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The Causal Direction of Equity Returns Volatility: Evidence From Selected Developed and Emerging Market's Economies

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ABSTRACT

This paper examines the causality directions of stock return volatility in selected developed (United States, Canada, Hong Kong, United Kingdom, Japan, France and Germany) and emerging market countries (Mexico and China) using daily data from January 2003 to March 2017. The study employes Granger Causality to identify the directions of causality between the markets. The findings revealed that there has been a mixed and strong indication of unidirectional and bidirectional causality between both the emerging and developed markets. The result illustrated that the developed countries act as a market leader especially during the pre, during and post crisis period, whereas the emerging countries act as a market follower. These results have significant implication for policy makers concerning the formulation of policy that could stabilize the economy, dwindle volatility and further contribute to the development of stock market. Besides, these findings could be necessity for the investors while making investment decisions that involves risk and also for hedgers to forecast risk and develop hedging strategies.

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INTRODUCTION

In this fast growing financial world, studies on volatility spillover between the stock markets is necessary due to its importance in investment decisions and risk diversification. If there exist spillover across the stock market, it means that there are fewer chances for diversification. Hence, the investors can leverage on segmented stock to diversify their portfolio. According to Kumar and Kamaiah (2017), the chances of volatility spillover among the equity markets has increased. This happens due to the increased amount of information flow and the trade and financial liberalization policies.

The globalization of financial system and the acceleration of information transmission have increased the risk of financial crises. For an instance, crisis in one country can spread to another country and bring about worldwide crises. The occurrences of huge price declines in emerging countries' stock market due to the Global Financial Crisis (GFC) have once again drawn attention to the consequences of international stock market diversification. Subsequently, this leads to the issue on why the study on international market diversification is important for investors especially when it involves both the developed and emerging stock markets. Eventhough, larger studies have been done on the international stock market diversification among the developed markets, the investors was devoured by curiousity when some literature found that the benefits of international portfolio diversification are larger for emerging countries relative to the developed countries (Driessen and Laeven, 2007). This is because some of the emerging countries are segmented from developed countries which gives an opportunity for the investors to maximize their benefit of portfolio diversification.

According to Patev et al. (2006) and Michel et al. (2008), the studies on causal direction of volatility are necessitous for the investors who yearning to maximize the benefits of portfolio diversification. The portfolio diversification benefits varies between stock markets because it is a consequence of globalization and holds a significant implications for the investors. Understanding the causal direction of volatility is mandatory for decision making process in allocation of the optimal asset and the planning of global hedging strategies. It is substantial for the investors and risk managers to perceive on how one market responds to the changes of another. Although these concerns can be usually satisfied with the measurement of correlation but an understanding of the causality direction between the markets is necessary compared to correlation (Sanford, 2011). Moreover, it's the nature of the stock market to fluctuate over the period. The fluctuation of the stock markets are closely observed by the society with great interest. However, the extent to which stock price indices in developed and emerging countries move together is important for individual investors, policy makers, researchers and most recently for investment bankers that are specializing in a new financial innovations to minimise risk.

The motivation of this study is the fact that the subprime crisis, which begins in autumn 2008 has spurred the subject on the contagion aftermath of the financial crisis. The subprime crisis has not only distressed the United States economy; but the impact has spread to other countries as well (Floros, 2011; Rajwani and Mukherjee, 2013; Kumar, 2013.; Nikmanesh et al. 2014a). Thus, it will be interesting to experience the extent to which the subprime crisis has shaped the stock markets internationally in terms of their volatility during different period of time specifically Pre-Crisis, Crisis and Post-Crisis. Centered on these backgrounds, few questions have been aggravated. Does the stock market's volatility have an asymmetric effect or symmetric effect during the pre, during and post crisis? Are the developed and emerging stock markets related? If so, what is the direction of the relation; unidirectional or bidirectional? All these will be further discussed in this paper.

This paper mainly focuses on the impact of the subprime crisis to the symmetric or asymmetric volatility in nine selected stock markets (United States, Canada, Hong Kong, Japan, United Kingdom, France, Germany, Mexico and China) across the region. Various empirical studies conducted previously have analysed and highlighted the relationship of stock market between various countries, but to the author's knowledge there have been no studies done to emphasized on the return of volatility and causality between the three main regions (i.e. America, Europe and Asia Pacific) (Karim and Ning, 2013). Hence, this study provides an analysis grounded on the stock market volatility transmission of the seven developed countries (Canada, Hong Kong, Japan, France, Germany, United Kingdom and United States) and two emerging nations (Mexico and China) from three different regions which are the America, Asia / Pacific and Europe.

