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## Article

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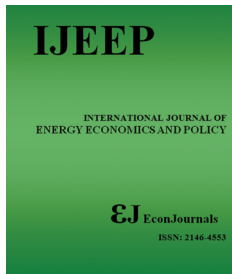
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# Impact of Crude Oil Price on Countries' and Vietnam's GDP Growth: Variance Decomposition Approach

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## ABSTRACT

The crude oil price fluctuation investigation is to explore the impact of crude oil price shocks on the countries' economic growth. The Vector Autoregressive Model (VAR) was applied and the variance decomposition is to analyze the impact of the GDP growth due to the shock of the crude oil price. Besides, nine countries' data were collected from 1990 to the third quarter of 2020. The countries' GDP growth was impacted by the crude oil price in 5 years respectively: 44.98%; 40.03%; 31.06%; 32.27%; 33.21%; 36.03%; 27.79%; 15.35%; 40.75% of the following countries are: China; America; Japan; Korea; Singapore; Thailand; Indonesia; Vietnam; Malaysia. This study identifies issues for countries to consider: have a comprehensive solution among macroeconomic policies, monetary policy, fiscal policy and other policies to control and stimulate growth.

**Keywords:** Impulse Response Functions, Oil Price Stabilization Fund, Economic Growth, Cointegration Method, Macroeconomic Policies

**JEL Classifications:** E31, E37, D24

## 1. INTRODUCTION

The widespread COVID-19 epidemic had a strong impact on the global economy, leading to a drop in world oil prices, and causing the world economy to be in crisis. The crude oil price fluctuation is considered the major cause of the economic crisis and negative economic growth. However, the impact of oil prices on economic growth is different in the literature (Dinh, 2018; Antony et al., 2018; Rebeca and Marcelo, 2006). Studies have analyzed the causes between energy consumption by countries and the impact of crude oil price fluctuation on economic growth in seven low-income oil-importing that namely Ethiopia, Gambia, Mali, Mozambique, Senegal, Tanzania and Uganda. The research results show the effect of economic growth and oil price. Evidence shows a mutual interdependence between energy consumption and economic growth Motunrayo and Nicholas (2020).

Also relating to the study of oil prices, Zied et al. (2016) studied the relationship between crude oil price and economic

growth in OPEC countries, which showed oil price fluctuation shock during periods in the global business cycle and financial instability. That affects the relationship between economic growth and oil in OPEC countries. Studies have analyzed the impact of crude oil price fluctuation on economic growth, as oil is the essential energy source for economic growth in each country. Specifically, oil is the input material of many economic sectors. So, the decreased gasoline prices make production costs decrease, leading to lower product costs which enhance the competitiveness of domestically produced goods. Thereby contributing to improving the competitiveness of the economy and vice versa, the increase in oil prices makes the production costs increase, leading to decreased competitiveness of the economy. Otherwise, the oil price fluctuation impacts the exporting and importing countries' income. In case the oil price increases, the oil exported countries have a high profit, but the oil-importing countries have to meet the high cost. In case the price falls, the oil-importing countries have an economic advantage.

## 2. LITERATURE REVIEW

Up to now, the world crude oil price is the biggest concern of each country because the world's crude oil is an indispensable source of energy for the country's economic development. When oil prices fluctuate, it always becomes the hot spot for each country, including Vietnam. Therefore, the author explores and find out the risk level of oil price fluctuation impacts on economic growth. The author's contribution to the article is explored the crude oil price fluctuation impact on countries' economic growth, including Vietnam from 1995 to 2020. It is important to consider the impact of oil prices on the countries' economic growth to define impacts that have systemic across countries. Besides, Considering the variance change of endogenous variables in oil prices and economic growth. The study applied the VAR model to find the impact level of oil price fluctuation for economic growth and considering these impacts are causality one-way or two-way. It means that oil price needs to be maintained at a reasonable price level to reach good economic growth. If the input fuel price is too high, leading to high CPI, the growth possibility goes down. Hence, the article applies the VAR model that has two variables that are the GDP and crude oil price variables that are endogenous variable. To keep the GDP growth target, the countries force on input-fuel valorization or fiscal and monetary policies make stabilization policy reasonably. Therefore, the empirical results on the crude oil price and economic growth showed that they had a close relationship and their relationship is negative and positive. Besides, they are causal relationship two-way. It means that the economic growth displays a causal relationship with the crude oil price and vice versa.

### 1.1. Contributions

The study evaluated whether the crude oil price impacts on GDP growth or not, and how does it impact? The results of the paper demonstrate that the change in input-fuel price impacts on the GDP growth and find out the fittest forecast model of economic growth. These contributions play an important role in planning, orienting or setting an appropriately adjusted oil valorization policy to promote economic growth through goals as follows:

- Explored the relationship between crude oil prices and countries' GDP
- Found out the impact of crude oil on countries' economic growth
- Evaluated the endogenous variables influence of countries' GDP and the impact of crude oil prices on their GDP
- Compared impact level of oil prices on countries' GDP
- Identified the cause of oil price impact on countries' GDP
- Lessons learned of nCovid impact from countries including Vietnam.

The remainder of the paper is organized as follows: Section 2 literature review; Section 3 explains the data and methodology of economics; Section 4 summarizes the results; Section 5 discusses the findings and the last section gives conclusions.

The main section of an article is started with an introductory section which provides more details about the paper's purposes, motivation, research methods, and findings. The introduction is relatively nontechnical, yet clear enough for an informed reader to understand the manuscript's contribution.

Over the past two decades, countries' economy was impacted by the oil price crisis in the world, but the oil price crisis of 2020 due to the spread of the Covid-19 pandemic is the biggest oil crisis since the regional war in the year 1991. So, the study of oil prices impact on economic growth has been mentioned by many researchers (Riadh et al., 2017; Antony et al., 2018; Dinh, 2019a). Authors Shuddhasawtta et al. (2009) used panel-auto regressive distributive lag (panel-ARDL) to explore the impact of oil prices on economic growth in seven low-income African oil-importing countries (SSA) in short- and long-term economic growth. The oil prices do not have a significant effect on short-term economic growth for these countries but have a significantly negative effect in the long run. However, the short-term coefficients suggest that oil prices have a significant effect on economic growth in all seven countries.

