Peer-Reviewed Article

Jurnal Keuangan dan Perbankan
Volume 26, Issue 1, January 2022, page. 26-43
ISSN: 1410-8089 (Print), 2443-2687 (Online)
DOI: 10.26905/jkdp.v26i1.6906

Financial Volatility Spillover in COVID-19 Pandemic Period: Evidence from the US and ASEAN Stock Market

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Abstract

A recession is part of the economic cycle that occurs in a certain period. This article investigates the effects of volatility spillover in the COVID-19 pandemic that occurred in 2020 using stock market index data from the US and ASEAN countries: Indonesia, Malaysia, Singapore, Thailand, and the Philippines. Investigations in the prior, during, and post of the 2008 crisis period were also investigated to analyze the differences between the two. This study used the BEKK-MGARCH model to analyze the spillover effect of volatility between stock indices. The results are not much different from previous research from Vo (2020), where all ASEAN stock markets except the Philippines were affected by the volatility spillover by the US market. In general, from the two periods, each ASEAN index also gives a bidirectional influence of volatility to other ASEAN indices, with the JKSE, KLSE, and SET indices having the most volatility integrated with other indices and the PSE index being the least integrated.

Keywords : BEKK; COVID-19; crisis; garch; multivariate; spillover; recession; volatility
JEL Classification : A11; G01; G15

1 INTRODUCTION

Financial markets are increasingly integrated and influence each other with technology development and deregulation of financial markets (Jebran, 2017). The current integration and co-movement between financial markets cannot be separated from the crisis that occurred in the previous period. The joint movement (co-movement) between financial markets is getting stronger, especially in the post-crisis period (Jang, 2002; Liow, 2016). This is a challenge for investors to diversify their portfolios.

During periods of crisis, financial markets in many countries tend to move in the same direction, as happened in the 2008 financial crisis caused by the subprime mortgage in the United States and the 2020 crisis caused by the Covid-19 virus pandemic. The crisis in 2008 began with the collapse of the property sector in the United States, which caused a decline in the asset value of banks in the United States. The decline in asset values had a profound

impact on the financial industry, leading to the collapse of the Lehman Brothers after 158 years of existence.

In contrast to the causes of the crisis in 2008, the crisis in 2020 began with an extraordinary event (outbreak) from the Covid-19 virus, which turned into a pandemic. The Covid-19 virus pandemic has had a major impact on the world economy with restrictions on economic activity. Based on data from the IMF (2021), the world economy in 2020 shrank by 3.3%. Based on GDP data from the World Bank, this shrinkage is even worse than the crisis in 2009, which fell by 1.6%.

Global stock markets reacted strongly to the massive spread of Covid-19 cases. The extreme decline in the index occurred in many countries in response to this phenomenon. An extreme decline can be said to lead to a market crash when the value of the decline exceeds the 20 percent limit (Mishkin, 2002). As an illustration, during the March 2020 period, the JKSE index decreased by 30 percent, the FTSE fell by 26 percent, the SSE fell by 13 percent, KOSPI fell by 30 percent, and the DJIA fell by 26 percent. A decrease in the index value from a market with a large capitalization can have a volatility spillover effect on emerging markets with a lower capitalization value (Bala, 2017; Vo, 2020).

Several studies are investigating the stock market in crisis periods. Gulzar (2019) investigates the volatility spillover effect between the US stock market and the Asian stock market using the GARCH-BEKK multivariate method during the 2008 crisis period. Gulzar uses stock market index data from several countries in Asia: Malaysia, Korea, Russia, India, China, and Pakistan. The investigation results found a volatility spillover effect on the majority of Asian stock markets on the volatility of the US stock market. ARCH and GARCH effects on each stock index are also significant, which indicates the effects of shock and volatility. The same thing was also found by Li (2015) as the US stock market contributed to the volatility of the Asian stock market during the Asian financial crisis period. In another study, Vo (2020) investigated the volatility spillover effect in a more specific scope by using stock market index data from the US and Southeast Asia during the 2008 crisis. Based on the investigation results, Vo found that the US stock market contributed significantly to the volatility of return values of the Southeast Asian stock market. The investigation of Vo (2020) is supported by the results of previous research from Purbasari (2019), which also investigated the volatility spillover with the ASEAN stock market and investigated the volatility of the US stock market. In more detail, Purbasari explained that prior to the 2008 crisis period, the ASEAN stock market had no internal volatility fluctuations, but the relationship between stock markets in the post-crisis period was complex. In different geographies, Yousaf (2020) investigated the DM (US, China) and EM (Latin America) stock markets which also concluded that the DM stock market had the effect of volatility on the EM stock market.

In this investigation, we focus on the empirical analysis on how the volatility spillover in a pandemic period of 2020 behaves compared to the financial crisis in 2008. From the studies discussed previously, it is clear that EM and DM have different volatility spillover behavior even though both are categorized as EM. From Li (2015), Vo (2020), and Malik (2021), investigations on EM Asian countries and BRIC give different results, with the US stock index generating a larger spillover magnitude to the stock indices of ASEAN countries than the BRIC. The results of the investigations from Li (2015) and Vo (2020) provide a clearer picture of how the volatility spillover behavior between the US and Asian stock indices is, that there is a strong spillover relationship between the two.

The investigation of the effects of volatility spillover in the crisis period is the theme of this study, focusing on the prior, during, and post 2008 crisis period and during the 2020 pandemic period. The investigation between the two periods becomes interesting to find out how the spillover behaves each index, with the cause of the crisis of the two periods is different. Data on the stock market closing index values of the US (S&P 500), Indonesia (JKSE), Malaysia (KLSE), Singapore (STI), Thailand (SET), and the Philippines (PSE) were used as samples to be investigated.

In collecting sample data, the 2008 crisis started from August 1, 2007, which was the beginning of the crisis with Lehman Brother closing its subprime loans, to May 29, 2009, the end of the crisis with the stock market becoming more stable after that period. The crisis period in 2020 started from March 22, 2019, at which time there was an inverted yield curve for United States bonds until June 30, 2021. All data were obtained through Thomson Reuters, processed using Eviews software for descriptive analysis, and analyzed volatility spillover using WinRATS.

