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# The Contagion Effect from U.S. Stock Market to the Vietnamese and the Philippine Stock Markets: The Evidence of DCC – GARCH Model

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## Abstract

Using a DCC – GARCH model analysis, this paper examines the existence of financial contagion from the U.S. stock market to the Vietnamese and the Philippine stock markets during the global financial crisis and the COVID-19 pandemic crisis. We use daily data from the S&P 500 (U.S.), VN-Index (Vietnam), and the PSEi (the Philippines). As a result, there is no evidence of contagion from the U.S stock market to the Philippine stock market that can be found during global financial crisis, while the Vietnamese market is influenced by this effect. Besides, both these developing stock markets (the Vietnamese and Philippine stock markets) are influenced by the contagion effect in COVID-19 pandemic crisis. Another finding is that the contagion effect during the coronavirus pandemic crisis in Vietnam is smaller than that during the global financial crisis, however, the opposite is the case for the Philippines. It is noticed that the Philippines seems to be more affected by the contagion effect from the COVID-19 pandemic than Vietnam at the time of this study. Because financial contagion is important for monetary policy, asset pricing, risk measurement, and portfolio allocation, the findings in this paper may give some useful information for policymakers and investors.

**Keywords:** Contagion, COVID-19, Financial Crisis, DCC – GARCH, Stock Market

**JEL Classification Code:** C58, G01, G15

## 1. Introduction

Over a decade ago, financial markets suffered from the global financial crisis triggered by a downturn of the U.S. subprime mortgage market. The global financial crisis exposed weaknesses that existed in financial industry regulations and the financial systems all over the world (Mighri & Mansouri, 2013). Not only the value of U.S stock price decreased, but also the stock price of other countries went down during crisis period. These cases imply that movements in one stock market may have a powerful impact on other markets around the world. These co-movements of different nations in financial markets may arise from contagion or interdependence between financial markets (Celik, 2012).

In the beginning of 2020, the coronavirus has appeared, and caused a worldwide pandemic. Since the COVID-19 pandemic has been declared as global health emergency by the World Health Organization, the world economy has suffered heavy losses. Due to COVID-19 pandemic, customers have changed their consumption behavior, which has led to a decline in sales and production; hence, companies have fallen into severe financial burdens, and the unemployment rates rose worldwide. Such serious changes in business and economy around the world are expected to affect stocks. From an investment perspective, it is necessary to assess the impact of the COVID-19 pandemic on the stock market. The purpose in doing this is to determine complexity traits of the stock market before and during the COVID-19 Pandemic.

Financial volatility has been impacted by many different reasons. According to Becketti and Sellon (1989), there are many factors that cause changes in financial volatilities such as increasing in inflationary expectations, restricting

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monetary policy, and the elimination of interest rate ceilings which led to the volatility of interest rates. The collapse of stock prices in the year 1997 also contributed to an increase in volatility of interest rates and exchange rates (Ezzati, 2013). This is a phenomenon that had received attention of many investors and financial market analysts.

Contagion is one of the definitions debated most in literature. In this paper, contagion is defined based on the definition of Forbes and Rigobon (2002), which is a significant rise in the cross-market correlation during the crisis period. Hence, it is essential that the correlation between two financial markets should be compared in relatively stable period (pre-crisis) and turmoil period (crisis period). If two markets are moderately correlated during stable periods and the appearance of a shock to one market leads to a dramatic increase in market co-movement, this would create contagion. Nevertheless, if the correlation between two markets is traditionally high, even if its correlation continues to soar after one market experiences an economic shock, this may not generate contagion (Celik, 2012). In other words, contagion only appears if the cross-market correlation goes up significantly in the period of crisis. If there is not a significant increase in correlation, this co-movement between financial markets is called interdependence that refers to strong real linkages between two economies (Forbes & Rigobon, 2002). Although the contagion effects among developed markets or to developing markets have been confirmed in several papers (Calvo & Mendoza, 2000; Bekaert et al., 2005; Chiang et al., 2007; Cho & Parhizgari, 2008; Bouaziz et al., 2012; Celik, 2012; Alam et al., 2020; Khan et al., 2020; Alshammari et al., 2020), to the best of authors' knowledge, the previous study has not explored the contagion effects of volatility return from a developed market like U.S. stock market to the Vietnamese stock market and the Philippine stock market in both the global financial crisis, and the COVID-19 pandemic, and then, has compared the results between these two crises.

Vietnam and the Philippines are developing countries which are assessed as having remarkable economies in Southeast Asia. According to World Intellectual Property Organization (2019), both Vietnam and the Philippines ranked as lower-middle income countries which have the innovation performance of economy above expectations for their level of development. Moreover, thanks to participating in the Association of Southeast Asian (ASEAN), the Asia-Pacific Economic Cooperation (APEC), and the World Trade Organization (WTO), Vietnam and the Philippines have become more integrated with the world economy. It also means that their stock markets are more closely related to the global financial markets. Because of the reasons stated above, this paper uses the DCC – GARCH model in order to examine the contagion effect from the U.S. stock market to the Vietnamese and the Philippine stock markets during the period of COVID-19 pandemic, compared with during the global financial crisis.

## 2. Literature Review

Worthington and Higgs (2004) explore the causes and extent of contagion of volatility in three developed Asian stock markets in Hong Kong, Japan, and Singapore and six emerging markets in Indonesia, Korea, Malaysia, the Philippines, Taiwan, and Thailand using MGARCH model. The results of the study demonstrate the existence of contagion effects and show the volatility of all markets, especially for developing markets. However, the volatility of these markets is largely determined by the historical data itself rather than by the influence of external shocks.

Chiang et al. (2007) apply the DCC – GARCH model to analyze the contagion effects of volatility across nine stock markets in Asia from 1990 to 2003 using the historic stock prices of these markets along with daily. Research results demonstrate that there are the contagion effects between observing markets. Chiang et al. (2007) examine a series of correlation coefficients in order to find out two periods of the Asian crisis: the first period shows an increase in the correlation (contagion) and the second period shows that the correlation continues to rise. In addition, the results also indicate that variance values have changed during the crisis period, leading to doubts as to whether diversifying international portfolios is truly beneficial or not.

Horta et al. (2008) examine contagion effects of American subprime mortgage crisis on Italian, UK, French, German, Canadian, Japanese, and Portuguese stock exchange markets by using copula models. As a result, while Canada, Japan, Italy, France and UK get remarkable contagion impact, this impact for Germany is not significant as other countries. The most contagion influence is found out in Canadian stock market.

Mulyadi (2009) tests the contagion effects of volatility in U.S, Indonesian and Japanese capital markets for five years (2004–2008). By using and exploiting the GARCH model (1, 1), the results show that the contagion effect between Indonesia and Japan is bidirectional, while that between Indonesia and the U.S. has a one-way spread effect, namely from the U.S. to Indonesia.

