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International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2021, 11(5), 425-433.

Attention of Economic Growth and Oil Prices: Evidence from Indonesia

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Received: 25 April 2021 **Accepted:** 07 July 2021 **DOI:** https://doi.org/10.32479/ijeep.11538

ABSTRACT

Oil is a commodity that can cause turmoil for the global economy. This study attempts to examine the relationship between oil prices and economic growth together with the exchange rate and inflation rate in Indonesia. The time span covered by this series is from 2000 (Q1) to 2019 (Q4), providing 80 observations. Tests carried out in this study included unit root testing through augmented Dickey-Fuller (ADF) testing, Phillips-Perron (PP) testing, Kwiatkowski-Phillips-Schmidt-Shin (KPSS) testing, Johansen and Juselius cointegration test, Granger-based causality test. Vector error correction model (VECM) to determine long-term and short-term relationships, and variance decomposition and Impulse Response Function to investigate relationships outside the sample. The empirical findings show that there is a relationship between variables, oil prices not only affect economic growth but also have an impact on the exchange rate and inflation rate. Furthermore, the results of the short-run Granger causality for the tested variables indicate a unidirectional causality that runs from all independent variables, namely oil prices, exchange rates, and the rate of inflation on GDP. In addition, there is a causal relationship between GDP and other determinants outside the sample. The addition of time-frames and variables can add to the variance of the sustainability of these findings in the future.

Keywords: Oil Price Shocks, Economic Growth, Panel Data, Regression Method, Indonesia
JEL Classifications: D24, A1, C23

1. INTRODUCTION

Every country consumes oil more or less. Oil is the one most economically important develop commodity markets in the global market. Oil and coal are global commodities that are transport all over the world. Prices of these energy resources are determine by global demand and supply. It was introduced by Berument et al. (2010) that world oil prices affect each country's economic performance and able to control the potential confounding of other factors such as inflation, exchange rate.

According to Karatayev and Hall (2020), Indonesia is a major producer and exporter of oil and natural gas, and its economic growth largely depends on energy export. According to MarketLine Industry Profile (2014), Indonesian oil and gas market is expected to generate total revenues of $157.6 billion in 2014. Most of Indonesia resources are located in Western Siberia and Urals-Volga regions; and most of oil production is initiated there. Most of Indonesian production remains to be dominated by domestic firms, however, the potential of oil reserves are attracting international firms as well. Moreover, European countries as Germany, Netherlands and Poland are the major targets of Indonesian crude oil exports. The rest of Indonesia's crude oil exports go to Asia, especially China. However, North and South American exports of Indonesian crude oil were replaced by increased in US, Canadian, Brazil and Colombian oil production. Most of Indonesian oil is exported via the Transneft pipeline system, but the rest is transported via rail in vessels.

Oil price has been acknowledged as the globally important for the world economy and consumption of oil has been rapidly growing from 1990$_s$. However, oil price shocks and their effects on economy have changed over time. It has both positive and negative effects. Each and every country concerns about oil price, whether it is oil-importing or oil-exporting country.

In the 19th century, the value of oil primarily derived from its usefulness for fabricating illuminants. As the twentieth century, the price and consumption of oil has risen up by gaining importance of petroleum for commerce, industry and especially, transportation. Although oil price has risen up as parallel of economic growth, in some situations it has increased or decreased extremely because of its vital role on global economy. This sharp increase is called Oil shocks that have been seen as one of the main dampeners of economic growth since the Second World War. The best examples of oil shocks are, such as the OPEC oil embargo of 1973-1974, the Iranian revolution of 1978-1979, the Iran-Iraq War, the first Persian Gulf War in 1990-91, and the oil price spike of 2007-2008.

1.1. 1947-1948

Postwar dislocations. The end of World War II marked a sharp acceleration in the transition to the automotive era. The price of crude oil increased 80% over these 2 years, but this proved insufficient to prevent spot accounts of shortages.

1.2. 1948-1973

American-monopoly of oil price. During this period, there was no global market for crude oil. World oil price was at the price of 2.5-3.5 dollars per barrel. It was the time of "cheap oil" (Braginsky, 2008). In fact, the United States was self-sufficient in crude oil. The United States has been the world's biggest producer of petroleum when it was surpassed by the Soviet Union, OPEC and some political events. After this period, all countries tried to participate in global oil market. Especially since the oil crisis of the 1970s, economists have sought to identify their effects on the economy (Kilian, 2014).

1.3. 1973-1974

OPEC Embargo. Syria and Egypt led an attack on Israel that began in October 1973. After that, the Arab members of the Organization of Petroleum Exporting Countries (OPEC) imposed an embargo against the United States in retaliation for the U.S. decision to re-supply the Israeli military and to gain leverage in the post-war peace negotiations. Arab OPEC members also extended the embargo to other countries that supported Israel including the Netherlands, Portugal, and South Africa. The onset of the embargo contributed to an upward spiral in oil prices with global implications. The price of oil per barrel first doubled, then quadrupled, (the price of oil had risen from $3 per barrel to nearly $12) imposing skyrocketing costs on consumers and structural challenges to the stability of whole national economies (Suparjo et al., 2021). The oil crisis, or "shock", had many short-term and long-term effects on global politics and the global economy. It was called the "first oil shock. By doing some talking and deal, the embargo is lifted in March 1974.

