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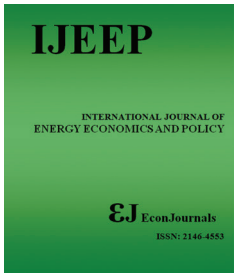

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Effects of Crude Oil Prices Volatility, the Internet and Inflation on Economic Growth in ASEAN-5 Countries: A Panel Autoregressive Distributed Lag Approach

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ABSTRACT

This paper aims to examine the effect of crude oil price volatility, the internet, and inflation on economic growth in ASEAN-5 countries (Indonesia, Malaysia, the Philippines, Singapore, and Thailand). To test this effect, we use the panel Autoregressive Distributed Lag model and panel data with annual time series for the period from 1995 to 2018. The test results show that only the internet affects economic growth in the long run, and this effect is positive. Meanwhile, in the short run, there is an impact of crude oil price volatility, the internet, and inflation on economic growth in all ASEAN-5 countries. However, the effect of inflation on economic growth only exists in Indonesia, the Philippines, Singapore, and Thailand.

Keywords: Crude Oil Price Volatility, The Internet, Inflation, Economic Growth, Autoregressive Distributed Lag Model, Pooled Mean Group
JEL Classifications: C330, E310, E230, O330

1. INTRODUCTION

In the current decade, factors that can influence economic growth have been of great interest to many researchers (Mohseni and Jouzaryan, 2016). Among these factors are oil prices (Rostin et al., 2019; Akinsola and Odhiambo, 2020), oil price volatility (Eyden et al., 2019; Maheu et al., 2020), energy consumption (Ozcan and Ozturk, 2019; Wei et al., 2020), money supply and internet (Saidi et al., 2020). Other factors include information and communication technology (ICT) (Bahrini and Qaffas, 2019; Nguyen et al., 2020), consumption expenditure (Rumbia et al., 2020), inflation (Karahan and Çolak, 2020) and public debt (Bexheti et al., 2020; Ndoricimpa, 2020). Based on the research sites, studies investigating these factors can be grouped into two research groups: the group of studies conducted in a particular country and the group of studies carried out in a group of countries in the form of panels. The present study is included in the latter, conducted in a group of Southeast Asian countries consisting of Indonesia, Malaysia, the Philippines, Singapore, and Thailand. We hereafter name this group the ASEAN-5 countries. In this study, the explanatory variables, which are the foci of our attention, are oil price volatility, the internet, and inflation.

The crude oil price volatility is a measure of risk in crude oil investment and trade (Misra, 2018; Millia et al., 2020). High crude oil price volatility can be caused by fundamental market conditions (so, supply and demand imbalance) and speculative surprises by investors in the financial sector where crude oil is an underlying asset in derivatives trading. Demand crude oil shock or supply crude oil shock can cause crude oil prices to rise or fall. The sharp rise in the price of crude oil, which occurred in 2007-2008, was due to the high demand for crude oil in Asian countries (Bhattacharyya, 2019). Such high demand is because crude oil plays a vital role in the global economy for production,

transportation, and power (Muthalib et al., 2018). Meanwhile, the fall in crude oil prices in 2008 was a consequence of declining world oil demand due to the economic crisis that occurred at that time (Bhattacharyya, 2019). The researchers found that the leading cause of the high crude oil price volatility was the increase in oil demand (Kilian, 2009) and speculative demand activity in the derivatives market (Beidas-Strom and Pescatori, 2014). Such high volatility of oil prices can cause uncertainty in the economy, which leads to investment delays and economic growth reduction (Elder and Serletis, 2010; Chiweza and Aye, 2018).

The internet is a technological tool in the form of computer networks that are interconnected throughout the world that function to send and receive information via applications (Comer, 2019), for example, Facebook and email. In the business world, it has a vital role because it allows the company to promote and sell its products via a website or other applications. For consumers, it allows them to make transactions online with sellers or companies. Thus, the internet can provide convenience in doing business and reduce the company's operational costs (Meltzer, 2014; Zengin and Arici, 2017). This situation can increase corporate revenue and ultimately drive economic growth (Saidi et al., 2020). In the Solow growth model and the endogenous growth model, the internet is one factor that can drive economic growth. In the Solow growth model, it is an external factor in the form of people's ability to use the internet in business, whereas, in the endogenous growth model, it is an internal factor that drives production output in the economy together with other factors of production such as capital (Mankiw, 2007).