Naoui et al. (2010) examine the existence of contagious phenomenon following the U.S. financial crisis for six developed stock markets and ten emerging stock markets by using Dynamic Conditional Correlation model (DCC – GARCH). They prove that the contagion effect is very strong between the United States and the developed and developing countries over the subprime crisis.

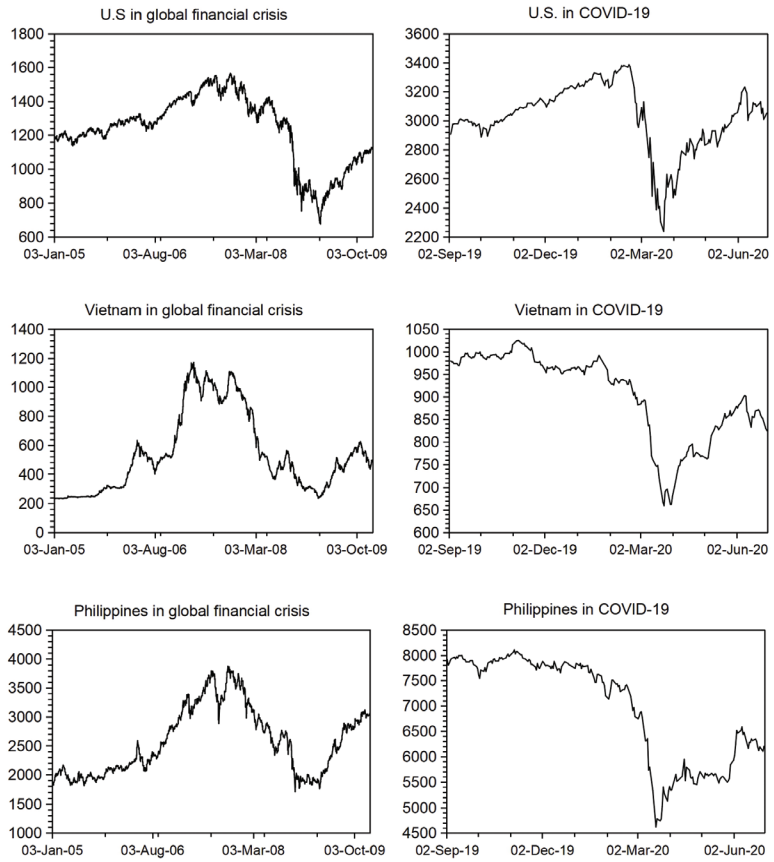


**Figure 1:** Stock market price series

Sok-Gee et al. (2010) measure the contagion effects of volatility from the U.S. and Japanese stock markets to the stock markets of Southeast Asian countries including Indonesia, Malaysia, the Philippines, Singapore, and Thailand during the post-crisis period of the Asian financial crisis in 1997. They use the historic returns data of the observed markets from March 1, 1999, to December 31, 2007, and apply the EGARCH model for this article. The result shows that in terms of returns volatility, the contagion effects from Japan to the stock markets of Southeast Asian countries is proven to be weaker than that effects from the U.S. market.

Hwang et al. (2010) analyze the contagion effects of the U.S. financial crisis on 38 international stock markets using a DCC – GARCH model. In summarize, they prove that financial contagion appears not only in emerging markets but also in developed markets over the U.S. subprime crisis.

Bouaziz et al. (2012) examine the contagion effect of the U.S. stock market on the stock markets of developed countries in the 2007-2008 financial crisis by applying DCC – GARCH model. As a result, they observe that correlations between these markets have dramatically rose during the U.S. financial crisis period. Bouaziz et al. (2012) conclude that this crisis has spread across different stock markets, which is also a reliable evidence of contagion.

Celik (2012) examine the existence of the contagion effect between the U.S. foreign exchange market and the foreign exchange markets of nine developed and ten emerging countries during the 2007-2008 global financial crisis. According to the analysis of the DCC – GARCH model, Celik (2012) demonstrates that there is a spread of returns volatility from the U.S. market to most the developed and emerging markets. In addition, emerging markets in Malaysia, China, and Brazil are affected the most by this effect.

Jones and Olson (2013) examine the time-varying correlation between macroeconomic uncertainty, inflation, and output. As a result of DCC – GARCH analysis, there was a change from negative to positive in terms of the sign of the correlation between inflation and macroeconomic uncertainty over the late 1990s, whereas the correlation between uncertainty and output has consistently negative.

Balli et al. (2015) evaluate the contagion effects from developed stock markets to 20 emerging stock markets, which are in the Middle East, Asia and North Africa (MENA) during the period from 2000 to 2013. The financial markets of the United States, Europe and Japan were seen as developed markets. The GARCH (1, 1) model is used in order to measure the spread of this economic shock to the emerging markets. The result of the study show that there is the existence of contagion effects from developed stock markets, especially the U.S. market, to emerging stock markets.

Nguyen and Le (2018) examine return spillover from the U.S. and Japanese stock markets to the Vietnamese stock market from January 1, 2012, to December 31, 2015 by using a frequency-domain analysis. A Granger-causality test is applied in order to examine the return spillover, and the test for causality in the frequency domain by Breitung and Candelon (2006) is used to evaluate the return spillover at various frequencies. The results reveal that there is a significant return spillover appearing from the U.S. to the Vietnamese stock market at all frequencies and from the Japanese to the Vietnamese stock market at higher frequencies. In addition, Nguyen and Le (2018) also prove that return spillover effects are not the same at different frequencies.

The literature on contagion effects of financial crisis seems to be studied in the stock market mainly. This paper aims to test the existence of financial contagion between for stock markets of the U.S and two developing stock markets in ASEAN (Vietnam and the Philippines) during the COVID-19 pandemic crisis, compared with during the 2007-2008 financial crisis. It also makes several essential contributions to the recent literature on financial contagion.

## 3. Data

The authors use daily data from the Standard & Poor's 500 Composite Index (S&P 500), Vietnam Stock Index (VN-Index) and Philippine Stock Exchange Composite Index (PSEi) representing the U.S., Vietnamese and the Philippine stock markets, respectively. The data is collected at Thomson Reuters DataStream from 03/01/2005 to 31/12/2009 and from 03/09/2019 to 30/06/2020. These are two periods in which two crises occur, the global financial crisis and the COVID-19 pandemic crisis. If database is unavailable because of public holidays or any other reason, the value of stock prices will be assumed based on data of the previous trading days by Stata statistical software.