The analysis of volatility transmission in developed and emerging markets serves as the subject of interest for international portfolio managers as these markets provide further portfolio diversification and offer

higher rate of return to investors. This is because it is well known that emerging markets are relatively risky as compared to the stock markets in developed economy (Gee and Karim, 2010). Further analysis on these markets regarding the volatility of its stock markets will provide relevant informations to portfolio managers regarding the risk associated with investment in these markets. Table 1 shows countries' selection of those three regions and their stock market index. The selections of the countries are done based on the top market capitalization from each region (See Table 1).

Table 1 Market capitalization of the selected countries based on regions

REGION	COUNTRY	INDEX	MARKET CAPITALIZATION (% of GDP)
America	United States (D)	NYSE COMPOSITE INDEX	151.16
	Canada (D)	S&P/TSX COMPOSITE INDEX	117.27
	Mexico (E)	IPC	37.09
Asia Pacific	Hong Kong (D)	HANG SENG INDEX	1111.41
	Japan (D)	NIKKEI 25	95.14
	China (E)	SSE COMPOSITE INDEX	57.99
Europe	United Kingdom (D)	FTSE 100 INDEX	106.48
	France (D)	CAC 40	73.73
	Germany (D)	DAX	44.94

Notes: D indicates the developed countries. E indicates the emerging countries.

The present study contributes to the existing literature in certain ways. Firstly, in terms of policy, the causal direction between stock markets is important in the sense that it may provide policy guidance related to the development of stock market especially in emerging countries where the stock markets are in nascent stage of development. Secondly, data used in this study bears a longer range of data and uses high frequency data which is daily frequency from January 2003 until March 2017. Thirdly, the countries selected as a part of this study are influential participants in the global economy and they appear as diversified unity as it consist a combination of developed and emerging countries.

All the mentioned countries have a hefty capitalization, large volume of shares traded and they are related with one of the three leading economic blocks namely NAFTA, the EU and APEC. Since, all the mentioned blocks consist of countries with large market capitalization, we are assured that the inclusion of all these countries in this study paints a complete sketch of the world economic condition. On the contrary, while past studies have focused on advanced and developing countries or even based on regions, our study is considered unique as it emphasizes both the developed and emerging countries in a single study based on market capitalization.

REVIEW OF LITERATURE

This section analyses the existing studies on stock market's volatility transmission for both the developed and emerging countries. Alongside the theoretical explanation, the existence of the spillover and volatility phenomena are shown in several empirical studies (Nishimura and Nen, 2010; Singhania and Anchalia, 2013). The existence of spillover and volatility phenomena are mostly examined in previous empirical studies by employing the asymmetric GARCH models (Mansor, 2012; Abdalla and Winker, 2012; Singhania and Anchalia, 2013; Fu et al. 2011). For instance, Nishimura and Nen (2010) investigated the day and overnight volatility transmission between China and G-5 countries. The method employed in this study was EGARCH. The result showed uni-directional volatility transmission effect from China stock market to United States, United Kingdom, Germany and France. Further analysis revealed that the investors from China are not rational and this led the China's stock market to enter the bubble period after the second half of the year 2006. Similarly, by using the same method as Nishimura and Nen (2010), Singhania and Anchalia (2013) discussed about the volatility of Asian stock markets by taking in account the global financial crisis. The findings of the study highlighted that the volatility return of Japan, China and India had a positive impact during the subprime crisis. Mansor (2012) have employed the model TGARCH and EGARCH to capture the leverage effect. These tests revealed that there are low correlation but signigicantly positive between the gold and stock market return in Malaysia.

Singhania and Anchalia (2013) also applied asymmetric GARCH model in their study and highlighted that there is a leverage effect, persistence, asymmetry and volatility clustering in the Hong Kong, Japan, China

and India's stock market. Similarly, in the study done by Abdalla and Winker (2012), the asymmetric GARCH model used exposed that there is a significant evidence for asymmetric in stock returns for both Sudan and Egypt and confirmed that leverage effect do exist in the return series. Conversely, Lim and Sek (2013) have applied both the symmetric GARCH and asymmetric GARCH in their study and the results discovered that both the symmetric and asymmetric model have performed differently according to the time frames. The end result of the empirical study showed that symmetric model performed better in the pre and post crisis period whereas the asymmetric model performed well during crisis period. This indicated that there is a leverage effect. Hence, all these findings based on the symmetric and asymmetric effect on the stock market revealed a mixed results as it varies based on the time frame and country selected and estimated in the empirical study. On the other hand, Fu et al. (2011) focused on the Japanese industrial sector by taking in account the asymmetric model BEKK-GARCH proved that five out of the ten industries sectors are significant and influenced by the asymmetric effect. The authors found that the stock price (oil and gas, industrials, health, telecommunication and financial sectors) of Japan generated greater volatility due to Japanese currency fluctuations.