Inflation is an increase in the prices of goods in general that can cause people's purchasing power to decline. Inflation can cause economic instability so that a country's government will conduct monetary policy to stabilize prices and inflation. Low inflation is fundamental to stabilizing the economy in a sustainable manner (Aydin et al., 2016). Therefore, if inflation is above inflation expectations, which has been determined by the central bank, then the central bank will raise interest rates to reduce inflation. This increase in interest rates will then reduce investment and economic growth (Saidi et al., 2019). The negative effect of inflation on economic growth is in controversy with the Keynesian view that states that inflation can positively affect economic growth (Karahan and Çolak, 2020). Fischer (1993), and López-Villavicencio and Mignon (2011) state that the positive or negative effect of inflation on economic growth will depend on a certain level of inflation called the inflation threshold. If inflation is above the inflation threshold, the effect of inflation on economic growth is negative. Conversely, if inflation falls below the inflation threshold, then the effect is positive.

Researchers have conducted empirical studies regarding the effect of the volatility of oil prices, the internet, and inflation on economic growth. Studies on the impact of oil price volatility on economic growth, for example, were carried out, among others, by Salim and Rafiq (2011) in the Asian group, Okoro (2014) in Nigeria, Tehranchian and Seyyedkolaee (2017) in Iran, Al-sasi et al. (2017) in Saudi Arabia, Eagle (2017) in the group of African countries, and Gazdar et al. (2018) in the Gulf Cooperation Council state group. To the best of our knowledge, no research has investigated the effect of volatilities on the ASEAN-5 group. Furthermore, studies on the influence of the internet on economic growth have been carried out by, among others, Saidi et al. (2020). However, similar studies are still rarely conducted (Choi and Yi, 2009; Elgin, 2013). Many studies on the effect of inflation on economic growth have also been carried out, including Mohseni and Jouzaryan (2016). Nevertheless, none of the previous studies have seen the influence of these three variables on economic growth in ASEAN-5 countries.

ASEAN is the name of an economic cooperation organization in Southeast Asia. Indonesia, Malaysia, the Philippines, Singapore, and Thailand were the countries that initiated this organization's establishment on August 8, 1967, and were the members of the organization. During the period 2010-2018, the average economic growth of each member country is fluctuating. However, on average, the ASEAN region's economic growth is relatively stable at around 5.1% (ASEAN Secretariat, 2019). The question now arises as to whether economic growth is influenced by the volatility of crude oil prices, the internet, and inflation, especially in ASEAN-5 countries. This study wants to address this question and fill the research gap by examining the effect of crude oil price volatility, the internet, and inflation on economic growth in ASEAN-5 countries. To test this effect, we use the panel autoregressive distributed lag (PARDL) model.

2. LITERATURE REVIEW

There are some empirical studies about the effect of oil price volatility, the internet, or inflation on economic growth in the literature. Studies on the effect of oil price volatility on economic growth are carried out not only in certain countries but also in group countries in panel form. For example, Nonejad (2019) examines the effect of crude oil price volatility on economic growth in the United States using the autoregressive distributed lag (ARDL) model. Test results using quarterly time-series data indicate that there is an influence of crude oil price volatility on economic growth. Based on these results, he concluded that the crude oil price volatility could predict economic growth. Meanwhile, located in the same country, Charles et al. (2017) also examine the effect of the volatility of oil prices on economic growth. Using a structural vector autoregressive and GARCH-in-mean model of monthly time series data spanning from October 1973 to October 2017, they found that oil price uncertainty negatively affected economic growth. Rafiq et al. (2009) examined the effect of oil price volatility on Thailand's economic activity, where one proxy for economic activity is GDP growth. The analysis of the vector autoregressive model (VAR) of quarterly data from 1993 Q1 to 2006Q4 shows that oil price volatility negatively affects GDP growth. Using panel datasets, Maghyereh et al. (2017) tested the uncertainty (volatility) of oil prices on real economic activity in Turkey and Jordan. They used the production index as a proxy for actual economic activity. The analysis results using the VAR model of panel data with monthly time series for the period from January 1986 to December 2014 showed that oil price volatility negatively affects economic activity. Gazdar et al. (2018) investigated the effect of oil price volatility and the development of Islamic finance

in the Gulf Cooperation Council countries (Saudi Arabia, Bahrain, Kuwait, United Arab Emirates, and Qatar). To test the effect, they used the panel data model and panel data with an annual time series from 1996 to 2016. The test results concluded that there was a positive impact of oil price volatility and Islamic finance development on economic growth. They argued that the positive effect of oil prices on economic growth is due to the intense drive to develop Islamic finance on economic growth.