Stock exchange rate returns are calculated as $\ln\left(\frac{P_t}{P_{t-1}}\right)\times 100$ where $P_t$ is the price level of for the stock exchange market at time t. This is also the return measurement method that is introduced by Campbell et al. (1997).

In the literature, it is very difficult to determine the crisis period (Kaminsky & Schmukler., 1999). With regard to the determination of crisis period for the global financial crisis, Dominguez et al. (2012) prove that this crisis started on October, 1st 2007, so the authors also choose that date as a starting date of crisis. It means that for the 2007–2008 global financial crisis, pre-crisis period covers data from 03/01/2005 to 30/09/2007, and crisis period covers between 01/10/2007 to 31/12/2009. As far as the identification of crisis period for the COVID-19 pandemic crisis, the authors refer to consider news-based data for determining that period. It is reported that the global stock markets dropped significantly on February, 24th 2020 owing to a dramatic increase in the number of COVID-19 cases outside China (McLean et al., 2020; Carrick, 2020); thus, in the existing literature, the authors observe that the COVID-19 pandemic crisis givers the first signal on 24 February 2020, and this date is also used as starting point of crisis period. While the period from 03/09/2019 to 23/02/2020 is considered as the pre-crisis period, the period between 24/02/2020 and 30/06/2020 is considered as the crisis period. However, at the time of this study, the COVID-19 translation is not over. Therefore, the results of this study are only relative.

## 4. Methodology

### 4.1. DCC – GARCH Model

In this paper, DCC – GARCH model of Engle (2002) is applied to examine the existence of contagion effects during the COVID-19 pandemic crisis and the global financial crisis. A great benefit of using this model is to find out possible changes in conditional correlation over time, allowing us to detect dynamic investor behavior in response to news and innovation (Celik, 2012). Furthermore, the measurement method of dynamic conditional correlations is suitable in order to explore possible contagion effects because of herding behavior in developing financial markets during the period of crisis (Chiang et al., 2007; Syllignakis & Kouretas, 2011). In addition, using DCC – GARCH model can be advantageous to measure correlation coefficients of the standardized residuals and so account for heteroscedasticity in a direct way (Chiang et al., 2007). Owing to the procedural adjustment of volatility, the time-varying conditional correlation (DCC) does not have any bias from volatility. Being not similar to the volatility-adjusted cross-market correlations that are employed in Forbes and Rigobon (2002), the correlation for the time-varying volatility is continuously adjusted by DCC – GARCH model. Therefore, DCC provides a super correlation measure (Cho & Parhizgari, 2008).

The analysis of Engle's DCC – GARCH model involves two steps: the first is to estimate the univariate GARCH model, and the second is to measure the conditional correlations varying over time.

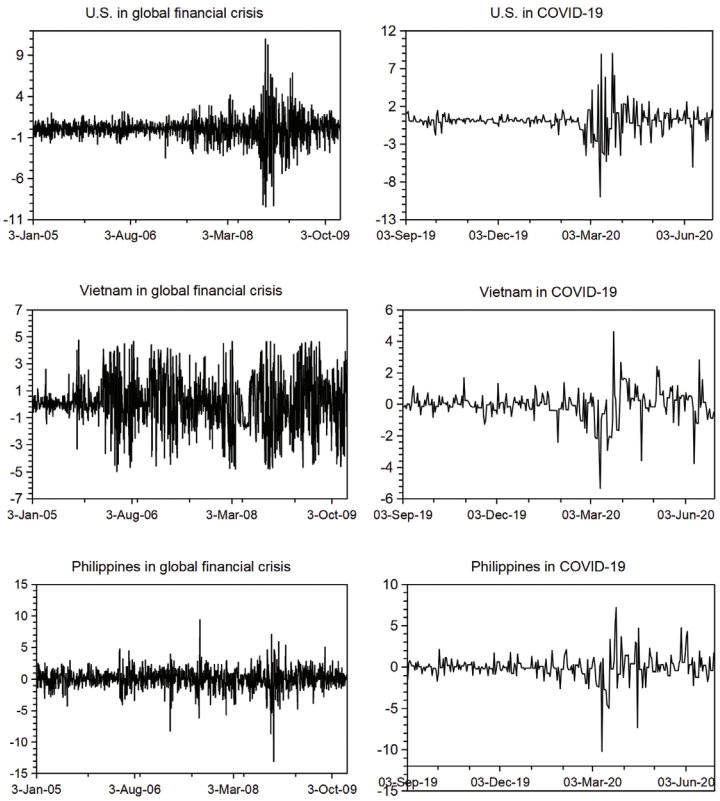


**Figure 2:** Stock market return series

The multivariate DCC–GARCH model that is proposed by Engle (2002) is defined as follows;

$$Y_t = \mu_t + H_t^{1/2}\varepsilon_t \tag{1}$$

$$\begin{cases} H_t = D_t R_t D_t \\ R_t = \left(\text{diag}\left(Q_t\right)\right)^{-1/2} Q_t \left(\text{diag}\left(Q_t\right)\right)^{-1/2} \\ D_t = \text{diag}\left(\sqrt{h_{11,t}}, \sqrt{h_{22,t}}, .....\sqrt{h_{NN,t}}\right) \end{cases} \tag{2}$$

where $Y_t$ = ($Y_{1t}$, $Y_{2t}$, $Y_{3t}$, ……, $Y_{Nt}$) is the vector of the past observations, $\mu_t$ = ($\mu_{1t}$, $\mu_{2t}$, $\mu_{3t}$, ……, $\mu_{Nt}$) is the vector of conditional returns, $H_t$ is the multivariate conditional variance, $\varepsilon_t$ = ($\varepsilon_{1t}$, $\varepsilon_{2t}$, $\varepsilon_{3t}$, ……, $\varepsilon_{Nt}$) is the vector of the standardized residuals, *Rt* is a $N \times N$ symmetric dynamic correlations matrix, and *Dt* is a diagonal matrix of conditional standard deviations for return series, which is got from analyzing a GARCH model with $\sqrt{h_{ii,t}}$ on the diagonal $i\left(i = 1,2,3,\ldots,N\right)$.

The DCC specification is defined as follows;

$$\begin{aligned} Q_t &= \left(1-\lambda_1-\lambda_2\right)\bar{Q} + \lambda_1 \delta_{i,t-1}\delta_{j,t-1} + \lambda_2 Q_{t-1} \\ R_t &= Q_t^{*-1} Q_t Q_t^{*-1} \end{aligned} \tag{3}$$

where $Q_t = \left[q_{ij,t}\right]$ is a $\left(N \times N\right)$ time varying covariance matrix of standardized residuals $\left(\delta_{it} = \frac{\varepsilon_{it}}{\sqrt{h_{it}}}\right)$, $\bar{Q}$ is the unconditional correlations of $\delta_{i,t}\delta_{j,t}$, $\lambda_1$ and $\lambda_2$ are nonnegative scalar parameters which satisfies $\lambda_1 + \lambda_2 < 1$, and $Q_t^* = \left[q_{ii,t}^*\right] = \sqrt{q_{ii,t}}$ is a diagonal matrix with the square root of the i$^{th}$ diagonal element of $Q_t$ on its $i^{th}$ diagonal position.