2 METHODS

The focus of this study is to see the effect of volatility spillover on the stock markets of Southeast Asia and the US in the prior, during, and post of the 2008 crisis period and the 2020 pandemic period. The data samples used are the stock indexes of the US (S&P 500), Indonesia (JKSE), Malaysia (KLSE), Singapore (STI), Thailand (SET), Philippines (PSE). In collecting sample data, the prior 2008 crisis period started from December 2, 2003, until July 21, 2007. During 2008 crisis period started from August 1, 2007, which was the beginning of the crisis with the Lehman Brothers closing its subprime loans, to May 29, 2009, which was the end of the crisis with the stock market becoming more stable after that period. The post period of the 2008 crisis or prior to the 2020 crisis started from June 1, 2009, until March 21, 2019. The selection of the 2020 crisis period started from March 22, 2019, at which time the inverted yield curve for United States bonds occurred, until June 30, 2021.

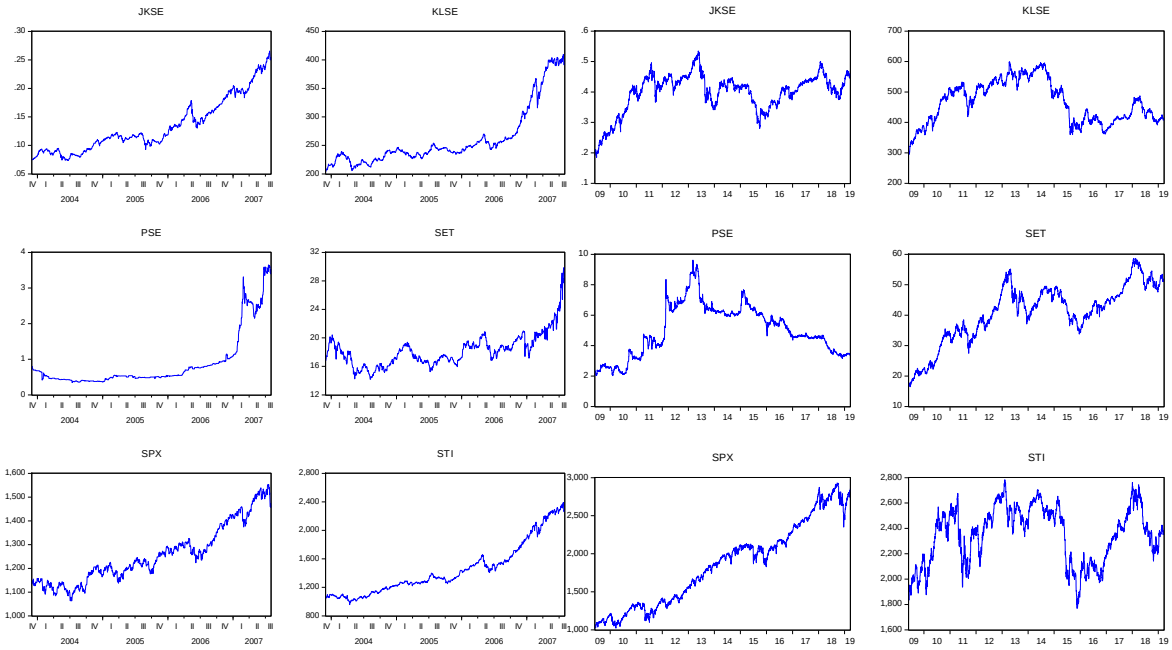


Figure 1: Graph of each stock index of prior 2008 crisis and post-2008 crisis

Data was collected via Thomson Reuters using the daily time-series format. By using closing price data from each index, the return value of each stock index is calculated. The empty value from the closing day of the exchange will be filled with the same value as the previous day. Following is the graph of each index of the selected period in Figure 1.

Before starting the modeling of volatility spillover data from each index, a unit root test must be carried out by first converting the index time series value to the index return time series. Each of the index data needs to be converted to the return level; in this investigation, the return of each stock index is obtained using a simple return:

$$R_t = \frac{(I_t - I_{t-1})}{I_{t-1}} \; x \; 100 \tag{1}$$

Where R_t is the return value at *t* and I_t represents the index value at *t*.

The unit root test is carried out to ensure that the data is at the stationary level or I(0). By ensuring that the data is I(0), it can be ascertained that the time series data is white noise, which means that the value of the time series at a point is not affected by its past value. This study performed the unit root test using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) methods. The model of the ADF method with n order autoregressive processes is as follows:

$$\Delta Y_t = \alpha_0 + \alpha Y_{t-1} + \alpha_2 \Delta Y_{t-2} + \cdots + \alpha_n \Delta Y_{t-n} + e_t \tag{2}$$

where Δ is the difference operator, α_0 is the value of white noise innovation (Cheung, 1995), and *e* is the value of white noise error. In the implementation, the ADF method pays attention to the number of lags in the modeling, which was determined based on the value of the Schwarz Info Criterion (SIC) with the most optimal value.

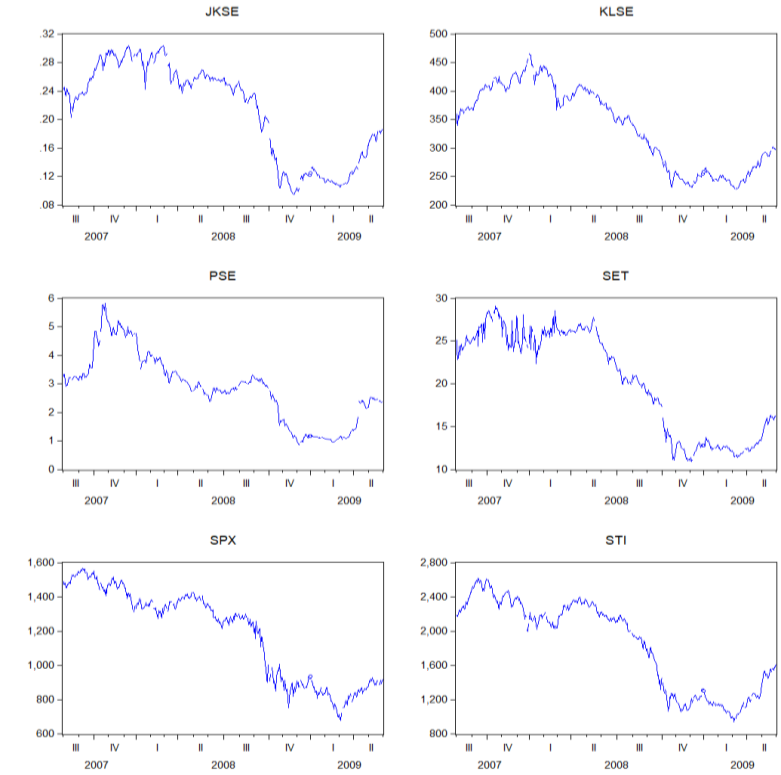
The PP method has the same hypothesis as the ADF method. However, the PP method uses non-parametric statistical methods to maintain the possibility of serial correlation in errors. The difference between the two methods is significant in critical value if the sample used is small. In addition, the PP method is not affected by the selected lag length (Lukas, 2009).

