Return and Volatility Spillovers Between the US, Japanese and Malaysian Stock Markets

(Limpahan Pulangan dan Volatiliti antara Pasaran Saham Amerika Syarikat, Jepun dan Malaysia)

Lida Nikmanesh
Abu Hassan Shaari Mohd Nor
Tamat Sarmidi
Hawati Janor
(Faculty of Economics and Management, Universiti Kebangsaan Malauysia)

ABSTRACT

The present study investigates the return and volatility spillover between the stock markets of the US, Japan and Malaysia using weekly data concerning the S&P 500, NIKKEI 225 and KLCI composite indices from January 1990 to May 2013. Employing a cross-correlation function method, the results show that a unidirectional causality-in-mean exists from the stock markets of the US and Japan to the Malaysian stock market. Malaysian stock returns immediately react to the shocks received from the stock markets of the US and Japan and the reaction continues for 12 weeks. The causality-in-variance test shows that the volatility of the Malaysian stock market is more affected by the US stock market than the Japanese stock market. Similarly, the variance-causality test shows that the speed of variance spillover from the US stock market to the Malaysian stock market is high; and is significant from the first week. The results from the present study are relevant for fund managers and investors when making investment decisions that involve the consideration of risk and return elements; for policy makers to monitor the financial market stability; and for hedgers to forecast risk and develop hedging strategies.

Keywords: Causality in mean; causality in variance; spillovers; stock market volatility; structural break in variance

ABSTRAK

Kertas ini mengkaji limpahan pulangan dan volatiliti antara pasaran saham Amerika Syarikat, Jepun dan Malaysia menggunakan data mingguan indeks komposit S&P 500, NIKKEI 225 dan Indeks Komposit Kuala Lumpur (KLCI) bagi Januari 1990 hingga Mei 2013. Melalui kaedah fungsian korelasi bersilang, hasil kajian mendapati wujudnya hubungan satu arah sebab akibat dalam min pulangan saham dari Amerika Syarikat dan Jepun terhadap pulangan saham Malaysia. Pulangan saham Malaysia menunjukkan reaksi segera terhadap kejutan dari Amerika Syarikat dan Jepun dan reaksi tersebut berlarutan sehingga 12 minggu. Hasil ujian sebab akibat dalam varians pula mendapati volatiliti pasaran Malaysia lebih dipengaruhi oleh Amerika berbanding Jepun. Begitu juga daripada hasil ujian sebab akibat dalam varians yang menunjukkan kesan signifikan bermula dari minggu satu bermakna limpahan varians dari pasaran Amerika Syarikat terhadap Malaysia adalah lebih laju. Hasil kajian ini relevan kepada pengurus dana dan pelabur dalam pembuatan keputusan pelaburan aset kewangan yang mementingkan pulangan dan risiko; pembuat polisi dalam mengawal kestabilan pasaran kewangan dan pelindungnilai dalam meramal risiko dan membentuk strategi lindungnilai.

Kata kunci: Hubungan sebab akibat dalam min; hubungan sebab akibat dalam varians; limpahan; pasaran saham volatiliti; perubahan struktur dalam varian

INTRODUCTION

Financial markets play a prominent role in economic growth and development by encouraging the accumulation of capital and facilitating the link between savers and investors for efficient capital allocation. Financial market volatility, particularly stock market volatility, may harm the smooth functioning of economic systems (Merton & Bodie 1995; Mala & Reddy 2007). Volatility, which is measured by the conditional standard deviation of the underlying asset return, denotes the risk and uncertainty of financial assets (Tsay 2010; Brooks 2008). The analysis of volatility among stock markets is an interesting and important subject in modern financial literature because stock market volatility directly affects stock pricing,

investing and economic performance. On the other hand, a stable stock market indicates stability in the economy of that particular country and will thereby attract investment to the country (Sharpe 1964; Lintner 1965; Gee & Karim 2010). Therefore, the importance of exploration to determine the sources of volatility in financial markets cannot be denied.

The subject of stock market volatility in emerging markets has attracted the attention of international portfolio managers in recent years because emerging markets provide opportunities for portfolio diversification; and a high rate of return for investors due to the risky nature of such markets (Gee & Karim 2010). The Malaysian stock market has attracted the attention of portfolio manager because Malaysia, which is deemed to be an emerging

market, has been in the process of implementing financial reforms[1] in recent decades to promote economic efficiency and to facilitate cross-country investing (Beirne et al. 2009; Wang et al. 2012).

In the age of globalization and financial liberalization, economies have become increasingly integrated due to information transmission and the elimination of the obstacles in international trade and capital investment (Wang et al. 2012; Karim & Gee 2006). Following the 1998 Asian financial crisis, the integration between financial markets increased the interdependency between stock markets through two channels: returns spillover and volatilities spillover (Wang et al. 2012).

Many studies observe that most stock markets are influenced by two principal stock markets: the US stock market and the Japanese stock market (see e.g. Gee & Karim 2010; Miyakoshi 2003; Ozdemir et al. 2009; Beirne et al. 2010; Sidek & Abdul-Rahman 2011; Wang et al. 2012). Investigating the spillover effects running from US and Japanese stock markets to the Malaysian stock market is important because the US and Japan are the largest trading partners of Malaysia and are the top two countries in terms of investment in Malaysia (http://www.state.gov/e/eb/rls/othr/ics/2013/204686.htm). Therefore, the present study investigates the mean and volatility spillover effects from the two major stock markets (i.e., the US stock market and the Japanese stock market) to the Malaysian stock market.

Extant studies that investigate volatility spillover from the US and Japanese stock markets to the Malaysian stock market generally employ multivariate GARCH modeling and Granger causality tests to investigate the issue. However, the cross correlation function (CCF) approach proposed by Cheung and Ng (1996) and Hong (2001) has certain advantages in comparisons with multivariate GARCH modeling and Granger causality tests. By employing the Monte Carlo simulation, Cheung and Ng (1996) demonstrate that the US approach is more robust regarding nonsymmetrical and leptokurtic errors than other causality-in-variance alternatives. Furthermore, Cheung and Ng (1996) find that the CCF statistics are asymptotically robust in distributional assumptions. On the other hand, the CCF approach has further advantages over Granger causality tests due to the fact that the CCF approach allows for non-linearity in causality, while Granger causality tests only detect linear causal relationships between variables. Furthermore, the results generated by Granger causality tests are sensitive to the choice of lag length (Jones 1989; Urbain 1989).

