0) *** |
| Unconditional Correlation (%) | | | | | | | | |
| IN | | | | 0.1070 | 0.0963 | 0.1315** | 0.0221 | 0.0779 |
| US | | | | -0.0955 | -0.0313 | -0.0130 | 0.0333 | -0.0654 |
| JP | | | | 0.0595 | 0.1239* | 0.0468 | 0.1668** | 0.0637 |

*Notes:* Lag length is given in parentheses. ***, **, * indicate significant at 1%, 5% and 10% respectively. For the ADF test, the lag length is based on SIC with MAXLAG=14.

The Augmented Dickey-Fuller (ADF) unit root test showed that all the series were non-stationary.[10] Hence, all series were transformed into first difference. The descriptive statistics are reported in Table 1.

The ASEAN-5 stock markets show positive average returns. The mean growth rate of the IPI was positive for India and the U.S. but for Japan it was at -0.06%; which is close to zero indicating economic stagnation over that period. The standard deviations for all economic conditions were below 3 percent. The risk of economic turbulence was particularly low in the U.S. as its economy is considered relatively stable over time. As for ASEAN-5 stock market's risk, it was around 5.5 to 8.5 percent; whereby in average, higher than India, the U.S. and Japan.

The series distribution is inclined to the left due to negative skewness except for the Philippines. This suggests that investment in the Philippines may have a higher probability of earning positive returns. All series reported a positive excess kurtosis, which means the stock markets might generated either very huge or very small future returns, thus investments in these countries could be highly volatile.

The Jarque-Bera normality test showed that all series were not normally distributed.[11] The presence of autocorrelation patterns in the series was shown by the Q-statistics of the Ljung-Box test. The Q-statistics were significant at lag 12 for all series except for PSE and THSE. Results from the Engle ARCH test indicated that a strong presence of ARCH-structure exists in all series; thus, the suitability of using the GARCH model except for the Philippines.

As for the unconditional cross-countries correlations, the economic activities of the U.S. were negatively correlated with most of the ASEAN-5 stock markets except for SSI. This relationship indicates that when there is a downturn in U.S.'s economy, most of the ASEAN-5 stock markets, except PSE, are less likely to tumble concurrently. The trend shows that both regions moved in different directions. Indian economic activities had low but positive correlation with ASEAN-5 stock markets. The economic activities of Japan were also mildly correlated with stock indices in the ASEAN-5, ranging from about 4% to 17%. In conclusion, the ASEAN-5 stock markets seem to be less correlated unconditionally with the three countries' economic activities.

## METHODS OF ANALYSIS

Methods employed to analyse the time-varying interdependency, structural breaks and volatility transmission were the DCC-MGARCH model, Bai-Perron structural breaks tests and VAR model - Granger causality test respectively.

## DCC-MGARCH MODEL

Time-variant correlation generated by the DCC-MGARCH provides more sensible results compared to time-invariant correlation estimated in the Constant Conditional Correlation (CCC) model by Bollerslev (1990). This is because economic activities can change over time and shocks to the stock market affect businesses from time to time. Hence, it is unrealistic to hold the conditional correlation constant over a long period of time. This model is also at the advantage because it allows a few extra parameters to be generated when the dimension of the model multiplies, which overcomes the weaknesses in other MGARCH models.

The DCC-MGARCH model simultaneously considers the $n$ return series' volatility and correlation on time dependence. The conditional covariance generated by the model shows the time-variant cross-market volatility correlation or the dynamic conditional correlation. The DCC-MGARCH model can be written as $r_{i,t} = \mu_{i,t} + \varepsilon_{i,t}$, $\mu_{i,t} = E(r_{i,t}| \Psi_{t-1})$, where $r_{i,t}$ is return for country $i$ at time, $t$, $\Psi_{t-1}$ is the set of information available at time $t-1$. The conditional mean equation of the return series for country $i$ is $\mu_{i,t} = \lambda_0 + \lambda_1 r_{i,t-1}$ where $\lambda_0$ is a constant term, $\lambda_1$ is the coefficient of the lagged return for each market.

The conditional variance-covariance matrix for the DCC-MGARCH model, $H_t$ can be decomposed as $H_t = D_t R_t D_t$ where $H_t$ is also denoted as the conditional correlation estimator. $R_t$ is the conditional correlation matrix which is allowed to be time-varying. $D_t$ = diag $(\sqrt{h_{1,t}}, ..., \sqrt{h_{n,t}})$ with $h_{i,t} = \tau_i + \alpha_i\varepsilon_{i,t-1}^2 + \beta_i h_{i,t-1}$ where $h_{i,t}$ is the time-varying conditional volatility of the return series for country $i$ at time $t$ (Bollerslev, 1990); $\tau_i$ is a constant term for the conditional variance equation for country $i$, $\alpha_i$ is the ARCH effect of the return series. $\beta_i$ is the GARCH effect of the return series. The sum of $\alpha_i$ and $\beta_i$ of the univariate GARCH indicates the persistency of the volatility shock.[12]

$R_t$ of the DCC model contains the coefficients of conditional correlation. $R_t = diag(Q_t)^{-1}Q_t diag(Q_t)^{-1}$ where $Q_t \equiv (q_i)_t$ is a conditional covariance matrix; $Q_t$ is a $(n \times n)$ matrix which is symmetric and positive definite given by $Q_t = (1 - \alpha_{dcc} + \beta_{dcc})\bar{Q} + \alpha_{dcc}(\varepsilon_{t-1}\varepsilon_{t-1}) + \beta_{dcc}Q_{t-1}$, where $\bar{Q}$ denotes the unconditional covariance of the standardised errors matrix which is a $(n \times n)$ symmetric positive definite matrix, and $\varepsilon_t = (\varepsilon_{1,t}, ..., \varepsilon_{n,t})'$ is the standardised residual terms.[13] The model is mean reverting when $(\alpha_{dcc} + \beta_{dcc}) < 1$. If $(\alpha_{dcc} + \beta_{dcc}) = 1$, the model is said to be integrated.