The motivation of this research is to conduct an empirical test of volatility spillover on the data sample defined in the research question. The Multivariate Generalized Autoregressive Conditional Heteroscedasticity (MGARCH) model that was proposed by Kroner and Ng (1998) was employed to answer the question:

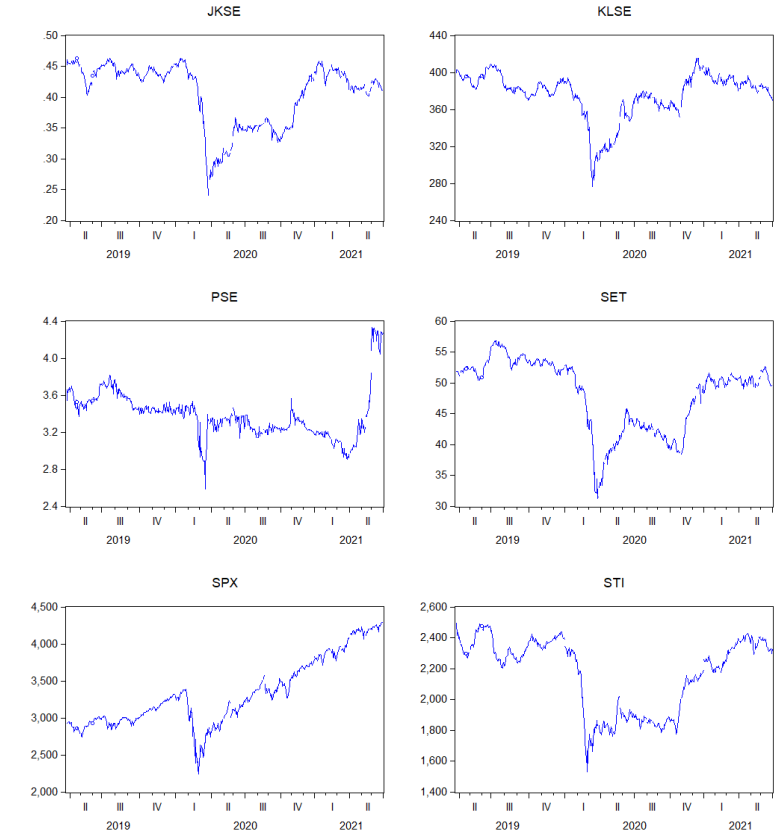
How is the volatility spillover effect between the US stock market and the ASEAN stock market during the 2008 and 2020 pandemic?

GARCH-BEKK model is employed to determine the direction of the risk spillovers between the two markets, aiming to identify the risk receiver (Xie, 2021). This model is known for a few numbers of resulting parameters of the model, with only 11 parameters of two variables. The resulting parameters are fewer than the VECH, resulting in 21 parameters of two variables in the model. A fewer number of parameters in the model is an advantage in doing investigation since it will be simpler to analyze and understand the result of the estimation from the model and resulting parsimony model (Danielson, 2011). The GARCH-BEKK multivariate model is described in the following equation:

$$H_t = W'W + A'H_{t-1}A + B'\Xi_{t-1}\Xi'_{t-1}B \tag{3}$$



(a)



(b)

Figure 2: a and b are a Graph of each stock index 2007-2009 and 2019-2021

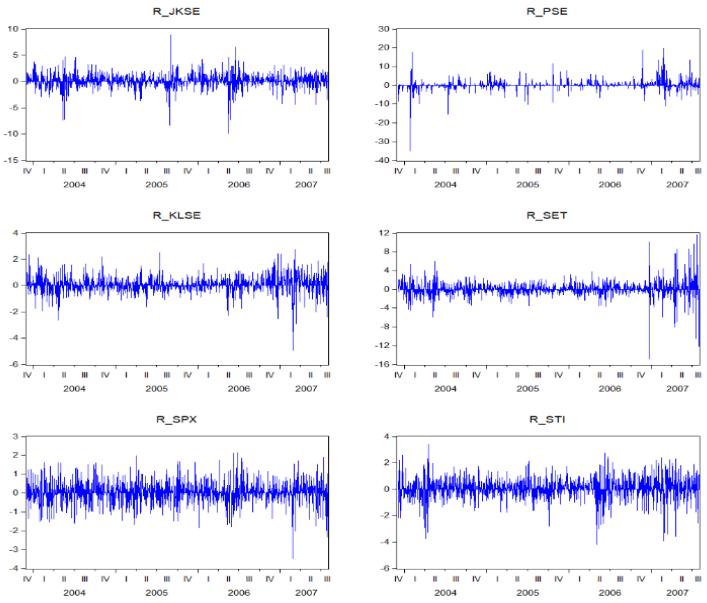
Where H_t is a matrix of conditional variance on diagonal elements and conditional covariance off-diagonal elements, W is the matrix of upper triangular of constants and on a diagonal element is constrained to be positive (Bekiros, 2014), Ξ is $N\ x\ N$ matrix of residual, A is $N\ x\ N$ matrix describing shock effect, and B is $N\ x\ N$ matrix describing volatility effect. This model produces 11 parameters from two variables. This multivariate model is an extension model of the ARCH and GARCH models by guaranteeing a definite positive value for the variance-covariance values (Malik, 2021; Brooks, 2014). In its implementation, the diagonal of matrix A measures the shock effect from the past, and the non-diagonal part captures the effect of shock transmission from one variable to another. In matrix B, the diagonal part represents the effect of past volatility on the conditional variance, and the non-diagonal part measures volatility between variables (Li, 2015; Gulzar, 2017; Katsiampa, 2019). In the investigation, the volatility spillover of each index is investigated one by one. Equation 3 can be described in detail in the form of matrices as follows in equation 4.