Another principal weakness relating to the models employed by extant studies that investigate spillover effects from the US and Japanese stock markets to the Malaysian stock market is that the existence of structural breaks in variance are effectively ignored in such studies. The volatility of financial time series is popularly estimated using the generalized autoregressive conditional heteroskedasticity (GARCH) method. However, the parameters of GARCH models are typically overestimated

if structural breaks in variance are present (Van Dijik et al. 2005; Rodrigues & Rubia 2007). Therefore, the presence of structural break in variance should be determined before estimating GARCH models.

The present study makes the following contributions. First, the current study is the first study to apply the CCF approach developed by Cheung and Ng (1996) and Hong (2001) to investigate return and volatility spillover from the US and Japanese stock markets to the Malaysian stock market. The CCF methodology overcomes the limitations associated with the multivariate GARCH method and Granger causality tests. Furthermore, the CCF approach allows for the investigation of how fast the spillover from one market is absorbed in another market; and the investigation of the persistency of shocks between the markets. Second, since the sample period under investigation in the present study is of considerable length and includes two significant financial crises (i.e., the Asian financial crisis and global financial crisis), it is plausible to consider the effect of structural breaks in variance in the model. Therefore, the present study uses the test developed by Sanso et al. (2004) to identify the structural break points in variance in the return series. The effects of structural breaks in variance are eliminated from the GARCH models by constructing a dummy variable corresponding to each breakpoint in the GARCH model. Third, the results also contribute to theoretical literature explaining the existence of a spillover phenomenon in international financial markets, which contradicts the efficient market hypothesis (EMH) theory. Finally, the present study takes into account the effect of causality-in-mean when testing causality-in-variance.

The remainder of the present paper is organized as follows. Section 2 presents theoretical and empirical literature relating to the present study. Section 3 discusses the data and methodology employed in the present study. Section 4 describes the data and the results of the study. Finally, the broader reaching conclusions and implication are presented in Section 5.

LITERATURE REVIEW

Classical financial theory is premised upon the efficient market hypothesis (EMH), which argues that no spillovers exist between markets because assets are 'informationally efficient' and all available information is fully reflected in security prices. The general idea of EMH is that the price of assets in an efficient market includes all available and related information so individuals cannot consistently obtain returns higher than average market returns on a risk-adjusted basis. EMH assumes that investors are rational and that new information is available for traders, resulting in an absence of bias to estimate asset prices from the accurate prices. Therefore, the asset prices of an efficient market move toward equilibrium quickly after any market shock.

While EMH maintains that no spillover exist between markets, scholars have pointed to factors that can be utilized to explain the existence of spillover phenomenon. First, different markets may reflect the same information at different speeds because of market imperfections (Kyle 1985). Second, the market needs time to react to foreign information since domestic investors can only access foreign market information after trading (Admati & Pfleiderer 1988). Furthermore, some alternative explanations for spillover phenomenon between markets are developed based upon behavioral financial theory, which assumes that the information and the characteristics of market participants systematically affect individual investment decisions and market outcomes (Fung et al. 2010).

Alongside the theoretical explanations, the existence of spillover phenomenon is proven in several empirical studies. Following the 1987 crisis in the US, the number of studies regarding financial integration increased. Hamao et al. (1990) examine volatility transmission between the stock markets of the US, the UK and Japan using a GARCH model. The results indicate significant volatility spillover running from the US and UK stock markets to the Japanese stock market. Furthermore, Cheung and Ng (1996) utilized a novel method. Employing the CCF method developed by Cheung and Ng (1996), which is based upon the CCF test and investigates the causality-in-mean and causality-in-variance between series, Hu et al. (1997) demonstrate that US stock market volatility is affected by Japanese stock market volatility. After increasing openness in emerging stock markets, scholars began to more frequently examine spillover among such markets, especially after financial crises spread from emerging markets to other countries during the Asian financial crisis (Beirne et al. 2009).

Although a number of studies exist that utilize the CCF approach to investigate return and volatility spillover between stock markets (Constantinou et al. 2006; Korkmaz et al. 2012; Papiez & Smiech 2013; Yang & Hamori 2013; Inagaki 2007), most extant studies examining the effects of international stock markets on Asian markets employ the multivariate GARCH method and Granger causality test. For example, Ng (2000) employs a bivariate GARCH model and explains that the Pacific Basin region is influenced by both the US and Japan stock markets. The findings indicate that the shocks from the US stock market are more influential than those of Japanese stock market in the case of Malaysian stock market. Furthermore, Miyakoshi (2003), utilizing a different bivariate GARCH model than Ng (2000), detects that the volatilities of Asian stock markets are affected more by the Japanese stock market than the US stock market. Cheong et al. (2007) investigate the effect of the US stock market on the eight sectoral indices in Malaysia using the asymmetric component GARCH (CGARCH) and Granger causality method through a vector autoregression (VAR) model. The study finds a significant volatility spillover from the overnight US stock market to some sectoral markets with both long and short persistence volatilities. Additionally, the conditional mean return in all sectors is affected significantly by the overnight US market. Using a VAR model, Yilmaz (2009) uses the forecast error variance decomposition from the VAR model and detects that East Asian equity markets are substantially affected by volatility in the US stock market. Gee and Karim (2010) utilize a multivariate EGARCH model and detect that the volatility of stock markets in ASEAN-5 countries are more affected by the US stock market than by the Japanese stock market. Furthermore, Wang et al. (2012) propose a method to measure the spillover index based on a VAR-structural-GARCH model and examine the spillover effect between the stock markets of US and nine Asian countries over the period of 1992 until 2012. The results reveal that the US stock market plays a prominent role in Asian financial market fluctuations. Furthermore, Japanese and Malaysian stock markets received the most spillovers from the US stock market during the 2008 global financial crisis.

As stated in the literature reviewed above, the models employed by extant studies investigating spillover effects from the US and Japanese stock markets to the Asian stock market are mostly based on multivariate GARCH modeling, Granger causality tests and VAR method (e.g., Cheong et al. 2007; Yilmaz 2009; Ng 2000; Miyakoshi 2003; Gee & Karim 2010). The Granger causality tests only detect the linear causal relationship between variables, however Cheong et al. (2007) uses the Granger causality test. Furthermore, while Cheong et al. (2007) and Yilmaz (2009) use VAR models, the results generated by VAR models are sensitive to the choice of lag length (Jones 1989; Urbain 1989). Meanwhile, although Ng (2000), Miyakoshi (2003) and Gee and Karim (2010) use multivariate GARCH models, Hafner and Herwartz (2006) indicate that the log-likelihood tests for multivariate models suffer from a curse of dimensionality.