Hence, the conditional correlation of a pair of markets *i* and *j* at time *t* can be defined as:

$$\rho_{ij,t} = \frac{(1-\lambda 1-\lambda 2)\bar{q}_{ij} + \lambda 1 \delta_{i,t-1}\delta_{j,t-1} + \lambda 2 q_{ij,t-1}}{\left[\begin{array}{l} \left[(1-\lambda 1-\lambda 2)\bar{q}_{ii} + \lambda 1 \delta_{i,t-1}^2 + \lambda 2 q_{ii,t-1}\right]^{\frac{1}{2}} \\ \times\left[(1-\lambda 1-\lambda 2)\bar{q}_{jj} + \lambda 1 \delta_{j,t-1}^2 + \lambda 2 q_{jj,t-1}\right]^{\frac{1}{2}} \end{array}\right]} \tag{4}$$

where $q_{ij}$ is the element which locates on the $i^{th}$ and $j^{th}$ column in the matrix $Q_t$.

The parameters are measured by applying quasi-maximum likelihood method (QMLE) which is proposed by Bollerslev et al. (1988). With regard to Celik (2012), the log-likelihood is defined as:

$$L(v) = -\frac{1}{2}\sum_{t=1}^{T}[(n\log(2\pi) + \log|D_t|^2 + \varepsilon_t' D_t^{-1} D_t^{-1}\varepsilon_t) + (\log|R_t| + \delta_t' R_t^{-1}\delta_t - \delta_t'\delta_t)] \quad (5)$$

where T is observation number, $n$ is equation number, and $v$ is the vector of parameters which is measured.

### 4.2. Contagion Effect Test With Dynamic Conditional Correlation Coefficient

In this paper, t-statistics is applied for a purpose which is to examine consistency of dynamic correlation coefficient between stock markets in the pre-crisis period and crisis period in order to evaluate the contagion effect. The authors define both null and alternative hypotheses as that of Celik (2012).

$$H_0 : \mu_{\rho}^{\text{pre-crisis}} = \mu_{\rho}^{\text{crisis}} \text{ and } H_1 : \mu_{\rho}^{\text{pre-crisis}} \neq \mu_{\rho}^{\text{crisis}} \quad (6)$$

where $\mu_{\rho}^{\text{pre-crisis}}$ and $\mu_{\rho}^{\text{crisis}}$ are the conditional correlation coefficient means of population in the period of pre-crisis and the period of crisis. If sample sizes are $n^{\text{pre-crisis}}$, and $n^{\text{crisis}}$, the population variances to be denoted by $\sigma^2_{\text{pre-crisis}}$ and $\sigma^2_{\text{crisis}}$ will unknown and different (Celik, 2012). If the means of dynamic correlation coefficients to be calculated by DCC – GARCH model are $\overline{\rho}_{ij}^{\text{pre-crisis}}$ and $\overline{\rho}_{ij}^{\text{crisis}}$ and the variances are denoted by $s^2_{\text{pre-crisis}}$, and $s^2_{\text{crisis}}$, the value of t-statistic can be measured based on the formula of Celik (2012), which is:

$$t = \frac{\left(\overline{\rho}_{ij}^{\text{crisis}} - \overline{\rho}_{ij}^{\text{pre-crisis}}\right) - \left(\mu_{\rho}^{\text{crisis}} - \mu_{\rho}^{\text{pre-crisis}}\right)}{\sqrt{\frac{s^2_{\text{crisis}}}{n^{\text{crisis}}} + \frac{s^2_{\text{pre-crisis}}}{n^{\text{pre-crisis}}}}} \quad (7)$$

If the absolute value of t-statistic is significantly greater than the critical value, the hypothesis $H_0$ can be rejected, and it also means that contagion effect exists.

## 5. Empirical Findings

### 5.1. Descriptive Statistics

Tables 1 and 2 illustrate the descriptive statistics of daily returns on the U.S., Vietnamese, and Philippines indices in the period of pre-crisis, the period of crisis, and entire period.

In Table 1, it can be clearly seen that the mean of all stock exchange rate returns are positive during period before the global financial crisis, while only that value for the U.S. market is positive in period before COVID-19 pandemic crisis. Besides, the kurtosis values in these markets are larger than 3, which implies a peaked distribution comparing with the normal distribution. In other words, for all three markets, big shocks of either sign are more likely to occur and that rate of return series in markets may not be distributed normally (Chiang et al., 2007). Furthermore, Jarque-Bera test results for all markets in both pre-crisis periods also show that stock exchange daily returns do not have normal distribution.

Table 1 also gives information about the descriptive statistics in the period of crisis. During this period, the mean of stock exchange market returns are negative for all countries in both crisis periods. Another noteworthy statistic in this table is that the values of kurtosis in crisis period are as high as pre-crisis period. In addition, the null hypothesis of series having normal distribution is rejected for three markets during two crisis period. For all countries, the mean of stock exchange daily returns in the pre-crisis period are higher than those in crisis period. The standard deviation of stock exchange market returns in pre-crisis period are lower than those in the period of crisis. It is an existence of leptokurtic distribution in all the stock exchange market returns, which can be considered as a common characteristics of financial variables.

### 5.2. The Contagion Effects

Table 3 presents the analysis results of DCC coefficients in the period of pre-crisis and the period of crisis in global financial crisis and COVID-19 pandemic crisis. According to the statistics during the 2007–2008 financial crisis, the DCC coefficients between the U.S. and Vietnamese markets in the pre-crisis period and crisis period are significant at 10% level and 5% level, respectively, however, that value from the U.S. to the Philippine markets is only significant at 10% level in the pre-crisis period, and is not significant at all the levels in the crisis period, implying that the correlation between two markets is very weak, and almost none. It can be clearly seen that DCC correlation between the U.S. and the Vietnamese stock markets increases in crisis period, while this correlation between the U.S. and the rest of market falls, which also shows the difference based on the change in the DCC mean values in percentage term between these markets are 91.78% for Vietnam, and –34.23% for the Philippines. As far as the DCC results for COVID-19 pandemic crisis is concerned, the coefficients from the U.S. to both developing markets in the pre-crisis period and crisis period are significant at 1% level and 5% level. The relative percentage difference of the DCC mean values between the U.S. and Vietnamese markets; and between the U.S. and the Philippine markets are 22.38% and 52.58%, respectively. This is also an indication that the contagion effect exists. The findings in Table 3 partly reflect the existence of the contagion effects, and this will help strengthen the analysis results in Table 4.

