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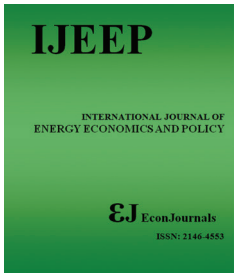

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Crude Oil Price Fluctuation and Economic Growth: ARDL Model Approach

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ABSTRACT

The relationship between crude oil prices and countries' GDP is used to consider whether crude oil prices impact their economic growth and the extent to which they are impacted. To explore and investigate this relationship, the autoregressive distributed lag model (ARDL) was combined with the unit root, Pearson's correlation (two-tailed) tests, and time series collected from 1991 to 2020 to explore their relationship. The crude oil prices affecting Vietnam, China, and South Korea are −52.6%, −37.6%, −48.5%, respectively, while other countries have a minimal impact, such as Thailand −20.3%), Singapore (−24.7%), Indonesia (11.1%), Malaysia (−23.4%), Japanese (−18.3%) and America (−12.8%). Crude oil prices negatively impact all countries except Indonesia. In addition, the empirical results provide accurate forecasting and alternative energy policymaking for micromanagers who set sustainable economic growth goals and have short-term and long-term economic development strategies.

Keywords: GDP Growth, Crude Oil Crisis, Energy Policy, Alternative Energy, Stabilization Policy
JEL Classifications: E31, E37, Q42, Q48

1. INTRODUCTION

Energy has influenced global economic growth and played an important role in several sectors. Thus, the increasing crude oil price crisis led to global economic crises such as the Middle East oil crisis from 1973 to 1975, Revolutionary Iran, fluctuations in the oil market in 1979, oil price plummeting in the 1980s, oil price drop in 1990, oil price fall in 2001, serious oil price crisis from 2007 to 2008, crude oil price shock in 2011 and the COVID-19 pandemic. The oil price crisis has become a great concern in the literature; thus, Gokmenoglua et al. (2015) concluded about the impact of oil prices on the Turkish economy and the relations among crude oil, inflation, and GDP. Although the nature of this relationship differs, it depends on each country's energy policies. Thus, oil price crises can lead to changes in a country's macroeconomic policies and microeconomic decisions (Nyangarika et al., 2018). Furthermore, crude oil has become an important input source for all economic activities. Regarding the interdependence of oil prices and economic growth, the literature has studied the relationship between four major nations: United Arab Emirates, Kuwait, Saudi Arabia, and Venezuela) in the Organization of Petroleum Exporting Countries (OPEC), and the results indicate that oil price shocks have a relationship between oil and economic growth in OPEC countries through fluctuations in oil prices on the input of economic activities (Ftiti et al., 2016). This empirical study shows that crude oil prices affect economic growth, because crude oil is a scarce natural resource. The results showed that, in the short or long term, oil price fluctuations have an impact on GDP (Zou, 2018). The other literature explored the degree of interdependence between crude oil prices and gross domestic product (GDP) according to data in Saudi Arabia and the main crude oil-exporting countries to the world market, was a close relationship (Nyangarika et al., 2018). Until now, academic economists have been interested in crude oil that relates to its impact on economic growth as mentioned above, thus, the empirical results show that oil price and economic growth are a

close correlated. However, literature has studied this relationship within the scope of one or several countries. Thus, this study focuses on the relationship between oil prices and the economic growth of Vietnam and some Southeast Asian countries and examines the impact of crude oil prices on the economic growth of the United States and China, the two countries that have the largest economies in the world.

This study examines whether economic growth is closely correlated with crude oil price. Thus, the study is based on data from nine countries, including two with the largest economies in the world, and applies the two-way correlation test (two-way) to consider the correlation between the variable crude oil price and the economic growth of each country. Thus, the hypothesis suggests that some countries have a close correlation between the two variables and some countries have a loose correlation between the two variables. Moreover, the correlation results are significant in determining the impact of crude oil prices on countries' economic growth. In addition, the Granger causality test was applied to consider the following cases.

- The one-way causal relationship only affects economic growth to the crude oil price.
- The two-way causal relationship between crude oil price and economic growth, and any crude oil price volatility may not affect economic growth and vice versa.

The author's contribution to this article is an exploration of the relationship between economic growth and crude oil prices in Vietnam and other countries from 1991 to 2020. In addition, the OLS model was applied to determine the correlation between crude oil prices and national economic growth. What impact does crude oil price have? Therefore, crude oil prices must be maintained at the appropriate levels to achieve economic growth. If the price is too high, the growth possibility declines because of the cost-push inflation. Furthermore, the study also applies the autoregressive distributed lag model (ARDL), which has two variables: the GDP dependent variable, the crude oil price independent variable, and endogenous variables. To maintain the GDP growth target, the government forces oil price stabilization or its reserves and suitable energy policies, which will increase or decrease inflation. These empirical studies on crude oil price fluctuations and economic growth showed that they had a close relationship with each other and that their relationship might be negative or positive, linear or non-linear, depending on the crude oil price fluctuations. Moreover, the previously studied results were only exact for the specific economic context of each country.