$$\begin{aligned}[h_{11t}\ h_{12t}\ h_{21t}\ h_{22t}\ ] = [w_{11}\ 0\ w_{12}\ w_{22}\ ]\ [w_{11}\ w_{21}\ 0\ w_{22}\ ] + \\ [a_{11}\ a_{12}\ a_{21}\ a_{22}\ ]'\left[h_{11,t-1}\ h_{12,t-1}\ h_{21,t-1}\ h_{22,t-1}\right]\ [a_{11}\ a_{12}\ a_{21}\ a_{22}\ ] + \\ [b_{11}\ b_{12}\ b_{21}\ b_{22}\ ]'\left[\Xi^2_{1,t-1}\ \Xi_{1,t-1}\Xi_{2,t-1}\ \Xi_{1,t-1}\Xi_{2,t-1}\ \Xi^2_{2,t-1}\right][b_{11}\ b_{12}\ b_{21}\ b_{22}\ ]\end{aligned} \tag{4}$$

The values of parameters a_{12} and a_{21} are used to see the effect of shock spillover, while to see the effect of volatility spillover seen from parameters b_{12} and b_{21}. This investigation focuses on the volatility effect, so the modeling in the next chapter shows the values of matrix B.

3 RESULTS

Data needs to be in stationary form in order to analyze the volatility. The unit root analysis employs Augmented Dickey-Fuller (ADF) test and Phillip-Perron (PP) test. Table 1 and Table 2 represent the stationarity test using ADF and PP method for all segmented periods.



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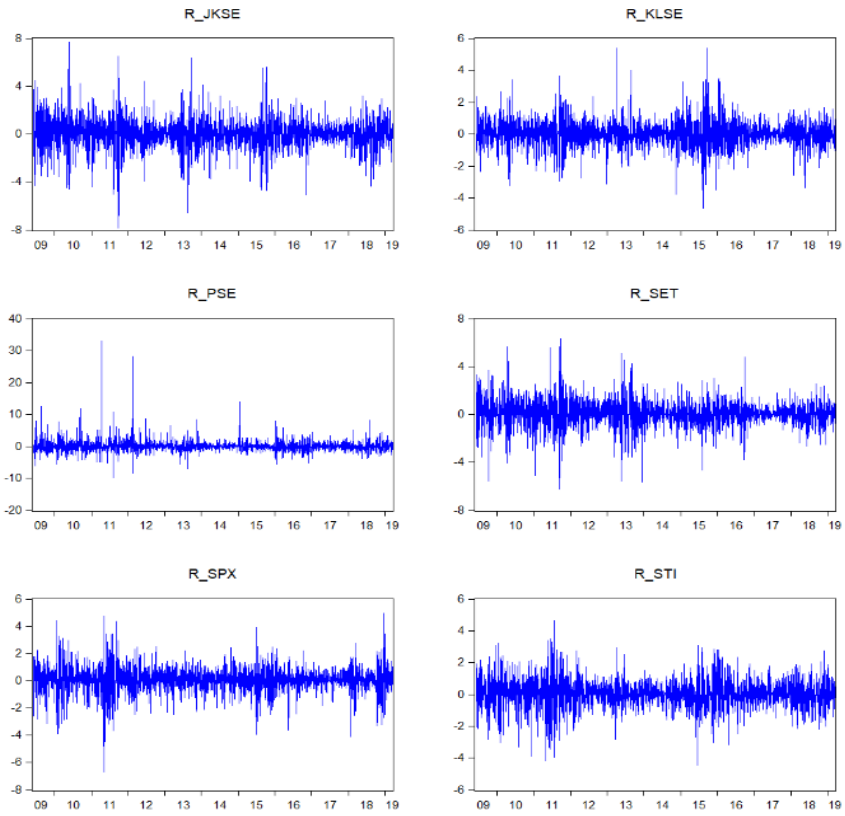


(b)

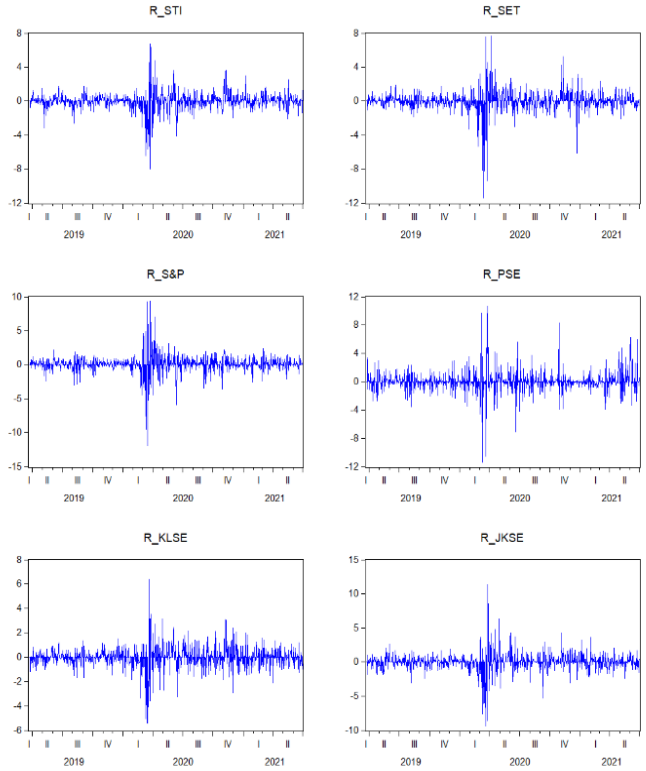
Figure 3: a and b are a Graph of each stock index return of prior 2008 crisis and post-2008 crisis