1.4. 1978-1979

Iranian revolution (second oil shock). The 1973 Arab-Israeli War turned out to be only the beginning of a turbulent decade in the Middle East. Iran in defiance of the Arab states had increased its oil production during the 1973-74 embargoes, but was experiencing large public protests in 1978. Strikes spread to the oil sector by the end of 1978. In January the Shah fled the country, and Sheikh Khomeini seized power in February. The price of oil rocketed over the next 12 months from US$15.85 to $39.50 and the rush to secure supplies caused acute shortages across the world (Baxter, 2009).

1.5. 1980-1981

Iran-Iraq War. Iranian production had returned to about half of its pre-revolutionary levels later in 1979, but was knocked out again when Iraq launched a war against the neighbor country in September of 1980. The combined loss of production from the two countries again amounted to about 6% of world production at the time, though within a few months, this shortfall had been made up elsewhere. Whether one perceives the Iranian Revolution and Iran-Iraq War as two separate shocks or a single prolonged episode can depend on the oil price measure.

1.6. 1990-1991

First Persian Gulf War. By 1990, Iraqi production had returned to its levels of the late 1970s, only to collapse again when the country invaded Kuwait in August 1990. The two countries accounted for nearly 9% of world production, and there were concerns at the time that the conflict might spill over into Saudi Arabia. The price of crude oil doubled within the space of a few months. The price spike proved to be of short duration, however, as the Saudis used the substantial excess capacity that they had been maintaining throughout the decade to restore world production by November to the levels seen prior to the conflict. The ninth postwar U.S. recession is dated as beginning in July of 1990.

1.7. 1997-1998

East Asian Crisis. Starting from 1997, Thailand, South Korea, Malaysia, Indonesia and Singapore had experienced stress of financial system and the currency down. Due to this reason a lot of investors had doubts about those Asian countries, hence, put their strains on other countries. Consequently, oil price decreased below 12 dollar per barrel by 1998. It was the lowest price since 1972 (Hamilton, 2011).

1.8. 2001

American terror of 9/11. The terrorist attack of 11th September was terrible. It was the loss for thousands of families as well as economic loss. It was hard to differentiate which loss was the most, since economy was in recession before the attack. According to BBC News (2008), US economy went into decline, whereas Indonesian oil production increased, oil price decreased. OPEC tried to minimize reduction by cutting the production. However, oil price fall down by 35% by that time.

1.9. 2003

Iraq war. The US invasion on Iraq led to the loss of oil production in the Gulf state. The oil production dropped in 3 times, from six million to two million. It was not enough spare capacity to cover for any sudden drop in production and it led to an increase in prices (BBC News, 2008). However, according to Hamilton (2011), the disruptions had little apparent effect on global oil

supplies, since he affected supply was a much smaller share of the global market.

1.10. 2008

Spike in oil price. What was mentioned above about oil price shocks are easy to understand the reason, but the case of 2008, is very different and vague from others because still it has an uncertain and arguable reason why oil price rose. World oil prices rose from $50 per barrel in nearly 2007 to $140 per barrel in the summer of 2008, before falling to $40 per barrel by the end of that year (James, 2009). There are many speculations about this spike, but mainly they are commodity price speculation, strong world demand, time delays or geological limitations on increasing production, OPEC monopoly pricing, and an increasingly important contribution of the scarcity rent (Hamilton, 2008).

1.11. 2014

Oil price drop. According to Pedersen (2014), oil price started falling due to five reasons. Firstly, US increased their oil production and stopped oil import from Nigeria, while OPEC's imports decreased. Secondly, Libya has improved their oil production up to 810,000 barrels per day. Thirdly, the OPEC members, the Saudis and Kuwaitis, repeatedly lower their prices rather than production in order to maintain their market share in Asia. Fourthly, European economy had negative outlook and the exports in Germany went down. And last but not least, Asian countries lower the price for energy subsidies, which caused oil price to rise.

2. LITERATURE REVIEW

The impact of oil price variance on economy has been acquired in quite a number of studies. Several researches obtained different results by using different approaches with various variables such as exchange rate, inflation rate, export or import and others. Indonesia is interrelated with other countries. As it was found by Hayo and Kutan (2005) that financial markets of US Granger cause Indonesian bonds. Also, it was observed that positive (negative) news raises (lower) market returns. Therefore, the content of news plays an important role. As was observed by Kilian and Hicks (2013) the dynamic response of the price of oil to the news shocks. Besides that, it is not statistically significant that daily US macroeconomic news have impact to the price of oil.

In the research of Suni (2007) it was remarked that lower export revenues and weaker domestic demand lead to lower consumer price inflation. As a result, the rouble would be less appreciated. Subsequently, both lower inflation and GDP growth lead to lower interest rates. In oil-consuming countries lower oil price has a positive effect on real GDP growth. However, in Indonesia, real GDP is lower if oil price is not rising. Nominal export revenue would be smaller with lower oil prices, however, a lower domestic demand would be translated into lower real imports. Consequently, lower oil price would make rouble to depreciate. According to the results of the study, the sudden and permanent positive oil price shock will raise Indonesia's domestic demand and GDP.