Few researchers have addressed the effect of one country's stock market towards another market (Chiou, 2011; and Karim and Ning, 2013). Chiou (2011) found that there is solid evidence that the three stock markets (Tokyo, London and New York) are significantly interdependent. In his analysis, Chiou (2011) concluded that Tokyo leads London and New York markets, London leads New York and Tokyo markets; and New York leads Tokyo and London markets. Karim and Ning (2013) had examined the determinants of the stock market integration between the ASEAN-5 countries, and reported that the volatility of stock market and trade impact significantly on the stock market integration in this region. Overall, it showed that stock market of one country can influence another even if these countries are not within the same region.

Besides that, a reasonable number of literature have been reported on the causality direction; this includes Beine et al. (2008), Nikola and Eldin (2013) and Bwo-Nung et al. (2000) among others. In general, these scholars have discussed the causality directions in term of linear and non-linear granger causality, causality within the region and causality across the regions. Beine et al. (2008) emphasized on the linear granger and non-linear granger causality. The author found that the linear granger causality shown that there is causality from the US market to other four developed stock markets (Japan, France, Germany and UK); however in contract the nonlinear granger causality documented evidence of a bidirectional non-linear dependence between the five stock markets. Moreover, Nikola and Eldin (2013) analyzed the causality direction within region, and found that out of five stock markets (Serbia, Croatia, Hungary, Slovenia and Germany) analyzed, only Serbia and Slovenia have bidirectional causality. Conversely, across the region, Bwo-Nung et al. (2000) found that US and Hong Kong to be contemporaneous of each other. Using variance causality test, Nikmanesh et al. (2014b) found that Malaysian stock market are more sensitive and follows the US stock market as compared to Japanese stock market.

To the best of our knowledge, previous studies conducted for both developed and emerging countries are still unconvincing. The previously-discussed literature unanimously agreed that the study on the causality direction will be quite interesting to be conducted among the developed and emerging stock markets across the regions. This is because the stock market of a country does not only granger the stock markets within the regions or neighboring countries, but can also affect countries across the regions as documented in the literature above. Thereby, by expanding the work by Chong (2011), who have analyzed the shock of subprime crisis on the S&P 100 index's returns and volatility, this paper seeks to address the gap by analyzing selected countries within three main regions which is mentioned by Karim and Ning (2013), that the study of the stock market volatility could be further bolstered up empirically by extending the selection of countries across the regions. This paper will be further analyzing the volatility effect between seven developed and two emerging countries' stock market.

RESEARCH METHODOLOGY

This present study utilizes the daily data of the stock market prices of the nine stock markets which includes NYSE Composite (United States), S&P/TSX Composite (Canada), Indice de Precios y Cotizaciones (Mexico), SSE Composite (China), Nikkei 225 (Japan), Hang Seng Index (Hong Kong), FTSE 100 Index (United

Kingdom), CAC 40 (France), and DAX (Germany). The daily data has been converted into return data (R_t) by using the formula as formulated in equation (1). In order to avoid any confusion when regressing the data, the name of the country is used to denote each of the stock market throughout the study. The return series is defined as:

$$R_t = \frac{p_t - p_{t-1}}{p_{t-1}} \times 100\% \quad (1)$$

The sample period for all the stock markets is daily data from 6th January 2003 until 3rd March 2017. The sample period was chosen based on the availability of data for all the selected market. The time period used in this study is divided into three sub-sample because the subprime crisis 2008 occurred in the time frame chosen (See Table 2). It should be appropriate to analyse the volatility effect of the stock markets during that period of time.

Table 2 Time period of sub-prime crisis

Time period of sub-prime crisis	
Pre-Crisis	6th January 2003 – 29th December 2006
During Crisis	2nd January 2007 – 8th January 2010
Post-Crisis	11th January 2010 – 3rd March 2017

Estimating the volatility of the series and determining the effect of volatility is the primary objective of this paper, therefore Generalized Autoregressive Conditional Heterocedasticity (GARCH) models are being utilized in this study to fulfil the requirement of the first objective.

According to Engle (1995), the ARCH specification is looked more like a moving average rather than an auto regression. Therefore, in 1986, Tim Bollerslev has introduced the model GARCH and lagged conditional variance terms have been included as an autoregressive term. The simplest form of the GARCH model is the GARCH (1,1) model has a variance equation as equations (2).

$$\text{Variance equation} \qquad \sigma^2_t = \omega + \alpha_1 \varepsilon^2_{t-1} + \beta_1 \sigma^2_{t-1} \quad (2)$$

Thus, this model specification is easier to estimate as it only has three unknown parameters ω, α and β.