Several studies report that the internet affects economic growth positively. For example, Scott (2012) examines the effect of the internet on economic growth in a group of countries: Sub-Saharan Africa, Latin America and the Caribbean (with a total of 87 countries) using panel data with time series for the period 2001-2011. Using the panel model data, he finds that the internet positively affects economic growth. Salahuddin and Gow (2016) examine the effect of the internet, financial development, and trade openness on economic growth in South Africa using annual time series data for the period from 1991 to 2013. The test results using the ARDL model demonstrate that the internet and financial development positively affect economic growth, while economic openness does not show effect.

The adverse effects of inflation on economic growth were reported by, among others, Rousseau and Yilmazkuday (2009), Mohseni and Jouzaryan (2016), and Fratzscher et al. (2020). Rousseau and Yilmazkuday (2009), for example, examined the effect of inflation and financial development in 84 countries worldwide, including countries with high incomes and countries with low income. These countries were grouped based on income criteria issued by the World Bank. Test results using the trilateral analysis shows that the combination of higher financial development (money supply M3 as a proxy) and lower inflation drives economic growth. Conversely, lower financial development, and higher inflation reduce economic growth. Mohseni and Jouzaryan (2016) examined the effect of inflation and unemployment on Iran's economic growth using annual time series data from 1996 to 2012. To analyze the data, they used the ARDL model. The analysis showed that inflation and unemployment negatively affect economic growth. Fratzscher et al. (2020) examined the effect of inflation on economic growth in 76 countries (mostly developed and emerging market countries) that implement inflation targeting policies. To test the effect, they employed the panel ARDL model and quarterly data from 1985Q1 to 1990Q1. Based on the test results, they concluded that inflation negatively affects economic growth.

Choi and Yi (2009) examine the influence of the internet, inflation, investment, and government spending on economic growth in 207 countries using panel data with annual time series from 1991 to 2000. Test results with panel data models show that the internet, investment, and government spending positively affect economic growth, while inflation negatively affects economic growth. Sepehrdoust (2018) investigates the effects of information and communication technology (internet users and telephone users as proxies), financial development (cash debts as a proxy), government spending, capital, active labor, inflation rates, and the degree of openness of trade-in OPEC countries. He uses panel data with annual time series for the period 2002-2015. The panel data model's test results show that for every 1% increase in financial and technology development and information communication, capital (foreign direct investment) increases economic growth to 0.48%, 0.50%, and o.46%. Government spending also has a positive influence on economic growth. Meanwhile, inflation and the degree of openness to trade negatively affect economic growth. Every 1% of inflation and the degree of trade openness rise, economic growth decreases to 0.0015% and 0.15%.

3. DATA AND METHODOLOGY

3.1. Data

In this study, we use panel data of five ASEAN-5 countries (Indonesia, Malaysia, Philippines, Singapore, and Thailand) with annual time series from 1995 to 2018. The time-series data consist of crude oil prices (OIL), internet (IUS), inflation (INF), and economic growth (GDC). OIL, IUS, and INF are natural logarithms. West Texas Intermediate (WTI) is used as a proxy for crude oil price (in USD per barrel), internet user as a proxy for the internet (in % per 100 population), consumer price index as a proxy for inflation and gross domestic per capita in 2010 in constant prices (in USD) as a proxy for economic growth. We obtained the time series data on WTI crude oil prices from the EIA website and the internet, inflation, and economic growth from the World Bank website.