**Table 1:** Descriptive statistics of stock exchange daily returns in pre-crisis period and crisis period

| | | | U.S. (S&P 500) | Vietnam (VN–Index) | Philippines (PSEi) |
|---|---|---|---|---|---|
| Pre-crisis period (03/01/2005 – 30/09/2007) | Global Financial crisis | Mean | 0.0004 | 0.0027 | 0.0012 |
| | | Minimum | –3.5343 | –4.9714 | –8.2513 |
| | | Maximum | 2.8790 | 4.7348 | 9.3653 |
| | | Standard deviation | 0.0065 | 0.0155 | 0.0127 |
| | | Skewness | –0.3138 | 0.0801 | –0.0309 |
| | | Kurtosis | 5.6336 | 4.0712 | 9.4507 |
| | | Jarque-Bera | 308.988*** | 49.0249*** | 1734.891*** |
| | | LB (10) | 9749.8*** | 9740.3*** | 9741.3*** |
| Pre-crisis period (03/09/2019 – 23/02/2020) | COVID-19 pandemic crisis | Mean | 0.0728 | –0.0412 | –0.0508 |
| | | Minimum | –1.8065 | –2.4218 | –2.6300 |
| | | Maximum | 1.4870 | 1.6650 | 2.0860 |
| | | Standard deviation | 0.500 | 0.4760 | 0.6914 |
| | | Skewness | –0.551 | –0.1892 | 0.2258 |
| | | Kurtosis | 5.764 | 7.4233 | 5.0154 |
| | | Jarque-Bera | 64.1927*** | 30.9648*** | 142.860*** |
| | | LB (10) | 1501.8*** | 1451*** | 1478.2*** |
| Crisis period (01/10/2007–31/12/2009) | Global Financial crisis | Mean | –0.0007 | –0.0009 | –0.0004 |
| | | Minimum | –9.4695 | –4.8019 | –13.0887 |
| | | Maximum | 10.9572 | 4.6468 | 7.0560 |
| | | Standard deviation | 1.9721 | 2.0970 | 1.6629 |
| | | Skewness | –0.0518 | 0.0485 | –1.0183 |
| | | Kurtosis | –0.0518 | 7.8330 | 10.4138 |
| | | Jarque-Bera | 795.400*** | 4.6346* | 2010.22*** |
| | | LB (10) | 7908.4*** | 7725.7*** | 7826.5*** |
| Crisis period (24/02/2020–30/06/2020) | COVID-19 pandemic crisis | Mean | –0.0400 | –0.0793 | –0.1211 |
| | | Minimum | –9.9945 | –5.3284 | –10.2159 |
| | | Maximum | 8.9683 | 4.6012 | 7.1717 |
| | | Standard deviation | 2.5270 | 1.3241 | 2.1246 |
| | | Skewness | 0.0158 | –0.5324 | –0.6456 |
| | | Kurtosis | 6.3176 | 5.6388 | 8.1185 |
| | | Jarque-Bera | 58.3338*** | 148.613*** | 43.1882*** |
| | | LB (10) | 1010*** | 976.45*** | 966.75*** |

Note: Table shows the descriptive statistics for pre-crisis period and crisis period. LB (10) is Ljung-Box Q test statistics for 10 lags. ***, ** and * indicate the significance level at 1%, 5%, 10% respectively.

In Table 4, the null hypothesis of the mean of DCC correlations for the Philippines in the global financial crisis which are same in pre-crisis and crisis periods can not be rejected. However, the authors reject the null hypothesis of no contagion effect between the U.S. and the Vietnamese stock markets during the subprime mortgage crisis. Regarding to the statistics for COVID-19 pandemic, the null hypothesis of the mean of DCC correlations for both Vietnam and the Philippines that are same in crisis and crisis periods can be rejected, which also means that it is a appearance of contagion effects between the U.S. and two developing (the Vietnamese and the Philippine) stock markets.

**Table 2:** Descriptive of stock exchange daily returns in entire period (03/01/2005–31/12/2009 and 03/09/2019–30/06/2020)

| | | U.S. (S&P 500) | Vietnam (VN–Index) | Philippines (PSEi) |
|---|---|---|---|---|
| Global Financial crisis | Mean | –0.0001 | 0.0011 | 0.0004 |
| | Minimum | –9.4695 | –4.9714 | –13.0887 |
| | Maximum | 10.9572 | 4.7348 | 9.3653 |
| | Standard deviation | 1.4107 | 1.8247 | 1.4630 |
| | Skewness | –0.1815 | –0.0298 | –0.7283 |
| | Kurtosis | 13.6312 | 3.2952 | 10.9681 |
| | Jarque-Bera | 8589.34*** | 6.4313*** | 4973.89*** |
| | LB (10) | 17968*** | 17906*** | 17964*** |
| COVID-19 pandemic crisis | Mean | 0.0250 | –0.0573 | –0.0806 |
| | Minimum | –9.9945 | –5.3284 | –10.2159 |
| | Maximum | 8.9683 | 4.6012 | 7.1717 |
| | Standard deviation | 1.856 | 0.9330 | 1.4767 |
| | Skewness | –0.0914 | –0.7076 | –0.8605 |
| | Kurtosis | 13.432 | 9.9626 | 14.845 |
| | Jarque-Bera | 1370.02*** | 634.447*** | 1801.4*** |
| | LB (10) | 2768.6*** | 2768.5*** | 2767.1*** |

Note: Table shows the descriptive statistics for entire period (03/01/2005–31/12/2009 and 03/09/2019–30/06/2020). LB (10) is Ljung-Box Q test statistics for 10 lags. ***, ** and * indicate the significance level at 1%, 5%, 10% respectively.

**Table 3:** Analysis of DCC – GARCH model

| | | Dynamic conditional correlation | | |
|---|---|---|---|---|
| | | Pre-crisis | Crisis | % difference |
| Global Financial crisis | US _Vietnam | 0.0596* (0.077) | 0.1143** (0.012) | 91.7785 |
| | US_Philippines | 0.0631* (0.097) | 0.0415 (0.399) | –34.2314 |
| COVID-19 pandemic crisis | US _Vietnam | 0.3431*** (0.001) | 0.4199*** (0.000) | 22.3841 |
| | US_Philippines | 0.2128** (0.036) | 0.3247*** (0.000) | 52.5846 |

Note: pre-crisis period is from 03/01/2005 to 31/09/2007 and from 03/09/2019 to 23/02/2020. Crisis period is from 01/10/2007 to 31/12/2009 and from 24/02/2020 to 30/06/2020. ***, ** and * indicate the significance level at 1%, 5%, 10% respectively.