The next model will be the GARCH-M model which permits the conditional mean to depend on its own conditional variance. Consequently, the GARCH-M model can be closely linked with the CAPM theory. The equations (3) below shows the simple model of GARCH-M (1,1):

$$\text{Variance equation} \qquad \sigma^2_t = \omega + \alpha_1 \varepsilon^2_{t-1} + \beta_1 \sigma^2_{t-1} \quad (3)$$

The variance equation is same like previous ordinary GARCH model but the mean equation is different. The parameter λ is termed as risk premium where the positive value of the parameter indicates higher risk is associated with high return.

The main drawback of these symmetric GARCH models (GARCH and GARCH-M) is that the conditional variance is incapable to reciprocate asymmetrically to surge and plunge in t, and such responses are considered to be vital in the performance of stock returns. According to Knight and Satchell (2002), the linear GARCH (p,q) model the conditional variance is a function of past conditional variances and squared innovations; thus, the sign of returns cannot affect the volatilities. Consequently, the symmetric GARCH models defined above cannot account for the leverage effect noticed in stock returns. On the other hand, this paper uses EGARCH and TGARCH to capture the asymmetric phenomena.

The EGARCH was proposed by Nelson (1991). This model allows the analyst to test asymmetric as well as the TGARCH. The variance equation of this model is computed as in Equation (4).

$$\text{Variance equation:} \qquad ln\sigma^2{}_t = \omega + \beta_1 ln\sigma^2{}_{t-1} + \alpha_1 \left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\right| + \gamma \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \quad (4)$$

The left hand side of the equation (4) is the log of the variance series, and this makes the leverage effect exponential and the estimations of the conditional variance are certain to be non-negative. Hence, when the < 0 , it means that the positive shocks generate less volatility than the negative shocks.

The TGARCH is a GARCH model introduced by Zakoian (1990). Thus the primary objective of this model is to capture asymmetric in terms of negative and positive shocks. This is because in the case of stock market equities, it has been observed that negative shocks in the market have a larger impact on volatility compared to positive shocks of the same magnitude. Thus, equation (5) shows the conditional variance for the TGARCH.

$$\text{Variance equation:} \qquad \sigma^2{}_t = \omega + \delta_1 \varepsilon^2{}_{t-1} + \partial_1 \sigma^2{}_{t-1} + \beth d_{t-1} \varepsilon^2{}_{t-1} \tag{5}$$

Where d_{t-1} takes the value of 1 for $\varepsilon_{t-1}^2 < 0$, and 0 otherwise. Thereby, the 'good news' and 'bad news' have different impacts.

Besides, GARCH models, the model VAR is also being utilized in this study. VAR is a model which is postulated by Sims (1980) and it is a set of regressions that includes more than one dependent variables. The VAR models are more flexible to be employed and easier to be utilized in the multivariate time series data. Besides that, it is not necessary to specify which variable is dependent and independent. Furthermore, it is important to use an appropriate lag to utilize the VAR procedure.

Generally, there are two approaches that can be applied to estimate the optimal lag length in a VAR model which are cross-equation restrictions and information criterion. Therefore, in this present study, information criterion such as AIC and SBC characteristics are utilized to determine the optimal lag length. Under the information criterion method, the best lag is chosen based on the highest star chosen based on the information criterions. According to Brooks (2008), the information criteria are more powerful compared to the cross-equation restrictions.

Granger Causality Test

Granger causality test suggested by Granger (1986) is used in the present study to identify the causal direction between the selected markets. The definition of Granger Causality can be explained using two time series variables, X and Y can be explained as below:

'x is said to Granger-cause Y if Y can be better predicted using the histories of both X and Y than it can history of Y alone'

The granger causality can be estimated in the context of VAR models as shown in equation (6) and (7).

$$y_t = a_0 + \sum_{i=1}^{n} \alpha_{1i}\, y_{t-i} + \sum_{i=1}^{n} \alpha_{2i}\, x_{t-i} + \mu_{1t} \tag{6}$$

$$x_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i}\, x_{t-i} + \sum_{i=1}^{n} \beta_{2i}\, y_{t-i} + \mu_{2t} \tag{7}$$

Hence;

$$H_0: \alpha_{2i} = 0; \textit{which implement that x does not granger cause y.}$$
$$H_1: \alpha_{2i} \neq 0; \textit{which implement that x does granger cause y.}$$

The main steps which are involved before employing this procedure is the determination of the lag length (p). The lag length (p) is determined by using the information criterion like Akaike Information Criterion (AIC), Schwartcz Information Criterion (SBC), Final Prediction Error (FPE) and Hannan-Quinn criterion (HQ).