In this study, a linear regression model is applied to evaluate whether changes in crude oil prices affect GDP. And how does it impact? The results of this study demonstrate that changes in the crude oil prices of Vietnam and other countries impact GDP. Why is it the case?

These contributions play a significant role in planning, orienting, and setting appropriate energy policies to promote economic growth. To avoid an economic recession, the government should not make decisions on energy policies to control oil prices to avoid economic recession. The remainder of the paper is organized as follows: Section 2 reviews the literature, Section 3 explains the data and methodology of economics, Section 4 summarizes the results, Section 5 discusses the findings and Section gives conclusions.

2. LITERATURE REVIEW

Over the past few decades, evidence has shown that global oil price crises have affected the global economy. Thus, the literature focuses on the causal relationship between increasing oil prices and economic growth. Applying the ARDL model to study the relationship between energy consumption and economic growth in Tunisia through oil prices, the empirical evidence indicates that an increase in oil prices has an impact on economic growth. (Brini et al., 2017).

The general perception of the correlation between oil prices and economic growth is that a decreased oil price leads to a decrease in inflation, because of lower production input costs. Oil prices also depend on the energy consumption of the economy for developing countries, using data from 157 countries from 1960 to 2014 and the panel cointegration test, long-run parameter estimation, and pool mean group tests to analyze the relationship between economic growth, electricity consumption, oil prices, capital, and labor (Sarwar et al., 2017). Other studies have examined the empirical relationships among economic growth, electricity consumption, oil prices, total capital formation, and population from 120 countries using panel cointegration, OLS, and panel vector error methods to analyze these relationships, which is a two-way relationship between electricity consumption and GDP, oil price and GDP, capital formation, population, and GDP (Sarwar et al., 2017).

The relationship between crude oil prices and economic growth is of concern to researchers because fluctuations in crude oil prices are considered one of the main factors affecting economic growth in all economies (Tugcu et al., 2012; Rafiq et al., 2009). COVID 19 pandemic, which has studied the impact of oil prices on the stock market, exchange rates, and real estate market in the US over the past decade, showed that the price of crude oil has a positive impact on the US stock market but a negative impact between the dollar and the price of crude oil. (Jawadi and Sellami, 2021; Dinh, 2018).

The literature also includes the same research on the empirical relationship between business conditions and crude oil prices and applies the ARDL model for analysis; thus, the evidence is that economic growth correlates with oil price fluctuations in countries and regions. Thus, the economy is significantly affected by global oil prices. Moreover, oil prices have a significant influence on business activities in countries but have a positive impact in other countries (Sodeyfi and Katircioglu, 2016). Some studies also mention that oil price fluctuations affect factors such as macroeconomics, investment costs, enterprise production structure, the unemployment rate, consumption, and monetary policy, including interest rates, exchange rates, and inflation. This shows that crude oil prices impact all sectors and the social lives of each country. (Nyangarika et al., 2018). In addition, increasing oil prices also affect finance and banking in importing countries, rather than exporting countries, which can have direct or indirect impacts (Naifar and Dohaiman, 2013; Chen, et al., 2019; Dinh, 2021).

Some authors find a statistically significant relationship between oil price volatility, economic growth, stocks, and macroeconomics. The author applied a VAR model based on a monthly time series from 1-1995 to 12-2008 to analyze the impact of oil prices on China's macroeconomy, given that the Chinese economy's national activity does not impact world oil prices (Du et al., 2010). However, oil price shocks negatively impact economic growth, stock markets, and international financial markets. The authors applied a structural vector auto-regression model to analyze the contagion impact of international crude oil price fluctuations on Chinese stock market investors in the long and short terms, so the international crude oil price fltagion impact of international crude oil's stock market sentiment, leading to China's negative impact on economic growth (Ding et al., 2017).

In general, studies have focused on the relationship between crude oil prices, economic growth, the stock market, monetary policy, unemployment, inflation, etc., and all research results are significant. However, the previous literature is only suitable for the research scope of actual time-series data, leading to some aspects that need to be further studied. Therefore, this study focuses on analyzing the relationship between crude oil prices and the economic growth of countries by investigating data on countries with time series from 1991 to 2020, including data on the COVID-19 pandemic. Thus, the difference between previous studies and ours is that the time-series data, research scope, OLS, and ARDL models were applied to explore the correlation and build a forecast model for the impact of crude oil. In some countries, crude oil prices have a significant impact on economic growth. However, it is also possible that oil prices have a minor impact on some nations' economic growth. In addition, it has a positive or negative impact on nations' energy policies, based on the correlation between oil prices and economic growth.