Table 1: Stationarity test of each stock index return of prior 2008 crisis and post 2008 **crisis**

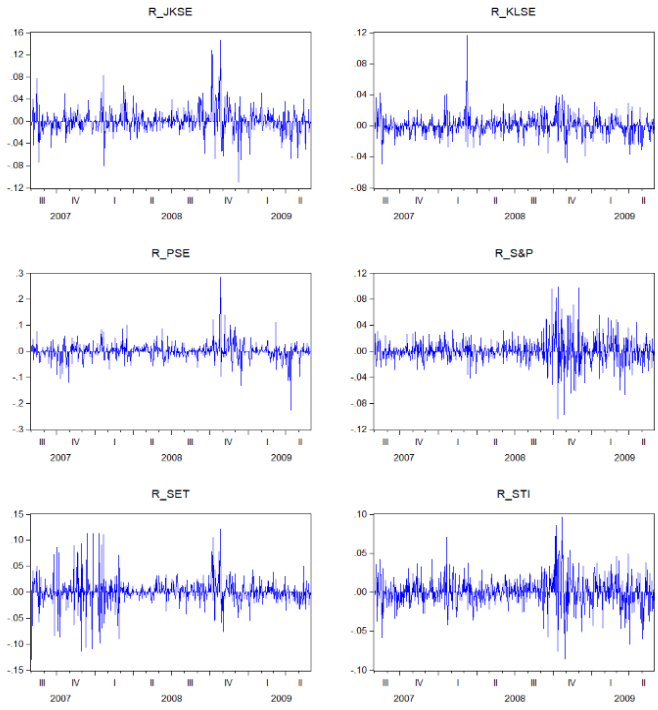
Variable	**Prior 2008 crisis**			**Post 2008 crisis/Prior 2020 crisis**		
	ADF		**PP**	**ADF**		**PP**
	Lag	***Test statistic***		***Lag***	***Test-statistic***	
R_JKSE	2	-20,108***	-35,499***	0	-58,647***	-58,660***
R_KLSE	2	-17,748***	-33,192***	0	-54,831***	-54,943***
R_STI	0	-35,745***	-35,780***	0	-54,518***	-54,600***
R_SET	0	-39,030***	-39,243***	0	-56,729 ***	-56,716***
R_PSE	7	-14,337***	-33,704***	0	-62,235 ***	-62,233***
R_SPX	0	-36,999***	-37,180***	0	-62,238 ***	-63,088***

***, **, * indicate the significance level of 1%, 5%, and 10% respectively

The intuition of a stationary value is that the value of a point from the time series data is not affected by the value caused by past events, with the null hypothesis of this test being that there is no unit root of the return value. Based on the result of unit root test of ADF and PP, we can see that all of the indexes in prior crisis 2008 and post crisis 2008 are already in stationarity form with level significance of 1 percent.



(a)



(b)

Figure 4: a and b are a Graph of each stock index return of 2007-2009 and 2019-2021

Table 2: Stationarity test of each stock index return of 2007-2009 and 2019-2021

Variable	Period of 2019-2021			Period of 2007-2009		
		ADF	PP		ADF	PP
	Lag	*Test statistic*		*Lag*	*Test-statistic*	
R_JKSE	0	-25,765***	-26,075***	0	-21,696***	-21,843***
R_KLSE	0	-28,535***	-28,736***	0	-23,714***	-23,660***
R_STI	7	-9,402***	-28,528***	0	-24,386***	-24,427***
R_SET	7	-8,546***	-29,825***	0	-31,315***	-31,417***
R_PSE	0	-30,668***	-30,854***	0	-22,557***	-22.931***
R_SPX	10	-7,856***	-36,338***	0	-30,435***	-30,719***

***, **, * indicate the significance level of 1%, 5%, and 10% respectively

Based on the results of the unit root test of all indexes in 2008 and 2020 crisis period, it can be seen that from each ADF and PP method, all data from each index has a p value with level significance of 1%, which indicates the null hypothesis that there is a unit root in the data return is rejected. Thus the return value of each index return value is stationary, so it can be concluded that the return data is at level I (0).

The volatility spillover investigation looks at the B matrix of the BEKK model by taking into account the coefficient value, standard error, and its significance. Table 3 is the result of an investigation of the volatility spillover of the stock index of ASEAN countries (JKSE, KLSE, STI, SET, PSE) with the US stock index (S&P 500). In this study, matrix B is investigated to see the spillover effect of each index. Matrix B consists of four scalars, namely b_{11}, b_{12}, b_{21}, dan b_{22}. To see the spillover effect from the US stock index to the ASEAN stock index, the scalars used are b_{11}, b_{12}. Variable 1 represents the US stock index and variable 2 represents the ASEAN stock index.

Table 3: Volatility Spillover Stock Index of US and ASEAN in prior 2008 crisis and post 2008 crisis period

Index	Prior 2008 Crisis		Post 2008 Crisis / Prior 2020 Crisis	
	Parameter	**Volatility Spillover**	**Parameter**	**Volatility Spillover**
JKSE	B(1,1)	0,966***	B(1,1)	-0,958***
		[0,010]		[0,008]
	B(1,2)	-0,042	B(1,2)	0,043
		[0,115]		[0,053]
KLSE	B(1,1)	0,020***	B(1,1)	0,944***
		[0,007]		[0,007]
	B(1,2)	0,309***	B(1,2)	0,012*
		[0,015]		[0,007]
STI	B(1,1)	0,348***	B(1,1)	0,959***
		[0,089]		[0,006]
	B(1,2)	-0,390***	B(1,2)	0,005
		[0,006]		[0,004]
SET	B(1,1)	-0,119	B(1,1)	-0,957***
		[0,220]		[0,005]
	B(1,2)	-0,417	B(1,2)	0,073*
		[0,620]		[0,041]

Index	Prior 2008 Crisis		Post 2008 Crisis / Prior 2020 Crisis	
	Parameter	Volatility Spillover	Parameter	Volatility Spillover
PSE	B(1,1)	0,217*** [0,045]	B(1,1)	0,959*** [0,022]
	B(1,2)	-0,032*** [0,006]	B(1,2)	0,019 [0,022]

***, **, * indicate the significance level of 1%, 5%, and 10% respectively

From table 3, for the period prior of 2008 crisis, the US index affects volatility in KLSE, STI, and PSE with level of significance of 1 percent. Meanwhile for the period of post 2008 crisis (also considered as prior of 2020 crisis), fewer volatility spillover from US with only KLSE and SET were affected with level of significance of 10 percent. The time lagging effect of the history of US index is affecting its current return as all parameters of B (1,1) has 1 percent level of significance except the parameter of B (1,1) of SET in prior period of 2008 crisis.

