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Do Oil Price Fluctuations Affect the Inflation Rate in Indonesia Asymmetrically?

Lim Thye Goh
Department of Economics
Faculty of Economics & Administration
University of Malaya
Jalan Universiti, 50603 Kuala Lumpur,
Wilayah Persekutuan Kuala Lumpur
Email: ltgoh@um.edu.my
Tel: +603 - 7967 3732
Fax: +603 - 7967 7252

Siong Hook Law
Department of Economics
Faculty of Economics and Management
Universiti Putra Malaysia
43400 Serdang Selangor,
Malaysia.
Email: lawsh@upm.edu.my

Trinugroho Irwan*
Faculty of Economics and Business
UniversitasSebelasMaret

Abstract

Changes in the oil price directly affect production costs, and subsequently the general price level of products. With Indonesia observing an inflation targeting policy, this study applies the nonlinear autoregressive distributed lag (NARDL) technique to investigate the effect of oil price fluctuations in Indonesia. The relationship is important for the central bank to gauge the effectiveness of the inflation targeting policy in immunising the country from oil price fluctuations. Our findings have revealed that there was asymmetric behaviour between the oil price and the inflation rate (producer price index), thus, questioning the effectiveness of the inflation targeting policy. More specifically, in the long-run, an increase in the oil price has tended to lead to an increase in the rate of inflation with a greater deviation, while an oil price reduction has led to a decrease in the inflation rate with a lower deviation. This suggests that the benefits of an oil price reduction are not passed down to the consumer.

JEL No: D4, H5, Q4

Keywords: Inflation targeting, Oil Price, Asymmetric cointegration, Indonesia

*Corresponding author

1.1 Introduction

Indonesia has observeda policy of inflation targeting since 2005, with the latest target being set at 3.5% +1% for the year 2019. The terminology of inflation targeting is often misinterpreted by normal citizens, where they often assume thata country's inflation rate is stagnating at 3.5% to 4.5% or even a zero rate of inflation. While the inflation rate is progressively compounding, for instance, a policy of targeting inflation at 3.5% indicates that the general price level is expected to increase by not more than 3.5%, compared to the last year. For example, the consumer price index (CPI) in Indonesia,as recorded in quarter three(Q3) of 2019, stood at 150.3 which was approximately 50 index pointshigher than the level of the CPI recorded in quarter three (Q3) of 2010 (101.30), and approximately 20% more than the level of the CPI recorded in quarter three (Q3) of 2015 (133.54), IMF (2019). In short, the general price level is always increasing in Indonesia. What worriescitizensis, whether their income can catch up with the rate of inflation or the inflation targeting policy rate, per se?

Fluctuationsin the oil price will directly affect product prices, or production costs and subsequently the general price level. Therefore, it is not surprising that the instability of oil prices in recent years has stimulated many types of academic research and interested discussions on the implications of oil price changes upon the rate of inflation. Indonesia's crude oil production has experienced a steady downward trend since 1990,which, in combination with increased domestic demand, has turned Indonesia into a net oil importer since 2004. Indonesia's crude oil imports in 2016 were reported at USD6,730.60 million and USD7,063.60 million in 2017. Bank Indonesia, the central bank of Indonesia, reported that, as of December 2018, the value of oil and gas exports for 2018 amounted to USD 1.3 billion, while imports amounted to USD 3 billion. With Indonesia being heavily reliant on oil imports to satisfy local demand, a soaring oil price is, therefore, expected to exert positive pressure on the inflation level of the country.

Very often the effects of higher oil prices are passed on to end-users,either; directly through increases in product prices (petroleum products), or indirectly through increased transportation costs or unit production costs. However, in the case of an oil price reduction, businesses are either; quite reluctant to reduce prices or the percentage of adjustment is significantly lower, due to profiteering. As a result, the relationship between the inflation rate and the oil price is not symmetrical in practice. Therefore, what is the actual impact of oil price fluctuations on general price levels in Indonesia? Will the magnitude of the impact on the inflation rate be greater when oil prices increase rather than when they reduce?

Indonesia is the fourth most populated country in the world with a population of 267 million people and a relatively high poverty level - approximately 10.9% - recorded in the year 2016 (World Bank, 2017). It is, therefore, important for policymakers to ensure price stability. Hence, unsurprisingly, the Indonesian government, together with Bank Indonesia, the Central Bank of Indonesia, established a coordination mechanism to keep the inflation rate of Indonesia between 2.5% to 4.5%,this policy came into effect in 2005. As the oil price can affect the general price level, both directly and indirectly, thus, the general price level is very vulnerable to fuel price fluctuations. Therefore, a study on the asymmetric integration of the inflation-oil price nexus is needed.

Historically, the inflation rate of Indonesia has fluctuatedin the positive zone since 1970, and was at its peak,at agrowth rate of 58.9%, during the Asian financial crisis throughout 1998-1999. With the country's energy prices determined by the government, rather than according to market conditions, the Indonesian government has spent trillions of Indonesian rupiahs in fuel subsidies. For example, the Indonesian government spent approximately 246.5 trillion Indonesian rupiahs in 2014 on fuel subsidies,whilst it only spent approximately 47 trillion Indonesian rupiahs in 2017, as a result of the government's decision to cut fuel subsidies in late 2014. The cut in fuel subsidies pushed Indonesia's monthly inflation rate to 1.50 percent and 2.46 per cent during November and December 2014, respectively. As reported by Reuters (2019), in 2018 the Indonesian government spent 153.5 trillion Indonesian rupiahsin energy subsidies. Three observations can be drawn from Indonesia's fuel subsidy policy. First, Indonesia relies heavily on fuel subsidies. Second, the general price level is rather sensitive to oil price fluctuations. Third, fuel subsidies could not prevent the inflation rate from continuing to soar. Hence, increases in the general price level could be due to increases in the producer price index due to the impact of oil price fluctuations,as captured through higher import costs (transportation costs) and imported input prices.