RESULTS AND DISCUSSION

Descriptive Statistics

The section begins by examining the descriptive statistics which consist of three sub periods; pre-crisis, during crisis and post-crisis. The summary of the descriptive statistics are tabulated in Table 3. As tabulated in Table 3, for pre-crisis the mean varies between 0.042 and 0.137, during crisis the mean varies from -0.060 to 0.026,

whereas during post-crisis the mean varies between 0.00009 and 0.037. During the pre-crisis, during crisis and post crisis the lowest mean is achieved by United Kingdom (UK), Japan and China respectively. Whereas, pre-crisis and during crisis period the highest mean hold by Mexico and post crisis is Germany.

Table 3 Descriptive statistics on return series

Country	Duration	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
	Pre-Crisis	0.061	0.693	-0.504	4.4566	135.766
	During-Crisis	-0.009	1.761	-0.579	8.587	1065.034
Canada	Post- Crisis	0.014	0.809	-0.341	5.300	446.358
	Pre-Crisis	0.066	1.254	0.489	5.815	384.239
	During-Crisis	0.020	7.917	1.058	329.614	3489368.
China	Post- Crisis	9.30E-05	1.418	-0.996	9.199	3286.382
	Pre-Crisis	0.052	4.383	0.426	458.941	8990951.
	During-Crisis	-0.041	1.845	0.153	8.861	1126.935
France	Post- Crisis	0.011	1.337	-0.155	6.626	1026.913
	Pre-Crisis	0.070	1.231	-0.173	6.455	521.646
	During-Crisis	-0.012	1.783	0.260	9.483	1383.67
Germany	Post- Crisis	0.037	1.278	-0.287	5.387	467.226
	Pre-Crisis	0.084	0.969	-0.247	5.625	308.788
	During-Crisis	0.011	2.262	0.053	7.318	610.419
HK	Post- Crisis	0.001	3.732	0.314	753.035	43597892
	Pre-Crisis	0.065	1.160	-0.394	4.298	99.820
	During-Crisis	-0.060	2.015	-0.376	10.199	1714.037
Japan	Post- Crisis	0.031	3.561	0.034	672.350	34722329
	Pre-Crisis	0.137	1.083	-0.052	5.741	325.623
	During-Crisis	0.026	1.789	0.204	7.247	595.551
Mexico	Post- Crisis	0.019	0.908	-0.368	6.073	774.255
	Pre-Crisis	0.042	0.829	0.041	8.073	1113.588
	During-Crisis	-0.016	1.701	-0.061	8.624	1035.171
UK	Post- Crisis	0.015	0.988	-0.164	5.355	438.536
	Pre-Crisis	0.053	0.736	-0.070	4.375	82.685
	During-Crisis	-0.026	2.060	-0.432	11.503	2389.439
US	Post- Crisis	0.023	1.009	-0.473	7.721	1796.933

Notes: HK indicate Hong Kong. UK indicate United Kingdom. US indicate The United States.

In addition, Canada has the lowest standard deviation in pre-crisis and post-crisis period and UK has the lowest standard deviation during crisis. The highest standard deviation during the pre, during and post crisis is hold by France, China and Hong Kong (HK) respectively. All the return series for pre-crisis, during-crisis and post-crisis show an excessive kurtosis, where the kurtosis value is positive and more than three which indicate the series are leptokurtic distribution. Besides that, the Jarque-Bera normality test rejects the null hypothesis for all the return series.

The result of the unit root tests employed in this study shows that the Augmented Dickey-Fuller (ADF) and Phillips-Peron (PP) are stationary at level I (0). The unit roots tests result are available upon request.

GARCH Models Estimation

The adequate GARCH model are chosen based upon the Akaike Information criterion (AIC), Schwartz criterion (SBC), log likelihood values and adjusted r-squared. Table 4, 5 and 6 (refer to Appendix) shows the fitted model for all the selected countries' stock market during the three time period i.e. pre-crisis, during crisis and post-crisis. The results tabulated in Table 4, 5 and 6 also show that all the stock markets in three sub-periods have asymmetric effect. The Q (8) statistics shows that there is no serial correlation up to lag 8 which indicates that the mean and variance equations are well-fitted.

Table 4 ARCH-GARCH MODEL RESULTS (Pre-Crisis)