Another weakness, which is related to the literature investigating the spillover effects from the US and Japanese stock market to the Asian stock markets, is that the effect of structural breaks in variance in GARCH models is effectively ignored in extant literature (e.g., Ng 2000; Miyakoshi 2003; Gee & Karim 2010). Rodrigues and Rubia (2007) argue that the parameters of GARCH models are overestimated in the presence of structural breaks in variance. Therefore, the presence of structural breaks in variance should be determined and eliminated from GARCH models during such examinations.

To the best of our knowledge, the effect of causality-in-mean is not filtered when estimating the causality-in-variance in literature concerning spillover effects from the US and Japanese stock markets to the Malaysian stock market. However, Cheung and Ng (1996) and Pantelidis and Pittis (2004) argue that the existence of causality-in-mean can have effect on the test for causality-in-variance, if the effects of causality-in-mean are not filtered out.

The present study contributes to the literature by utilizing the CCF approach developed by Hong (2001) to investigate the return and volatility spillover from the US and Japanese stock markets to the Malaysian stock market.

The CCF method allows for non-linearity in causality; is not sensitive to the choice of lag length; and fits powerfully to large lag data series. Furthermore, the present study takes into account the effect of possible structural breaks in the variance of series; and the effect of causality-in-mean when testing the causality-in-variance.

DATA AND METHODOLOGY

The purpose of the present study is to estimate the presence of return and variance causality between the US, Japanese and Malaysian stock markets. The analysis of causality is conducted using weekly data concerning the S&P 500 COMPOSITE – PRICE INDEX (USA); the NIKKEI 225 STOCK AVERAGE – PRICE INDEX (Japan); and the FTSE BURSA MALAYSIA KLCI – PRICE INDEX (Malaysia). The data covers the period from January 1990 to May 2013, which includes 1217 observations. The weekly data are employed to avoid problems associated with non-synchronous data due to noise with higher frequencies, such as daily data. The returns in all series are obtained by taking the log difference of the prices ($R_t = \ln P_t - \ln P_{t-1}$) where is the return at time t on the stock markets; is the current monthly price; and P_{t-1} is the price during the previous month. All data are collected from Thomson Reuters Data Stream.

CROSS-CORRELATION FUNCTION (CCF) METHOD

The existence of causal relationship between series is typically examined by employing the causality test developed by Granger (1969). According to Granger's definition of causality, variable X Granger causes variable Y if X contains unique information about Y and past changes in X cause changes in the current Y. Although this definition of causality is general for both first and second moment of series, the Granger causality test is traditionally employed to investigate causal relationships in the first moment (return) of series.

Cheung and Ng (1996) extend the definition of causality to the second moment (volatility) of variables as follows. Assuming two stationary and *ergodic* series X_t and Y_t, Y_t are said to cause X_{t+1} in variance if:

$$E\{(X_{t+1} - \mu_{x,t+1})^2 | I_t\} \neq E\{(X_{t+1} - \mu_{x,t+1})^2 | J_t\} \qquad (1)$$

where I_t and J_t are two information sets that are defined as:

$$I_t = \{X_{t-j}, j \geq 0\}, J_t = \{X_{t-j}, Y_{t-j}, j \geq 0\} \qquad (2)$$

and $\mu_{x,t+1}$ is the mean of X_{t+1} conditioned on the I_t information set.

In a similar manner, the causality-in-mean running from Y_t to X_{t+1} is defined as:

$$E\{X_{t+1} | I_t\} \neq E\{X_{t+1} | J_t\} \qquad (3)$$

Causality-in-variance provides additional information concerning the economic and financial time series since the changes in variance are associated with information arrival (uncertainty) and reflect the extent to which markets evaluate the value of new information.

The method introduced by Cheung and Ng (1996) is a two-step procedure that is conducted to detect causality-in-mean and causality-in-variance between series. In the first step, the GARCH model is fitted to both selected series to obtain the standardized residuals of each series. Then the *S* statistic introduced by Cheung and Ng (1996) is calculated using the M sample CCF between the standardized residuals to test the existence of causality-in-mean. Similarly, the M sample CCF is estimated between the squared standardized residuals to detect the causality-in-variance between series. The *S* statistic for causality-in-mean (or causality-in-variance) is based upon the summation of the first M squared correlations and presented as follows:

$$S = T \sum_{j=1}^{M} \hat{\rho}_{uv}^2(j) \qquad (4)$$

where T is sample size and $\hat{\rho}_{uv}$ is the sample cross-correlation between the standardized residuals (or squared standard residuals) obtained from the GARCH model for series x and y. S is asymptotically χ_M^2 distributed under the null hypothesis of no causality-in-mean (or no causality-invariance).

Hong (2001) argues that the *S* statistic introduced by Cheung and Ng (1996) is not efficient in a large lag order because it gives equal weighting to each M sample cross-correlation. However, in financial time series, recent past volatility exerts more influence on current volatility than distance past volatility due to the clustering features of volatility series. Therefore, the cross-correlation between series decreases to zero when the lag order increases.

In order to resolve the issue, Hong (2001) adjusted the *S* statistic using a non-uniform kernel weighting function. Hong (2001) introduced two modified statistics (i.e., Q_1 and Q_2) for detecting mean and variance causality. To test the causality-in-mean, the Q_1 statistic is defined as follows:

$$Q_1 = \frac{T \sum_{j=1}^{T-1} k^2\left(\dfrac{j}{M}\right) \hat{\rho}_{uv}^2(j) - C_{1T}(k)}{\sqrt{2D_{1t}(k)}} \qquad (5)$$

where,

$$C_{1t}(k) = \sum_{j=1}^{T-1} (1 - j/T) k^2(j/T); \text{ and} \qquad (6)$$

$$D_{1t}(k) = \sum_{j=1}^{T-1} (1 - j/T)\{1 - (j+1)/T\} k^4(j/M) \qquad (7)$$

M is the lag order, which is a predetermined positive integer; and $k\left(\dfrac{j}{M}\right)$ is the weighting function, which, in the case of Bartlett kernel[2], is defined as:

$$k(j/M) = \begin{cases} 1 - |j/(M+1)| & if \ |j/M| \leq 0 \\ 0 & otherwise \end{cases} \qquad (8)$$

The Q_2 statistics is similarly obtained using the CCF between the centered squared standardized residuals. Q_1 and Q_2 are compared with the upper-tailed critical value of N(0,1). If the computed values of Q_1 and Q_2 are larger

than the upper-tailed critical value, the null hypotheses of no causality in mean and no causality in variance are rejected.