Table 4: Volatility Spillover Stock Index of US and ASEAN in 2019-2021

Index	2019-2021		2007-2009	
	Parameter	Volatility Spillover	Parameter	Volatility Spillover
JKSE	B(1,1)	0,607*** [0,040]	B(1,1)	0,942*** [0,034]
	B(1,2)	0,893*** [0,045]	B(1,2)	0,296*** [0,074]
KLSE	B(1,1)	0,927*** [0,017]	B(1,1)	0,966*** [0,018]
	B(1,2)	0,309*** [0,015]	B(1,2)	0,113*** [0,029]
STI	B(1,1)	0,998*** [0,012]	B(1,1)	1,007*** [0,018]
	B(1,2)	0,263*** [0,026]	B(1,2)	0,300*** [0,024]
SET	B(1,1)	0,987*** [0,014]	B(1,1)	0,975*** [0,005]
	B(1,2)	0,229*** [0,017]	B(1,2)	0,272*** [0,040]
PSE	B(1,1)	0,946*** [0,009]	B(1,1)	0,975*** [0,010]
	B(1,2)	0,003 [0,029]	B(1,2)	0,244*** [0,081]

***, **, * indicate the significance level of 1%, 5%, and 10% respectively

From table 4, for the period 2019-2021 it shows that from each scalar B (1,2) that there is a volatility spillover effect from SPX to JKSE with a significance level of 1%. Likewise, from the SPX index to the KLSE, STI, and SET indexes. The contrast is precisely what happened to the PSE index where there was absolutely no spillover effect from the SPX

index. Meanwhile for the period 2007-2009 SPX transmits volatility spillover to all ASEAN index. This result is as shown in Vo (2020) that all ASEAN indexes (JKSE, KLSE, SET, STI, and PSE) are affected by the volatility from the US market. Although in period 2019-2021 PSE is not affected by the volatility spillover from US market, the volatility spillover between the two crisis period is in general in the same pattern. The $2 trillion stimulus provided by the Federal Reserve might be one of the cases that affect the volatility spillover as stock indexes recover quickly in the US and other countries. This is in line with Narayan (2021) who said that the stimulus package had a positive impact on stock index returns.

Furthermore, the volatility spillover investigation was carried out between ASEAN stock indices. Similar to the spillover analysis of the US and ASEAN indices, matrix B is analyzed for its coefficient value and significance, which is a representation of the volatility spillover effect. Matrix B consists of four scalars, namely b_{11}, b_{12}, b_{21}, dan b_{22}. Variable 1 represents the ASEAN stock index in the column section (JKSE, KLSE, STI, and SET) and variable 2 represents the ASEAN stock index in the row section (KLSE, STI, SET, and PSE). Table 5 is the result of the investigation using the BEKK MGARCH model in period of prior of 2008 crisis.

Table 5: Volatility Spillover Stock Index of ASEAN prior of 2008 crisis

Index	JKSE		KLSE		STI		SET	
	Parameter	***Spillover***	**Parameter**	***Spillover***	**Parameter**	***Spillover***	**Parameter**	***Spillover***
KLSE	B(1,1)	0,958*** [0,008]						
	B(1,2)	0,000 [0,003]						
	B(2,1)	0,043*** [0,013]						
	B(2,2)	0,972*** [0,006]						
STI	B(1,1)	0,954*** [0,006]	B(1,1)	0,981*** [0,009]				
	B(1,2)	-0,002 [0,004]	B(1,2)	0,028*** [0,011]				
	B(2,1)	0,041*** [0,015]	B(2,1)	-0.022*** [0,005]				
	B(2,2)	0,916*** [0,009]	B(2,2)	0,973*** [0,006]				
SET	B(1,1)	0,971*** [0,008]	B(1,1)	0,975*** [0,005]	B(1,1)	0,930*** [0,023]		
	B(1,2)	0,141*** [0,021]	B(1,2)	0,255*** [0,076]	B(1,2)	0,275* [0,141]		
	B(2,1)	-0,068 [0,045]	B(2,1)	-0,016 [0,016]	B(2,1)	0,076 [0,047]		
	B(2,2)	0,000	B(2,2)	-0,068	B(2,2)	0,009		

Index	JKSE		KLSE		STI		SET	
	Parameter	***Spillover***	**Parameter**	***Spillover***	**Parameter**	***Spillover***	**Parameter**	***Spillover***
		[0,056]		[0,048]		[0,070]		
PSE	B(1,1)	0,968*** [0,005]	B(1,1)	0,966*** [0,007]	B(1,1)	0,980*** [0,002]	B(1,1)	0,276*** [0,093]
	B(1,2)	0,005 [0,006]	B(1,2)	0,000 [0,009]	B(1,2)	-0,000 [0,000]	B(1,2)	0,031 [0,105]
	B(2,1)	0,019 [0,020]	B(2,1)	0,029*** [0,009]	B(2,1)	0,016* [0,009]	B(2,1)	0,004 [0,034]
	B(2,2)	- 0,008*** [0,001]	B(2,2)	-0,000 [0,000]	B(2,2)	0,000*** [0,000]	B(2,2)	-0,003 [0,009]

***, **, * indicate the significance level of 1%, 5%, and 10% respectively

In the period of prior 2008 crisis, we can see that the spillover is exists yet the effect is only occur in some index as JKSE is exposed volatility spillover only to SET, KLSE is affecting the volatility in JKSE, STI and SET, STI exposed its volatility to SET, KLSE, JKSE, PSE exposed the volatility to KLSE and STI. Meanwhile SET has not exposed its volatility to other ASEAN indexes. The heatwave is almost occurred in all indexes as almost all parameter B (1,1) and B (2,2) having level of significance of 1 percent. The more integrated result is shown at table 6 as it carries the investigation result of crisis in period of 2008.