The estimation of time-varying conditional correlations $(q_{ij,t})$ for any two return series included in $R_t$ by GARCH (1, 1) process can be written as $q_{ij,t} = \bar{\rho}_{ij} + \alpha_{dcc}(\varepsilon_{i,t-1}\varepsilon_{j,t-1} - \bar{\rho}_{ij}) + \beta_{dcc}(q_{ij,t-1} - \bar{\rho}_{ij})$ where $\bar{\rho}_{ij}$ is the unconditional correlation between $\varepsilon_{i,t}$ and $\varepsilon_{j,t}$, and $\bar{q}_{ij,t}$ is the mean value of $q_{ij,t}$. The average variance is unity and the conditional correlation estimator is $\rho_{ij,t} = \dfrac{q_{ij,t}}{\sqrt{q_{ii,t} q_{jj,t}}}$. Hence,

the conditional correlation coefficient between $r_{i,t}$ and $r_{j,t}$ is $[R_t]_{ij} = \rho_{ij,t}$. The $\rho_{ij,t}$ for the DCC (1, 1) is expressed as $\rho_{ij,t}$

$$= \frac{(1 - \alpha_{dcc} - \beta_{dcc})\overline{q}_{ij} + \alpha_{dcc}\varepsilon_{i,t-1}\varepsilon_{j,t-1} + \beta_{dcc}\,q_{jj,t-1}}{\sqrt{(1 - \alpha_{dcc} - \beta_{dcc})\overline{q}_{ij}\,\varepsilon_{i,t-1}^2 + \beta_{dcc}q_{ii,t-1})(1 - \alpha_{dcc} - \beta_{dcc})}}.$$
$$\overline{q}_{ij} + \alpha_{dcc}\varepsilon_{j,t-1}^2 + \beta_{dcc}q_{jj,t-1})$$

The significance of $\alpha_{dcc}$ and $\beta_{dcc}$ implies the estimators obtained in the DCC-MGARCH are dynamic and time-varying. $\rho_{ij,t}$ indicates the direction and strength of the correlation.[14] When the estimated $\rho_{ij,t}$ is positive, the correlation between the return series is rising and moving in the same direction; and vice versa.

The DCC-MGARCH model is estimated by the maximum likelihood method. The parameter estimation of the DCC-MGARCH model can be done sequentially in two steps. First, the univariate GARCH (1, 1) model is estimated for each return series in the multivariate system. Second, use the generated standardised residuals from the first step to estimate the DCC parameters. Under acceptable uniformity circumstances, the consistency of the second step is dependent on the consistency of the first step.

### MULTIPLE STRUCTURAL BREAKS TEST

This study employed the Bai and Perron (1998, 2003) multiple structural breaks test to detect the presence of structural changes in the dynamic conditional correlation series amongst the selected countries in the study. The structural breaks occurring naturally in a time series at time $t$, is given by $y_t = \eta_j x_j + \varepsilon_t$ where $t = T_{j-1} + 1, \ldots, T_j$ $(j = 1, \ldots, m + 1)$, $\eta_j$ is the coefficient of vectors of covariates, $x_j$. $\varepsilon_t$ is the error term at time $t$. The model is estimated by minimising the sum of squared residuals (SSR) to find $m$ multiple structural breaks in the model. The estimated break points $(\hat{T}_1 \ldots, \hat{T}_m) = \arg \min_{T_1, \ldots, T_m} S_T(T_1, \ldots, T_m)$ that obtain global minimisers of the SSR where $S_T(T_1, \ldots, T_m)$ denotes the resulting SSR.[16] The null hypothesis of 'no structural breaks' against alternative hypothesis of 'unknown number of breaks' with upper bound of $m$ is set at 5, which means 5 is the maximum number of breaks allowed in the model. The selection of the optimal number of breaks is based on the minimum value of the Bayesian Information Criterion (BIC).

### VOLATILITY SPILLOVER EFFECTS

The study proceeded with the testing of Granger causality between the time-varying conditional variances, which evaluate the possible changes in the degree of integration and direction of volatility spillover in the short-run amongst the studied markets. The VAR model and Granger causality test were adopted to capture the short-run dynamic adjustment and causal relations.

Results obtained from the stationary test indicate that the conditional variances in all the models consist a mix of I(1) and I(0) variables.[17] Consequently, it is recommended to use the Autoregressive Distributed Lag (ARDL) approach by Pesaran and Shin (1999) and Pesaran et al. (2001) to test the cointegration relationship. The result justifies our decision to use the VAR in first difference specification in the Granger causality analysis as a cointegration relationship does not exist amongst the conditional variances.

### FINDINGS

#### PRE-DIAGNOSTIC TESTS

To evaluate the presence of dynamic effects in the endogenous variables used in the DCC-MGARCH model, Tse (2000) Lagrange Multiplier (LM) test was employed to test for the presence of dynamic properties of the conditional correlation series generated by the Constant Conditional Correlation (CCC)-MGARCH model. As reported in Table 3, the null hypothesis of constant correlation against dynamic correlation of Tse (2000) was strongly rejected at the one percent level, which implies the existence of dynamic properties in the correlation series for all pairs of countries selected in this study. This test's results justified the used of the series in the estimation of the DCC-MGARCH model.

#### MISSPECIFICATION TESTS

After the estimation of the DCC-MGARCH model, adequacy of the model specification needs to be validated. All the models in this study were correctly specified and the test results were sufficient to provide the conclusion that DCC-MGARCH specification is appropriate in its application. This can be verified by using the univariate misspecification tests. Table 2 reports the post-diagnostic checking of DCC-MGARCH model in order to ensure statistical fit of the endogenous variables in this study. The Q statistics for the estimation residuals were insignificant for most of the series except JSE, KLCI and US. The $Q^2$ statistics were insignificant at one percent level for all series for the AR(1) model. The statistically insignificant results of these two tests indicated the absence of serial correlation and ARCH-effects in the conditional means and variances. The majority of the series were consistent, thus passing the misspecification tests. Results of these two tests justified the employment of DCC-GARCH specification for the selected countries.

The skewness, excess kurtosis and Jacque-Bera test of the standardised residuals were also examined. The skewness was negative for most series except for IN, KLCI, PSE and THSE. Excess kurtosis was positive for all indices except for the US. This represents a sizable departure from normality. India showed a high excess kurtosis of more than three. Thus, the level of risk for India was low as the past return yield a leptokurtic