	Canada AR(1)-TGARCH (1,1)	China AR(1)-EGARCH (1,1)	France AR(1)-EGARCH (1,2)	Germany AR(1)-TGARCH (1,1)	HK AR(1)-EGARCH (1,1)	Japan AR(1)-EGARCH (1,1)	Mexico AR(1)-TGARCH (1,1)	UK AR(1)-TGARCH (1,1)	US AR(2)-TGARCH (1,1)
					Mean Equation				
C	0.065	0.056	0.165	0.064	0.079	0.051	0.127	0.032	0.050
	(0.002)	(0.140)	(0.000)	(0.024)	(0.004)	(0.101)	(0.000)	(0.108)	(0.012)
AR	0.015	0.023	-0.001	-0.047	0.063	0.041	0.067	-0.102	-0.003
	(0.659)	(0.472)	(0.853)	(0.152)	(0.070)	(0.255)	(0.062)	(0.002)	(0.917)
					Variance Equation				
ω	0.028***	-0.083***	-0.495***	0.015***	-0.087***	-0.123***	0.081***	0.014***	0.009***
α		0.137***	-0.526***		0.115***	0.169***			
β		**-0.008**	**-0.211*** **		**-0.029*** **	**-0.074*** **			
γ		0.959***	0.912***		0.981***	0.968***			
δ	0.007			-0.004			0.007	-0.016	-0.002
∂	**0.092*** **			**0.118*** **			**0.161*** **	**0.152*** **	**0.082*** **
ב	0.882***			0.928***			0.834***	0.912***	0.940***
Log-Likelihood	-1056.715	-1679.381		-1489.271	-1386.285	-1568.088	-1460.745	-1096.733	-1081.359
Q(8)	5.675	12.586	7.585	8.287	2.835	12.526	10.882	5.634	6.167
	(0.684)	(0.127)	(0.475)	(0.406)	(0.944)	(0.129)	(0.208)	(0.688)	(0.629)

Notes: *, **, *** indicate the significant level at 1%, 5% and 10% respectively.

Table 5 ARCH-GARCH MODEL RESULTS (During-Crisis)

	Canada AR(1)-EGARCH (1,1)	China AR(1)-EGARCH (1,2)	France AR(1)-EGARCH (1,1)	Germany AR(1)-EGARCH (1,1)	HK AR(1)-TGARCH (1,1)	Japan AR(1)-EGARCH (1,1)	Mexico AR(1)-EGARCH (1,1)	UK AR(1)-EGARCH (1,1)	US AR(1)-EGARCH (1,1)
					Mean Equation				
C	-0.009	0.036	-0.031	-0.006	0.015	-0.083	-0.003615	-0.025	0.085
	(0.848)	(0.936)	(0.500)	(0.895)	(0.801)	(0.098)	(0.944)	(0.558)	(0.000)
AR	-0.045	-0.0002	-0.069	-0.014	0.030	-0.053	0.072	-0.063	-0.155
	(0.244)	(0.936)	(0.091)	(0.717)	(0.466)	(0.194)	(0.060)	(0.121)	(0.000)
					Variance Equation				
ω	-0.058***	3.879***	-0.068***	-0.076***	0.123***	-0.076***	-0.054***	-0.065***	0.034***
α	0.085***	-0.532***	0.110***	0.124***		0.124***	0.088***	0.102***	-0.045***
β	**-0.094*** **	**-0.335***	**-0.14*** **	**-0.133*** **		**-0.122*** **	**-0.127*** **	**-0.126*** **	**-0.083*** **
γ	0.988***	-0.094	0.976***	0.975***		0.980***	0.984***	0.980***	0.995***
δ					0.042*				
∂					**0.185*** **				
ב					0.837***				
Log-Likelihood	-1340.729	-2468.424	-1410.003	-1393.944	-1603.897	-1458.762	-1445.664	-1342.746	-1446.508
Q(8)	4.776	3.867	6.056	5.146	8.300	4.795	3.872	11.371	3.475
	(0.781)	(0.869)	(0.641)	(0.742)	(0.405)	(0.779)	(0.868)	(0.182)	(0.901)

Notes: *, **, *** indicate the significant level at 1%, 5% and 10% respectively.

Table 6 ARCH-GARCH MODEL RESULTS (Post-Crisis)

	Canada AR(1)-EGARCH (1,1)	China AR(1)-EGARCH (1,1)	France AR(1)-EGARCH (1,1)	Germany AR(1)-EGARCH (1,1)	HK AR(2)-EGARCH (1,1)	Japan AR(1)-EGARCH (1,1)	Mexico AR(1)-TGARCH (1,1)	UK AR(1)-TGARCH (1,1)	US AR(1)-EGARCH (1,1)
					Mean Equation				
C	0.005	0.02	-0.018	0.018	-0.172	0.077	0.001	-0.0004	0.017
	(0.750)	(0.357)	(0.483)	(0.458)	(0.000)	(0.000)	(0.970)	(0.978)	(0.372)
AR	0.059	0.002	-0.014	0.029	0.011	-0.183	0.046	0.013	-0.025
	(0.017)	(0.925)	(0.512)	(0.186)	(0.129)	(0.000)	(0.037)	(0.584)	(0.214)
					Variance Equation				
ω	-0.065***	-0.074***	-0.059***	-0.087***	-0.364***	-0.719***	0.014***	0.034***	-0.107***
α	0.062***	0.106***	0.095***	0.128***	1.544***	1.271***			0.128***
β	**-0.152*** **	**0.005**	**-0.180*** **	**-0.136*** **	**1.043*** **	**-0.390*** **			**-0.151*** **
γ	0.973***	0.995	0.965***	0.964***	0.252***	0.795***			0.964***
δ							-0.038***	-0.027***	
∂							**0.138*** **	**0.247*** **	
ב							0.950***	0.868***	
Log-Likelihood	-2000.313	-3014.618	-2938.630	-2875.774	-3549.265	-3405.099	-2302.921	-2367.827	-2360.592
Q(8)	9.976	12.385	9.112	8.690	1.829	11.727	8.876	9.917	6.818
	(0.267)	(0.135)	(0.333)	(0.369)	(0.986)	(0.164)	(0.353)	(0.271)	(0.556)