Besides, the study on the relationship between economic growth with energy consumption, oil prices, capital and labor in developing countries and industrial infrastructure. The energy consumption relative to the oil price, developing countries almost used on crude oil consumption for economic growth. So, the oil price impact on economic growth strongly Muhammad et al. (2017). The dynamic relationships between oil price and economic growth were applied by the bounds testing approach to cointegration and the ARDL. The crude oil plays an important role in each country's economic development in many sectors because the increased oil price makes the high input cost of enterprises, households and economic organizations, leading to the oil price fluctuation impact on economic growth. So, several studies focused on these impacts (Dinh, 2020a; Mehmet et al., 2017; Mehrara, 2007).

The evidence showed a negative relationship between oil prices and economic development. This relationship diminishes over time because of oil alternatives and government preventive measures against the sudden increase in oil price shock. Besides, the literature showed that fluctuations in oil prices affect economic growth at different levels (Melike and Özgür, 2015; Niaz and José, 2013; Dinh, 2020b). The literature identified the long-term relationship between oil prices and economic growth. This relationship is analyzed based on data from the US economy countries, G7 economies, Europe and the Euro area. Besides, the study has applied the VAR model to determine the disproportionate cointegration between oil price and GDP Sandrine and Valérie (2008). Another study analyzed the effects of oil price volatility on GDP and applied automatic vector regression (VAR), Granger causality test and impulse response functions to analyze variance. Finding out that oil price volatility significantly impacts on economic growth Shuddhasawtta et al. (2009).

The crude oil is directly related to the production process, and it has a significant effect on the consumer price index through increased commodity prices that lead to inflation. Besides, employment, output and inflation are impacted by the increased oil price shock. It makes increased production costs. The inflationary pressures can lead to reduced demand and this leads to output cuts, leading to unemployment (Dinh, 2019b; Jungwook and Ronald, 2008)

applied variance decomposition analysis to estimate oil price shock and oil price volatility relate to actual stock returns. The oil price volatility impacted on stock markets and investors' profit when increased volatility in oil prices can reduce the real return of stocks. Endogenous variable impact analysis is to assess the volatility of oil prices itself and economic growth, the events of 2008 showed that the volatility of oil prices is a source of exogenous volatility, but influences Financial benefit is an endogenous variable. Besides, the oil-rich countries have the impact of their financial crisis when their economic growth has depended on continuously falling oil prices (Uchechukwu et al., 2019; Dinh, 2020c).

Almost the literature applied the VAR model to estimate the impact of crude oil price, economic growth and other analysis indexes. So, this model is the most common estimation method for economic growth forecast models. Regression analysis is like other deductive methods. The objective of the paper is to collect a random-walk sample from countries' GDP growth and crude oil price to estimate their characteristic by Var model. Dinh (2020a)

### 3. METHODOLOGY

Applied the empirical method is to investigate the effect of the dynamic relationship between the oil price shock and countries' economic growth. Therefore, the paper applied the vector automatic regression (VAR) model to establish the forecast model. The VAR model has been frequently used to estimate the impact of an oil price shock on economic activity. Besides, the advantage of this model is the ability to analyze dynamic relationships between endogenous economic variables. Applied the VAR Model to systematically analyze equations because each equation is represented for each variable in the model as a linear equation for its lag value and its lag of all other variables.

A VAR model is a set of k variables, which is called endogenous variables, over the same sample period ( $t = 1, \dots, T$ ), that is a linear function. The variables are collected in a k-vector ( $(k \times 1)$ -matrix)  $y_t$  and  $y_{i,t}$  is the observation at time  $t$  of the  $i$ th variable. So, the  $i$ th variable is GDP, then  $y_{i,t}$  is the value of GDP at time  $t$ , and the  $i$ th variable is the crude oil price, then is the value of crude oil price at time  $s$ .

A  $p$ -th order VAR denoted VAR( $p$ ), is

$$y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + \dots + A_p y_{t-p} + e_t \text{ or}$$

$$y_t = c + \sum_{i=1}^p A_i y_{t-i} + e_t \tag{1}$$

where the observation  $y_{t-i}$  ( $i$  periods back) is called the  $i$ -th lag of  $y$ ,  $c$  is a  $k$ -vector of constants (intercepts),  $A_i$  is a time-invariant ( $k \times k$ )-matrix and  $e_t$  is a  $k$ -vector of error terms satisfying.

$E(e_t) = 0$  every error term has mean zero;  $E(e_t e_t') = \Omega$  the contemporaneous covariance matrix of error terms is  $\Omega$  (a  $k \times k$  positive-semidefinite matrix);  $E(e_t e_{t-k}') = 0$  or any non-zero  $k$  — there is no correlation across time; in particular, no serial

correlation in individual error terms. A  $p$  th-order VAR is also called a VAR with  $p$  lags. The process of choosing the maximum lag  $p$  in the VAR model requires special attention because inference is dependent on correctness of the selected lag order.

Thus, the relationship between the crude oil price and countries' GDP growth, including Vietnam's GDP growth is considered whether they have a positive or negative and linear or nonlinear relationship or not and find the response of oil price impulses to economic growth. So, the study used the following econometrics model for analysis. To determine the cointegration model, it is tested by first unit root to determine if it is lag and trend. Hence, the model is tested by unit root as follows:

Unit root test is a commonly used test to test whether a time series is stationary or not. Dickey and Fuller (1981) introduced Dickey and Fuller (DF) tests and extended Dickey and Fuller (ADF) tests. This study applies the ADF test to perform unit root test Doan Van (2019c). Specifically, according to Dickey and Fuller (1981) the ADF extended unit test model has the form:

$$\Delta Crude\ oil\ price_t = \alpha_0 + Crude\ oil\ price_{t-1} + \sum_{j=1}^n \gamma_j \Delta Crude\ oil\ price_{t-j} + \varepsilon_{1t} \tag{2}$$

And

$$\Delta Crude\ oil\ price_t = \alpha_0 + \delta_t + \beta Crude\ oil\ price_{t-1} + \sum_{j=1}^n \gamma_j \Delta Crude\ oil\ price_{t-j} + \varepsilon_t \tag{3}$$

The GDP variable similarly is written above.