3. METHODOLOGY AND HYPOTHESES DEVELOPMENT

Economic growth is defined as the increase in GDP over a period and is normally calculated annually. Therefore, GDP is the monetary value of all final products and services produced within an economy in a year, as follows: GDP = C + I + G + NX, where C is consumption, I is investment, G is government expenditure, and NX is net export. According to economist John Maynard Keynes (1883–1946), GDP can be divided into two categories: real and nominal GDP. Thus, real GDP is a nominal GDP after the inflation rate is eliminated. This is based on Fisher's exchange equation M x V = P x Y. where: M is the quantity of money (M1 or M2), P is the price of output, V is the velocity of money, y is the quantity of output (real GDP), P x Y is the value of output (nominal GDP) (Mishkin, 2016). The quantity theory of money implies that countries with higher money growth rates should have higher inflation rates, and that the long-run trend behavior of a country's inflation should be similar to the long-run trend in its money growth rate.

To determine the correlation between oil prices and economic growth, it is necessary to apply an OLS model, which is the regression method most use. Although other regression methods are preferred, the OLS regression results are still considered to be standard. Therefore, the correlation coefficient (r) is a statistical indicator that measures the correlation between two variables, such as the impact of the oil price (y) and GDP (x). Thus, the correlation coefficients ranged from -1 to 1, if the correlation coefficient is 0 (or close to 0), the two variables are not related to each other; otherwise, if the coefficient is −1 or 1, the two variables have an absolute relationship.

The hypotheses are as follows:
H_1: r < 0, the value of the correlation coefficient is negative, i.e., when the oil price increases, the GDP decreases, and vice versa, when the oil price falls, economic growth increases
H_2: r > 0, the correlation coefficient value is positive, which means that when the oil price increases, the GDP also increases, and when the oil price increases, the GDP also increases.

To establish an analysis regression model that is the study of the dependent variable on one or more independent variables (explanatory variables) to estimate or predict the mean value of the dependent variable that is based on values of the explanatory variables. This paper analyses two variables that are independent variables and dependent variables, in which the crude oil price () the variable is the independent variable, the dependent variable is the GDP (), the regression model is written as follows:

$$\widehat{\mathrm{GDP}}_t = \hat{\alpha} + \hat{\beta}\,\mathrm{Crude\,oil\,price}_t + \omega_t \quad (1)$$

The Pearson correlation coefficient test was used to examine the linear relationship between independent and dependent variables. Independent variables that were closely correlated and considered to have multicollinearity were excluded from the model. If the independent and dependent variables have a loose relationship, is removed from the model because the impact of these two variables is insignificant (Granger and Newbold, 1974).

In addition, the spurious regression phenomenon is corrected because the F and t statistics are still significant, and the value of R square is high, but there is no real relationship between them, which generally identifies spurious regression as a low Durbin-Watson statistic (Yule, 1926).

In this study, the autoregressive distributed lag model (ARDL) was applied to avoid spurious regression because it was tested using the unit root test and the cointegration relationship to consider the time series of stationary variables. Dickey and Fuller (1981), Dickey and Fuller (DF), extended Dickey and Fuller (ADF) tests were conducted according to Dickey and Fuller tests. The ADF test to perform the unit root test and the ADF extended unit root test model as follows:

$$\sum_{i=1}^{n}\beta_i Log(GDP)_t = \sum_{i=1}^{n}\alpha_i Log(Crude\,oil\ price)_{t-i} + \sum_{i=1}^{n}\beta_i Log(GDP)_{t-i} + \varepsilon_t \quad (2)$$

$$\Delta_{y_t} = \alpha_0 + \delta_t + \beta y_{t-1} + \sum_{j=1}^{k}\partial_j \Delta y_{t-j} + \varepsilon_t \quad (3)$$

Where: $\Delta y_t = y_t - y_{t-1}$, y_t: is time-series; k: is order lag; ε_t: is white noise.

Model (3) differs from model (4), which adds a trend variable t time (δ_t), a variable with values from th 1 to th n, where th 1 represents the first observation in the data, and th n represents the last observation in the data series. White noise is a random error term derived from the classical assumption that it has a mean value of zero, constant variance, and is not autocorrelated. In addition, the ADF test result, which is Akaike's information criterion, is used to select the optimal k lag for the ADF model. Thus, the k value was selected when the AIC was the smallest (Akaike, 1973).

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).

According to Johansen (1991), the cointegration test for a data series determines the number of linear combinations of cointegration between stationary time series at the first difference, thereby indicating the number of relationships that exist in an equilibrium system in the long run. Johansen's cointegration test, which is used in a multivariate framework, was applied to determine the cointegration relationships between the dependent and independent variables. Therefore, this study applied this model to test whether the variables are I (0) or I (1), and Johansen's methodology takes its starting point in the ARDL model of order p given:

$$Z_t = AZ_{t-1} + \ldots + A_n Z_{t-n} + \beta X_t + \varepsilon_t \quad (4)$$

Where Z_t is the vector of the degree of difference (I(1)) between the independent and dependent variables, X_t is the vector of the non-random variable, and ε_t is the error correction term.