**Table 4:** Dynamic conditional correlation coefficient and contagion effect test

| | | | Mean | Variance | t-statistic $H_0 : \mu_\rho^{pre-crisis} = \mu_\rho^{crisis}$ |
|---|---|---|---|---|---|
| Global Financial crisis | DCC US_Vietnam | Pre-crisis | 0.06 | 0.06 | –19.32*** |
| | | Crisis | 0.11 | 0.02 | |
| | DCC US_Philippines | Pre-crisis | 0.06 | 0.00 | –0.33 |
| | | Crisis | 0.04 | 0.00 | |
| COVID-19 pandemic crisis | DCC US_Vietnam | Pre-crisis | 0.24 | 0.00 | –18.39*** |
| | | Crisis | 0.42 | 0.01 | |
| | DCC US_Philippines | Pre-crisis | 0.18 | 0.01 | –12.96*** |
| | | Crisis | 0.42 | 0.00 | |

Note: pre-crisis period is from 03/01/2005 to 31/09/2007 and from 03/09/2019 to 23/02/2020. Crisis period is from 01/10/2007 to 31/12/2009 and from 24/02/2020 to 30/06/2020. ***, ** and * indicate the significance level at 1%, 5%, 10% respectively.

The reasons why the contagion effects exist in the Vietnamese market in the global financial crisis, and occur in both the Vietnamese and the Philippine stock markets during the COVID-19 pandemic crisis is that investors around the world in general, and in Vietnam and the Philippines in particular are sensitive to news and the volatility of stock prices from foreign markets. Besides, the U.S. is one of the largest economy which can impact other countries such as Vietnam and the Philippines. Another reason worth considering is the integration of Vietnam and the Philippines into the global economy which also explains the contagion effects from the U.S. to the Vietnamese and the Philippine stock markets. Thanks to being members of ASEAN, the APEC, and the WTO forum, the Vietnamese and the Philippine economies receive more investment from foreign investors, involving those in the U.S. It also explains the contagion effects from the U.S. to two developing markets, the Vietnamese and the Philippine markets. In addition, when those crises appear, import and export activities as well as production activities are almost suspended due to credit scarcity in the U.S. subprime crisis, and the spread of coronavirus disease in COVID-19 pandemic crisis. This phenomenon will negatively affect to not only the economic growth, but also the stock market indices. In fact, the global financial crisis was originally from the U.S. Furthermore, during COVID-19 pandemic, the United States has the highest number of COVID-19 cases in the world, with more than 2.5 million cases and approximately 126,000 deaths, confirmed on June 30, 2020 by World Health Organization (2020). Therefore, the authors can deny that America is the country that suffered the most from these two crises. This also will create the contagion effects between the U.S. and other countries markets, including Vietnam and the Philippines.

However, the authors do not find evidence of a contagious impact from the U.S. stock market to the Philippine stock market during the global financial crisis. This result is consistent with reality and can be explained by the following reasons. Firstly, in this period, the Philippine government has a quasi-capital control. Although the country has been liberalizing its capital account since the 1990s, the Philippines' constitution still has some specific prohibitions related to the banking industry and a few sectors that are listed on Foreign Investment Negative List. Besides, the central bank of the Philippines has set up appropriate policy guidelines among banks through macroprudential policy to limit the risks taken by domestic banks when conducting both domestic and foreign transactions (Zoleta, 2018). This has not only made the Filipino banks less connected with major U.S. banks than in the previous period, but also made the two economies less connected. Secondly, according to Zoleta (2018), before and during the global financial crisis, the debt to equity ratio of companies in the Philippines drops sharply, and their foreign exchange reserves in this period are also very large. This has contributed to an increase in the current account balance of the Philippines and the surplus of this account is considered an additional source of funding in case the Philippine capital flow suddenly stops due to the impact of the crisis. Moreover, the increase in remittance from abroad to the Philippines via Business process outsourcing industry and Overseas Filipino workers has contributed to supporting the Philippines' consumer economy. The above reasons have inadvertently made the Philippine economy become inward and not dependent on exports. Hence, during the crisis, the Philippines economy and stock market did not suffer as much losses as other countries.

## 5.3. Comparison

The analysis of the contagion effects in two crises stated above shows that the Vietnamese stock market during the COVID-19 pandemic crisis is less affected by the U.S. market than in the global financial crisis, with a percentage change in the conditional correlation coefficients of 22.38% for the crisis in 2020 and 91.78% for the crisis in 2008, while the Philippines is more influenced by the COVID-19 pandemic crisis rather than by the U.S. subprime crisis, with the relative percentage difference of the DCC mean values of 52.58% for the crisis in 2020 and -34.23% for the crisis in 2008. The key factors that can explain these phenomena are the background of each crisis, and how Vietnam and the Philippines cope with them.

With regard to the 2007–2008 financial crisis, it began with a downturn in the subprime mortgage market in the United States, and developed into a full-blown international banking crisis with the bankruptcy of Lehman Brothers on September 15th, 2008; excessive risk-taking by banks in America such as Lehman Brothers enlarged this crisis to a global scale (Williams, 2010). Even though the global financial crisis exposed weaknesses that were existing in many financial industry regulations and the financial systems all over the world (Mighri & Mansouri, 2013), including Vietnam, the economy and financial markets of the Philippines were not significantly affected by this crisis. Thanks to tight control of capital markets and the banking industry as well as efforts to turn the economy inward, the Philippines has successfully isolated its economy from the global financial crisis.

Nevertheless, the COVID-19 pandemic crisis is completely different from the 2007–2008 global financial crisis in terms of its background, characteristics and the way it affects economic, political and social aspects. In fact, the coronavirus pandemic is a global health crisis that has broken out in 2020, and become the biggest challenge that humans have faced since World War II. Since its appearance in Asia in late 2019, the COVID-19 virus has spread to many continents except Antarctica. This pandemic is not only a health

crisis, it is also considered as an unprecedented socio-economic crisis. According to World Health Organization (2020), until the end of June 2020, approximately 10.2 million COVID-19 infection cases around the world have been confirmed and the total number of confirmed COVID-19 deaths are more than 500 thousands people. This has negatively affected the production activities which are essential for economic growth. In other words, the shortage of human resources in manufacturing and business activities will cause the economy as well as the financial markets to go down. Therefore, to overcome economic recession in the COVID-19 pandemic, governments in every countries need to get effective and timely practices in order to limit the spread of the potentially deadly virus, coronavirus. It also means that countries that have well controlled the increase in the number of cases and deaths in the COVID-19 will be less affected by this crisis. It can be clearly seen that Vietnam's relative difference of the conditional correlation coefficients in the COVID-19 is only approximately a quarter of that rate in the global financial crisis, which means Vietnam is less influenced by the contagion effect from the COVID-19 pandemic crisis than the remaining crisis.