The results of the CCF method rely on the correct specifications of the GARCH model employed. As determined by Javed and Mantalos (2011), the result of causality-in-variance test is extremely sensitive to the parameters of the GARCH model. However, the existence of structural breaks in variance requires changing the size of the parameters of GARCH model (Rodrigues & Rubia 2007). Therefore, the return series in the present study are tested to detect the structural break points in variance utilizing the test developed by Sanso et al. (2004).

STRUCTURAL BREAKS IN VARIANCE

Inclan and Tiao (1994) suggest a procedure to detect the structural breaks in unconditional variance. When testing the null hypothesis "constant unconditional variance" against the alternative hypothesis "existence of a break in the unconditional variance," Inclan and Tiao (1994) suggest the use of the following statistic (i.e., IT):

$$IT = \sqrt{T/2D_k} \qquad (9)$$

where $D_k = (C_k/C_T) - (k/T)$; and $C_k = \sum_{t=1}^{k} \varepsilon_t^2$ is the cumulative sum of squares of a series of uncorrelated random variables with mean 0 and variance σ_t^2, when $t = 1,2,3,\ldots T$. The critical value of the IT statistic is $C_{0.05} = 1.358$ at the 5% level, which is calculated by Inclan and Tiao (1994).

A problem attributed to IT statistics is that the distributions of random variables are assumed to be independent and identical. To overcome the problem, Sanso et al. (2004) modify the IT statistic and demonstrate that the new test outperforms the original IT statistic. Two statistics are introduced by Sanso et al. (2004). The first statistic, the Kappa-1 (K_1) statistic, is suitable when the assumption of normality does not hold. The K_1 statistic is provided as follows:

$$K_1 = \sup_k |T^{-1/2} B_k| \qquad (10)$$

where,

$$B_k = \frac{C_k - \frac{k}{T} C_T}{\sqrt{\hat{\eta}_4 - \hat{\sigma}^4}}; \qquad (11)$$

$$\hat{\eta}^4 = T^{-1} \sum_{t=1}^{T} \varepsilon_t^4; \text{ and} \qquad (12)$$

$$\hat{\sigma}^2 = T^{-1} C_t. \qquad (13)$$

The second statistic is the Kappa-2 (K_2) statistic, which is suitable when the assumption of normality does not hold and the ARCH effect exists. The K_2 statistic is provided as follows:

$$K_2 = \sup_k |T^{-1/2} G_k| \qquad (14)$$

where $G_k = \hat{\omega}_4^{-1/2} \left(C_k - \frac{k}{T} C_T \right)$; and $\hat{\omega}_4$ is a consistent estimator of ω_4. The non-parametric estimator of ω_4 is provided as follows:

$$\hat{\omega}_4 = \frac{1}{T} \sum_{t=1}^{T} (\varepsilon_t^2 - \hat{\sigma}^2)^2 + \frac{2}{T} \sum_{l=1}^{m} \omega(l,m) \sum_{t=l+1}^{T} \qquad (15)$$
$$(\varepsilon_t^2 - \hat{\sigma}^2)(\varepsilon_{t-1}^2 - \hat{\sigma}^2)$$

where $\omega(l,m)$ is a lag window, such as the Bartlett window, which is defined as $\omega(l,m) = 1 - l/(m + 1)$.

EMPIRICAL RESULTS

The objective of the present study is to investigate the effects of the return and volatility of the US and Japan stock markets on the Malaysian stock market. Firstly, the summary descriptive statistics, using weekly data of returns concerning the S&P 500, the NIKKEI 225 and the KLCI, are presented in Table 1. As demonstrated in Table 1, the mean of the return series varies between -0.08 and 0.121. The lowest mean return occurs in the case of the Japanese stock market, which obtains a negative value. On the other hand, the US stock market yields the highest mean return and lowest standard deviation during the period under investigation. The Malaysian stock market has the highest standard deviation, which is common phenomenon for emerging markets that are characterized by higher volatility.

All return series show evidence of excess kurtosis, which indicates that they have a fatter tail distribution than the normal distribution. The US and Japan stock returns are negatively skewed, which indicates that the left side of return series is fatter than the right side in these stock markets. The Jarque-Bera normality test rejects the null hypothesis of normality for all return series. The Ljung-Box statistics indicate that serial correlation exists in all return series and squared return series up to lag 20. Based upon the results of Ljung-Box statistics, the ARCH-type model is appropriate for analyzing the series under investigation. The significant autocorrelations in squared return series also exhibit volatility clustering. The results of the Augmented Dickey-Fuller (ADF), Phillips-Peron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root tests indicate that all return series are stationary.

Figure 1 depicts the visual pattern of the return series concerning the S&P 500, the NIKKEI 225 and the KLCI during the sample period. As demonstrated in Figure 1, the returns of the S&P 500 and the NIKKEI 225 show high fluctuations during the 2008 global financial crisis, while KLCI returns show high fluctuations during the 1998 Asian financial crisis.