Where:

$\Delta GDP_t = GDP_t - GDP_{t-1}$ ;  $GDP_t$ : time-series data over time;  $n$ : stationary time series;  $\varepsilon_t$ : white noise

The model (2) is different from the model (1), where there is an additional trend variable in time  $t$ . The trend variable is a value from number 1 to number  $n$ . White noise is the term for random errors, the assumption that it has an average of zero, the variance is constant and non-correlation.

The results of the ADF test are often very sensitive to the choice of the length of the stationary  $n$ , so the Akaike's Information Criterion (AIC) Akaike (1973) is used to select the optimal  $k$  for the ADF model. Specifically, the value of  $n$  is chosen such that the minimum AIC.

Testing hypothesis:

$H_0: \beta = 0$  ( $GDP_t, Crude\ oil_t$  are the non-stationary data time-series)  
 $H_1: \beta < 0$  ( $GDP_t, Crude\ oil_t$  are the stationary data time-series).

Tests for Cointegration: Tests for cointegration identify stable, long-run relationships between sets of variables. However, Rao (2007) notes that if the test fails to find such a relationship, it isn't proof that one doesn't exist it only suggests that one doesn't exist. Three of the most popular tests are Engle-Granger, Phillips-Ouliaris and Johansen test. However, the Johansen's test is applied because it

is another improvement over the Engle-Granger test. It avoids the issue of choosing a dependent variable as well as issues created when errors are carried from one step to the next. As such, the test can detect multiple cointegrating vectors Dinh (2019a).

The equation OLS is written:  $\varepsilon_t = GDP_t - \beta_2 Crude\ oil_t$  where  $\beta_2$  is a stationary process. Let  $GDP_t$  and  $Crude\ oil_t$  be cointegrated if there exists a vector when  $GDP_t$  and  $Crude\ oil_t$  are in equilibrium. The reason for unit roots and cointegration tests is to avoid the spurious regression.

### 3.1. Tests for Cointegration

Tests for cointegration identify stable, long-run relationships between sets of variables. However, Rao (2007) notes that if the test fails to find such a relationship, it isn't proof that one doesn't exist it only suggests that one doesn't exist. Three of the most popular tests are Engle-Granger, Phillips-Ouliaris and Johansen test. However, the Johanssen's test is applied because it is another improvement over the Engle-Granger test. It avoids the issue of choosing a dependent variable as well as issues created when errors are carried from one step to the next. As such, the test can detect multiple cointegrating vectors Dinh (2019a).

The  $i^{th}$  variable is GDP, then  $Y_{i,t}$  is the value of GDP at time  $t$ , and the  $i^{th}$  variable is crude oil price, then  $Y_{i,t}$  is the value of crude oil price at time  $t$ . The Var model is considered as follows:

$$GDP_{1t} = \alpha_0 + \sum_{j=1}^n \alpha_j GDP_{t-j} + \sum_{j=1}^n \beta_j Crude\ oil\ price_{t-j} + U_{1t} \tag{4}$$

$$Crude\ oil\ price_t = \beta_0 + \sum_{j=1}^n \beta_j Crude\ oil\ price_{t-j} + \sum_{j=1}^n \alpha_j GDP_{t-j} + U_{2t} \tag{5}$$

Where:  $U_{1t}$  and  $U_{2t}$  are white noise.

As mentioned above, the major objective of the paper is to analyze and evaluate the VAR model of the crude oil price and GDP growth rate as well as optimal lag, impulse response and the goodness-fit VAR model.

To consider the VAR Granger Causality from (4) and (5) equations, the hypothesizes as follows:

The hypothesis  $H_1: \sum \alpha_i = 0; \sum \beta_j \neq 0$ ; the economic growth rate causes the crude oil price ( $GDP \rightarrow Crude\ oil\ price$ ), one-way Granger.

The hypothesis  $H_2: \sum \alpha_i \neq 0; \sum \beta_j = 0$ ; the crude oil price causes the economic growth rate ( $Crude\ oil\ price \rightarrow GDP$ ), one-way Granger

The hypothesis  $H_3: \sum \alpha_i \neq 0; \sum \beta_j \neq 0$ ; both the crude oil price and the economic growth rates cause interactions ( $Crude\ oil\ price \leftrightarrow GDP$ ), two-way Grange, where the arrow indicates causality.

The Granger causality test assumes that the relevant information to predict individual variables, that are the GDP and Crude oil price, is only included in the time series data for these variables.

Advantages of the VAR model as follows: This method fits with the research; It doesn't need to worry about determining which variables are endogenous or are exogenous. Because all variables of the VAR model are endogenous; Sample size fit to the model estimation; the method can be applied to equations.

### 3.2. Data Analysis

This paper uses monthly crude oil price data from January 1990 to September 2020 for nine Countries including Thailand, Vietnam, Singapore, Indonesia, Malaysia, Japan, Korea and America. Simultaneously, data on economic growth rates of nine countries is also collected during this period. The rationale for selecting this stage is the appropriateness of the data because crude oil data had no relevant data before the period 1990. Therefore, this study limited the empirical analysis to this time series. Since the volatility of oil prices is calculated monthly, so the empirical analysis estimated on a yearly mean of crude oil price to correspond to countries' annual GDP growth indices. Time series data on gross domestic product (GDP) growth rate variables are collected from the World Bank The World Bank Group (2020), and data crude oil price is collected from Federal Reserve Economic Data (2020). The measure used here to construct the annual oil price variance is a measure of the volatility taken here, which is detailed below.

## 4. RESULTS

Based on the nature of the data to consider various variability measures of crude oil price and GDP variables and the data of the goodness-fit model ensured that the data is stationary or I (0). Therefore, the data is done by a test of econometrics over the time series to check for the presence of unit-roots. Thus, this paper uses the two most common methods: The Augmented Dickey-Fuller test (ADF) to select optimum lag (Table 1).

There are many methods to select lag for a VAR model but the study applied the VAR lag Order Selection Criteria method to find the optimum lag for the model such as Akaike Information Criterion (AIC), Schwarz Criterion (SC) and Hannan Quinn (HQ). However, The AIC was selected to find the optimum lag of model (Table 2).