TABLE 2. DCC-MGARCH Step 1 Estimation Results for Full Sample (January 1991-March 2013)

| Panel A: | IN | US | JP | JSE | KLCI | PSE | SSI | THSE |
|---|---|---|---|---|---|---|---|---|
| | | | | Mean Equation : AR(1) model: | | | | |
| Constant: $\lambda_0$ | 0.0056*** | 0.0032*** | -0.0001 | 0.0134 | 0.0081** | 0.0130 | 0.0077* | 0.0120*** |
| AR (1): $\lambda_1$ | -0.4961*** | -0.0064 | -0.3774*** | 0.1986 | 0.1587** | 0.1277 | 0.2124*** | 0.0638 |
| | | | | Variance Equation : GARCH (1, 1) model: | | | | |
| Constant: $\tau_i$ | 0.0586 | 0.1523*** | -0.3774 | 0.1988 | 1.5879** | 0.0005 | 1.7186* | 0.0007** |
| ARCH: $\alpha_i$ | 0.0941*** | 0.3977*** | 0.0910*** | 0.1354 | 0.2198*** | 0.1696 | 0.1292*** | 0.3153** |
| GARCH: $\beta_i$ | 0.8932*** | 0.2575*** | 0.8977*** | 0.7225 | 0.7431*** | 0.7423 | 0.8084*** | 0.5939*** |
| $\alpha_i + \beta_i$ | 0.9873 | 0.6552 | 0.9887 | 0.8580 | 0.9629 | 0.91187 | 0.9376 | 0.9092 |
| | | | | Consistency Test: | | | | |
| Q | 11.5649 (8) | 71.7916 (8)*** | 0.1938 (2) | 18.2687 (8)** | 15.5130 (8)** | 5.8945 (8) | 11.8471 (8) | 7.4012 (8) |
| $Q^2$ | 10.0412 (8) | 6.4436 (8) | 13.3790 (8)* | 10.0412 (8) | 10.1387 (8) | 4.0273 (8) | 6.7162 (8) | 12.8700 (8) |
| Skewness | 0.6993*** | -0.0759 | -0.9416*** | -0.6657*** | 0.1186 | 0.1464 | -0.1535 | 0.1683 |
| Excess Kurtosis | 3.5543*** | -0.0924 | 2.4682*** | 1.9861*** | 0.7570** | 1.7521*** | 1.1840*** | 1.3506*** |
| Jarque-Bera | 162.31*** | 0.3512 | 107.23*** | 63.602*** | 7.0022** | 35.106*** | 16.646*** | 21.554*** |

*Remarks*: Lag length is based on SIC with MAXLAG=14. Lag length is given in parentheses. ***, **, * indicate significant at 1%, 5% and 10% respectively. UniGARCH for A5-US model will be used as a comparison reference for all models. Only minor and insignificant differences exist in the results for all models.

distribution. The normality test strongly rejects the null hypothesis, which means that the indices did not follow a normal distribution except for the US. The normality test results suggest that the excess kurtosis in the residuals of the return indices was not fully eliminated by the conditionally normal GARCH process.

INTERPRETATION OF UNIVARIATE GARCH SPECIFICATIONS

Univariate GARCH specifications for each data series are generated from the DCC model. As reported in Table 2, the AR(1) coefficients are statistically significant for ASEAN-5 stock markets except for JSE, PSE, THSE and the U.S. The impact of previous disturbances on the conditional variance is significant for all selected countries in this study except for the stock markets of Indonesia and the Philippines. The impact of previous disturbances on the conditional variance is denoted by the ARCH coefficient (α) in Table 2. The GARCH effect is statistically significant for all countries except for stock markets in Indonesia and the Philippines. The sum of (α + β) is less than one for all, which indicates the persistence of disturbance over time. We noted that the sum of (α + β) for the U.S. is only 0.7 which indicates less persistence relative to the others.

ASEAN-5 STOCK MARKET VOLATILITIES

The conditional variances for ASEAN-5 stock market are depicted in Figure 1a. The most noticeable feature in Figure 1a is the tendency for the volatility to cluster around 1994, 1997, 2000 and 2008-2010 for most of the ASEAN-5 stock returns. This suggests the existence of ARCH-GARCH effects.

INDUSTRIAL PRODUCTION VOLATILITY IN INDIA, THE U.S. AND JAPAN

The plots in Figures 1b show the changes in conditional variances for the industrial production growth rates that occurred over the sample period of this study. Volatility in the IPI growth rate series of India, the U.S. and Japan were relatively stable with extremely low volatility except for certain years. However, industrial production growth rate of India was quite volatile before 1995; followed by relatively low (below 0.02%) movement of business activities from 1995 until 2009. In 2010, Indian industrial production growth rate conditional variances displayed volatile movement. The industrial production growth rate in the U.S. was noticeably low in 1990-1997; followed by moderate volatility in 1998-1999 and relatively high volatility in 2008-2010, during the subprime crisis. The conditional variance of industrial production in Japan experienced relatively low and calm movement since 1990 until 2008. Beyond this point, the volatility in industrial production in Japan was apparently high at 0.6%. The graph in Figure 1b is indicative of the presence of ARCH-GARCH effects.