Note: *, **, *** indicate the significant level at 1%, 5% and 10% respectively

Based on the estimation, throughout the pre-crisis period, China, HK, Japan and France which their adequate model is EGARCH (1, 1) has the coefficient of the β term is negative and statistically significant except China which is insignificant, indicate that the stock market's negative shock has larger effect on the volatility series rather than the positive shock which is the good news in the economy. Whereas, Canada, Germany, Mexico, United States (US) and UK have threshold effect, and the term ∂ in TGARCH (1, 1) are positive and statistically significant. It shows that the stock market of these countries have asymmetric effect in the news.

During crisis period, all the stock markets have leverage effect expect for Hong Kong which have threshold effect. The ∂ term of HK is positive and statistically significant, which explains that there are asymmetries in the news. To be specific, negative shock (bad news) has a larger impact on the volatility series than the positive shock (good news). Furthermore, during the post-crisis period, Canada, France, Germany, Japan, China, HK and US have negative and significant β term which indicate that bad news have larger effect on the volatility series than good news. In other hand, only Mexico and UK have threshold effect with positive and significant
∂ term.

In conclusion, the empirical result obtained contradicted with the finding which is done by Lim and Sek (2013). According to Lim and Sek (2013), the symmetric GARCH perform well during the pre and post crisis, whereas the asymmetric GARCH performed well during the crisis period. In contract, it is found that in all the three sub-period, the asymmetric GARCH performed well which shows that the leverage effects have been capture. The result maybe contracted because the time periods utilized in both the studies are different.

Granger Causality Test

Granger Causality in the framework of VAR is suggested for the pre-crisis, during crisis and post-crisis period. Prior to estimating the causality direction, it is important to run the VAR test. Subsequently, the AIC, SBC, FPE and HQ information criterion are utilized to identify the optimum lag length. Table 7 shows the summary of causality direction of emerging and developed stock markets obtained by the granger causality test.

Table 7 Causality direction of selected emerging and developed market

Pre-Crisis		
Country	Direction	Country
Canada	→	France
	↔	Hong Kong
	→	Mexico
	→	United States
China	→	United States
France	↔	United States
	↔	United Kingdom
Germany	→	China
	→	France
	↔	United Kingdom
	↔	United States
Hong Kong	→	United States
Japan	→	France
	→	Mexico
	→	United Kingdom
	→	United States
Mexico	→	China
	→	France
	→	United Kingdom
	↔	United States
United Kingdom	→	China
	→	Hong Kong
	↔	United States

Table 7 Causality direction of selected emerging and developed market

During Crisis		
Country	Direction	Country
Canada	↔	France
	↔	Germany
	↔	Hong Kong
	↔	Japan
	↔	Mexico
	↔	United Kingdom
	↔	United States
France	↔	Germany
	↔	Hong Kong
	↔	Japan
	↔	Mexico
	↔	United Kingdom
	↔	United States
Germany	↔	Hong Kong
	↔	Japan
	↔	Mexico
	↔	United Kingdom
	↔	United States
Hong Kong	↔	Japan
	→	Mexico
	↔	United States
	↔	United Kingdom
Japan	→	Mexico
	↔	United Kingdom
	↔	United States
Mexico	↔	United Kingdom
	↔	United States
United Kingdom	↔	United States
Post Crisis		
Country	Direction	Country
Canada	→	France
	→	Germany
	↔	Hong Kong
	→	Mexico
	↔	United Kingdom
	→	United States
China	→	Hong Kong
France	↔	Germany
	↔	Hong Kong
	→	Japan
	↔	Mexico
	↔	United Kingdom
	↔	United States
Germany	→	Japan
	→	Mexico
	↔	United Kingdom
	↔	United States
Hong Kong	→	Germany
	→	Japan
	→	United Kingdom
	↔	United States
Japan	→	Canada
	↔	United States
Mexico	→	Japan
	↔	United Kingdom
	↔	United States
United Kingdom	→	Japan
	↔	United States

Note: Unidirectional →← Bidirectional↔

Based on Table 7, it shows that as an emerging country Mexico are more vigorous compared to China in our study. During the pre-crisis period, Mexico shows bidirectional causality towards US, whereas China shows unidirectional causality only to US. At the same period, Mexico does granger cause China, France, UK and Canada and Japan does granger cause Mexico. Similarly, Germany, Mexico and UK does show unidirectional causality towards China.