The Granger causality test involves estimating two equations that allow for a simple autoregressive distributed lag (ARDL) model for crude oil prices and economic growth. The simple vector auto-regression (VAR) for these two variables is given by the following equation.

$$\sum_{i=1}^{n} \beta_i Log(GDP)_t = \sum_{i=1}^{n} \alpha_i Log(Crude\ oil\ price)_{t-i} + \sum_{i=1}^{n} \beta_i Log(GDP)_{t-i} + \varepsilon_t \quad (5)$$

$$Log(Crude\ oil\ price)_t = \sum_{i=1}^{n} \beta_i Log(GDP)_{t-i} + \sum_{i=1}^{n} \alpha_i Log(Crude\ oil\ price)_{t-i} + \varepsilon_t \quad (6)$$

The ARDL model prediction method considers several time-series at the same time, so the key features of the model show that it is indeed a concurrent system in which all variables are considered endogenous, the value of a variable is represented as a linear function in the past, or hysteresis values of that variable and all other variables in the model. If each equation contains the same number of hysteresis variables in the system, then it can be estimated using the OLS method without using any system method.

Besides, the ARDL model (p, q) is also applied in this paper, so to consider the impact of crude oil price on GDP growth of countries, the ARDL model is applied, in which the dependent variable is GDP (Y) and the explanatory variable is crude oil price (X), so the model is written as follows:

$$Log(GDP)_t = \alpha_{0i} + \sum_{i=1}^{q} \varphi_i Log(GDP)_{t-i} + \sum_{i=1}^{p} \beta_i Log(Crude\ oil\ price)_{t-i} + u_{1t} \quad (7)$$

Where GDP variable is a vector and variables in crude oil price variable are allowed to be purely I (0) or I (1) or co-integrated; β and φ_i are coefficients; α is the constant; i = 1…, k; p and q are optimal lag order; u is a vector of the error items – unobservable zero-mean white noise vector process.

The ARDL bounds test method is the basis for calculating long-term effects and using an error correction model (ECM), according to the ARDL approach, to determine the short-term impacts between them. Thus, the three options for decisive criteria are as follows:

If the calculated F-statistic is greater than the critical value bound for the upper bound (I(1)), it can be concluded that the model has a cointegration and long-term relationship.

If the calculated F-statistic falls below the critical value for the lower bound I (0), no cointegration exists; thus, no long-term relationship exists.

The test is considered to have no conclusion if the F-statistic is between the lower bound I (0) and upper bound (I(1)); therefore, in this case, it can consider both the long - and short-term models. The bound test of the ARDL method used in this study is as follows:

$$\Delta Log\left(GDP\right)_t = \alpha_{0i} + \sum_{i=1}^{q} \varphi_i \Delta Log\left(GDP\right)_{t-i} + \sum_{i=1}^{p} \beta_i \Delta Log\left(Crude\ oil\ price\right)_{t-i} + \gamma_1 Log(GDP)_{t-i} + \gamma_2 Log(Crude\ oil\ price)_{t-i} + u_{1t} \quad (8)$$

Dataset: This study used monthly crude oil price data from January 1990 to September 2020 from nine countries: Thailand, Vietnam, Singapore, Indonesia, Malaysia, Japan, Korea, and America. Simultaneously, data on the economic growth rates of nine countries were 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 1990. Therefore, this study limits the empirical analysis of this time series. As the volatility of oil prices is calculated monthly, the empirical analysis estimates the yearly mean of crude oil prices corresponding to the countries' annual GDP growth indices. Time-series data on the GDP growth rate variables were collected from the World Bank (World Bank Group, 2020), and crude oil price data is collected from Federal Reserve Economic (Federal Reserve Economic, 2020) (Table 1).

The dataset is used to estimate the relationship between crude oil price and countries' GDP growth, which is detailed below.