It is known, the multivariate LM test statistics for residual serial correlation up to the specified order. A Breusch-Godfrey test statistic for autocorrelation at lag order h is computed by running an auxiliary regression of the residuals  $u_t$  on the original right-hand regressors and the lagged residual  $u_{t-h}$ , where the missing first h

**Table 1: Selected time-series stationary at I (0) and I (1)**

Variables	I(0) Prob.*	I(1) Prob.**
Log (Crude oil)	0.6697	0.0022**
China's GDP	0.4907	0.0079**
America's GDP	0.1677	0.0001**
Japan's GDP	0.0008**	
Korea's GDP	0.003**	
Singapore's GDP	0.0047**	
Thailand's GDP	0.0409**	0.0000**
Indonesia's GDP	0.0082**	
Vietnam's GDP	0.2542	0.0201**
Malaysia's GDP	0.0021**	

Source: Author's analysis. \*, \*\* Statistical significance at 1%, 5%

values of  $u_{t-h}$  are filled with zeros. Besides, The Breusch–Godfrey test is a test for autocorrelation in the errors in a regression model Asteriou and Hall (2011) (Table 3).

Johansen's test is another improvement over the Engle-Granger test. It avoids the issue of choosing a dependent variable as well as issues created when errors are carried from one step to the next. As such, the test can detect multiple cointegrating vectors. The goal of

cointegration tests is to analyze non-stationary time series processes that have variances and means that vary over time. In other words, the method allows estimating the long-run parameters or equilibrium in systems with unit root variables Rao (2007) (Table 4).

The goal of variance decomposition or forecast error variance decomposition (FEVD) is used to aid in the interpretation of a vector autoregression (VAR) model once it has been fitted. The

**Table 2: VAR lag order selection criteria of countries' GDP and log (crude oil price)**

Variables	Lag	FPE	AIC	SC	HQ
Japan's GDP	0	0.054178*	2.760190*	2.856966*	2.788058*
Korea's GDP	0	0.122866*	3.579018*	3.675795*	3.606887*
Singapore's GDP	0	0.154191*	3.806116*	3.902893*	3.833984*
China's GDP	1	0.051637*	2.710751*	2.993640*	2.799348*
America's GDP	1	0.032247*	2.239952*	2.522840*	2.328549*
Thailand's GDP	1	0.211898*	4.122455*	4.407927*	4.209727*
Indonesia's GDP	1	0.187586*	4.000585*	4.286058	4.087857*
Vietnam's GDP	1	0.020801*	1.801530*	2.084419*	1.890127*
Malaysia's GDP	1	0.150785*	3.782204*	4.067676	3.869475

Source: Author's analysis

**Table 3: VAR residual serial correlation LM tests of countries' GDP and log (crude oil price)**

Variables	Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
China's GDP	1	2.159949	4	0.7064	0.54083	(4, 46.0)	0.7065
	2	3.633423	4	0.4579	0.924296	(4, 46.0)	0.4581
America's GDP	1	2.159949	4	0.7064	0.54083	(4, 46.0)	0.7065
	2	3.633423	4	0.4579	0.924296	(4, 46.0)	0.4581
Japan's GDP	1	1.091864	4	0.8956	0.270286	(4, 46.0)	0.8956
	2	5.318306	4	0.2562	1.377769	(4, 46.0)	0.2564
Korea's GDP	1	4.961836	4	0.2912	1.280467	(4, 46.0)	0.2914
	2	4.769978	4	0.3117	1.228403	(4, 46.0)	0.3119
Singapore's GDP	1	1.27619	4	0.8654	0.316537	(4, 46.0)	0.8655
	2	3.724329	4	0.4446	0.94835	(4, 46.0)	0.4448
Thailand's GDP	1	0.463623	4	0.9769	0.114001	(4, 46.0)	0.977
	2	1.144142	4	0.8872	0.283385	(4, 46.0)	0.8873
Indonesia's GDP	1	1.953358	4	0.7443	0.48802	(4, 46.0)	0.7444
	2	2.808029	4	0.5904	0.70801	(4, 46.0)	0.5906
Vietnam's GDP	1	0.824012	4	0.9352	0.203012	(4, 40.0)	0.9352
	2	0.721446	4	0.9487	0.17752	(4, 40.0)	0.9487
Malaysia's GDP	1	1.380745	4	0.8475	0.342853	(4, 46.0)	0.8476
	2	4.529337	4	0.3391	1.163399	(4, 46.0)	0.3393

Source: Author's analysis. Null hypothesis: No serial correlation at lag h

**Table 4: Johansen cointegration test of countries' GDP and log (crude oil price)**

Variables	Hypothesized No. of CE(s)	Trace statistic	0.05 - Critical value	Prob.**
China's GDP	None*	28.78555	15.49471	0.0003
	At most 1*	13.2738	3.841466	0.0003
America's GDP	None*	28.78555	15.49471	0.0003
	At most 1*	13.2738	3.841466	0.0003
Japan's GDP	None*	27.40525	15.49471	0.0005
	At most 1*	8.86543	3.841466	0.0029
Korea's GDP	None*	22.52619	15.49471	0.0037
	At most 1*	6.078504	3.841466	0.0137
Singapore's GDP	None*	22.55684	15.49471	0.0037
	At most 1*	6.967873	3.841466	0.0083
Thailand's GDP	None*	28.0727	15.49471	0.0004
	At most 1*	11.54715	3.841466	0.0007
Indonesia's GDP	None*	25.21873	15.49471	0.0013
	At most 1*	7.24584	3.841466	0.0071
Vietnam's GDP	None*	24.03182	15.49471	0.002
	At most 1*	7.026184	3.841466	0.008
Malaysia's GDP	None*	27.21554	15.49471	0.0006
	At most 1*	6.326749	3.841466	0.0119

Source: Author's analyses. \*Trace test indicates 2 cointegrating eqn(s) at the 0.05 level

variance decomposition indicates the amount of information each variable contributes to the other variables in the autoregression. It determines how much of the forecast error variance of each of the variables can be explained by exogenous shocks to the other variables Lütkepohl (2007) (Table 5).