This result is in line with reality because Vietnam has been cited by the global media as one of the countries with the best-organized epidemic prevention and control programs in the world (Walden, 2020; Winn, 2020), and this is an undeniable fact that the total number of COVID-19 infections in Vietnam are only 355 cases and zero deaths are confirmed as of 30th June 2020 (World Health Organization, 2020). However, the results for the contagion effect of the Philippines are in stark contrast to that of Vietnam. It is noticed that the Philippines's relative change of the DCC mean values in the COVID-19 pandemic crisis is greater than that rate in the global financial crisis by a difference of 86.81%, which means the contagion effect from the coronavirus pandemic affects the Philippines more than from the global financial crisis. This finding is consistent with reality in the study area that the Philippines is in danger of losing the battle against COVID-19 due to poor detection, isolation, and contact tracing (Fonbuena, 2020), making this country has become the second largest outbreak of COVID-19 in Southeast Asia with the total of 36,438 confirmed cases and 1,255 deaths till 30th June 2020 (World Health Organization, 2020). Moreover, the authors also observe that the Vietnam's percentage change of DCC mean values in the COVD-19 pandemic crisis (22.38%) is lower than that rate of the Philippines (52.58%), which means that at the time of this study, the Philippines seems to be more influenced by the contagion effect from the COVID-19 pandemic than Vietnam. This is obvious because, regarding to those facts that are stated above, it can be denied that Vietnam is coping so well with the coronavirus, and they are doing this better than the Philippines.

## 6. Conclusions

In this paper, daily returns on the S&P 500, VN-Index and PSEi from 03/01/2005 to 31/12/2009 and from 01/11/2019 to 30/06/2020 are used to test the existence of financial contagion from the U.S. stock market to the Vietnamese and the Philippine stock markets during the U.S. subprime crisis and the COVID-19 pandemic crisis by applying DCC – GARCH model that has some advantages over other methodologies.

As a result of analysis, the authors cannot find evidence of contagion during global financial crisis from the U.S. stock market to the Philippine stock market, while the Vietnamese market is influenced by this effect. Besides, both these developing stock markets are influenced by the contagion effect in COVID-19 pandemic crisis. This result is expected since developing markets are more unstable than developed markets (Celik, 2012), which means that contagion can have wide spread harmful consequences in the developing markets. Another finding is that the contagion effect in the coronavirus pandemic crisis less affects to Vietnam than that in the global financial crisis, whereas the Philippines has opposite result with Vietnam. It is also noticeable that the Philippines seems to be more influenced by this effect from the COVID-19 pandemic than Vietnam at the time of this study. These phenomena appear due to differences in crisis management strategies of both Vietnam and the Philippines in the global financial crisis and the COVID-19 pandemic crisis.

The findings of this article are necessary for policymakers in the Vietnamese, the Philippine markets and other developing markets because financial contagion instability affects their development. Hence, policy makers in Vietnam and the Philippines should find ways to close the channels of contagion to reduce the instability in their countries. In addition, policy makers in these countries also should understand clearly the characteristics of each crisis in order to propose policies that are suitable for their own country, and should pay close attention to information about the U.S. economy. Moreover, investors should follow information on the U.S. stock market when investing or diversifying their portfolio by investing in the Vietnamese or the Philippine stock market.

Examining the presence of financial contagion on other asset markets such as foreign exchange markets or sovereign bond markets and on other developing countries such as Malaysia, Thailand, Indonesia, China and so on. Besides, employing high frequency datasets will provide broader evidence of financial contagion.

## References

Alam, M. N., Alam, M. S., & Chavali, K. (2020). Stock market response during COVID-19 lockdown period in India:

An event study. *Journal of Asian Finance, Economics, and Business, 7*(7), 131–137. https://doi.org/10.13106/jafeb.2020.vol7.no7.131

Alshammari, T. S., Ismail, M. T., Al-wadi, S., Saleh, M. H., & Jaber, J. J. (2020). Modeling and Forecasting Saudi Stock Market Volatility Using Wavelet Methods. *Journal of Asian Finance, Economics, and Business, 7*(11), 83–93. https://doi.org/10.13106/jafeb.2020.vol7.no11.083

Balli, F., Hajhoj, H. R., Basher, S. A., & Ghassan, H. B. (2015). An analysis of returns and volatility spillovers and their determinants in emerging Asian and Middle Eastern countries. *International Review of Economics & Finance, 39*, 311–325. https://doi.org/10.1016/j.iref.2015.04.013

Becketti, S., & Sellon, G. H. (1989). Has financial market volatility increased? *Economic Review from Federal Reserve Bank of Kansas City, 74*(June), 17–30. https://www.kansascityfed.org/PUBLICAT/ECONREV/EconRevArchive/1989/2q89beck.pdf

Bekaert, G., Harvey, C. R., & Ng, A. (2005). Market integration and contagion. *Journal of Business, 78*(1), 39–69. http://dx.doi.org/10.1086/426519

Bollerslev, T., Engle, R. F., & Wooldridge, M. (1988). A capital asset pricing model with time-varying covariance. *Journal of Political Economy, 96(1),* 116–131. http://dx.doi.org/10.1086/261527

Bouaziz, M. C., Selmi, N., & Boujelbene, Y. (2012). Contagion effect of the subprime financial crisis: evidence of DCC multivariate GARCH models. *European Journal of Economics, Finance and Administrative Sciences, 44*, 66–76. https://www.europeanjournalofeconomicsfinanceandadministrativesciences.com/

Breitung, J., & Candelon, B. (2006). Testing for short- and long-run causality: A frequency-domain approach. *Journal of Econometrics, 132*(2), 363–378. https://doi.org/10.1016/j.jeconom.2005.02.004

Calvo, S., & Mendoza, E. (2000). Rational contagion and the globalization of securities markets. *Journal of International Economics, 51*, 79–113. https://doi.org/10.1016/S0022-1996(99)00038-0

Campbell, J. Y., Lo, A. W., & MacKinlay, A. C. (1997). *The econometrics of financial markets*. Princeton, NJ: Princeton University Press.