3.2. Methodology

To examine the long-run effect of crude oil price volatility (VOT), the internet (IUS), and inflation (INF) on economic growth (GDC) in ASEAN-5 countries, we specify a long-run model with the panel multiple regression equation as follows.

$$GDC_{it} = C_i + \alpha_i VOT_{it} + \beta_i IUS_{it} + \gamma_i INF_{it} + \varepsilon_{it} \quad (1)$$

where t = 1995,1996,…,2018, and C_i, α_i, β_i, and γ_i are the same for all cross-sections i = Indonesia, Malaysia, Philippines, Singapore, and Thailand. The coefficients $\alpha = \alpha_i$, $\beta = \beta_i$, and $\gamma = \gamma_i$ are the long-term multipliers of the volatility of crude oil prices, the internet, and inflation on economic growth. Furthermore, ε_{it} is an error or residual. Model (1) is a form of the long-term relationship between the crude oil price volatility, the internet, inflation, and economic growth if the four variables are co-integrated. In equation (1), the time series of crude oil price volatility is generated from the price of crude oil using the GARCH(1,1) model as follows.

$$OIL_t = w + \phi OIL_{(t-1)} + v_t \quad (2)$$

$$h_t \left| \Omega_{t-1} \sim iidN(0, h_t) \right.$$

$$h_t = a + bv_{t-1}^2 + ch_{t-1} \quad (3)$$

where h_t is the variance of error v_t, and Ω_{t-1} is the set of information at time t-1. The parameters: w, ϕ, a, b, and c in equations (2) and (3) are estimated by the maximum likelihood method.

The PARDL model specification with time lag p, q, r, and s are written as PARDL (p, q, r, s) relating to the model (1) (Pesaran et al., 1999; Asteriou and Hall, 2011; Pesaran, 2015) are as follows.

$$GDC_{it} = C_i + \sum_{j=1}^{p}\delta_{ij}GDC_{i(t-j)} + \sum_{k=0}^{q}\alpha_{ik}VOT_{i(t-k)} + \sum_{l=0}^{r}\beta_{il}IUS_{i(t-l)} + \sum_{m=0}^{s}\gamma_{im}INF_{i(t-m)} + \varepsilon_{it} \quad (4)$$

where C_i, δ_{ij} (j = 1,2,…,p), α_{ik} (k = 0,1,…,q), β_{il} (l = 0,1,…,r), and γ_{im} (m = 0,1,…,s) are the parameters of the regression equation where C= C_i is a fixed effect. Error ε_{it} is identical and independent of crossection i and time t, and has a mean of 0 and variance σ_i^2. The equation parameters (4) are estimated with the pooled mean group (PMG) method.

To examine the short-term effect of the crude oil price volatility, the internet, and inflation on economic growth, we use the panel error correction (ECM-PARDL) model, a modified form of equation (4). The ECM-PARDL(p-1, q-1, r-1, s-1) model is as follows.

$$D(GDC)_{it} = C_i + \theta_i GDC_{i(t-1)} + \vartheta_i VOT_{it} + \varphi_i IUS_{it} + \psi_i INF_{it} + \sum_{j=1}^{p-1}\delta_{ij}^{*}D(GDC)_{i(t-j)} + \sum_{k=0}^{q-1}\alpha_{ik}^{*}D(VOT)_{i(t-k)} + \sum_{l=0}^{r-1}\beta_{il}^{*}D(IUS)_{i(t-l)} + \sum_{m=0}^{s-1}\gamma_{im}^{*}D(INF)_{i(t-m)} + \varepsilon_{it} \quad (5)$$

where $\theta_i, \vartheta_i, \varphi_i, \psi_i, \delta_{ij}^{*}, \alpha_{ik}^{*}, \beta_{il}^{*}$ and γ_{im}^{*} and are the parameters of the ECM-PARDL model in (5) for each cross-section. These parameters can be different in each cross-section i.

To test the effect of the short and long term, we take three steps: testing for stationary (panel root test) of all the variables involved in the model in equation (1) or (4), testing for cointegration, and estimating model parameters. In the first step, we used two panel unit-root tests, namely the Levin, Lin and Chu test abbreviated as LLC (Levin et al., 2002) and the Im, Pesaran, and Shin test abbreviated as IPS (Im et al., 2003). The null hypothesis of the two panel unit root tests is H_0: time-series has a root unit (time-series is not stationary). The criterion of both unit root test is the null hypothesis rejected if the P-value of the test statistic is less than the significance level of 1%, 5% or 10%.

In the second step, we conducted a cointegration test. We used the Pedroni cointegration test (Pedroni, 2004). The null hypothesis of this test is H_0: The volatility of crude oil prices, the internet, inflation, and economic growth are not co-integrated. The test criterion is that the null hypothesis H_0 rejected if the P-value of the test statistic is less than the significance level of 1%, 5%, or 10%.