Table 2 shows the results of the variance break tests, which are conducted using the Sanso et al. (2004) test on the return series of the KLCI, the NIKKEI 225 and the S&P 500. The Kappa-1 statistics suggest 6 break points in variance for the KLCI. However, the Kappa-2 statistics suggest 3 break points for KLCI returns. The IT test cannot

TABLE 1. Descriptive statistics for weekly return series

	S&P 500	NIKKEI 225	KLCI
Mean	0.121958	-0.085192	0.088831
Std. dev.	2.301350	3.127936	3.157228
Skewness	-0.608323	-0.351148	0.315699
Kurtosis	7.435078	5.892063	12.86358
Jarque-Bera	1072.488(0.0000)	449.1364 (0.0000)	4953.636(0.0000)
Q(20)	39.369(0.006)	29.493(0.078)	48.612(0.000)
$Q^2(20)$	338.66(0.000)	15639(0.000)	466.03(0.000)
ADF	-37.66***	-35.56***	-33.84***
PP	-37.62***	-35.56***	-34.20***
KPSS	0.17***	0.22***	0.053***

Note: ADF indicates Augmented Dickey-Fuller test under null hypothesis of existence of unit root. PP indicates Phillips-Peron unit root test under the null hypothesis of existence unit root. KPSS indicates Kwiatkowski-Phillips-Schmidt-Shin unit root test under the null hypothesis of being stationary. Q(20) and $Q^2(20)$ are the Ljung-Box statistics for return and squared return series. The numbers in parenthesis show the p-value. In Table 1, '***' denotes 'stationary at the 1% level.'
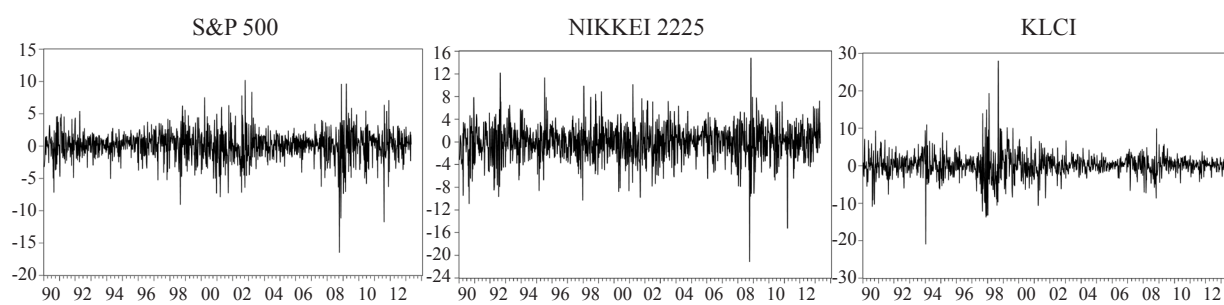

FIGURE 1. Return series

TABLE 2. Variance break test

Variable	Sanso et al. (2004) Kappa-1		Sanso et al. (2004) Kappa-2	
The return of	No. of breaks	Break dates	No. of breaks	Break dates
KLCI	6	7/30/1997 8/18/1999 11/21/2001 7/7/2004 1/10/2007 5/6/2009	3	7/30/1997 11/25/1998 11/21/2001
NIKKEI225	0		0	
S&P500	7	4/15/1992 12/13/1995 7/22/1998 7/2/2003 7/11/2007 9/10/2008 7/15/2009	1	4/15/1992

Note: Dates are formatted as mm/dd/yyyy.

detect any structural breaks in variance for the NIKKEI 225. In the case of the S&P 500, the Kappa-1 statistics suggest the existence of 7 break points, while the Kappa-2 statistics suggest the existence of 1 break point in variance. Based upon the results detected by the IT test, a dummy variable is constructed and accounts for each break point in the variance equation of the GARCH model. In this manner, the effects of structural breaks in variance are eliminated from the model. This is consistent with the practice in other studies (e.g., Rapach & Strauss 2008; Ewing &

Malik 2010; Korkmaz et al. 2012). Furthermore, using dummy variables helps to determine which break point is statistically significant in the variance equation.

Table 3 presents the result of estimation GARCH family in all return series. The selected models are chosen based upon the Akaike information criterion, Schwartz criterion and log likelihood values. AR(1)-GARCH(1,1) for the S&P 500; GARCH(1,1) for the NIKKEI 225; and AR(1)-GARCH(1,1) for the KLCI are found to be sufficiently adequate models for volatility. The EGARCH and GARCH-in-mean models are also implemented to detect the presence of leverage effects and GARCH in mean for the return series, but these models are not found to be sufficiently adequate. Ljung-Box statistics show that no serial correlation exists up to lag 20 in all series, which justifies the fitted GARCH model. The coefficient of AR terms for the S&P 500 and the KLCI are statistically significant at the 1% level and 10% level, respectively. ARCH and GARCH coefficients are strongly significant in all series. In addition, the parameter, which

illustrates the persistence in volatility, is more than 0.9 for all series, indicating that the response of markets to shocks decays at a slow rate. Furthermore, shock persistency obtains the highest value in the case of the KLCI and the lowest value in the case of the NIKKEI 225. The break points in variance suggested by the IT test are included as dummy variables in the variance equations of the GARCH model for the KLCI and the S&P 500 series. The coefficient of the dummy variables corresponding to September 2008 is found to be significant at the 5% level for the S&P 500. The time coincides with the global financial crisis initiated by the subprime crisis and the Reiman crisis in the US. Therefore, it is reasonable to consider a structural change in volatility at this time. Furthermore, the dummy variable corresponding to November 1998 is significant at the 1% level for the KLCI series. The finding must be the result of the Asian financial crisis which gripped much of East Asian beginning in 1997.

TABLE 3. ARCH-GARCH model results

	S&P 500	NIKKEI 225	KLCI
	AR(1)-GARCH(1,1)	GARCH(1,1)	AR(1)-GARCH(1,1)
AR(1)	-0.128(0.0001)	-	0.050(0.0958)
ARCH(α)	0.106(0.0000)	0.112(0.0000)	0.121(0.0000)
GARCH(β)	0.862(0.0000)	0.788(0.0000)	0.876(0.0000)
Dum(9/10/2008)	77.738(0.0313)	-	-
Dum(11/25/1998)	-	-	-34.093(0.0633)
$\alpha + \beta$	0.96	0.90	0.99
Log-likelihood	-2583.377	-3055.509	-2828.351
Q(20)	17.379(0.564)	27.249(0.128)	23.162(0.230)
Q^2(20)	8.810(0.977)	15.029(0.775)	15.981(0.718)

Note: The numbers in parenthesis show the *P*-value. Q(20) and Q^2(20) show the Ljung-Box statistics for return and squared return series. Dum stands for a dummy variable related to a structural break in variance.