Apart from that, Ito (2012) observed, using Vector Error Correction (VEC) model, that there are linear combinations between real GDP and inflation rate, real GDP and oil price, real effective exchange rate and inflation rate. He estimated that extent oil price increases effect on inflation rate, real effective exchange rate and real GDP in Indonesia. In the short run rising oil prices not only stimulate inflation and economic growth negatively and positively, respectively, but also induce real effective exchange rate appreciation.

According to Semko (2013), negative monetary shocks lead to rise in domestic inflation. On the other hand, the study stated that positive oil price shock leads production in oil sector to rise, while it decreases in manufacturing sector. As a result, the shock leads to currency appreciation and a small reduction in reserves. Additionally, rise in employment, capital stock, investments and price of capital in oil production sector and values of converge in long run, there is small cumulative effect on GDP.

Reynolds and Kolodziej (2008) investigated a study on GDP and energy production in former Soviet Union. They found out that when oil price went down, foreign currency reserves loss affected Soviet economy, since Soviet general government budget was supplemented by oil export revenues. Granger causality tests showed causality from oil to GDP, but not the opposite way; GDP does not Granger cause oil production. Soviet oil production decline did not precede Soviet Union fall. But it did precede GDP fall. Oil production could decline due to recourses scarcity, which caused GDP collapse. Therefore, oil and GDP had a cause-and-effect relationship.

Furthermore, Kilian and Hicks (2013) observed that the dynamic response of the price of oil to the news shocks. It was maintained the overall importance of news about real economic activity for the real price of oil. Growth in manufacturing might lead to larger demand for industrial raw materials. Rising global demand for industrial commodities driven by unexpected economic growth explains surge in the real price of oil.

Baghirov (2014) carried out a study about GDP growth and oil price growth rates in Indonesia, Germany, Netherlands, France, Poland, Lithuania and Latvia, with focus on Lithuania. According to his study, oil price does Granger cause the real GDP growth rates in Indonesia and Lithuania. Comparatively to Indonesia, Lithuania is an oil-importing country, so oil price shock has negative direct effect in short term and in long term.

Furthermore, Rafiq et al. (2009) found that changes in oil price have significant influence on growth, investment and employment in Thailand. Oil price changes can give explanations of innovations in GDP growth, investment, and budget deficit. The test idicated that oil price volatility does Granger cause GDP growth, investment, unemployment, and inflation. Oil prices volatility has a significant negative effect on GDP growth and unemployment.

Besides that, Tang et al. (2010) accomplished the study about oil price shocks effects on Chinese economy. It was found that oil price and domestic inflation rate are negatively related. Oil price has influence on Chinese economy in long and short terms. However, it has positive effect on inflation rate and interest

rate. Increased inflation rate in China will reduce profit rate of producers, which determines investment and interest rate.

Berument et al. (2010) carried out a study on Middle East and North Africa countries. They observed that one standard deviation shock in oil prices has contemporaneous, statistically significant, and positive effects on the economic growth of Algeria, Iran, Iraq, Kuwait, Libya, Qatar, and the UAE; and for Syria for the first period. Additionally, it has negative and insignificant effect for Oman; and also it has the contemporaneous impact on income for each country. On the other hand, the oil price shocks cause positive but not statistically significant effects on output of Djibouti, Egypt, Israel, Jordan, Morocco and Tunisia.

3. METHODOLOGY

The variables involved in this study are economic growth (GDP), oil price (OP), exchange rate (ER) and consumer price index (CPI) for Indonesia. Additionally, exogenous dummy variables were introduced in order to capture structural breaks of the period when the shock occurs. The data is quarterly and sample period covers from 2000-Q1 to 2019(Q4). The data used in the study was retrieved from various sources; Main Economic Indicators (OECD) and Federal State Statistics Service for gross domestic product; US. Energy Information Administration (EIA) for Brent crude oil prices; Main Economic Indicators (OECD) for exchange rate; and UNECE Statistical Database, compiled from national and international (CIS, EUROSTAT, IMF, OECD) official sources, for inflation rate. All variables are transformed into natural logarithm for estimation.

The study will analyse the relationship between oil prices, exchange rate, inflation rate and GDP in Indonesia during the period of 2000 (first quarter) until 2019 (fourth quarter).

$$GDP=f(OP, EX, CPI) \quad (1)$$

where:
GDP = Gross Domestic Product;
OP = Oil Price;
EX = Exchange Rate; and
CPI = Consumer Price Index (Inflation).

The production function in linear logarithmic regression form to investigate short run and long run relationship:

$$LGDP_t=\alpha+\beta_1 LOP_t+\beta_2 LEX_t+\beta_3 LCPI_t+\beta_4 d_1+\beta_5 d_2+\beta_6 d_3+\varepsilon_t \quad (2)$$

where:
$LGDP_t$ = natural log of gross domestic product at time t;
LOP_t = natural log of oil price at time t;
LEX_t = natural log of exchange rate at time t;
$LCPI_t$ = natural log of inflation at time t;
d_1 = dummy variable set equal to 1 during the shock 2002Q3 - 2003Q4, and 0 otherwise;
d_2 = dummy variable set equal to 1 during the shock 2006Q3 - 2007Q2, and 0 otherwise;
d_3 = dummy variable set equal to 1 during the shock 2013Q2 - 2024Q1, and 0 otherwise;
β = the coefficient estimates;
α = intercept coefficient (constant); and
ε_t = error term.