During crisis period, Mexico shows bidirectional causality towards two developed market which is UK and US. On the other hand, China does not have any causality direction between the developed markets during

the crisis period. Lastly, during the post-crisis period, Mexico have bidirectional causality towards UK and US, meanwhile China has unidirectional causality only towards HK. Besides that, Mexico does granger cause Japan and have bidirectional causality towards UK and US.

Interestingly, during the crisis period most of the markets have bidirectional causality between them except Hong Kong and Japan have unidirectional causality towards Mexico. This highlights that during the crisis period, the spillover effect from one country to another country seems to be obvious especially between the developed markets. Sakthivel et al. (2012) finding supported this outcome where the study indicated that the shock increasing from one market may have destabilizing effect on another market. In conclusion, the obtained result shows that the relationship between the developed and emerging markets varies over time, as shown in Table 7 where the co-movements are different between them in each sub-period.

CONCLUSIONS

This paper has modeled the volatility series and identified the effect of volatility; in addition the direction of causality is also investigated. The findings for the pre-crisis period shows that all the selected country's stock markets illustrated that they have experienced asymmetric effect of volatility (TGARCH and EGARCH). This is because as projected in the estimation of volatility during the pre-crisis period as tabulated in Table 4 shows that Canada, Germany, Mexico, UK and US has a positive threshold effect which means the country's volatility series best fitted the TGARCH (1,1). In contrast, the EGARCH (1,1) model best fitted for the volatility series of China, HK, Japan and France's stock markets. Thus, the EGARCH (1,1) model's estimation shows that all the country's leverage effect is negative and significant except for China their leverage effect is negative but not significant. This leads to the assumption that good news (positive shock) cause less volatility than the bad news (negative shock).

To summarize the finding that has been estimated for during crisis period shows that all the stock market's volatility still having asymmetric effect as in the pre-crisis period. The estimated volatility result in table 5 shows that volatility series of HK only has an asymmetric effect of TGARCH (1,1). All the mentioned stock markets have a positive threshold effect and significant. Whereas, the other stock market's volatility has an asymmetric effect of EGARCH (1,1) which means that they have a leverage effect with a negative sign and all are significant at 1% level. Similarly, this means that the positive shocks (good news) generate less volatility than the negative shocks (bad news).

To evaluate the complete picture of the post-crisis period, the finding shows that all the selected country's stock markets illustrated that they have experienced asymmetric effect of volatility (TGARCH and EGARCH). This is because as projected in the estimation of volatility during the pre-crisis period as tabulated in Table 6 shows that volatility series of stock market Canada, China, France, Germany, Japan, HK and US has an asymmetric effect of EGARCH (1,1). The result of leverage effect shows that all the coefficient are negatively significant which means the good news generate less volatility than the bad news. While, the volatility series of UK and Mexico shows that there has an asymmetric effect of TGARCH (1,1), where the coefficient value of the threshold effect are positive thus significant. Finally, through granger causality using VAR framework, we can summarize that there is more causality direction between the developed countries especially during the crisis period.

The findings of the present study help the policymakers to formulate policies that stabilize sentiment, dwindle volatility and reduce uncertainty in the stock markets. Additionally, the policy makers should pay close consideration not only to the local stock markets but also the international stock markets and must be prepared to deal with the adverse circumstances accordingly. Moreover, the causality direction between the nine stock markets varies between the three periods (pre-crisis, during crisis and post crisis). However, the pattern of the causality direction across the three regions can be used as a meaningful policy recommendation.

Hence, this study has implication for investors, portfolio managers and policy makers to implement economic and financial policy that promote stability thus reduce vulnerability during crises. To the concern of investors and portfolio managers if they are not convinced with the return obtained in the domestic markets, they normally will look forward to endow in the global financial markets. Despite that, if the relationship of volatility between the markets are significant, then this indicate that the shock increasing from one market may have a destabilizing effect on another stock market (Sakthivel et al., 2012 and Ait-Shalia et al., 2012).

Therefore, it is important for the investor to investigate the relationship between stock markets before they diversified their portfolio. Moreover, the relationship between developed and emerging markets varies over time as shown in this study where the causality direction differs between them in each of the sub-periods. Finally, based on the findings we can conclude that the causality direction of the volatility between developed and emerging markets can guide further understanding into socioeconomic connections and produce fruitful knowledge to both domestic and foreign investors.

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