DCC-MGARCH - TIME-VARYING CO-MOVEMENTS' PATTERNS

DCC-α and DCC-β reported in Table 3 are significant, which imply ASEAN-5's stock returns with industrial
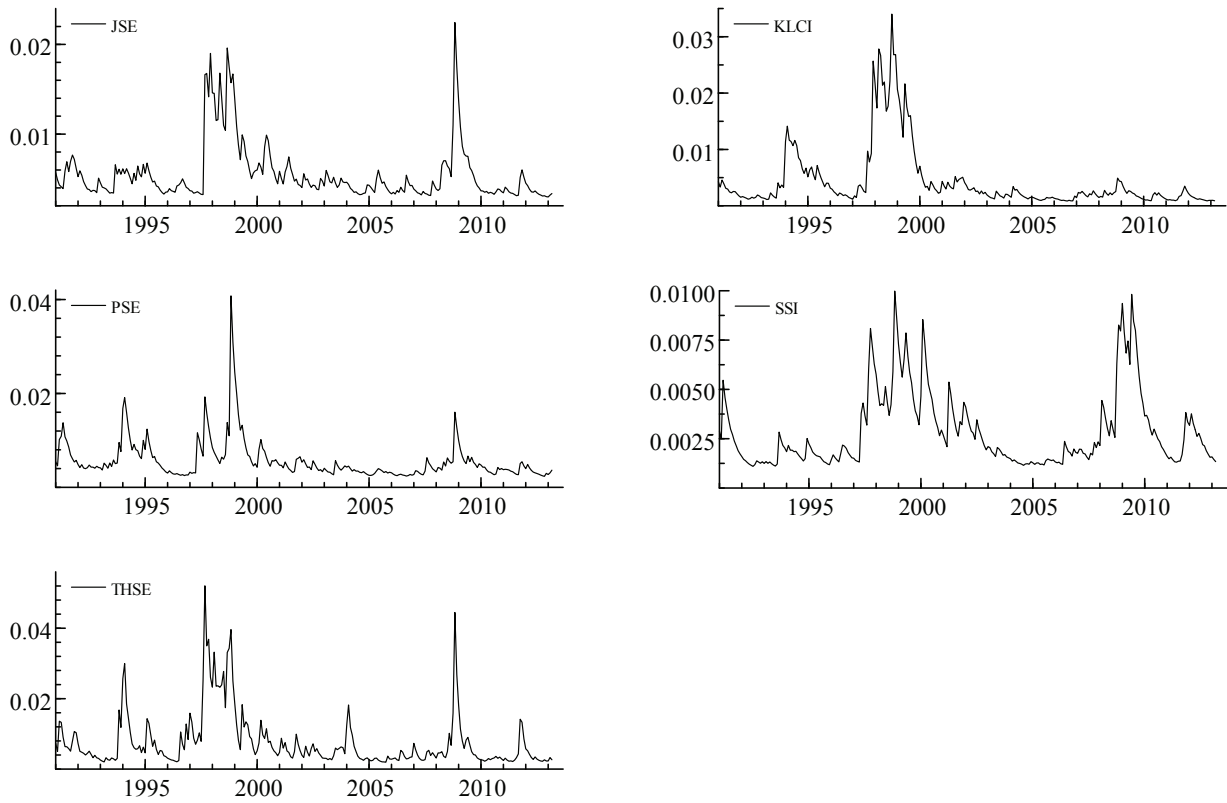
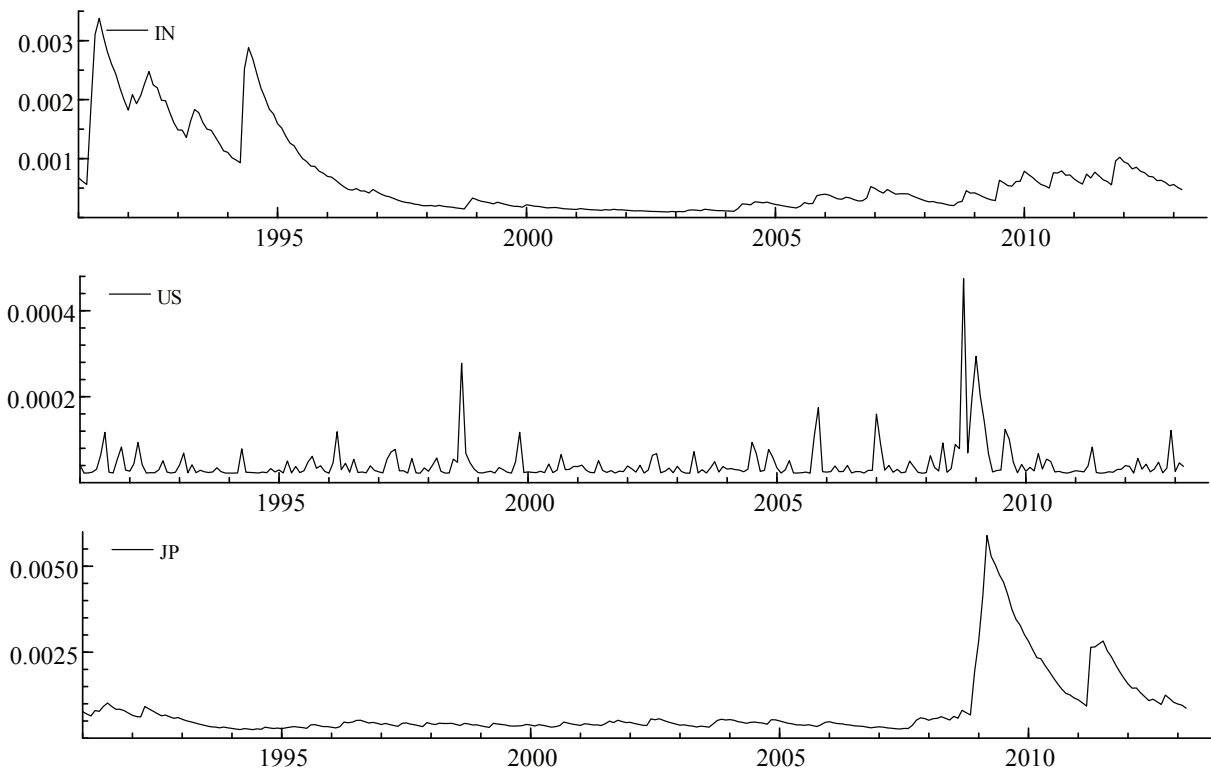FIGURE 1a  Conditional Variances of Stock Return for ASEAN-5



FIGURE 1b. Conditional Variances of Industrial Production Growth Rate for India, the U.S. and Japan

TABLE 3  DCC-MGARCH Step 2 Estimation Results for Full Sample (January 1991-March 2013)

|  | ASEAN-5 + India | ASEAN-5 + the U.S. | ASEAN-5 + Japan |
|---|---|---|---|
| LM Tse Test | 56.1425*** | 53.6307*** | 57.4217*** |
| $\alpha_{dcc}$ | 0.0214** | 0.0210** | 0.0226* |
| $\beta_{dcc}$ | 0.8300*** | 0.8579*** | 0.8180*** |
| $\alpha_{dcc} + \beta_{dcc}$ | 0.8514 | 0.8789 | 0.8406 |

*Remarks*: ***, **, * indicate significant at 1%, 5% and 10% respectively. LM Tse test $\sim \chi^2(N*(N-1)/2))$ under $H_0$: CCC model; ASEAN-5 and the reference country are tested as a group of six countries.

production growth rate of the other three economies are highly dynamic and time varying. The DCC-$\beta$s for all models indicate the high persistence in the dynamic conditional correlation of stock returns of ASEAN-5 with the other three countries' economic activities. The sum of the DCC-$\alpha$ and the DCC-$\beta$ are all less than one, which indicates that the conditional correlations in the models are time-variant over time.

To have a better picture of intra- and inter-regional stock market correlation, the plots for time-varying conditional correlations amongst ASEAN-5 stock markets with economic performance of India and the U.S. and Japan are illustrated in Figures 2. All the DCCs are maintained at a level below 0.2, which is relatively low.[18] The plot for the DCC between Indian economic activities and ASEAN-5 stock markets shows that it is constantly maintained below the 0.15 level except an impulsive rise around 2009. The DCC between IN and SSI was particularly low with most of the time at a negative DCC. Hence, it is highly beneficial for Singaporean investors to diversify their equity portfolios into Indian

economy. This is aligned with Singapore appearing to be the second highest contributor for Indian FDI equity inflow in year 2012-13 (April-December).