Table 1: Variable description

Variable	Acronym	Description	Source
The price of crude oil in the world market	Crude oil price	The global price of Brent Crude: Value represents the benchmark prices that are representative of the global market. They are determined by the largest exporter of a given crude oil. Prices are period averages in nominal U.S. dollars.	Federal Reserve Economic Data. https://fred.stlouisfed.org/series/POILBREUSDM
The gross domestic product growth	GDP	The gross domestic product growth rate measures how fast the economy is growing. The rate compares the most recent year of the countries' economic output to the previous year (Economic output is measured by GDP).	World development indicators The World Bank Group. https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG

Table 2: Summary of correlation between crude oil price and countries' GDP growth

Items	China	Vietnam	Singapore	Thailand	Indonesia	Malaysia	Japan	Korea	America
Crude Oil Price									
Pearson Correlation	−0.376*	−0.526**	−0.247	−0.203	0.111	−0.234	−0.183	−0.485**	−0.128
Sig. (2-tailed)	0.041	0.003	0.188	0.281	0.560	0.213	0.332	0.007	0.502
N	30	30	30	30	30	30	30	30	30

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed). Source: Author's analyses

Table 3: Summary of unit root test of crude oil price, Vietnam's, China's and Korea's GDP growth at Lag I (0)

Items	China		Vietnam		Korea		Log (crude oil)	
	t-Statistic	Prob.*	t-Statistic	Prob.*	t-Statistic	Prob.*	t-Statistic	Prob.*
Augmentedb Dickey-Fuller test statistic	−2.691022	0.0877	−3.275418	0.0256	−4.550451	0.0011	−1.174438	0.6715
Test critical values:								
1% level	−3.679322		−3.679322		−3.679322		−3.679322	
5% level	−2.967767		−2.967767		−2.967767		−2.967767	
10% level	−2.622989		−2.622989		−2.622989		−2.622989	

*MacKinnon (1996) one-sided P values. Source: Author's analyses

Table 4: Summary of unit root test of crude oil price, Vietnam's and China's GDP growth at lag I (1)

Items	China		Vietnam		Log (crude oil)	
	t-Statistic	Prob.*	t-Statistic	Prob.*	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	−5.800484	0.0000	−6.098691	0.0000	−4.495477	0.0014
Test critical values:						
1% level	−3.689194		−3.689194		−3.689194	
5% level	−2.971853		−2.971853		−2.971853	
10% level	−2.625121		−2.625121		−2.625121	

*MacKinnon (1996) one-sided P values. Source: Author's analyses

4. RESULTS

Crude oil affects the economies of most countries because it is an important input in the production of goods and services. However, fluctuations in crude oil prices significantly impact some countries' economies and some countries' economies are less affected, as identified by empirical correlation results (Table 2).

The correlation results between crude oil prices and GDP growth of other countries show that the GDP growth of the three countries has a close correlation and is statistically significant, which is the GDP growth of Vietnam, China, and South Korea. Simultaneously, the economies of other countries are loosely correlated with world crude oil prices, implying that crude oil prices have an insignificant impact on the GDP growth in these countries. Therefore, these differences were not statistically significant. Therefore, this study selected three countries whose economies were significantly affected by global crude oil prices to explore their impact levels (Table 3).

In statistics, a unit root test tests whether a time-series variable is non-stationary and possesses a unit root. The null hypothesis is generally defined as the presence of a unit root, whereas the alternative hypothesis is either stationary or trend stationary. The unit root test results show that Korea's time-series variable is stationary at lag I (0) and the time-series variables of crude oil prices in China, and Vietnam are non-stationary at lag I (0). Therefore, these time-series variables were tested using the first difference as follows (Table 4):

All likelihood ratio tests (LR), final prediction error (FPE), Akaike Information Criterion (AIC), Schwarz Information Criterion (SC), and Hannan-Quinn Information Criterion (HQ) were applied to compare and then select the optimal lag for each ARDL model. However, one of the criteria, the AIC, was chosen to determine the optimal lag (Table 5).

The bounds test is to test the long-term relationship between countries' economic growth and world oil prices, so, the bound test method is the basis for calculating long-term impacts, which is applied to adjust error correction (ECM), besides, the ARDL approach also determines the short-term impacts between them (Table 6).

The Wald test is to evaluate the constraints on statistical parameters based on the weighted distance between the unrestricted estimate and its assumed value under the null hypothesis, where the weight is the accuracy of the estimate (Table 7).

The ARDL model is more commonly used in studies of the long-run relationships between economic variables. Therefore, applying the high-reliability ARDL model when the stationary time-series variables, which are the mean, variance, and covariance, always remain unchanged, the optimal lag, non-autocorrelation, and non-variable variance. The time-series stationarity was tested using the unit root test, which determines the appropriate model for each country, as China's model is short-term, and the Vietnamese and Korean models are long-term (Table 8).

The model forecasts the crude oil price impact on countries' economic growth.

- China's GDP (Short-term) = 6.005 + 0.5996 × China's GDP (−1) − 1.5523 × Crude oil price
- China's GDP (Long-term) = 6.005 − 0.4004 × China's GDP (−1) − 1.5523 × Crude oil price
- Vietnam's GDP (Long-term) = 7.4273 + 0.3026 × Vietnam's GDP (−1) − 1.6846 × Crude oil price
- Korea's GDP (Long-term) = 15.117 + 0.1444 × Korea's GDP (−1) − 6.2351 × Crude oil price

The CUSUM test, which is asymmetric distribution centered at 0 with degrees its dispersion increases as t-k does, is used to verify model stability, so the countries' oil prices and GDP growth is tested by the CUSUM statistic, which is drawn from the CUSUM (t-k) distribution, (Figures 1-3).