In the third step, we estimated the parameters for the model (1) and model (5). Before we proceeded, we first determined the lag length p, q, r, and s of the PARDL model using the Akaike Information Criteria (AIC). All the parameters are estimated using the PMG method. The significance criteria of the parameter are determined based on the t-test or F-test. The parameters are significant if the P-value of the test statistic is less than the significance level of 1%, 5%, or 10%.

4. RESULTS AND DISCUSSION

4.1. Results

First of all, we tested the stationarity or unit root of all variables involved in the PARDL model. We provide the results of the panel unit root test using the LLC and IPS tests in Table 1. We conclude that the variables of crude oil price volatility and the internet are stationary at level or process I(0) and at first difference or process I(1). Meanwhile, inflation and economic growth variables are stationary at first difference or process I(1).

Since inflation and economic growth variables are stationary at first difference, we tested the cointegration among crude oil prices, the internet, inflation, and economic growth in the second step using the Pedroni test. Table 2 summarizes the panel cointegration test results. Based on these results, we conclude that there is cointegration among the volatility of oil price, internet, inflation, and economic growth.

In the third step, we estimated the long-term coefficients of the variables of crude oil price volatility, the internet, and inflation in equation (1). Also, we estimated the short-term coefficients in the ECM-PARDL model in equation (5). In this step, we started by determining the lag length using the AIC. We obtained the lag length p = 1 and q = r = s = 2. Next, we estimated the parameters of the PARDL(1,2,2,2) model. Table 3 presents the results of estimating these coefficients and intercepts.

It appears from panel A of Table 3 that the internet variable's coefficient is significant at a 1% significance level, whereas

Table 1: Panel unit root test

Variable	LLC test statistics		IPS test statistics	
	Constant	Constant and linear trend	Constant	Constant and linear trend
VOT	3.6774*	4.4894*	1.8245**	2.1420**
D(VOT)	7.4988*	6.1054*	6.7066*	5.0866*
IUS	7.7382*	9.8367*	7.9826*	9.1478*
D(IUS)	5.8269*	2.2959**	5.6146*	-2.9768*
INF	3.0477	0.6776	0.2579	0.2355
D(INF)	3.3613*	3.6517*	2.6471*	-2.7260*
GDC	3.4400	3.9421	5.6533	2.3259
D(GDC)	-6.2465*	7.5185*	5.4742*	6.8298*

*,**Means significant at the 1%, 5% significance level

Table 2: The pedroni panel cointegration test results

Name of statistical test	Statistic	P-value
Within-dimension		
Panel v-Statistic	9.1481	0.0000
Panel rho-Statistic	−0.1981	0.4215
Panel PP-Statistic	−2.5469	0.0054
Panel ADF-Statistic	−1.4445	0.0743
Between-dimension		
Group rho-Statistic	0.6704	0.7487
Group PP-Statistic	−1.9913	0.0232
Group ADF-Statistic	−0.2805	0.3896

Table 3: PARDL(1,2,2,2) model parameter estimation results

Independent variable and intercepts	ASEAN-5	Indonesia	Malaysia	Philipine	Singapore	Thailand
Long-term equation. dependent variable: GDC						
VOT	−0.0619					
IUS	0.1893*					
INF	0.1134					
Short-term equation. dependent variable: D(GDC)						
EC	−0.1744*	−0.2203*	−0.0958*	−0.0753*	−0.1597*	−0.3210*
D(VOT)	−0.0455**	0.0332*	−0.1050*	−0.0317*	−0.0585*	−0.0655*
D(VOT(−1))	−0.0719**	−0.0023*	−0.2007*	−0.0262*	−0.1023*	−0.0280*
D(LIUS)	−0.0227***	0.0059*	−0.0622*	−0.0100*	−0.0038	−0.0435*
D(LIUS(−1))	−0.0442	−0.0048*	−0.0203*	−0.0089*	−0.2067*	0.0201*
D(LINF)	−0.0511	−0.1461*	−0.1148	−0.2826**	0.2530***	0.0351
D(LINF(−1))	−0.2791***	0.1114*	−0.3229	−0.1365**	−0.8758*	−0.1715**
C	1.3850*	1.6017*	0.8006**	0.5541*	1.5570*	2.4114*

*.**.***Means significant at 1%, 5%, 10% significance level

crude oil price volatility and inflation variables' coefficient are not significant. It means that in the long run, there is an influence of the internet on economic growth in the ASEAN-5 region and ASEAN-5 member countries: Indonesia, Malaysia, the Philippines, Singapore, and Thailand. On the other hand, there is no influence of crude oil price volatility and inflation on economic growth in the long run. The influence of the internet is positive. So, the use of the internet encourages economic growth. Every 1% rise in the internet, economic growth rises by 0.893%.