The DCC between Indian economic activities with ASEAN-5 stock markets displays a sudden spike at the end of 2009; followed by a downward turn simultaneously as shown in Figure 2. This sudden increase provides an evidence of contagion effect amongst Indian economic activities with ASEAN-5 stock markets at the initial stage of the crisis; and followed by herding behaviour at the latter stage. The change from contagion effect to herding behaviour in this context is consistent with the finding by Chiang et al. (2007). This change coincided with the European sovereign debt crisis as during that period of time, there was no significant economic event or crisis happened in India and ASEAN-5. This can be seen by the sudden increase of volatility in stock returns for all the countries above being relatively weak, i.e. below 0.05. Hence, contagion spreading should be from the crisis-hit country to the studied countries. When the crisis
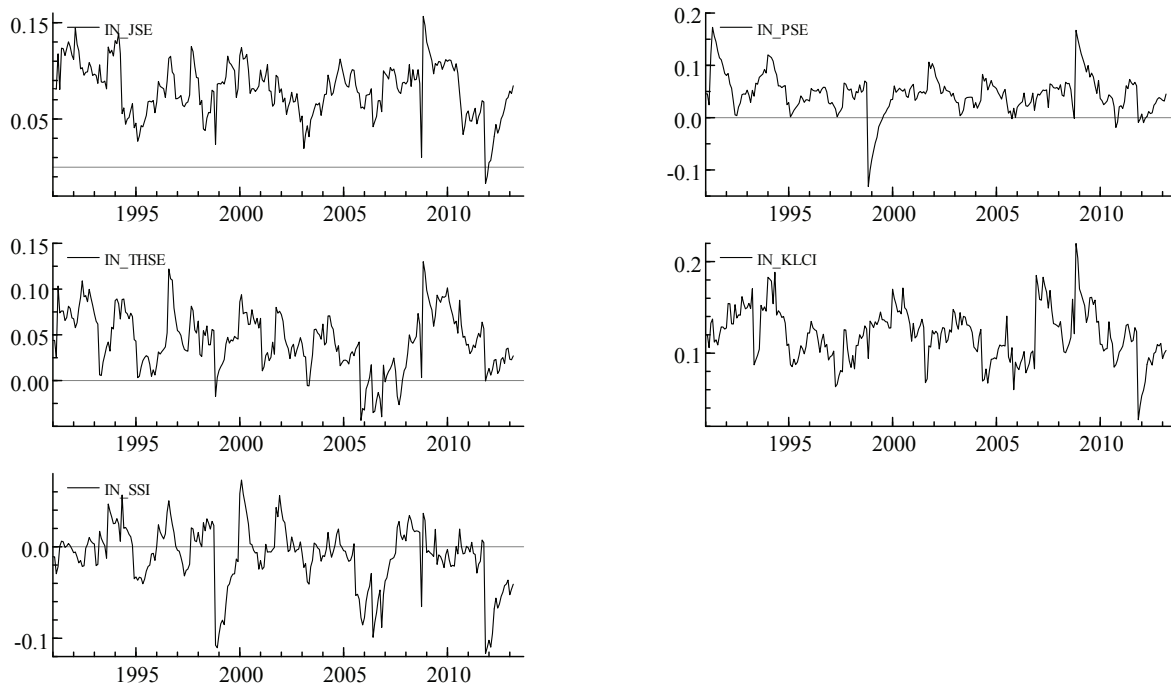


FIGURE 2a  Dynamic Conditional Correlation between Stock Markets in ASEAN-5 and India's Economic Activities
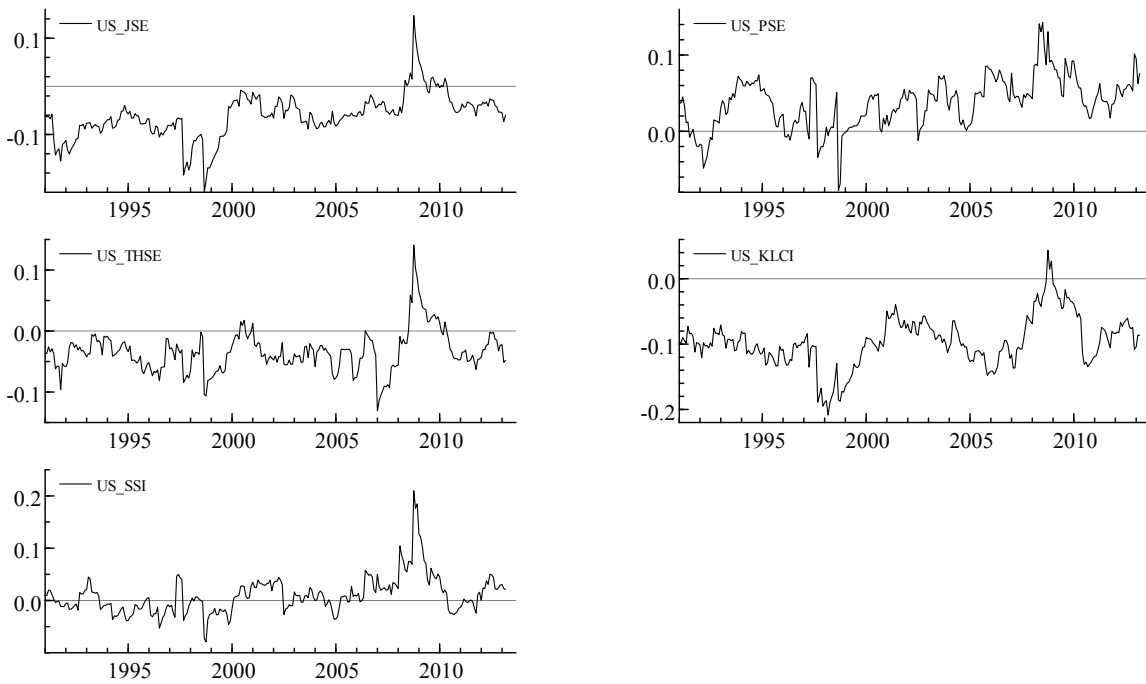
FIGURE 2b  Dynamic Conditional Correlation between Stock Markets in ASEAN-5 and the U.S. Economic Activities

raised public awareness and dispersed widely, this leads to a more uniform behaviour among the studied markets, their DCC and volatility will simultaneously become temporary higher, as proven by herding behaviour. This negative news leads to uncertainty on gain of international portfolio diversification during the crisis. The DCC decreased significantly immediately