This study explores the impact of oil prices on GDP growth and shows that economic growth was significantly affected in some countries. However, the economic growth of the other countries was not significantly impacted. This effect depends on the country's energy policy and oil resources. The empirical results provide a basis for clarifying this impact in the discussion section.

5. DISCUSSION

Crude oil prices play an important role in global economic growth because they directly affect a country's economic growth through production input costs. Moreover, crude oil prices impact the revenue sources of exporting countries.

Figure 1: Stable crude oil price and China's GDP

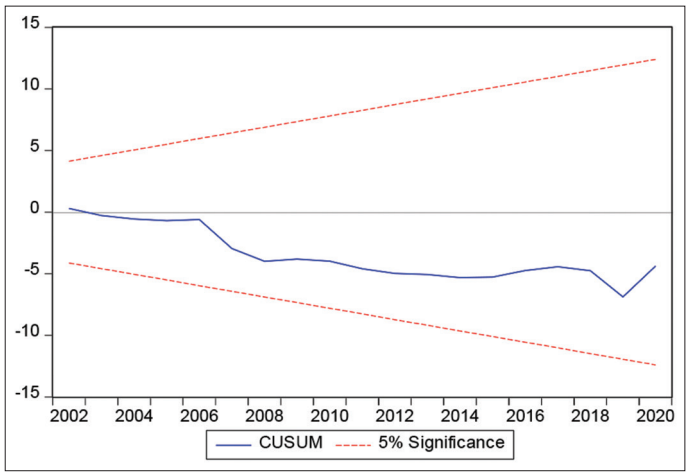


Table 5: Summary of VAR lag order selection criteria of crude oil price, Vietnam's, China's, and Korea's GDP growth

Lag	China - Log (crude oil)		Vietnam - Log (crude oil)		Korea - Log (crude oil)	
	LogL	AIC	LogL	AIC	LogL	AIC
0	−69.36241	5.097315	−49.70819	3.693442	−76.18335	5.584525
1	−35.18269	2.941621*	−20.02730	1.859093*	−49.21316	3.943797*
2	−34.01107	3.143648	−18.51000	2.036428	−45.95813	3.997009

*Indicates lag order selected by the criterion. AIC: Akaike information criterion. Source: Author's analyses

Table 6: Summary of F-Bounds test of Vietnam's, China's and Korea's GDP growth

F-Bounds Test			Null Hypothesis: No levels relationship							
Items			China		Vietnam			Korea		
Test Statistic	Value	Signif.	I (0)	I (1)	Value	I (0)	I (1)	Value	I (0)	I (1)
Asymptotic: n=1000										
F-statistic:	4.45	10%	4.04	4.78	8.26	4.04	4.78	16.87	4.04	4.78
K:	1	5%	4.94	5.73	1	4.94	5.73	1	4.94	5.73
		2.5%	5.77	6.68		5.77	6.68		5.77	6.68
		1%	6.84	7.84		6.84	7.84		6.84	7.84

Source: Author's analyses

Table 7: Summary Wald Test of Vietnam's, China's and Korea's GDP growth

Items	China			Vietnam			Korea		
Test Statistic	Value	df	Probability	Value	df	Probability	Value	df	Probability
F-statistic	220.6599	(3, 26)	0.0000	346.0520	(3, 26)	0.0000	23.45971	(3, 26)	0.0000
Chi-square	661.9797	3	0.0000	1038.156	3	0.0000	70.37914	3	0.0000
Null Hypothesis: C (1)=C (2)=C (3)=0									

Source: Author's analyses

Table 8: Summary of crude oil price and countries' GDP growth

Dependent Variable: CHINA'S GDP				
Method: ARDL Short-Run				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
CHINA'S GDP (−1)	0.599641	0.135642	4.420768	0.0002
CRUDE OIL PRICE	−1.552268	1.259688	−1.232264	0.0289
C	6.004262	2.671040	2.247912	0.0333
Dependent Variable: D (CHINA)				
ARDL Long Run Form and Bounds Test				
Conditional Error Correction Regression				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.004262	2.671040	2.247912	0.0333
CHINA'S GDP (−1)*	−0.400359	0.135642	−2.951594	0.0066
CRUDE OIL PRICE**	−1.552268	1.259688	−1.232264	0.0289
Dependent Variable: D (VIETNAM'S GDP)				
ARDL Long Run Form				
Conditional Error Correction Regression				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7.427296	2.105236	3.528010	0.0016
VIETNAM'S GDP (−1)*	−0.697462	0.172234	−4.049515	0.0004
CRUDE OIL PRICE**	−1.684541	0.801059	−2.102892	0.0453
Dependent Variable: D (KOREA'S GDP)				
ARDL Long Run Form				
Conditional Error Correction Regression				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	15.11609	4.135220	3.655450	0.0011
KOREA'S GDP (−1)*	−1.144340	0.197126	−5.805117	0.0000
CRUDE OIL PRICE**	−6.235058	2.232128	−2.793324	0.0097