It is known that impulse response analysis is an important step in econometric analysis. It used in the automatic vector regression model. Besides, the main purpose of this test is to describe the development of model variables in response to a single shock in one or more variables. So, the impulse response test allows finding the transmission of a single shock in another noisy system of equations. Thus, it makes them a very useful tool in evaluating economic policies (Figure 1).

The inverse roots of the characteristic AR polynomial test are to estimate the VAR model stable (stationary). It means that, if all roots have modulus that is less than one and lie inside the unit circle, the estimated VAR model is stable, otherwise, if the estimated VAR is not stable, certain results are not valid (Figure 2).

The above results are the basis for analyzing the impact of crude oil prices on GDP of each country and vice versa. Besides, based on empirical research results as a basis for each country to refer to the macro policymakers.

## 5. DISCUSSION

This study mainly analyses variance decomposition to analyze the variation of GDP and crude oil price variables affected by the shock of that variable and the shock of other endogenous variables. This method provides information on the importance of random errors to the variables in the VAR model, thereby showing the tendency to interact among variables. Therefore, the analysis of the variance of the GDP variables of the countries affected by the crude oil price shock.

The results show that oil price affects the GDP of each country with different significant lags. Considering generally, crude oil price variables have the stationary time series at I (0) and countries' GDP variables also have the stationary time series at I (0) and I (1) at 1% and 5% significance levels. This result is consistent with the research model. The time series of each country's GDP showed that the stationary time series is dependent on the impact degree of world crude oil prices on each country. In particular, countries include China's GDP, America's GDP, Thailand's GDP and Vietnam's GDP have the stationary time series at I (1) with a 5% significance. But countries include Japan's GDP, Korea's GDP, Singapore's GDP, Indonesia's GDP and Malaysia's GDP have the stationary time series at I (0) with 5% significance. It means that these countries' stable series is the series of observed values revolving around the mean and having constant variance. Results based on the test statistic value with 1%, 5%, 10% Critical Value. If the absolute value test  $>$  Absolute Critical Value, the data is stationary. Besides, the stationary time series are also considered by the P-value test. If P-value  $<$   $t_{\alpha}$  (1%, 5% and 10%), the data series is stationary. If P-value  $>$   $t_{\alpha}$  (1%, 5% and 10%), the time series is not stationary. So, all data series is stationary when it's P-value  $<$   $t_{\alpha}$  (1%, 5% and 10%) (Table 1).

Based on AIC criteria, it shows that the variable crude oil price has different impacts on the economic growth of countries. Some countries are affected by oil price immediately when it's optimal lag 0, but some countries are affected by oil price after 1 year when it's optimal lag 1. Specifically, countries' economic growth includes China's GDP America's GDP Thailand's GDP Indonesia's GDP Vietnam's GDP and Malaysia's GDP that has the optimal lag at lag 1 with the AIC value of 2.710751 \* - China's GDP, 2.239952 \* - America's GDP, 4.122455 \* - Thailand's GDP, 4.000585 \* - Indonesia's GDP, 1.801530 \* - Vietnam's GDP and 3.782204 \* - Malaysia's GDP. For the remaining countries with optimal lag at lag 0 such as AIC of 2,760190 \* - Japan's GDP, 3.579018 \* - Korea's GDP, 3.806116 \* - Singapore's GDP (Table 2).

Test residuals from the model to consider in regression analysis and the test statistic is derived from these. The null hypothesis is that there is no serial correlation of any order up to the p. So, the test residuals are based on the LM test for serial correlation. The residual correlation test results show that all variables have no serial correlation at lag 1 and lag 2 when Prob- value is greater than alpha 0.05 (Table 3).

Cointegration is that there exist close relationships between variable factors in the model. Therefore, the paper applied the Johansen Cointegration Test to find the relationship between the countries' GDP variables and oil crude price variable. Consider two trace statistic values (Trace) and 5% - critical value (value). If value  $<$  Trace, there is cointegration at (\*). Thus, the data series have Value  $<$  Trace, and Prob.\*\*  $<$  0.05. Therefore, the relationship between the variables is cointegration. The results show that world crude oil prices and countries' economic growth have a close relationship with each other and have positive fluctuation Dickey and Fuller (1981) (Table 4).

The impulse response results show that countries' economic growth including China, Japan, South Korea, Singapore and Thailand that were greatly affected by fluctuation shock of crude oil price in the 1<sup>st</sup> year and the impact tends to decrease gradually and stabilize in the 6<sup>th</sup> year. However, these countries' economic growth is positive. Besides, countries including the US, Indonesia, Malaysia and Vietnam were also were affected by the shock of crude oil prices in the 1<sup>st</sup> and 2<sup>nd</sup> years, which decreased gradually and stabilized in the 5<sup>th</sup> year. Besides, the model's stability determination results showed that all roots have modulus that is less than one and lie inside the unit circle, the estimate VAR model is stable (Figures 1 and 2).

As mentioned above, test variance decomposition is to determine how many predictive variances of each variable can be explained by exogenous shocks to other variables. This paper applied the forecast of variance decomposition to examine the volatility of crude oil prices and countries' economic growth. Consider the crude oil prices impact on countries' economic growth in the 5 years as follows:

### 5.1. In China

The results showed that the endogenous variable of economic growth fluctuates at 95%, the crude oil price variable is influenced by the economic growth impact that is about 5%.