after the spike. This is because investors become more rational in analysing the fundamentals of each market rather than following the crowd by herding. This is consistent with the findings of Baur and Fry-McKibbin (2009) that stated time span for contagion effect can be short-lived and reverses quickly, which mean split between positive and negative movements.
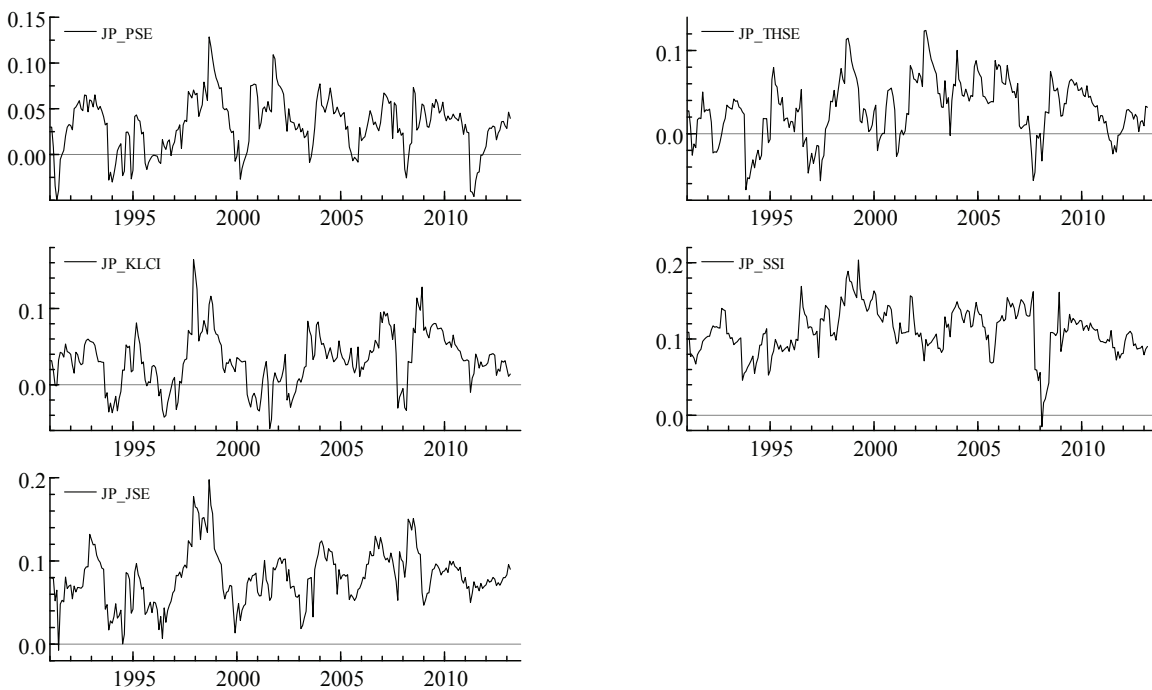


FIGURE 2c  Dynamic Conditional Correlation between Stock Markets in ASEAN-5 and Japan's Economic Activities

The trend of DCC between these two regions switched to upward movement around year 2012 which happened during the trouble of Indian economy; i.e. persistent ballooning in fiscal and current account deficits with persistently high inflation, as well as plunging Indian rupee and stock market. However, the rising DCC is still at a relatively low level. If this trend continues with apparent high correlation between India and ASEAN-5, this implies that the gain of investors from India in ASEAN-5 stock markets is limited and investors from India could reduce or withdraw investment fund of their stock portfolios from contagion country.

It is interesting to note that the DCC between the U.S.'s economic activities and ASEAN-5 stock markets was negatively correlated; with a DCC around −0.1 before 2008 except for the Philippines. There was a significant drop during the Asian financial crisis, which means that when the ASEAN-5 stock markets tumbled, the U.S.'s economic activities were not moving in tandem with the ASEAN-5 stock markets. However, during the sub-prime crisis in 2008-09, a temporary sign of positive co-movement was observed between ASEAN-5 stock markets with the U.S.'s economic activities. This is true as the sub-prime crisis dragged the U.S. into recession from December 2007 to June 2009 and the effect spilled over to all ASEAN-5 stock markets.[19]

Japanese economic activities performance was positively correlated with ASEAN-5 stock markets for most of the period in this study, which is totally opposite compared to the U.S. The DCC was below 0.2, but it was the highest compared to the other three countries.

Hence, the performance of Japanese economy is closely synchronised with the behaviour of ASEAN-5 stock markets.

STRUCTURAL CHANGES FOR ASEAN-5 STOCK MARKETS

The dynamic cross-countries correlation is subjected to structural changes. Detected structural break dates in the conditional correlations based on the Bai and Perron (2003) test are reported in Table 4. The structural break observed between ASEAN-5 and Indian economic activities in 1994 could be attributed to the gradual financial reforms and liberalisation that took place in India. That includes the transformation of the exchange rate regime into a more unified and market-determined system as well as an introduction of the current account convertibility.

The structural break date in 1996 was in conjunction with the temporary economic revival in Japan in that year (Ito 1999). During that period, temporary boom was experienced in residential properties, the construction sector and consumer durable products in Japan. This condition spiralled until the government decided to curb the inflationary situation in Japan.

Most of the breaks happened in 1997 as a reaction to the Asian financial crisis while the breaks dates observed within the period of 1998 and 1999 were as the results of a wide range of post-crisis reformations in economic, banking and financial sectors in ASEAN-5; and these were done to regain investors' confidence and to maintain currency stability.[20] During the period 1997-

TABLE 4  Bai and Perron Structural Break Dates for the Conditional Correlations

| Multivariate Model 1: | | (JSE, KLCI, PSE, SSI, THSE, IN) | | |
|---|---|---|---|---|
| JSE-IN | KLCI-IN | PSE-IN | SSI-IN | THSE-IN |
| 1994M04 | 1994M11 | 1994M11 | | 1994M11 |
| 1998M11 | 1998M05 | | | |
| 2002M03 | 2003M03 | 2000M01 | | |
| 2006M07 | 2006M07 | | 2005M07 | 2004M10 |
| 2009M11 | 2009M11 | 2009M11 | | 2008M02 |
| Multivariate Model 2: | | (JSE, KLCI, PSE, SSI, THSE, US) | | |
| JSE-US | KLCI-US | PSE-US | SSI-US | THSE-US |
| 1996M06 | 1997M03 | 1995M07 | 1994M04 | 1995M02 |
| 1999M10 | 2000M08 | 1999M12 | 2000M01 | 1999M10 |
| 2003M04 | 2004M05 | 2005M09 | 2006M05 | 2004M09 |
| 2008M03 | 2007M09 | 2009M11 | 2009M11 | 2008M11 |
| Multivariate Model 3: | | (JSE, KLCI, PSE, SSI, THSE, JP) | | |
| JSE-JP | KLCI-JP | PSE-JP | SSI-JP | THSE-JP |
| 1996M06 | 1997M02 | 1997M06 | 1996M05 | 1997M11 |
| 1999M10 | 2000M06 | | 2000M11 | 2001M09 |
| 2003M09 | 2003M10 | 2002M05 | | |
| 2008M11 | | | 2007M09 | 2006M12 |