Carrick, A. (2020, February 24). FTSE 100 plunges 3.4 per cent as Italy confirms seventh coronavirus death. *CITYA.M*. Retrieved July 10, 2020 (actual access date), from https://www.cityam.com/ftse-100-plunges-2-per-cent-as-coronavirus-takes-hold-in-italy/

Celik, S. (2012). The more contagion effect on emerging markets: The evidence of DCC-GARCH model. *Economic Modelling, 29*(5), 1946–1959. https://doi.org/10.1016/j.econmod.2012.06.011

Chiang, T. C., Jeon, B. N., & Li, H. (2007). Dynamic correlation analysis of financial contagion: evidence from Asian markets. *Journal of International Money and Finance*, 1026-1228. https://doi.org/10.1016/j.jimonfin.2007.06.005

Cho, J. H., & Parhizgari, A. M. (2008). East Asian financial contagion under DCC-GARCH. *International Journal of Banking and Finance, 6(1)*. https://doi.org/10.32890/ijbf2009.6.1.8380

Dominguez, K. M. E., Hashimoto, Y., & Ito, T. (2012). International reserves and the global financial crisis. *Journal of International Economics, 88*(2), 388–406. https://doi.org/10.1016/j.jinteco.2012.03.003

Engle, R. (2002). Dynamic conditional correlation: A simple class of multivariate generalized autoregressive conditional heteroskedasticity models. *Journal of Business & Economic Statistics*, *20*(3), 339–350. https://doi.org/10.1198/073500102288618487

Ezzati, P. (2013). Analysis of Financial Markets Integration of Iran within the Middle East and with the Rest of the World. *American Journal of Applied Sciences, 10*(12), 1492–1508. https://doi.org/10.3844/ajassp.2013.1492.1508

Fonbuena, C. (2020, August 1). Global report: Philippines 'losing battle' as WHO records biggest jump in Covid-19 cases. *The Guardian*. Retrieved July 7, 2020 from https://www.theguardian.com/world/2020/aug/01/global-report-philippines-losing-battle-as-who-records-biggest-jump-in-covid-19-cases

Forbes, K., & Rigobon, R. (2002). No contagion, only interdependence: measuring stock market co-movements. *Journal of Finance, 57*(5), 2223–2261. https://doi.org/10.2307/3094510

Horta, P., Mendes, C., & Vieira, I. (2008). Contagion effects of the US subprime crisis on developed countries. *CEFAGE-UE Working Paper*. Évora, Portugal: CEFAGE-UE.

Hwang, I., Haeuck, I. F., & Kim, T. S. (2010). Contagion effects of the U.S. subprime crisis on international stock markets. *Finance and Corporate Governance Conference 2010 Paper.* Melbourne, Australia, April 2010. Victoria, Australia: La Trobe University. https://dx.doi.org10.2139/ssrn.1536349

Jones, P. M., & Olson, E. (2013). The time-varying correlation between uncertainty output and inflation: Evidence from a DCC–GARCH model. *Economics Letters, 118*(1), 33–37. https://doi.org/10.1016/j.econlet.2012.09.012

Kaminsky, G. L., & Schmukler, S.L. (1999). What triggers market jitters? A chronicle of the Asian crisis. *Journal of International Money and Finance, 18*, 537–560. https://doi.org/10.1016/S0261-5606(99)00015-7

Khan, K., Zhao, H., Zhang, H., Yang, H., Shah, M. H., & Jahanger, A. (2020). The impact of COVID-19 pandemic on stock markets: An empirical analysis of world major stock indices. *Journal of Asian Finance, Economics, and Business, 7*(7), 463–474. https://doi.org/10.13106/jafeb.2020.vol7.no7.463

McLean, R., He, L. & Tappe, A. (2020, February 24). Dow plunges 1,000 points, posting its worst day in two years as coronavirus fears spike. *CNN Business*. Retrieved July 7, 2020 from

https://edition.cnn.com/2020/02/23/business/stock-futures-coronavirus/index.html

Mighri, Z., & Mansouri, F. (2013). Dynamic conditional correlation analysis of stock market contagion: evidence from the 2007-2010 financial crises. *The International Journal of Economics and Financial issues, 3*(3), 237–661. https://www.econjournals.com/index.php/ijefi/article/view/390

Mulyadi, M. (2009). Volatility spillover in Indonesia, USA, and Japan capital market. *MPRA Paper 16914*. Munich, Germany: University of Munich

Naoui, K., Liouane, N., & Brahim, S. (2010). A dynamic conditional correlation analysis of financial contagion: the case of the subprime credit crisis. *International Journal of Economics and Finance, 2*(3), 85–96. https://doi.org/10.5539/ijef.v2n3p85

Nguyen, M. K., & Le, D. N. (2018). Return Spillover from the US and Japanese Stock Markets to the Vietnamese Stock Market: A Frequency-Domain Approach. *Emerging Markets Finance & Trade*, 1–12. https://doi.org/10.1080/1540496X.2018.1525357

Sok-Gee, C., Karim, M. A., & Karim, M. A. (2010). Volatility spillovers of the major stock markets in ASEAN-5 with the US and Japanese stock markets. *International Research Journal of Finance and Economics, 44*, 156–168. http://www.internationalresearchjournaloffinanceandeconomics.com/ISSUES/IRJFE%20issue%2044.htm

Syllignakis, M. N., & Kouretas, G. P. (2011). Dynamic correlation analysis of financial contagion: evidence from the Central and Eastern European markets. *International Review of Economics & Finance, 20*(4), 717–732. https://doi.org/10.1016/j.iref.2011.01.006

Walden, M. (2020, May 13). How has Vietnam, a developing nation in South-East Asia, done so well to combat coronavirus?. *ABC News*. Retrieved July 7, 2020 (actual access date), from https://www.abc.net.au/news/2020-05-13/coronavirus-vietnam-no-deaths-success-in-south-east-asia/12237314

Williams, M. (2010). *Uncontrolled Risk: The Lessons of Lehman Brothers and how systemic risk can still bring down the world financial system* (1st ed.). New York, NY: McGraw-Hill.

Winn, P. (2020, May 07). Is Vietnam the coronavirus-fighting champ of the world? *The World.* Retrieved July 7, 2020 from https://www.pri.org/stories/2020-05-07/vietnam-coronavirus-fighting-champ-world

World Health Organization. (2020). *Coronavirus disease (COVID-19): situation report, 162*. World Health Organization. https://apps.who.int/iris/handle/10665/332970

World Intellectual Property Organization. (2019). *The Global Innovation Index 2019: Creating healthy lives - The future of medical innovation.* World Intellectual Property Organization (WIPO). https://www.wipo.int/global_innovation_index/en/2019/

Worthington, A. & Higgs, H. (2004). Transmission of Equity Returns and Volatility in Asian Developed and Emerging Markets: A Multivariate GARCH Analysis. *International Journal of Finance & Economics, 9*(1), 71–80. https://doi.org/10.1002/ijfe.222

Zoleta, A. (2018). *The great financial crisis and how the Philippines got away from it*. Unpublished internal document, Chartered Institute for Securities & Investment.