Figure 2 demonstrates the graphical pattern of volatility series concerning the S&P 500, the NIKKEI 225 and the KLCI during the sample period. The volatilities of the S&P 500, the NIKKEI 225 and the KLCI indicate a constant trend during the sample period. However, the

volatilities of the S&P 500 shows a sharp rise during the 2008 global financial crisis, while KLCI volatility increases during the 1998 Asian financial crisis, which is consistent with the results of the structural break points tests.
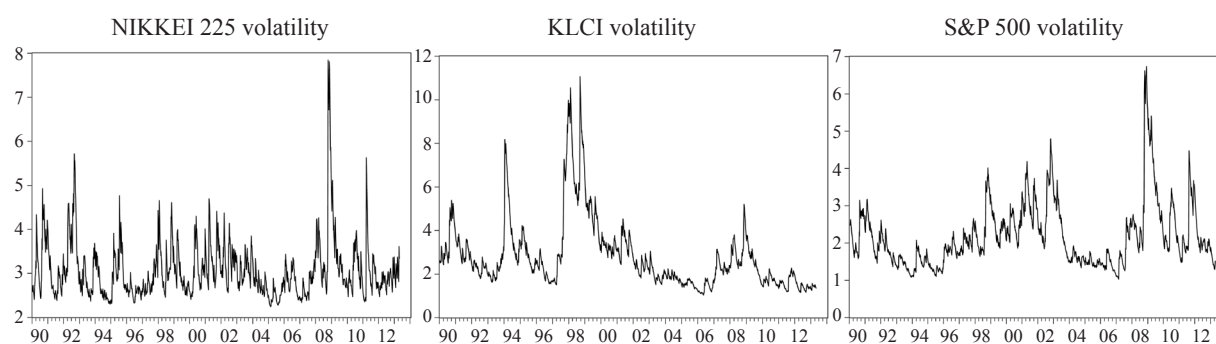

FIGURE 2. Volatility series

Next, the causal relationship between the KLCI, the NIKKEI 225 and the S&P 500 is determined utilizing the CCF method introduced by Hong (2001). In order to investigate the causality-in-mean, the standardized residuals obtained from GARCH models are employed in the test procedure. The present study computes the test statistics for one week (M = 1); two weeks (M = 2); one month (M = 4); and three months (M = 12). The results of causality-in-mean between series are provided in Table 4. Malaysian stock returns are found to be strongly affected by the stock returns of the US and Japanese stock markets. However, the value of the CCF is higher in the case of return spillover from the US stock market to the Malaysian stock market (9.13) when compared against the return spillover from the Japanese stock market to the Malaysian stock market (3.45). This result is consistent with the results of Ng (2000); Miyakoshi (2003); Gee and Karim (2010) and Wang et al. (2012). The result may be attributed to the world-wide market power of the US. Additionally, according to the Malaysian Investment Development Authority (MIDA), the US and Japan are the top countries investing in Malaysia with the US being the larger investor of the two (http://www.state.gov/e/eb/rls/othr/ics/2013/204686.htm).

However, no evidence exists of return-causality from the Malaysian stock market to the US and Japanese stock markets. Therefore, a unidirectional causality-in-mean from US and Japanese stock returns to Malaysian stock returns exists. The reason that Malaysian stock returns do not affect the returns of US and Japanese stock markets

may stem from the fact that the period under investigation in the present study includes capital control, which was imposed by the Malaysian government to protect the country from the contagion effect of the Asian financial crisis. Malaysian capital control began in September 1998 and included both exchange controls and limitations on outflows from portfolio investment (Kaplan & Rodrik 2002).

In addition, as reported in Table 4, the results of the present study indicate that the US stock market exerts cause-in-mean on the Japanese stock market. The result may be due to the world-wide market power of the US. The speed of return spillover effects from the US stock market to the Malaysian and Japanese stock markets; and from the Japanese stock markets to the Malaysian stock market are so fast that the effects are statistically significant from the first week (M = 1). The reactions persist for 12 weeks (M = 12).

The causality-in-variance is conducted by employing the squared standardized residuals described in Section 2. As stated by Cheung and Ng (1996), and later by Pantelidis and Pittis (2004), the existence of causal relationships in the mean between two series affects the results of testing causality-in-variance. For filtering such effects, Gebka and Serwa (2007) suggest including the lagged return of series 'i,' which exerts cause-in-mean on series 'j,' in the mean equation of the GARCH model for series 'j.' Using the results presented in Table 4, the three causality-in-mean effects must be filtered before estimating the causal relationship in variance.

TABLE 4. Causality in mean

Causality direction	M = 1	M = 2	M = 4	M = 12
Malaysia → US	-0.2827	-0.2827	-0.0153	-0.2993
Malaysia → Japan	-0.4028	-0.4028	-0.4284	-0.4130
US → Malaysia	9.3424***	9.3424***	9.3995***	9.3207***
US → Japan	6.1635***	6.1635***	5.9757***	6.1669***
Japan → Malaysia	3.5993***	3.5993***	4.1645***	3.5956***
Japan → US	-0.6651	-0.6651	-0.7624	-0.6564

Note: *** indicate that causal relationship is significant at 1% level. M represents the number of weeks.

The result of causality-in-variance is reported in Table 5. According to the results, no causality in variance running from the Malaysian stock markets to the US and Japanese stock markets exists. The US stock market has a significant causal-in-variance effect on the Malaysian stock market. However, no evidence is found concerning the effect of the Japanese stock market on Malaysian stock market volatility, which indicates that volatility spillover from US plays a more important role in stock market volatility in Malaysia. The result is consistent with the result of studies performed by Ng (2000), Gee and Karim (2010), Cheong et al. (2007) and Wang et al. (2012). The result may be attributed to the fact that US has a higher level of investment in Malaysia than Japan (http://www.state.gov/e/eb/rls/othr/ics/20 13/204686.

htm). The result can also be related to the time difference of opening and closing hours between the US stock market and the Malaysian stock market. At the time of opening Malaysian stock market, the news coming from US stock market, which has closed after Malaysian stock market, can affect Malaysian stock market volatility.

Although no evidence of causal-in-variance effects from the US stock market to the Japanese stock market exists, the causal-in-variance effects from the Japanese stock market to the US stock market is found to be statistically significant. The result is consistent with the results of Hu et al. (1997). No feedback (bidirectional causality) relationship is found between the stock markets of US, Japan and Malaysia in both causality-in-mean and causality-in-variance. Similar to return-causality, the

TABLE 5. Causality in variance

Causality direction	M = 1	M = 2	M = 4	M = 12
Malaysia → US	-0.6891	-0.6891	-0.7943	-0.6456
Malaysia → Japan	-0.5934	-0.5934	-0.4945	-0.6093
US → Malaysia	6.2871***	6.2871***	6.1062***	6.2698***
US → Japan	-0.5934	-0.5934	-0.4945	-0.6093
Japan → Malaysia	-0.5934	0.1099	0.1820	0.0998
Japan → US	4.1004***	4.1004***	4.1296***	4.0836***

Note: *** indicate that causal relationship is significant at the 1% level. M represents the number of weeks.

variance spillover is absorbed by the markets so fast that it is significant in the first lag. The reaction persists for 12 weeks (M = 12).