1999, the conditional variance for economic activities in India and developed economies (the U.S. and Japan) was relatively low at around 0.03%; while in ASEAN-5, the volatility in their stock markets fluctuated upwards to 4%. Only the volatility of Singapore's stock market remained below 1%. In summary, detected structural break dates are mostly related to the crisis faced by Indonesia, Malaysia, the Philippines and Thailand. In fact, India was not affected by the Asian financial crisis as its monetary authorities had taken precautionary measures as a response to the crisis.

Most of the estimated break dates from 2000 to 2002 can be attributed to the dot-com bubble's burst and meltdown as well as the September 11 terrorist attack in the United States in 2001. As for the structural change for ASEAN-5 with Japanese economic activities post-2000, it could be the effects of quantitative easing strategy implemented by the Bank of Japan to curb deflation.[21]

The observed break dates that fall within 2003 and 2005 for India with the studied markets were mostly coincided with the active period of negotiation, conclusion and implementation of free trade agreements and the Comprehensive Economic Cooperation Agreement (CECA). For instance, the structural break between India and Singapore dated July 2005 could be explained by the CECA between India and Singapore which took effect within two months after the agreement was concluded in June 2005. Similar explanation for the break date observed between India and Thailand (October 2004), whereby the CECA came into effect after the signed agreement.

The break date detected in December 2006 occurred only in conditional correlation between THSE and JP. This change seemed to coincide with the implementation of new monetary policy after the end of the zero-rate policy in Japan. Lastly, a straightforward intuition is that the common break date for pairs of correlations between 2007 and 2009 was related to the execution of series of monetary policies and financial regulatory reforms to overcome the subprime mortgages crisis and the happening of European sovereign debt crisis. The European sovereign debt crisis did have an impact on Asian financial system, specifically on its equity and bond markets, banking sector, exposure to Eurozone lending and Asian private credit growth (Lee. Park, Abdon & Estrada 2013; Swamy 2013)

In sum, the structural break detected in November, 2009 between India and ASEAN-5 which coincided with the European sovereign debt crisis, further confirmed the contagion effect and herding behaviour observed in the DCC behaviour as shown in Figure 2.

DIRECTION OF VOLATILITY SPILLOVER

Outcomes on the direction of volatility causality between ASEAN-5 stock markets with Indian economic activities

are given in Table 5. The results show significant volatility spillover of stock prices of Indonesia and Singapore into Indian economic activities in the short run. This finding is valid as Singapore is one of the major contributors in terms of FDI equity inflows for India. Economic activities of India do not Granger cause ASEAN-5 stock markets in the short run. This implies that the contagion effect and herding behaviour of the two regions observed in their DCC structures responded to similar external systematic risk. In this case, both responded to the European sovereign debt crisis.

For comparison, we also examined the direction of volatility causality between ASEAN-5 stock markets with the U.S. and Japanese economic activities respectively. The U.S. and Japan were selected because both are the major trading partners of ASEAN-5. Significant volatility spillover was observed from the U.S.'s economic activities to ASEAN-5 stock markets except to Thailand's stock market. This implies that ASEAN-5 stock markets were vulnerable to the fluctuation in the U.S. economy's industrial production. In the short run, only economic activities volatility in Japan strongly spilled over to Singapore's stock market, but not to other stock markets in ASEAN-5.

Overall the empirical results showed significant influence of economic activities in the U.S., spilling over to stock market activities in ASEAN-5. This can be explained by a slowdown in the economy as one of the factors causing the volatility in the stock market. Stock market performance, at the same time, is one of the key leading indicators for the economic performance of a country (Schwert, 1989). Similar observations

TABLE 5  VAR Results for Volatility Spillover

| Null hypothesis | $\chi^2$( full period ) |
|---|---|
| IN does not Granger cause JSE | 0.6532 |
| IN does not Granger cause KLCI | 0.1274 |
| IN does not Granger cause PSE | 1.4489 |
| IN does not Granger cause SSI | 2.4616 |
| IN does not Granger cause THSE | 0.9575 |
| JSE does not Granger cause IN | 7.8480** |
| KLCI does not Granger cause IN | 0.3441 |
| PSE does not Granger cause IN | 2.2821 |
| SSI does not Granger cause IN | 9.1611** |
| THSE does not Granger cause IN | 3.0161 |
| US does not Granger cause JSE | 19.8595** |
| US does not Granger cause KLCI | 31.3970*** |
| US does not Granger cause PSE | 20.5600** |
| US does not Granger cause SSI | 32.9291*** |
| US does not Granger cause THSE | 13.3225 |
| JP does not Granger cause JSE | 7.0110 |
| JP does not Granger cause KLCI | 7.7559 |
| JP does not Granger cause PSE | 4.6709 |
| JP does not Granger cause SSI | 20.7983*** |
| JP does not Granger cause THSE | 4.2240 |

*Remarks*: ***, **, * indicate significant at 1%, 5% and 10% respectively.

were found in Hamilton and Gang (1996) and Tsouma (2009).

DISCUSSION AND CONCLUSION

This study analyses whether Indian economic movements have a significant influence on ASEAN-5 stock markets by applying a DCC-MGARCH model. It emphasizes the relative importance of the impact of Indian economy on ASEAN-5 stock markets as compared to the two main traditionally influential economies, the U.S. and Japan. The findings of this study indicated that stock markets' volatility of ASEAN-5 was correlated with economic activities of India and their level of dynamic correlation is almost at par with ASEAN-5's correlation with the U.S. and Japan within the studied period. This study suggests that the dynamic correlation analysis between Indian economic activities with ASEAN-5 stock markets revealed the presence of contagion effect and herding behaviour during the European sovereign debt crisis but these effects are non-persistence.