Furthermore, it can be seen from panel B of Table 3 that the coefficients of the variables of the crude oil price volatility and the internet are significant in the ASEAN-5 region and each of its member countries. It is also the case for the coefficient of inflation variables but Malaysia. It provides evidence that, in the short run, the influence of crude oil price volatility and the internet on economic growth exists in all ASEAN-5 countries (Indonesia, Malaysia, the Philippines, Singapore, and Thailand). Meanwhile, the effect of inflation on economic growth only occurs in Indonesia, the Philippines, Singapore, and Thailand.

4.2. Discussion

In this study, we find that there is a positive long-run effect of the internet on economic growth. This finding is in line with Solow's growth theory and endogenous growth theory, in which technology is a factor that drives economic growth (Mankiw, 2007). Empirically this study agrees with Sepehrdoust's finding (2018).

In the short run, this study finds that crude oil price volatility and the internet affect each ASEAN-5 country's economic growth. However, inflation affects economic growth in four countries only: Indonesia, the Philippines, Singapore, and Thailand. It does not affect Malaysia's economic growth. The effect of the crude oil price volatility on economic growth agrees with the results of empirical studies of Nonejad (2019), Charles et al. (2017), Rafiq et al. (2009), Maghyereh et al. (2017) and Gazdar et al., (2018). Meanwhile, the significant influence of the internet on economic growth is in agreement with findings of previous research: Scott (2012), Salahuddin and Gow (2016), Choi and Yi (2009), and Sepehrdoust (2018). The findings of this study state that inflation affects economic growth, confirming the findings of Mohseni and Jouzaryan (2016) and Fratzscher et al. (2020).

This study's results can provide policy implications in price stability and the development of internet technology. The governments of each ASEAN-5 country need to carry out a policy of subsidizing crude oil prices and also stabilizing the prices of other goods so that households can still have the ability to buy, especially the power to buy crude oil. The ability to buy crude oil will later increase household spending, making a positive contribution to economic growth. Besides, each ASEAN-5 country needs to continue to develop information technology, so that the impact of internet use in doing business in the economic and financial sectors can increase sustainable economic growth.

5. CONCLUSION

Crude oil is an essential commodity in the world economy. All countries need this commodity to run production machinery, generate power, and operate transportation equipment. The need for crude oil often causes a rise in crude oil prices worldwide. However, the price of crude oil can fall sharply due to falling oil demand as a result of the economic crisis. The rise and fall in crude oil prices can cause high crude oil price volatility, affecting the other macroeconomic variables, such as economic growth.

This study seeks to examine the effect of the volatility of crude oil prices, the internet, and inflation on economic growth in ASEAN-5 countries. To this end, we use the PARDL model with the PMG method. We use panel data with crosssections in five countries: Indonesia, Malaysia, the Philippines, Singapore, and Thailand, and with annual time series data for the period 1995-2018.

The test results show cointegration among crude oil price volatility, the internet, inflation, and economic growth. The four variables' cointegration indicates a long-run relationship running from crude oil price volatility, the internet, inflation to economic growth. This long-run effect can be seen from the estimation results of each coefficient in equation (1), as shown in Table 3. In the long run, while crude oil price volatility and inflation do not affect all ASEAN-5 countries, the effect of the internet on economic growth is significantly positive. Furthermore, in the short run, crude oil price volatility and the internet affect economic growth in every country of the ASEAN-5. This long-run effect can be seen from the estimation results of each coefficient in equation (1), as shown

in Table 3. In the long run, while crude oil price volatility and inflation do not affect all ASEAN-5 countries, the effect of the internet on economic growth is significantly positive. Furthermore, in the short run, crude oil price volatility and the internet affect economic growth in every country of the ASEAN-5. Similarly to inflation, it significantly affects Indonesia, the Philippines, Singapore, and Thailand, except Malaysia.

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