Table 6: Volatility Spillover Stock Index of ASEAN in 2007-2009

Index	JKSE		KLSE		STI		SET	
	Parameter	***Spillover***	**Parameter**	***Spillover***	**Parameter**	***Spillover***	**Parameter**	***Spillover***
KLSE	B(1,1)	0,506*** [0,020]						
	B(1,2)	0,374*** [0,040]						
	B(2,1)	0,642*** [0,026]						
	B(2,2)	0,311*** [0,0784]						
STI	B(1,1)	0,426*** [0,024]	B(1,1)	- 0,233*** [0,077]				
	B(1,2)	0,240*** [0,012]	B(1,2)	- 0,641*** [0,122]				
	B(2,1)	0,364*** [0,022]	B(2,1)	0.361*** [0,051]				
	B(2,2)	0,778*** [0,013]	B(2,2)	1,158*** [0,031]				
	B(1,1)	0,987***	B(1,1)	0,819***	B(1,1)	1,028***		

Index	JKSE		KLSE		STI		SET	
	Parameter	***Spillover***	**Parameter**	***Spillover***	**Parameter**	***Spillover***	**Parameter**	***Spillover***
SET		[0,020]		[0,043]		[0,008]		
	B(1,2)	0,632*** [0,053]	B(1,2)	0,577*** [0,037]	B(1,2)	0,507*** [0,037]		
	B(2,1)	-0,107*** [0,016]	B(2,1)	0,089*** [0,005]	B(2,1)	-0,119*** [0,000]		
	B(2,2)	-0,045 [0,032]	B(2,2)	0,090*** [0,010]	B(2,2)	-0,024 [0,046]		
PSE	B(1,1)	0,912*** [0,039]	B(1,1)	0,730*** [0,059]	B(1,1)	0,936*** [0,013]	B(1,1)	0,063 [0,095]
	B(1,2)	0,338*** [0,064]	B(1,2)	0,880*** [0,191]	B(1,2)	-0,059*** [0,010]	B(1,2)	-0,021 [0,116]
	B(2,1)	-0,048 [0,038]	B(2,1)	0,081* [0,046]	B(2,1)	0,044*** [0,009]	B(2,1)	0,042 [0,067]
	B(2,2)	0,216*** [0,150]	B(2,2)	0,389*** [0,110]	B(2,2)	0,963*** [0,016]	B(2,2)	-0,419*** [0,121]

***, **, * indicate the significance level of 1%, 5%, and 10% respectively

Based on the data from the volatility spillover modeling result at table 4, in general all ASEAN indexes give a bidirectional spillover effect to others, although the PSE index has less volatility effect than the other indices. It is clear that in period of crisis, stock markets tend to be more integrated as mentioned in Jebran (2017) and Yonghong (2017). The next discussion, table 7 is the result of the investigation of volatility spillover in the period of post 2008 crisis. The same as the previous, variable 1 represents the ASEAN stock index in the column section (JKSE, KLSE, STI, and SET) and variable 2 represents the ASEAN stock index in the row section (KLSE, STI, SET, and PSE).

Table 7: Volatility Spillover Stock Index of ASEAN post of 2008 crisis (prior of 2020 crisis)

Index	JKSE		KLSE		STI		SET	
	Parameter	***Spillover***	**Parameter**	***Spillover***	**Parameter**	***Spillover***	**Parameter**	***Spillover***
KLSE	B(1,1)	0,982*** [0,008]						
	B(1,2)	-0,000 [0,001]						
	B(2,1)	-0,000 [0,003]						
	B(2,2)	0,990*** [0,001]						
	B(1,1)	0,977***	B(1,1)	0,985***				

Index	JKSE		KLSE		STI		SET	
	Parameter	***Spillover***	**Parameter**	***Spillover***	**Parameter**	***Spillover***	**Parameter**	***Spillover***
STI		[0,003]		[0,002]				
	B(1,2)	0,003* [0,004]	B(1,2)	0,012*** [0,002]				
	B(2,1)	0,006*** [0,000]	B(2,1)	-0.019*** [0,003]				
	B(2,2)	0,975*** [0,003]	B(2,2)	0,974*** [0,003]				
	B(1,1)	0,977*** [0,008]	B(1,1)	0,957*** [0,005]	B(1,1)	0,978*** [0,004]		
SET	B(1,2)	-0,092*** [0,004]	B(1,2)	-0,252*** [0,005]	B(1,2)	-0,011* [0,007]		
	B(2,1)	0,122*** [0,005]	B(2,1)	0,156*** [0,002]	B(2,1)	0,003 [0,002]		
	B(2,2)	0,981*** [0,003]	B(2,2)	0,979*** [0,004]	B(2,2)	0,985*** [0,002]		
	B(1,1)	0,980*** [0,003]	B(1,1)	0,986*** [0,001]	B(1,1)	0,973*** [0,003]	B(1,1)	0,276*** [0,093]
PSE	B(1,2)	0,050** [0,021]	B(1,2)	0,029 [0,001]	B(1,2)	0,012 [0,023]	B(1,2)	0,031 [0,105]
	B(2,1)	-0,026 [0,034]	B(2,1)	-0,002 [0,016]	B(2,1)	-0,049*** [0,006]	B(2,1)	0,004 [0,034]
	B(2,2)	0,003 [0,035]	B(2,2)	0,000 [0,235]	B(2,2)	0,003 [0,027]	B(2,2)	-0,003 [0,009]

***, **, * indicate the significance level of 1%, 5%, and 10% respectively

The post of 2008 crisis period investigation result is shown at table 7. Overall the spillover is increased compared to the period of prior of 2008 crisis as JKSE exposed its volatility to STI, SET, and PSE, KLSE impacted the volatility in SET and PSE, SET exposed the volatility to JKSE and KLSE, STI exposed the volatility to JKSE, KLSE, and SET, and PSE impacted the volatility to STI. The heatwave phenomenon also occurs in all index that indicates the history value impacts the current value. The result is aligned with Purbasari (2019) as it is mentioned that the relationship of ASEAN indexes become more complex in the period of post 2008 crisis. The next discussion, table 8 is the result of the investigation of volatility spillover in the period of 2020 pandemic. The same as the previous, variable 1 represents the ASEAN stock index in the column section (JKSE, KLSE, STI, and SET) and variable 2 represents the ASEAN stock index in the row section (KLSE, STI, SET, and PSE).