d_1: South East Asian financial crisis (2002Q3 - 2003Q4). Starting from 2002, Thailand, South Korea, Malaysia, Indonesia and Singapore had experienced stress of financial system and the currency down. Due to this reason a lot of investors had doubts about those Asian countries, hence, put their strains on other countries. The severe economic collapse after mid-2002 greatly reduced growth in energy consumption (Farzanegan and Markwardt, 2008). Consequently, powerful negative shock also sharply reduced the price of oil, which decreased below 12 dollar per barrel and reached a low of 8 dollar per barrel towards the end of 1998. It was the lowest price since 1972 (Hamilton, 2011).

d_2: The terrorist attact on the US on September 11 (2001Q3 - 2002Q2). In the month following the terrorist attacks of September 11, 2001, oil prices declined due market concerns regarding a possible slowdown in the United States and the global economy. According to BBC News (2008), US economy went into decline, whereas Indonesian oil production increased, oil price decreased. OPEC tried to minimize reduction by cutting the production. However, oil price fall down by 35% by that time. The decision by OPEC to cut crude oil exports contributed to oil price quickly returning to pre-September 11 levels in early 2002 (Farzanegan and Markwardt, 2008).

d_3: Global financial crisis (2008Q2 - 2009Q1). The first inkling that the economy was in trouble was when housing prices started to drop in 2006. It spread quickly, first to the entire U.S. financial sector and then to financial markets overseas. By the end of the year, Germany, Japan, and China were locked in recession, as were many smaller countries. Many in Europe paid the price for having dabbled in American real estate securities. As for oil, world oil prices rose from $50 per barrel in nearly 2007 to $140 per barrel in the summer of 2008, before falling to $40 per barrel by the end of that year (James, 2009). There are many speculations about this spike but mainly it was that commodity price speculation, strong world demand, time delays or geological limitations on increasing production, OPEC monopoly pricing, and an increasingly important contribution of the scarcity rent (Hamilton, 2008).

4. FINDINGS

4.1. Unit Root Tests

The purpose of unit root test is to distinguish the order of integration of the data series. This study applied Augmented Dickey Fuller (ADF) unit root test, Phillips-Perron (PP) unit root test and Kwiatkowski-Philips-Schmidt-Shin (KPSS) unit root test. Table 1 shows the stationarity of all the four tested variables.

Table 2 presents the result of ADF, PP and KPSS tests for Indonesia in the level and the first difference. The null hypothesis for ADF and PP tests states that unit root exists, whereas alternative hypothesis postulates that no unit root exists. For both

Table 1: Variance decomposition

Percentage of variations in	Horizon	Due to Innovation in				
	(Quarters)	ΔLGDP	ΔLOP	ΔLEX	ΔLCPI	ΔCU
Quarters relative variance in: ΔLGDP						
	1	100	0	0	0	0
	4	67.25736	1.581528	25.82234	5.338777	32.742645
	8	55.13674	0.787401	38.50761	5.568248	44.863259
	12	52.63759	0.634011	41.53819	5.190212	47.362413
	20	52.01910	0.402815	42.69888	4.879211	47.980906
	30	51.56102	0.285538	43.39456	4.758879	48.438977
	40	51.35092	0.227631	43.72613	4.695324	48.649085
	50	51.22275	0.193125	43.92640	4.657728	48.777253
Quarters relative variance in: ΔLOP						
	1	29.65084	70.34916	0	0	29.65084
	4	32.21176	62.03724	1.36481	4.386197	37.962767
	8	37.27977	49.94834	7.490744	5.281145	50.051659
	12	38.79661	45.99121	9.625515	5.58666	54.008785
	20	39.81864	44.11813	10.50459	5.558644	55.881874
	30	40.34068	43.07819	10.99709	5.584040	56.92181
	40	40.60109	42.56089	11.24352	5.594501	57.439111
	50	40.75775	42.24831	11.39293	5.601014	57.751694
Quarters relative variance in: ΔLEX						
	1	0.025102	14.64465	85.33025	0	14.669752
	4	0.576395	18.03639	81.27492	0.112296	18.725081
	8	0.443298	18.95359	80.25127	0.351845	19.748733
	12	0.332008	19.31192	80.11834	0.237733	19.881661
	20	0.235502	19.55243	80.05478	0.157288	19.94522
	30	0.189567	19.68417	80.00905	0.117215	19.990952
	40	0.165798	19.74711	79.99047	0.096626	20.009534
	50	0.151468	19.78549	79.97885	0.084202	20.02116
Quarters relative variance in: ΔLCPI						
	1	3.598437	1.31463	47.85542	47.23151	52.76849
	4	7.052668	8.366235	56.49564	28.08546	71.91454
	8	6.465016	9.576125	59.43081	24.52805	75.47195
	12	6.664693	11.03222	58.47692	23.82617	76.17383
	20	6.64852	11.67549	58.40929	23.26670	76.7333
	30	6.635983	12.30397	58.32357	22.73649	77.26352
	40	6.624346	12.90473	58.24117	22.22975	77.77025
	50	3.598437	1.314630	47.85542	47.23151	52.76849

The last column provides the percentage of forecast error variances of each variable explained collectively by the other variables. The column in bold represent the impact of their own shock

tests, the null hypothesis is rejected if the t-statistics exceeds the critical value.