In general, the results of the present study provide evidence of a spillover phenomenon between international financial markets. The results contribute to theoretical literature explaining the existence of spillover phenomenon in international financial markets, the existence of which is not supported by EMH theory.

SUMMARY AND CONCLUSION

In the era of extensive globalization, financial markets have become more integrated. Therefore, shocks and movements in one financial market not only affect that market, but are also transmitted to other financial markets. With respect to the importance of financial stability and its effect on economic growth and development, examinations of the spillover effect between financial markets has become an interesting topic for researchers in modern financial literature.

Several studies investigate return and volatility spillover effects from the US and the Japanese stock markets to other stock markets in the world. However, the results of such studies vary due to the use of different methodologies and sample periods. The CCF approach introduced by Cheung and Ng (1996) and Hong (2001) has certain advantages over the methodologies that are typically used to investigate spillover effects between international financial markets. The CCF test of Hong (2001) is powerfully fit for leptokurtic series with large sample sizes. Therefore, the present study employs the CCF method of Hong (2001) to investigate the return and volatility spillover from the stock market of the US and Japanese stock markets to the Malaysian stock market by allowing for the effect of structural breaks in variance in the series and eliminating the effects of such breaks from the model.

The major empirical findings of the present study clearly indicate the degree of integration between the Malaysian stock market and the US stock market. The results show that the Malaysian stock market is more sensitive to, and follows, the stock market of the

UScompared against the Japanese stock market. The speed of variance spillover from the US stock market to the Malaysian stock market is as fast as it is significant from the first week. No evidence of feedback relationship in mean or variance is detected between the US stock market and the Malaysian stock market; and between the Japanese stock market and the Malaysian stock market. The findings of the present study may stem from several factors. First, although both the US and Japan are major trading partners of Malaysia, the US has a higher level of investment in Malaysia than Japan (http://www.state.gov/e/eb/rls/othr/ics/20 13/204686.htm). Second, the results may be related to the world-wild market power of the US stock market. Third, the results may stem from the time difference of opening and closing between the US stock market and the stock markets of Asian countries. The results of the present paper contribute to theoretical literature explaining the existence of spillover phenomenon in international financial markets and contradict EMH theory, which argues that no spillover exists between markets.

The findings of the present study provide preliminary insights about the risk and return elements for fund managers and investors when making investment decisions. The findings imply that investors and fund managers can gain greater profits in the Malaysian stock market using signals running from the markets that open sooner than the Malaysian stock market. International investors seeking to profit from Malaysian stock returns should pay attention to the US stock market before making investment decisions. Furthermore, it is advisable for hedgers to consider information relating to US stock market volatility when engaging in risk forecasting and developing their hedging strategies.

The results are also useful for policy makers monitoring the stability of financial markets by providing insights about volatility spillovers and risk transmission between the US and Malaysian stock markets. A policy maker should expect strong return and volatility spillover effects from the US stock market to the Malaysian stock market. Hence, it is advisable for policy makers and those concerned about Malaysian economic development and stock market to heed the fluctuations of the US stock market, as well as the drifts in the American policies that may exert considerable impacts on the US stock market.

ENDNOTES

[1]   The globalization of financial markets has increased the integration of financial market, which, in turn, has resulted in increased risks that need to be effectively managed. During the 1980s, Malaysia began to adopt financial reforms involving the process of structural deregulations; and prudential reregulation and liberalization of the financial system in order to address the concerns associated with the inherent risks associated with emerging markets. The result of the reforms, thus far, include the emergence of a financial systems that is more stable and competitive; comprised of a wider public choice of financial instruments and institutions; and more effective conduct in accordance with monetary policy promulgated by the central bank (Gerard et al. 1996).

[2]   Hong (2001) shows that the same results are generated using deferent non-uniform kernels, thus the Bartlett kernel is utilized in the present study.

REFERENCES

Admati, A.R. & Pfleiderer, P. 1988. A theory of intraday patterns: Volume and price variability. *The Review of Financial Studies* 1: 3-40.

Beirne, J., Caporale, G.M., Schulze-Ghattas, M. & Spagnolo, N. 2009. Global and regional spillovers in emerging stock markets: A multivariate GARCH-in-mean analysis. Brunel University West London. Working Paper 09-34.

Brooks, C. 2008. *Introductory Econometrics for Finance*. Cambridge: Cambridge University Press.

Cheong, C.W., Md Nor, A.H.S. & Isa, Z. 2007. Long persistence volatility and links between national stock market indices. *International Research Journal of Finance and Economics* 7: 175-195.

Cheung, Y.W. & Ng, L.K. 1996. A causality-in-variance test and its application to financial market prices. *Journal of Econometrics* 72(1-2): 33-48.

Constantinou, E., Georgiades, R., Kazandjian, A. & Kouretas, G.P. 2006. Mean and variance causality between the cyprus stock exchange and major equity markets. *Investment Management and Financial Innovations* 3(1): 104-119.

Engle, R.F. & Kroner, K.F. 1995. Multivariate simultaneous generalized ARCH. *Econometric Theory* 11(1): 122-150.

Ewing, B.T. & Malik, F. 2010. Estimating volatility persistence in oil prices under structural breaks. *The Financial Review* 45: 1011-1023.

Fung, A.K.W., Lam, K. & Lam, K.M. 2010. Do the prices of stock index futures in Asia overreact to U.S. market returns? *Journal of Empirical Finance* 17: 428-440.

Gebka, B. & Serwa, D. 2007. Intra- and Inter-regional spillovers between emerging capital markets around the world. *Res. Int. Bus. Finance* 21: 203-221.

Gee, S.C. & Karim, M.Z.A. 2010. Volatility spillovers of the major stock markets in ASEAN-5 with the U.S. and Japanese stock markets. *International Research Journal of Finance and Economics* 44: 156-168.

Granger, C.W.J. 1969. Investigating causal relations by econometric models and cross-spectral methods. *Econometrica* 37(3): 424-438.