An important finding emerged from the dynamic behaviour of correlations between India and ASEAN-5 is that their correlation structure is subject to structural changes. The correlation coefficient between India and ASEAN-5 is found to be significantly influenced by major changes in the economic liberalisation process, formation of trade agreements and news about crises occurring in other countries, particularly the European sovereign debt crisis. Thus, this has added credibility to the hypothesis that the shifts indeed revealed the actual gradual economic integration transformation amongst these countries.

Another important finding is there is no volatility spillover from Indian economic movements to ASEAN-5 stock markets but there is a spillover from stock markets of Singapore and Indonesia to Indian economic activities. As a conclusion, in the short run, ASEAN-5 appears to be an attractive destination for the Indian investors to diversify their portfolios.

In response to the conclusion obtained from this empirical study, ASEAN leaders can make an effort to enhance economic integration with India through education restructuring and trade promotion. ASEAN leaders should consider changing the direction of their development of human capital to the area of high value-added activities by focusing on enhancing the productivity of labour with better marketable skills while minimising the rise in their wages in order to remain competitive in the regional and global markets.[22] This is because it is impossible for ASEAN countries to compete with India in terms of wage levels (Thorbecke, 2010).[23] ASEAN leaders should strive to maintain and improve ASEAN's current trade cooperation with India with additional bilateral or multilateral FTAs as the underlying channels to enhance economic integration through trade liberalisation among countries in the region (Karim and Majid 2010). Stronger regional economic integration may also help in cushioning the volatility of ASEAN stock markets and improving market discipline in the ASEAN-5 stock markets.

Taken together, these signals suggest the findings of this study are deemed important and supported ASEAN and India in strengthening the Asian regional cooperation and slowly reducing their dependency on U.S.'s economy. This is to lessen the adverse impact of the U.S.'s economic calamity on Asian growing economies. Low interest rates in the U.S. to boost the performance of its stock market make U.S. bonds less attractive in the international markets. Thus, ASEAN can be one of the more reliable and trustworthy regions for long-term investment in the near future for investors from India compared to the U.S.

As a precautionary measure, international investors and policy makers in ASEAN-5 still need to be more watchful to the economic activities in India in the near future. This is implicated by rising trend in dynamic correlation behaviour at the end of the study period which is year 2012 onwards in conjunction to the economic slowdown in India and its internal macroeconomic problems.

ENDNOTES

1  For details, refer to http://www.bilaterals.org/?asean-india-free-trade-area#sthash.Ey0Oiwpu.dpuf and http://dipp.nic.in/English/Publications/SIA_NewsLetter/Annualreport2012/chapter6.1.C.pdf

2  ASEAN-5 refers to the five founding members of the Association of Southeast Asian Nations (ASEAN), namely Indonesia, Malaysia, the Philippines, Singapore and Thailand.

3  MGARCH model is preferred to the univariate GARCH model because univariate GARCH model is not stable over time and may generate poor forecasts. The MGARCH model is able to generate more reliable and precise forecasts compared to the univariate GARCH model (Hamilton and Gang, 1996). It is also more relevant and practical to use the MGARCH model when the study involves international portfolio diversification and risk management.

4  According to Kenourgios et al. (2011), BRIC was only mildly affected by the Asian financial crisis.

5  Countries in this study are under different exchange rate systems, thus all the indices are denominated in local currency to avoid the impact of exchange rate volatility on the stock market linkages (Lucey and Muckley, 2011). The conversion of the local currency into a common currency will cause spurious findings for stock market linkages (Click and Plummer, 2005). This is because the rise in stock market linkages could be originated from the behaviour of the common currency, such as toward the depreciation or appreciation of the USD.

6  The stock market indices and the IPI series are seasonally adjusted (SA) with Census X-12 filter (Savva, Neanidis & Osborn 2007; Pagan and Sossounov, 2003).

7   See UBS outlook for details, available from <www.ubs.
    com/outlook>

8   See Camacho, Pérez-Quirós and Saiz (2006) for a
    discussion of the IPI advantages.

9   The multivariate models to illustrate interdependencies
    among the ASEAN-5 stock markets with the economic
    activities in India, the U.S. and Japan are a group of six
    countries namely Model 1 = ASEAN-5 with IN, model 2
    = ASEAN-5 with US and model 3 = ASEAN-5 with JP.

10  The results of the ADF test are not reported in the paper
    but are available upon request from the authors.

11  The unreported first order autocorrelations are low, thus
    indicates that the first-order autoregressive process,
    AR(1) needs to be included in the mean equation of
    GARCH (1,1) model (Hamilton & Gang 1996; Arouri &
    Nguyen 2009).

12  $\alpha_i$ is the volatility from the previous period on the
    volatility of the present period due to a shock. $\beta_i$ is the
    impact of the forecasted variance from the last period.
    A positive coefficient of $\beta_i$ implies volatility clustering
    and persistency in positive changes in stock market
    indices.

13  Positive covariance implies the tested variables are
    strongly linked and moved in the same direction and vice
    versa.

14  $\alpha_{dcc}$ measures the short-run volatility impact, which
    means the persistency of the standardised residuals from
    the previous period. $\beta_{dcc}$ measures the lingering effect of
    a shock impact on the conditional correlations, which
    means the persistency of the conditional correlation
    process. $\rho_{ij,t}$ measures the degree of covariance between
    two assets in relation to the market's individual variances
    (Savva, 2009).

15  The rule of thumb for misspecification test is that as long
    as there is consistency in the step 1 estimation of the
    DCC-MGARCH model, it will ensure estimation in step
    2 is consistent and able to generate the true parameters
    (Engel, 2002).

16  "arg min" in the equation refers to the set of functions
    efficiently compute argument of minimum for vectors and
    matrices.

17  Results are available upon request.

18  A figure of 0.2 for DCC is considered high as stated in the
    study by Chiang et al. (2007).

19  Details refer to Dow Jones, Reuters, http://www.reuters.
    com/finance/markets/.

20  Detailed discussion on the post-crisis reforms can be
    referred to Teng, Yen, Chua and Lean (2013a).

21  The interest rate was decreased to a rate near-zero.
    However, this strategy failed to revive the economy from
    deflation.

22  The EU establishment caused the loss of competitiveness
    for some of its members. This can be explained by the
    widening of accessed markets that has led to a sudden
    boom in the demand, which then caused a rise in wages.
    Germany was able to sustain its competitiveness by
    improving its productivity while controlling the rise in
    wages to a minimal level after the reunification.

23  PRC is well known for labour endowment and specialisation
    in labour intensive production with low wages, while Japan
    is famous for its technological based capital-intensive
    production.

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