*P-value incompatible with t-Bounds distribution. **Variable interpreted as Z=Z (−1) + D (Z). Source: Author's analyses

Figure 2: Stable crude oil price and Vietnams GDP

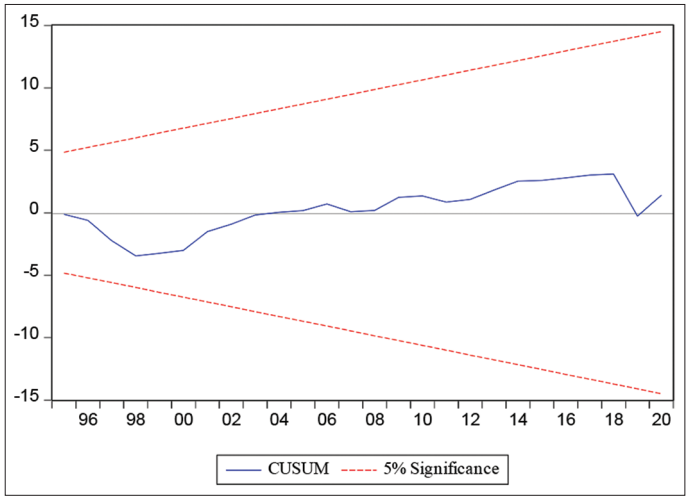
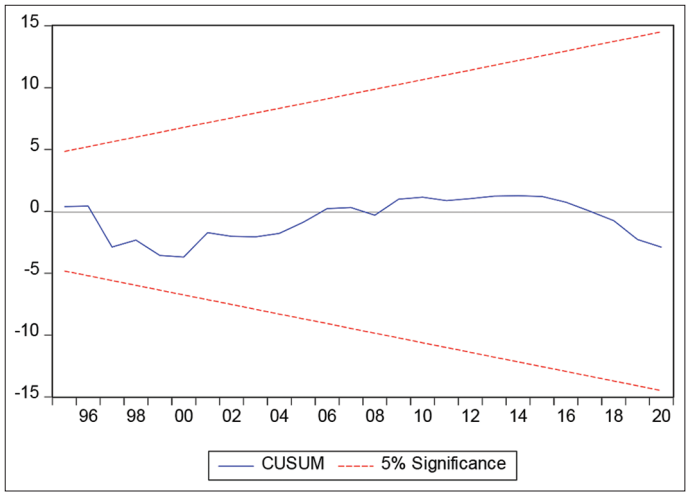


Figure 3: Stable crude oil price and Korea's GDP



The correlation test shows that the impact of global oil prices on GDP growth differs. The impact on Vietnam's GDP growth was 52.6% at the 1% level (0.003 < 0.05), whereas the impact on China's GDP growth was 37.6% at the 5% level, which was statistically significant (sig = 0.041 < 0.05 = alpha), the impact on Korea's GDP growth is 48.5% at the 1% statistical significance level (sig = 0.007 < 0.05 = alpha). The correlation levels of the three countries are close and statistically significant. However, the correlation levels for the remaining countries are loose and not statistically significant. In particular, the impact of crude oil prices on Singapore's economic growth is 24.7%; Thailand's economic growth is 20.3%; Indonesia's economic growth is 11.1%; Malaysia's economic growth is 23.4%; America's economic growth is 12.8%; Japan's economic growth is 18.3%. All the variables are >0.05, indicating that they are statistically insignificant because their impact on the economic growth of these countries is insignificant. Thus, this study selected countries that had a significant impact on economic growth for the analysis.

The unit root test results show that Vietnam's and Korea's time series are stationary at lag I (0), which means that oil price fluctuations immediately affect GDP growth. However, China's GDP growth and oil price time series are stationary at lag I (1), which shows that when the world oil price fluctuates, it does not immediately impact China's economic growth, but its impact the following year because China already has a large crude oil reserve, The empirical result is also appropriate for China's energy reserve policy.

To select the optimal lag for the ARDL model, the optimal lag for Vietnam, Korea's, and China's economic growth is I(1) according to the AIC criterion. Based on these results, to establish the most suitable model for each country (Pesaran and Shin, 1999). In addition, the models need to determine whether the oil price impact on countries' economic growth is long-term, short-term, or both using the F-bounds test. The F-statistic results show that Vietnam's and Korea's economic growth has a long-term impact because the F-statistic of 8,252 is greater than the bounds I (1) at Sign if = 10%, 5%, 2.5%, and 1%. China's economic growth has short- and long-term impacts as the F-statistic of 4.1023 is between the lower bound I(0) and upper bound I(1) at Sign if = 10%, 5%, 2.5%, and 1%.