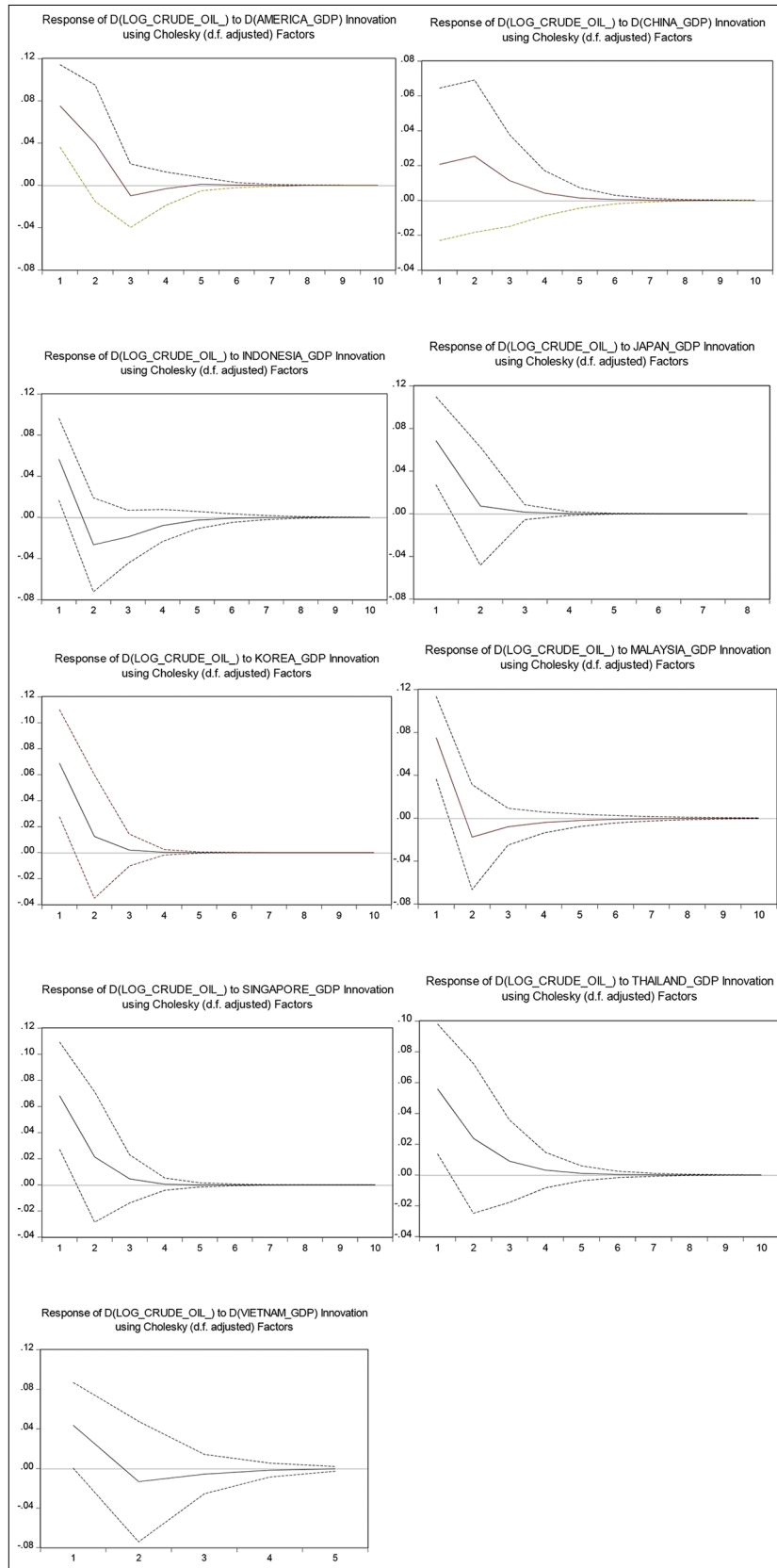
**Table 5: Variance decomposition using Cholesky (d.f) factor**

Variance decomposition of China's GDP				Variance decomposition of D (log crude oil price)		
Period	S.E.	D (GDP)	D (log crude oil price)	S.E.	D (GDP)	D(log crude oil price)
1	1.92	100.00	0.00	0.12	40.01	59.99
2	2.04	95.23	4.77	0.12	46.13	53.87
3	2.05	95.23	4.77	0.12	46.23	53.77
4	2.05	95.20	4.80	0.12	46.26	53.74
5	2.05	95.20	4.80	0.12	46.26	53.74
Variance Decomposition of America's GDP				Variance Decomposition of D (log crude oil price)		
Period	S.E.	D (GDP)	D (log crude oil price)	S.E.	D (GDP)	D(log crude oil price)
1	1.96	100.00	0.00	0.12	37.20	62.80
2	2.15	99.26	0.74	0.12	38.45	61.55
3	2.22	97.48	2.52	0.13	41.35	58.65
4	2.26	97.15	2.85	0.13	41.37	58.63
5	2.26	96.88	3.12	0.13	41.79	58.21
Variance decomposition of China's GDP				Variance decomposition of D (log crude oil price)		
Period	S.E.	D (GDP)	D (log crude oil price)	S.E.	D (GDP)	D(log crude oil price)
1	1.92	100.00	0.00	0.12	40.01	59.99
2	2.04	95.23	4.77	0.12	46.13	53.87
3	2.05	95.23	4.77	0.12	46.23	53.77
4	2.05	95.20	4.80	0.12	46.26	53.74
5	2.05	95.20	4.80	0.12	46.26	53.74
Variance decomposition of Korea's GDP				Variance decomposition of D (log crude oil price)		
Period	S.E.	GDP	D (log crude oil price)	S.E.	GDP	D(log crude oil price)
1	3.43	100.00	0.00	0.12	32.03	67.97
2	3.52	95.92	4.08	0.12	32.32	67.68
3	3.53	95.39	4.61	0.12	32.33	67.67
4	3.53	95.36	4.64	0.12	32.33	67.67
5	3.53	95.35	4.65	0.12	32.33	67.67
Variance decomposition of Singapore's GDP				Variance decomposition of D (log crude oil price)		
Period	S.E.	GDP	D (log crude oil price)	S.E.	GDP	D(log crude oil price)
1	4.17	100.00	0.00	0.12	31.71	68.29
2	4.35	94.95	5.05	0.12	33.54	66.46
3	4.37	94.10	5.90	0.12	33.61	66.39
4	4.37	94.03	5.97	0.12	33.61	66.39
5	4.37	94.03	5.97	0.12	33.60	66.40
Variance decomposition of Thailand's D(GDP)				Variance decomposition of D (log crude oil price)		
Period	S.E.	D(GDP)	D (log crude oil price)	S.E.	D(GDP)	D(log crude oil price)
1	4.20	100.00	0.00	0.11	23.53	76.47
2	4.61	93.03	6.97	0.12	38.80	61.20
3	4.64	92.96	7.04	0.12	39.18	60.82
4	4.65	92.88	7.12	0.12	39.31	60.69
5	4.65	92.88	7.12	0.12	39.34	60.66
Variance decomposition of Indonesia's GDP				Variance decomposition of D (log crude oil price)		
Period	S.E.	GDP	D (log crude oil price)	S.E.	GDP	D(log crude oil price)
1	3.81	100.00	0.00	0.11	24.37	75.63
2	3.99	99.93	0.07	0.12	27.19	72.81
3	4.00	99.91	0.09	0.12	28.92	71.08
4	4.00	99.91	0.09	0.12	29.23	70.77
5	4.00	99.91	0.09	0.12	29.26	70.74
Variance decomposition of Vietnam's D(GDP)				Variance decomposition of D (log crude oil price)		
Period	S.E.	D(GDP)	D (log crude oil price)	S.E.	D(GDP)	D(log crude oil price)
1	1.17	100.00	0.00	0.12	8.98	91.02
2	1.18	99.56	0.44	0.12	9.76	90.24
3	1.26	93.46	6.54	0.13	18.84	81.16
4	1.26	92.66	7.34	0.13	18.77	81.23
5	1.28	91.76	8.24	0.13	20.40	79.60
Variance decomposition of Vietnam's D(GDP)				Variance decomposition of D (log crude oil price)		
Period	S.E.	GDP	D (log crude oil price)	S.E.	GDP	D(log crude oil price)
1	3.83	100.00	0.00	0.12	41.26	58.74
2	3.89	97.68	2.32	0.12	40.81	59.19
3	3.90	97.15	2.85	0.12	40.60	59.40
4	3.91	97.02	2.98	0.12	40.55	59.45
5	3.91	96.98	3.02	0.12	40.54	59.46