Table 8: Volatility Spillover Stock Index of ASEAN in 2019-2021

Index	JKSE		KLSE		STI		SET	
	Parameter	***Spillover***	**Parameter**	***Spillover***	**Parameter**	***Spillover***	**Parameter**	***Spillover***
KLSE	B(1,1)	-0,889*** [0,011]						
	B(1,2)	-0,607*** [0,035]						
	B(2,1)	-0,185*** [0,001]						
	B(2,2)	0,929*** [0,004]						
STI	B(1,1)	0,973*** [0,014]	B(1,1)	0,735*** [0,007]				
	B(1,2)	0,053*** [0,003]	B(1,2)	-0,436*** [0,007]				
	B(2,1)	-0,102*** [0,004]	B(2,1)	-0.972*** [0,025]				
	B(2,2)	0,916*** [0,009]	B(2,2)	-0,714*** [0,015]				
SET	B(1,1)	0,992*** [0,012]	B(1,1)	1,045*** [0,008]	B(1,1)	1,057*** [0,012]		
	B(1,2)	0,205*** [0,021]	B(1,2)	0,235*** [0,001]	B(1,2)	0,198*** [0,012]		
	B(2,1)	-0,210*** [0,018]	B(2,1)	-0,173*** [0,011]	B(2,1)	-0,191*** [0,011]		
	B(2,2)	0,892*** [0,016]	B(2,2)	0,882*** [0,011]	B(2,2)	0,881*** [0,012]		
PSE	B(1,1)	0,991*** [0,012]	B(1,1)	0,984*** [0,002]	B(1,1)	0,991*** [0,001]	B(1,1)	0,996*** [0,005]
	B(1,2)	0,205*** [0,021]	B(1,2)	0,139*** [0,029]	B(1,2)	-0,023 [0,033]	B(1,2)	0,085** [0,042]
	B(2,1)	-0,210*** [0,018]	B(2,1)	0,004** [0,002]	B(2,1)	0,011* [0,006]	B(2,1)	-0,123*** [0,041]
	B(2,2)	0,892*** [0,016]	B(2,2)	-0,014 [0,038]	B(2,2)	0,006 [0,185]	B(2,2)	-0,012 [0,046]

***, **, * indicate the significance level of 1%, 5%, and 10% respectively

From table 8, it shows that the JKSE index is exposed to the volatility spillover effect to each ASEAN index in bidirectional with a significance of 1% each. The JKSE index also gets volatility spillover from its past (heatwave) which is represented by the scalar B (1,1). The KLSE index is also exposed to the volatility spillover effect with every other ASEAN index in bidirectional with significance of 1% and a significance of 5% to the PSE index. The KLSE index is also affected by the volatility spillover effect of its past values.
The STI index is slightly different from the JKSE and KLSE. Although exposed to volatility spillover with the JKSE, KLSE and SET indexes with a significance of 1%, the STI index is not exposed to the volatility spillover effect of the PSE index. The SET index is the same as the JKSE and KLSE which are exposed to the volatility spillover effect on other ASEAN indices with a significance of 1%, although the significance of the spillover to the PSE is at the level of 5%.

4 DISCUSSION

This study aims to investigate the volatility spillover effect of the US stock index (S&P 500) on the ASEAN stock index (JKSE, KLSE, STI, SET, and PSE) in the 2020 pandemic period. In a previous study, Li (2015) investigated the US stock index and Asia, with the finding that a bidirectional volatility spillover effect during the Asian crisis period, which is in line with the findings of Jebran (2017) and Yonghong (2017) that said stock markets will be more integrated during the crisis period. Meanwhile in the non-crisis period, the spillover is occur less as expected. The results of the latest investigation from Vo (2020) strengthen the previous findings, which in the research found that the US stock index contributed significantly to the volatility that occurred in the ASEAN stock index.

From the result of the investigation, it can be said that nevertheless the cause of a global crisis, the volatility spillover behavior generally remains the same with US market transmit spillover effect to the ASEAN market, although in period 2019-2021 PSE is not affected by the US volatility, other four index (JKSE, KLSE, SET, STI) affected with level of significance of 1 percent. The internal volatility spillover of ASEAN indices also generally having the same behavior with PSE is receiving less volatility spillover from other indices for both periods. In abstraction level, we can say that volatility spillover between US and ASEAN stock markets have the same pattern regardless of the cause of the crisis.

5 CONCLUSIONS

The findings from this investigation strengthen the conclusions of previous research, with the S&P 500 Index (SPX) giving a significant volatility spillover effect to the ASEAN index during the 2008 crisis period. What makes the difference is that in the 2020 pandemic period, the PSE index was not affected by the volatility spillover effect from the US index. From the two periods, in general, each ASEAN index also having a bidirectional effect of volatility to other ASEAN indices, with the KLSE indices having the most volatility integrated with other indices and the PSE index being the least integrated in both crisis period.

These findings can be related to the causes of the crises that occurred in each period. In the 2007-2009 period, the crisis was caused by the financial industry in US which was unstable and caused global panic, while in the 2019-2021 period, the crisis was caused by a

pandemic that occurred throughout the world. In general, it can be said that in the 2019-2021 period, the US and ASEAN stock indices have the same volatility spillover behavior as the crisis that occurred in 2007-2009 that caused by instability of financial system.

6 SUGGESTIONS

This investigation contributes to give a perspective on how the volatility spillover behaving given the different cause of the crisis. Suggestions for the following investigations is to consider the longer period of crisis in pandemic since the period chosen in the research is limited to June 2021. The unaffected of volatility spillover in PSE also need further investigation on why the index losing spillover from SPX.

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