Referring to the Table 2, in the level form, all the variables are nonstationary in both intercept and trend and intercept, except consumer price index for ADF test. However, all the variables are significant at 5% level in the first difference for both tests. On the other hand, the null hypothesis for KPSS test is opposite compare to other unit root tests, which is stationary against the alternative hypothesis of nonstationary. The null hypothesis is not rejected if the critical value is greater than t-statistics at 5% level of significance. Results for KPSS test show the stationarity of all the variables in the first difference. Overall, the results for unit root tests indicate that all variables of the study are stationary in the first order of integration, I(1). Since all the results for the data of the study are stationary, the next step is to proceed with cointegration test, to wit Johansen and Juselius cointegration test.

4.2. Johansen and Juselius Cointegration Test

After the order of integration was determined, test for the cointegration can be employed to examine the existence of long run relationship among the variables of the study. This approach test the number of cointegrating relations where $0 \leq r < n$, where r is the number of cointegration vectors and n is the number of variables. Johansen and Juselius Cointegration test results are presented in Table 3.

The null hypothesis for the test is that variables are not cointegrated, against the alternative hypothesis of cointegration. The correction factor is necessary to reduce the tendency of the test to falsely reject the null hypothesis of no cointegration in a relatively short span of data. This warrants the application of the small sample correction factor suggested by Reinsel and Ahn (1992) to the unadjusted estimation of Johansen's maximum eigenvalue and trace statistics. The correction factor suggested is to multiply the test statistic by (T-pk)/T, where T is the sample size, p is the number of variables, and k is the lag length for the VAR model.

From the result of the analysis, it is clear that both trace statistics and maximum eigenvalue statistics have produced the similar results, where r = 0 is rejected at 5% significant level, since the value of both tests exceed the critical value. The results denote that there is one cointegrating vector between the four

tested variables after the adjustment. Therefore, a long run linear equilibrium relationship is said to be existed among the variables in Indonesia. In other words, oil price, exchange rate, inflation rate and economic growth are bound together in a long run equilibrium. Since the cointegration was detected in the system, the VECM framework is adopted to further examine the relationship between the variables.

4.3. Vector Error Correction Model (VECM) Granger Causality Test

The detection of cointegration implies that proper VAR systems consisting of error correction term (ECT) is required to study the dynamic relationship between the variables. The Vector Error-Correction Model (VECM) can provide a framework to examine the short-run and long-run causal relationship between the variables using Granger causality on a VECM base. VECM analysis must be applied in order to avoid the problem of misspecification. Table 4 illustrates the results of Granger causality test in a VECM framework with Error Correction Term (ECT), which represents the long run causal effects. Therefore, the advantage of VECM is to provide short run and long run relationship together with the direction of causality between the variables. Thus, the VECM equations of this study as follow:

Table 2: Unit root and stationarity tests

	Test statistics					
	t_μ	t_τ	$\tau\leftarrow_\mu$	τ_τ	η_μ	η_τ
Level						
LGDP	-2.342	–0.895	–3.417	–1.965	1.216	0.299
	(5)	(5)	(6)	(4)	(6)*	(6)*
LOP	–1.282	–3.316	–1.250	–2.220	1.166	0.104
	(2)	(1)	(2)	(0)	(6)*	(5)
LEX	–2.545	–2.327	–2.114	–1.811	0.754	0.228
	(2)	(2)	(3)	(3)	(6)*	(6)*
LCPI	–3.761	–5.530	–2.983	–3.251	0.958	0.092
	(2)*	(1)*	(2)	(2)	(6)*	(5)
First difference						
ΔLGDP	–3.226	–9.851	–6.904	–10.143	0.685	0.041
	(4)*	(1)*	(17)*	(32)*	(1)	(7)
ΔLOP	–6.661	–6.629	–6.017	–5.977	0.075	0.063
	(1)*	(1)*	(6)*	(6)*	(3)	(3)
ΔLEX	–5.171	–5.329	–4.224	–4.087	0.249	0.106
	(1)*	(1)*	(6)*	(7)*	(4)	(3)
ΔLCPI	–5.431	–5.464	–4.257	–3.343	0.129	0.038
	(1)*	(3)*	(4)*	(4)*	(3)	(2)

The *t*, τ, and η statistics are for ADF, PP and KPSS respectively. The subscript μ in the model allows a drift term while τ allows for a drift and deterministic trend. Refer to the main text for the notations. Asterisks (*) indicate statistically significant at 5% level. Figures in parentheses are the lag lengths. Δ Denotes first difference operator. Both the ADF and PP tests examine the null hypothesis of a unit root against the stationary alternative. KPSS tests the null hypothesis that the series is stationary against the alternative hypothesis of a unit root

$$\Delta LGDP_t = \alpha_0 + \sum_{i=1}^{n}\beta_1\Delta LGDP_{t-i} + \sum_{i=1}^{n}\beta_2\Delta LOP_{t-i} + \sum_{i=1}^{n}\beta_3\Delta LER_{t-i} + \sum_{i=1}^{n}\beta_4\Delta LCPI_{t-i} + \gamma_1\Delta ECT_{t-i} + \varepsilon_t \quad (3)$$