Source: Author's analyses. Cholesky Ordering: (Variables log (crude oil price and countries' GDP))



**Figure 1:** Response of crude oil price to countries' GDP innovation using Cholesky (d.f. adjusted) factors

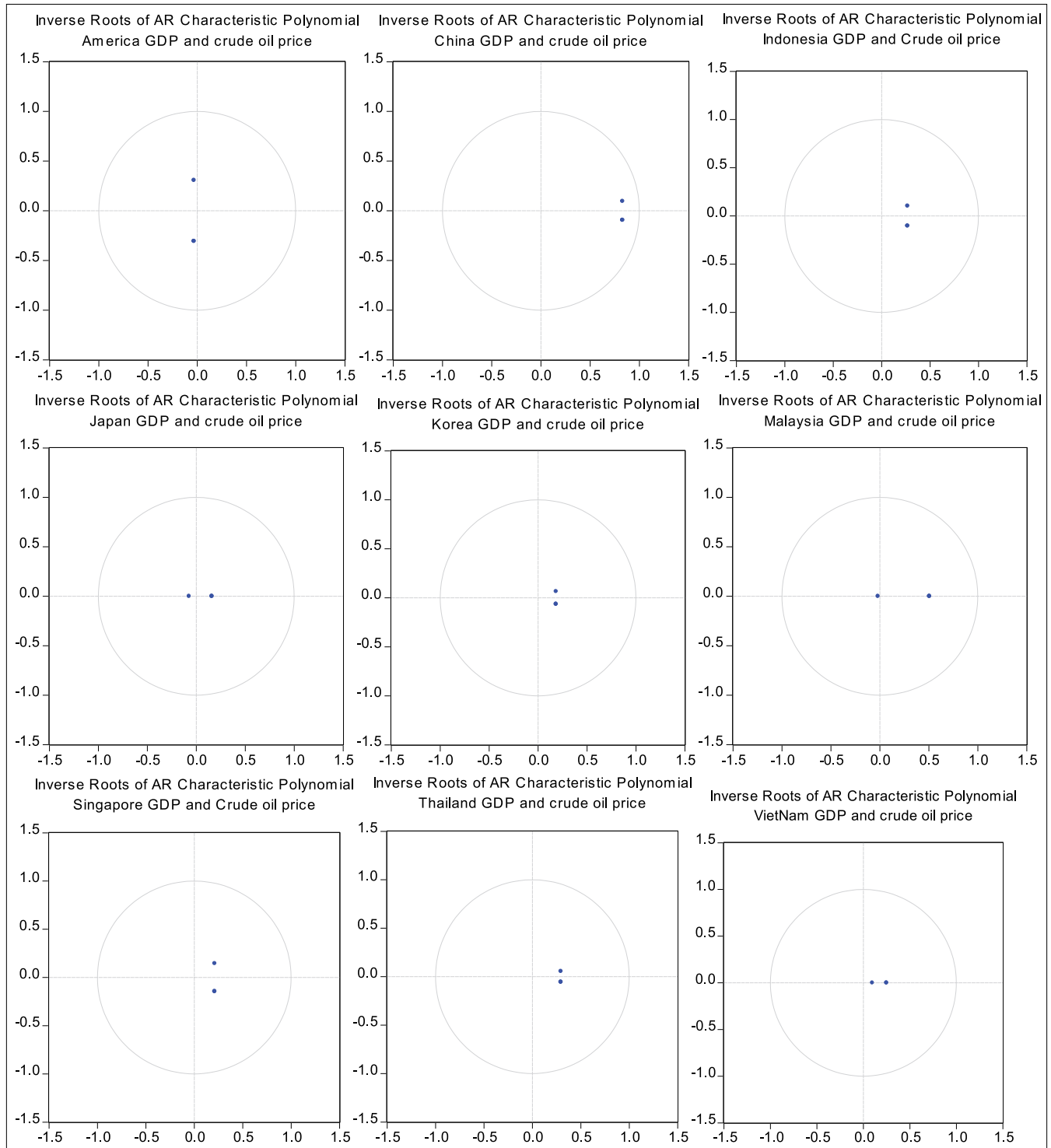


The endogenous variable of crude oil price fluctuates around 53%, China's growth variable was impacted by the crude oil price is about 46%. Thus, the price of crude oil has a significant impact on China's economy.