Hafner, C.M. & Herwartz, H. 2006. A Lagrange multiplier test for causality in variance. *Economics Letter* 93(1): 137-141.

Hamao, Y., Masulis, R.W. & Ng, V. 1990. Correlations in price changes and volatility a cross International stock markets. *The Review of Financial Studies* 3(2): 281-307.

Hong, Y. 2001. A test for volatility spillover with application to exchange rates. *Journal of Econometrics* 103: 183-224.

Hu, J.W.S., Chen, M.Y., Fok, R.C.W. & Huang, B.N. 1997. Causality in volatility and volatility spillover effects between US, Japan and four equity markets in the South China Growth Triangular. *Journal of International Financial Markets, Institutions and Money* 7: 35l-367.

Inagaki, K. 2007. Testing for volatility spillover between the British pound and the euro. *Research in International Business and Finance* 21: 161-174.

Inclan, C. & Tiao, G.C. 1994. Use of cumulative sums of squares for retrospective detection of changes in variance. *Journal of the American Statistic Association* 89: 913-923.

Javed, F. & Mantalos, P. 2011. Sensitivity of the causality in variance test to the GARCH(1;1) parameters. Available at http://ssrn.com/abstract=1856055.

Jones, J.D. 1989. A comparison of lag-length selection techniques in tests of Granger causality between money growth and inflation: Evidence for the US, 1959-86. *Applied Economics* 21: 809-822.

Kaplan, E. & Rodrik, D. 2002. Did the Malaysian Capital Controls Work? In *Preventing Currency Crises in Emerging Markets*, edited by S. Edwards & J. A. Frankel, 393-440. Chicago: University of Chicago Press.

Karim, M.Z. & Gee, C.S. 2006. Stock market integration between Malaysia and its major trading partners (1994-2002). *Applied Econometrics and International Development* 6(3): 203-224.

Korkmaz, T., Çevik, E.I. & Atukeren, E. 2012. Return and volatility spillovers among CIVETS stock markets. *Emerging Markets Review* 13: 230-252.

Kyle, A.S. 1985. Continuous auctions and insider trading. *Econometrica* 53(6): 1315-1336.

Lintner, J. 1965. The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets. *Review of Economics and Statistics* 47(1): 13-37.

Mala, R. & Reddy, M. 2007. Measuring stock market volatility in an emerging economy. *International Research Journal of Finance and Economics* 8: 126-133.

Merton, R.C. & Bodie, Z. 1995. *A Conceptual Framework for Analysing the Financial Environment*. Boston: Harward Business School Press.

Miyakoshi, T. 2003. Spillovers of stock return volatility to Asian equity markets from Japan and the US. *Int. Fin. Markets, Inst. and Money* 13(4): 383-399.

Ng, A. 2000. Volatility spillover effects from Japan and the US to the Pacific–Basin. *Journal of International Money and Finance* 19(2): 207-233.

Özdemir, Z.A., Olgun, H. & Saracoglu, B. 2009. Dynamic linkages between the center and periphery in international stock markets. *Research in International Business and Finance* 23: 46-53.

Pantelidis, T. & Pittis, N. 2004. Testing for Granger causality in variance in the presence of causality in mean. *Economics Letters* 85: 201-207.

Papież, M. & Śmiech, S. 2013. Causality-in-mean and causality-in-variance within the international steam coal market. *Energy Economics* 36: 594-604.

Rapach, D.E. & Strauss, J.K. 2008. Structural breaks and GARCH models of exchange rate volatility. *Journal of Applied Econometrics* 23: 65-90.

Rodrigues, P.M.M. & Rubia, A. 2007. Testing for causality in variance under nonstationarity in variance. *Economics Letters* 97: 133-137.

Sanso, A., Arago, V. & Carrion, J.L. 2004. Testing for change in the unconditional variance of financial time series. *Revista de Economia Financiera* 4: 32-53.

Sharpe, W. 1964. Capital asset prices: A theory of market equilibrium under conditions of risk. *Journal of Finance* 19(3): 425-442.

Sidek, N.Z. M. & Abdul-Rahman, A. 2011. Spill-over effect of US Sub-Prime Crisis on ASEAN-5 stock markets. *International Review of Business Research Papers* 7(3): 207-217.

Tsay, R.S. 2010. *Analysis of Financial Time Series*. New Jersey: Wiley.

Urbain, J.P. 1989. Model selection criteria and Granger causality tests: An empirical note. *Economics Letters* 29: 317-320.

Van Dijk, D., Osborn, D.R. & Sensier, M. 2005. Testing for causality in variance in the presence of breaks. *Economics Letters* 89: 193-199.

Wang, Y., Liu, L. & Lu, G. 2012. Spillover effect in Asian financial markets: AVAR-structural GARCH Analysis. Available at http://ssrn.com/abstract=2140312.

Yang, L. & Hamori, S. 2013. Dynamic linkages among foreign exchange, stock, and commodity markets in Northeast Asian countries: Effects from two recent crises. *Journal of Reviews on Global Economics* 2: 278-290.

Yılmaz, K. 2009. Return and volatility spillovers among the East Asian equity markets. tüsiad-koç university economic research forum. Working Paper 0907.

Yusof, Z.A., Hussin, A.A., Alowi, I., Sing, L.C. & Singh, S. 1996. Financial reform in Malaysia. In *Financial Reform Theory and Experience*, edited by G. Caprio, Jr., I. Atiyas & J.A. Hanson, 277-322. Cambridge: Cambridge University Press.

Lida Nikmanesh (corresponding author)
Faculty of Economics and Management
Universiti Kebangsaan Malaysia
43600 UKM Bangi, Selangor, MALAYSIA
E-Mail: lida_nikmanesh@yahoo.com

Abu Hasssan Shaari Mohd Nor
Faculty of Economics and Management
Universiti Kebangsaan Malaysia
43600 UKM Bangi, Selangor, MALAYSIA
E-Mail: ahassan@ukm.edu.my

Tamat Sarmidi
Faculty of Economic and Management
Universiti Kebangsaan Malaysia
43600 UKM Bangi, Selangor, MALAYSIA
E-Mail: tamat@ukm.edu.my

Hawati Janor
Faculty of Economics and Management
Universiti Kebangsaan Malaysia
43600 UKM Bangi, Selangor, MALAYSIA
E-Mail: hawati@ukm.edu.my