In addition, the purpose of the Wald test is to explore multivariate regression, because the t-values in the Wald test are used to evaluate the significance of each coefficient or are based on the probability of considering whether the degree of probability is greater or less than the coefficient alpha (5%). If the probability hypothesis is greater than alpha (5%), the variables in the model are rejected; if it is less than alpha (5%), the variables in the model are accepted. Thus, the empirical results show that all the variables have Prob. 0.00 is <0.05, indicating that the variables in the models were statistically significant.

The empirical results show that crude oil prices, which are negatively related in both short and long-term relationships, significantly impact China's economic growth, which depends on world crude oil prices because China is an importing country. For the short-term impact, when the oil price increases by 1%, China's GDP decreases by 0.82% and by 0.72% in the long term, which shows that in the short term, the Chinese economy falls much more than in the long term when oil prices rise by 1%. Unlike China's economy, Vietnam's economic growth and world crude oil prices have a long-term relationship; therefore, crude prices increased by 1%, causing Vietnam's GDP to decrease by 0.94%. However, in the short term, oil prices increase, insignificantly impacting economic growth. Korea's economy and world crude oil prices also have long-term relationships without short-term relationships. When the oil price increases by 1%, the GDP growth decreases by 0.9%, which shows that the price of crude oil insignificantly affects Korea's economic growth in the short term. A comparison of the crude oil price impact with countries' economic growth shows that Vietnam's economy is most affected by 0.94%, Korea's economy is 0.9%, and China's economy is 0.82% in the short term and 0.72% in the long term when the oil price increases by 1%.

The above figures show that the parameters of the model are not different during the forecast period compared with those during the sampling period; thus, it is statistically significant. Furthermore, the CUSUM diagram shows that all data series are under steady conditions in the ARDL model; therefore, they are considered stable in long-run relationships with the CUSUM test. Additionally, the CUSUM line was within the critical bounds at the 5% significance level; hence, the model was stable and reliable.

6. CONCLUSION

The empirical results have explored the significant impact of world crude oil prices on countries' economic growth in short- and long-term relationships; therefore, governments should focus on their energy policies. However, several countries' economies are insignificantly impacted by oil prices in Singapore, Thailand, Indonesia, Malaysia, and America, and the corresponding countries' influence levels are −24.7%, −20.3%, 11.1%, −23.4%, −18.3% and −12.8%, respectively. Although this has an insignificant impact on a country's GDP, governments should implement appropriate energy policies to promote their economic development. In addition, countries' GDP is slightly affected by world crude oil prices, because their economies are less dependent on world oil prices.

Additionally, the economies of countries such as Vietnam, China, and South Korea are negatively and significantly impacted by global oil prices in the long run, implying that if oil prices continuously increase for a long time, they negatively impact these two economies. However, in the short term, they had an insignificant impact. Therefore, the governments of these two countries should implement appropriate energy policies for economic development.

Vietnam is also a crude oil and petroleum importing country; therefore, its GDP is affected by the oil price of imports and exports. However, Vietnam has the advantage of being a crude oil exporter, although the export value of oil is lower than its import value, the Vietnamese government has to adopt an energy strategy. This suggests that if the crude oil prices fall, the government should increase oil imports. If the crude oil price increases, the government can increase exports and reduce oil imports; and the government can also spend the percentage from the oil value export to stabilize the domestic oil price in case of the high oil price increase.

They found that crude oil price fluctuations have a significant impact on a country's economic growth, which is important for this study because it provides a forecasting model for the country's economic growth. In addition, the government should seriously consider this impact to ensure that the energy policy enactment is consistent with the global oil price fluctuations.

The results indicate that crude oil price is also positively related to economic growth, as Indonesia's economic growth in such a situation is that of the country's GDP, which mainly has income from crude oil exports, because when the crude price increases, GDP increases, and vice versa; when the price of crude oil falls, it causes their GDP to decrease.

As mentioned above, crude oil price fluctuations affect countries' GDP growth through the input costs of the economy because it is cost-push inflation when a high actual cost price leads to a higher consumer price. Finally, crude oil prices influence the economies of all the countries. This shows that the empirical results are consistent with those of the previous studies.

7. DATA AVAILABILITY STATEMENT

Data used for the study are available here.

The crude oil price variable can be found at the Federal Reserve Economic Data.

Retrieved from https://fred.stlouisfed.org/series/POILBREUSDM.

The GDP growth variable can be found at *The World Bank Group*. Retrieved from https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG.

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