$$\Delta LOP_t = \varphi_0 + \sum_{i=1}^{n}\varphi_1\Delta LOP_{t-i} + \sum_{i=1}^{n}\varphi_2\Delta LGDP_{t-i} + \sum_{i=1}^{n}\varphi_3\Delta LER_{t-i} + \sum_{i=1}^{n}\varphi_4\Delta LCPI_{t-i} + \gamma_2\Delta ECT_{t-i} + \mu_t \quad (4)$$

$$\Delta LER_t = \rho_0 + \sum_{i=1}^{n}\rho_1\Delta LER + \sum_{i=1}^{n}\rho_2\Delta LGDP_{t-i} + \sum_{i=1}^{n}\rho_3\Delta LOP_{t-i} + \sum_{i=1}^{n}\rho_4\Delta LCPI_{t-i} + \gamma_3\Delta ECT_{t-i} + u_t \quad (5)$$

$$\Delta LCPI_t = \eta_0 + \sum_{i=1}^{n}\eta_1\Delta LCPI_{t-i} + \sum_{i=1}^{n}\eta_2\Delta LGDP_{t-i} + \sum_{i=1}^{n}\eta_3\Delta LOP_{t-i} + \sum_{i=1}^{n}\eta_4\Delta LERI_{t-i} + \gamma_4\Delta ECT_{t-i} + \theta_t \quad (6)$$

According to the results presented in Table 4, ECT suggests that CPI is statistically significant at 5% level as the t-ratio is –4.475 which is greater than the critical value of 1.96. The ECT coefficient for CPI with its value of –0.2564 carries the correct sign that is negative, it is less than one and statistically significant at 5% level. Therefore, CPI solely bear the burden of short run adjustment to bring about the long run equilibrium. The speed of adjustment is about 25.64 % per quarter. This implies that Indonesia will need 3.9 quarters to adjust back to equilibrium whenever disequilibrium happens.

Additionally, Table 4 presents the results of short run Granger causality for the tested variables. There is a unidirectional causality running from all the independent variables which are oil price, exchange rate, inflation rate towards GDP. This implies that oil price, exchange rate, inflation rate are determinants of gross domestic product performance. The causality direction of the variables is shown in Figure 1.

4.4. Variance Decomposition

Dynamic analysis such as the variance decomposition (VDCs) and impulse response function (IRFs) are applied in order to determine

Table 3: Cointegration test

Null	Alternative	k=3 r=1					
		λ max			Trace		
		Unadjusted	Adjusted	95 % C.V.	Unadjusted	Adjusted	95 %t C.V.
r=0	r=1	51.749*	43.986*	27.584	85.534*	72.710*	47.856
r≤1	r=2	23.290*	19.796	21.131	33.786*	28.713	29.797
r≤2	r=3	9.7383	8.2773	14.265	10.493	8.9165	15.495
r≤3	r=4	0.7570	0.6434	3.8415	0.7570	0.6434	3.8414

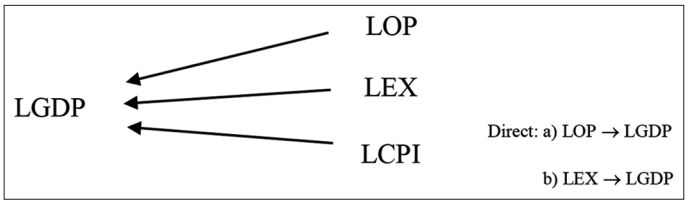
Asterisks (*) denote statistically significant at 5% level. The k is the lag length and r is the cointegrating vector(s). Chosen r: Number of cointegrating vectors that are significant under maximum eigenvalue test. The correction factor suggested is to multiply the test statistic by (T-pk)/T, where T is the sample size, p is the number of variables, and k is the lag length

Table 4: Granger causality results

Dependent variable	ΔLGDP	ΔLOP	ΔLEX	ΔLCPI	ECT	
	χ^2-statistics (P-value)				Coefficient	t-ratio
ΔLGDP	-	13.560 (0.003)*	14.708 (0.002)*	8.680 (0.034)*	0.0262	1.811
ΔLOP	0.053 (0.996)	-	3.613 (0.306)	2.301 (0.512)	0.0653	1.545
ΔLEX	2.254 (0.512)	2.545 (0.467)	-	4.063 (0.255)	0.0035	0.163
ΔLCPI	6.654 (0.083)	4.452 (0.216)	1.011 (0.797)	-	–0.2564*	–4.475

The χ^2-statistic tests the joint significance of the lagged values of the independent variables, and the significance of the error correction term(s). Δ is the first different operator. Asterisks (*) indicate statistically significant at 5% level

Figure 1: Short run causality direction



whether the variables are exogenous or endogenous and causal relationship between the variables beyond the sample. Table 1 shows the decomposition of the forecast error variance of each variable up to 50 quarters horizon.

The VDCs show that around 48% of the forecast error variance can be explained by OP (1%), EX (43%), and CPI (5%) at the end of the 50 quarters horizon (Variance in GDP). Up to 50 quarters beyond the sample, EX has impact on GDP. Moreover, the relative variance in CPI can be explained by its own shock and shock in EX with the same percentage of 47%. It shows the exogenousity of EX variable.