### 5.2. In America

America's economic growth endogenous variable and crude oil prices are fluctuations at 99.26% and 61.55% in the 2<sup>nd</sup> year, after that it is going down up to the 5<sup>th</sup> year. As well, America's

**Figure 2:** Inverse roots of AR characteristic polynomial countries' GDP and crude oil price



economic growth is impacted by crude oil prices at 37.20% in the first and 38.45% in the 2<sup>nd</sup> year, and then it is also stable from the third year to the 5<sup>th</sup> year. It shows that the fluctuation of variables is stable for the final 3 years.

**5.3. In Japan**

Japan's economic growth endogenous variable and crude oil prices are very high volatility at 99% and 68.9%, Japan's economic growth is impacted by crude oil prices at 31%, it is stable

for 5 years. It showed a significant impact on the endogenous variable and the other variables in the model.

**5.4. In Korea**

Korea's economic growth endogenous variable and crude oil prices are fluctuations at 95% and 68%, Korea's economic growth is impacted by crude oil prices at 32%, it is stable for 5 years. It also showed a significant impact on the endogenous variable and the other variables in the model.

### 5.5. In Singapore

Singapore's economic growth endogenous variable and crude oil prices are fluctuations at 94.9% and 68.3% in the 2<sup>nd</sup> year, after that it goes down at 94.03% and 66.04% in the 5<sup>th</sup> year. Besides, Singapore's economic growth was impacted by crude oil prices at 33.60%, it is not stable for 5 years. It also showed a significant impact on the endogenous variable and the other variables in the model.

### 5.6. In Thailand

Thailand's economic growth endogenous variable and crude oil prices are fluctuations at 93.03% and 76.5% in the 2<sup>nd</sup> year, after that it goes down at 92.88% and 60.66% in the 5<sup>th</sup> year. But Thailand's economic growth is impacted by crude oil prices at 23.53% in the 2<sup>nd</sup> year and then it goes up at 39.34% in the 5<sup>th</sup> year, it is not stable for 5 years.

### 5.7. In Indonesia

Indonesia's economic growth endogenous variable and crude oil prices are high fluctuations at 99.93% and 75.63% in the 2<sup>nd</sup> year, after that, crude oil price variable goes down at 70.74% in the 5<sup>th</sup> year. Besides, Thailand's economic growth is impacted by crude oil prices at 24.37% in the 2<sup>nd</sup> year, and then it goes up at 29.26% in the 5<sup>th</sup> year, the fluctuation of variables is not stable for 5 years.

### 5.8. In Vietnam

Vietnam's economic growth endogenous variable and crude oil prices are also high fluctuations at 99.56% and 90.24% in the 2<sup>nd</sup> year, after that, it goes down at 91.76 and 79.60% in the 5<sup>th</sup> year. Besides, Vietnam's economic growth is very lowly impacted by crude oil prices at 8.98% in the 1<sup>st</sup> year, and then it goes up at 20.40% in the 5<sup>th</sup> year, the fluctuation of variables is not stable for 5 years.

### 5.9. In Malaysia

Malaysia's economic growth endogenous variable and crude oil prices are fluctuations at 97.68% and 59.74% in the 2<sup>nd</sup> year, after that it is stable up to the 5<sup>th</sup> year. As well, Malaysia's economic growth is impacted by crude oil prices at 41% in the first and 40.81% in the 2<sup>nd</sup> year, and then it is also stable up to the 5<sup>th</sup> year. It shows that the fluctuation of variables is stable for 5 years.

Results show that countries' GDP includes China, America, Thailand, Indonesia, Vietnam and Malaysia will not be affected by oil price immediately, but it will affect countries' GDP next year. It means that when the world oil price fluctuates, it does not have an immediate impact on these countries' economic growth, but the crude oil price fluctuation will affect economic growth next year. Countries' GDP include Japan, Korea and Singapore are affected by crude oil prices immediately when crude oil prices increase or decrease. Besides, the countries' GDP is highly affected by the price of crude oil, that is China at 46.26% and the US at 41.79%, the countries' GDP is significantly affected, that is Thailand at 39.34%, Singapore at 33.6%, Korea at 32.33% and Japan at 31%, the countries' GDP is low impacted, that is Vietnam at 20.4% and Indonesia at 29.6%.

Why is there a different impact of crude oil price on countries' GDP?

The impact of oil prices on GDP depends on each country's macro policy and its economic growth. Besides, there are some

countries not only crude oil imports but also exports of crude oil such as Vietnam or Indonesia etc. The comparison result between Vietnam's GDP and the countries' GDP shows that Vietnam's GDP is least impacted by crude oil prices. So, Vietnam has an achievement by an appropriate macro policy such as implementing an oil-to-oil stabilization fund. Thus, Vietnam has had a strategy to stabilize petroleum prices for a long time. The empirical result is also consistent with relevant literature Dinh (2020d).

## 6. CONCLUSION

The study applied the VAR model to explore the fluctuations of countries' economic growth endogenous variables and the shock from crude oil prices. The crude oil is the input material of many economic sectors, so the decrease in gasoline prices make production costs decrease leading to decreased produced costs that improve the competitiveness of domestically produced goods, contributes to improving the competitiveness of the economy and GDP growth. Based on the input costs of the product, countries can make reasonable policy to grow their economies. If the crude oil price goes down, the crude oil-importing countries have benefit. If the price of crude oil increases, the importing countries have not to benefit. According to (Wikipedia), oil-importing countries including the United States' rank second, China's rank 1<sup>st</sup>, Malaysia's rank 33<sup>rd</sup>, Indonesia's rank 23<sup>rd</sup>, Vietnam's ranked 32<sup>nd</sup>, Thailand's rank 14<sup>th</sup> and Japan's rank fourth. The data based on the list of 84 oil-importing countries in the world. So, the United States and China don't have benefit when the crude oil price increases.

The above experimental results are the key for Governments to have suitable macro policies for economic development. Especially the context that all economies in the world are being affected by the COVID-19 epidemic. So, social-distancing almost makes social-activity to interrupt lead to reduced fuel consumption, so the crude oil price falls. It is also the opportunity for importing countries to increase oil imports and reserve crude oil to stabilize domestic oil prices.

The maintenance of the Petroleum Price Stabilization Fund is essential to stabilize the domestic petroleum price, avoid an increased shock and cause stability the national economy. Therefore, in case the world oil price changes, the domestic oil price is adjusted to stable the socio-economics.

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