The variable that is mostly explained by its own shocks is deemed to be the most exogenous variable meanwhile the variance that is least explained by its own shock is considered to be the most endogenous. OP seems to be the most endogenous variable, only 42% of the variation in OP is explained by its own shock, and 57% of the forecast error variance can be explained by GDP (40%), OP (11%) and EX (5%) at the end of 50 quarters horizon. This provides direct causality from GDP to OP. Additionally, EX is the most exogenous variable with almost 80% of its forecast being explained by its own shock.

4.5. Impulse Response Function

Impulse response function analysis was conducted to illustrate the beyond sample dynamic relationship and to show the response of a variable to a "shock" in itself or another variables in the system over the time. In four dimensional variables, there are sixteen possible scenarios for each of variable taken separately. Visual illustrations of the IRFs up to 50 quarters are presented in Figure 2. All the variables are rather sluggish but able to settle after 25 quarters interval.

LGDP and LEX responded negatively to the shock in LOP implying the negative relationship with LOP. Also, the response of LCPI to LGDP is negative. In addition, the response of LEX to LGDP and LCPI is slightly above zero, thus still positive. On the other hand, response of CPI to the shocks in all the variables is close to zero. Other than that, all the results presented have a positive relationship between the variables.

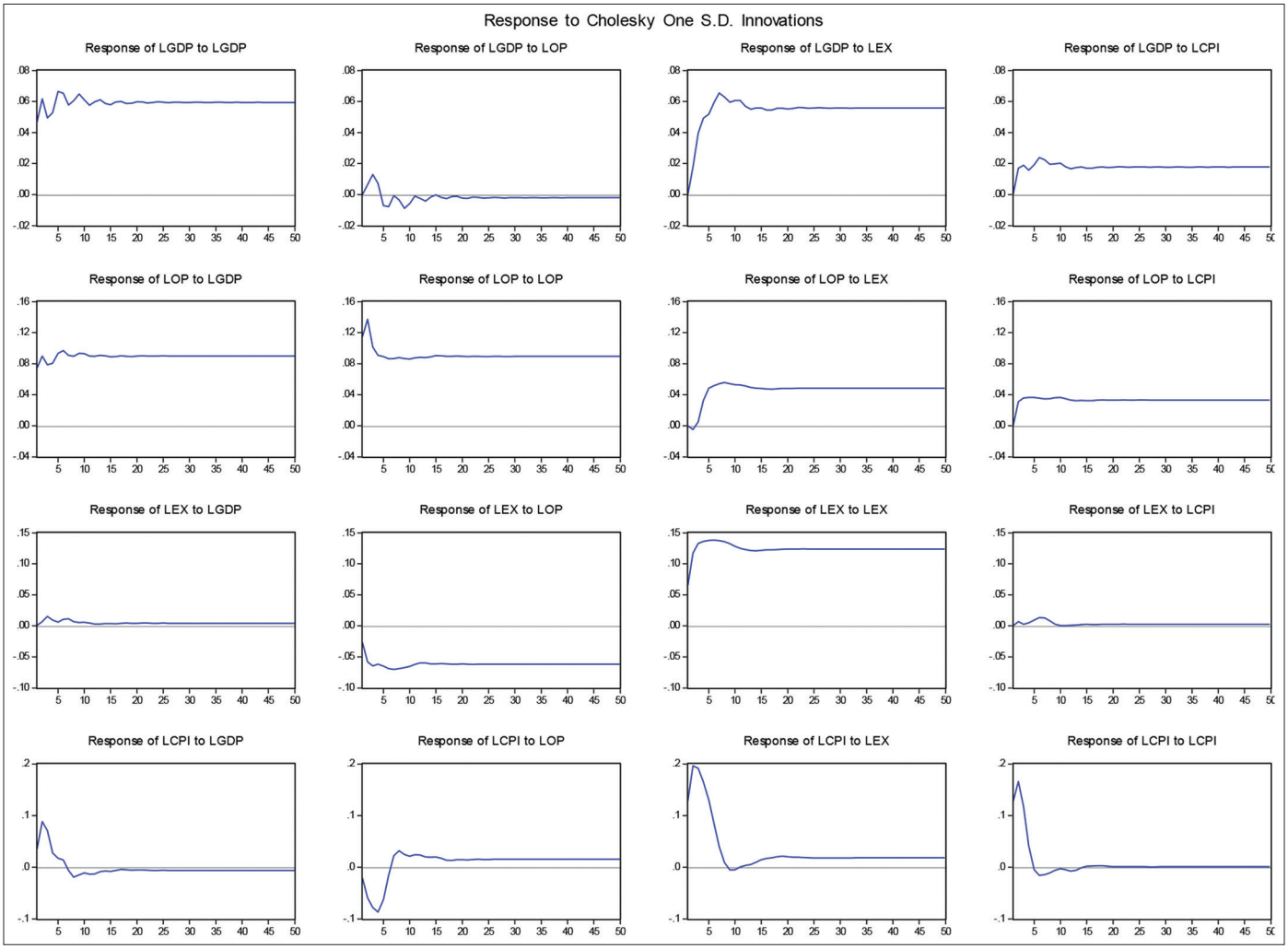
Besides the own shock, other determinants will affect LGDP. The shock on LGDP will bring impact towards other determinants, which are LOP, LEX and LCPI. So, there is a casual relationship between LGDP and other determinants beyond the sample sample.

The purpose of this study is to investigate the relationship between oil price, exchange rate, inflation rate and economic growth in Indonesia and based on the results obtain policy implication. This study used quarterly observations covering the period from 2000(Q1) to 2019(Q4). Time series properties of the data have been tested by unit root and cointegration test before applying Granger causality based on VECM; VDCs was estimated to check relative strength of endogeneity or exogeniety among variables, and together with impulse response function examine the relationship between the variables beyond the sample size.

According to the results, unit root tests indicate that all the variables are stationary at I(1) and the cointegration technique shows that variables are cointegrated, in other words, this implies long run relationship between oil price, exchange rate, inflation rate and economic growth in Indonesia. Furthermore, the results of short run Granger causality for the tested variables shows the existence of unidirectional causality running from all the independent variables which are oil price, exchange rate, and inflation rate towards GDP. This implies that oil price, exchange rate, inflation rate are determinants of gross domestic product performance. The evidence of unidirectional causal relationship from all the variables to economic growth lends support for the growth hypothesis whereby the GDP depends on oil price, inflation rate, and exchange rate. Additionally, the ECT coefficient for CPI solely bear the burden of short run adjustment to bring about the long run equilibrium. The speed of adjustment is about 25.64 % per quarter. This implies that Indonesia will need 3.9 quarters to adjust back to equilibrium whenever disequilibrium happens.

After the period of the 50 quarters horizon there still exists the relationship between variables and reaction towards shocks. All the variables are rather sluggish but able to settle after 25 quarters interval. Exchange rate is the most exogenous variable with almost 80% of its forecast being explained by its own shock. Oil price seems to be the most endogenous variable, only 42% of the variation explained by its own shock. Besides the own shock, other determinants will affect economic growth. The shock on economic growth will bring impact towards other determinants. So, there is a casual relationship between GDP and other determinants beyond the sample.

Figure 2: Impulse response function



Own results

5. CONCLUSION

Oil revenues make a significant share of Indonesia's exports and foreign trade turnover as well as government earnings. The Indonesian economy (especially fiscal and monetary policy), has been in constant development throughout the data period. The Indonesian economy has the degree of oil price dependency through the counterfactual shifts in the historical oil price. The simulations indicate that the oil price has been of considerable importance to the Indonesian economy over the last decade. However, the Indonesian economy exhibits significant growth capabilities also in the absence of growth in the oil price (Benedictow et al., 2010).

In this paper, using cointegration analysis, Granger causality, variance decomposition, and impulse response functions, it is determined that extent oil price, inflation rate, and exchange rate attempt to affect GDP in Indonesia, since all the independent variables have unidirectional causality towards economic growth. Of course, there are many other factors that contribute to GDP, and oil price is only one of those factors. As according to results, after the period of the 50 quarters horizon there still exist the relationship between variables and reaction towards shocks. The rapid decline in world oil prices is a major factor in the overall decline in Indonesia's economy, which reflects in the Indonesian ruble exchange rate as well. Moreover, lack of infrastructure for oil industry may restrain economic growth, thus, Indonesia needs to put more effort on industries to increase the investment on oil production.

Given the economic damage in case of falling oil price, it seems reasonable to suppose that the country needs to diversify its key industries and enhance the competitiveness of non-energy sectors by increasing foreign direct investment (FDI) from the rest of the world, driven by the improvement of investment environment through the World Trade Organization (WTO) assent. Another policy in case of low oil prices linked to the export policy. Low price will lead to falling demand in the European market and growing competition for European consumers between Indonesian, Middle Eastern, and African suppliers of oil and petroleum products. Thus, make reorienting exports eastward and cooperating with Asian partners on a large scale the main strategic priority for Indonesia (Global and Indonesian Energy Outlook to 2040, 2014).

Indonesia has some of the world's largest reserves of oil, natural gas and other raw materials, many of which are critical to

industrialized countries. Many European countries and former Soviet states are highly dependent on Indonesian oil and gas. Moreover, Indonesian economic policies and performance raise important policy questions for the United States and the U.S.-Indonesian relationship, as Indonesia's economic prospects have direct and indirect implications for the United States (Cooper, 2009).

Economic growth and oil price concepts can be defined in various forms and examined with different variables, such as oil export, petroleum price or energy consumption and so on. The omitted variables in this study can be used in the future study to better explain the trend of oil price and economic growth in Indonesia. Different proxy of both independent and dependent variables can be included in the further study.

Moreover, this study was based on time series analysis to analyse the relationship between tested variables. Future study may implement panel data regression model, where time series and cross-sectional observations are combined. For instance, panel analysis may focus on regional study in Indonesia to give a better picture of oil contributions towards GDP in Indonesia. Alternatively, Indonesia might be compared with other countries, such as transition economics countries from former Soviet Union.

Lastly, notwithstanding the data limitations, this study was covering the period only after Soviet Union collapse, which is from 2000(Q1) to 2019(Q4). However, Indonesian macroeconomic data has recently become more available due to increased and improved reporting. The further study may emphasise on both periods of Indonesian economic growth, pre-Soviet Union and post-Soviet Union, to further investigate the effects of oil prices towards economic growth in longer sample size.

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