This study contributes to the existing literature in four important aspects. First, we adopted the nonlinear autoregressive distributed lag (NARDL) model, proposed by Shin *et al*. (2014), to highlight the potential long-run asymmetries in the inflation-oil price nexus. Second, this study examined the immunisation of the inflation targeting policy from oil price fluctuations. Third, given that Indonesia has turned into a net oil importer since the early 2000s, this study may prompt policymakers to explore alternative energy resources, instead of relying heavily on crude oil. Considering that crude oil is a non-renewable resource, the Indonesian government may be required to hike their fuel price subsidies in the future to ensure price stability. Fourth, this study investigated the pass-through effects of the oil price on producer prices in Indonesia.

The remainder of this paper is structured as follows. The following section provides abackground to the study, which is followed by a review of the previous literature. Section 3 outlines the methodology and data. Section 4 reports and discusses the empirical results. And Section 5 offers both policy implications and concluding remarks.

1.2 Theoretical background

The theoretical background of the impact of oil price fluctuations on producer prices in this study can be explained, based on the calculation of the Gross Domestic Product, using the production approach (value-added). The mathematic representation of the production approach is as follows:

$$GDP = P_1Q_1 + P_2Q_2 + P_3Q_3 + P_4Q_4 + \cdots P_nQ_n \quad (1)$$

Equation 1 highlights the Gross domestic product (GDP) that measures the market value of all final goods and services produced within a country, in a given time. As postulated by the production approach, only the total value added at all of the stages of production is counted in the GDP, hence, mathematically, the total is equal to the value of the final output ($P_1Q_1 + P_2Q_2 + P_3Q_3 + P_4Q_4 + \cdots P_nQ_n$), as long as the value chain goes back to the first stage of production.

The role of oil price fluctuations on producer prices (product price) can be explain based on the production flow chart presented in Figure 1. As indicated in Figure 1, oil price fluctuations will have an impact on producer prices in various ways. First, as a direct consequence, if the input or raw material is an oil-based product. Second, as an indirect influence, through oil-based processes and transportation cost fluctuations. Hence, oil price fluctuations are expected to lead to the variation ofproducer prices, both directly or indirectly.

** Insert Figure 1**

2.0 Literature review

2.1Empirical evidence on the asymmetric cointegration between the oil price and inflation

Our argument on the asymmetric relationship between oil price fluctuations and inflation is derived from the concept of sticky prices (price stickiness hypothesis) instituted by Rotemberg (1983). As postulated by the hypothesis, price changes are costly, hence prices do not reach long-run value instantly after an oil shock. The author also concluded that, in the United States, although increases in the prices of energy ultimately lead to higher domestic prices, the response was not immediate. The stickiness of prices was due to the presence of costs associated with changing prices. Besides, a few empirical studies have been found in parallel with the theoretical argument, where the relationship between oil price fluctuations and inflation was asymmetric. Those studies included;Alimi*et al*. (2020) who explored the asymmetric oil price-inflation nexus of Nigeria using quarterly data from the year 2009 until 2018 and confirmed the nonlinear long-run cointegration between oil prices and inflation in Nigeria. More specifically, both increases and decreases in global oil prices tended to exert a negative impact on the inflation rate of Nigeria.

Additionally, Salisu*et al.* (2017) investigated the role of asymmetries in the oil price-inflation nexus ofnet oil-exporting and net oil-importing countries. Their findings revealed that, although the oil price and the rate of inflation were positively and significantly correlated in the long-run, oil price asymmetries were not detected by net oil-importing nations. Lacheheb and Sirag (2019) utilised the nonlinear autoregressive distributed lag (NARDL) method to examine the relationship of oil price fluctuations on the rate of inflation in Algeria on data ranging from 1970-2014. They confirmed the existence of a nonlinear effect of oil prices on the inflation rate, where oil price increases tended to lead to increased inflation, but oil price reductionsdidnot have an impact on the rate of inflation inAlgeria. Similarly, Long and Liang (2018) utilised the NARDL method on quarterly data fromChina from the year 1998 and concluded that the impact of global oil price fluctuations onChina's producer prices index (PPI) and consumer prices index (CPI) wasasymmetrical in the long-run. More specifically, the impact ofupward oil price fluctuations on its PPI and CPI weregreater than that of oil price reductions.

Further evidence was provided by, Sek (2017) who detected evidence of both symmetric and asymmetric pass-through effects fromthe oil price on domestic prices in Malaysia, where the direct impact of oil price fluctuations on domestic prices, in the long-run, was concentrated on oil-intensive sectors, rather than on the general price level. In evaluating the impact of global oil price fluctuations on the level of domestic inflation in 72 advanced and developing economies, over the period from 1970 to 2015, Choi *et al*. (2017) found that the effect of fluctuationsofthe oil price on the inflation rate was asymmetric, where the impact of positive oil price fluctuations was larger than those of oil price reductions. Hammoudeh and Roboredo (2018) using a Gaussian affine term structure model, on data fromthe United States, concluded that oil prices hada nonlinear impact on the 5- and 10-year market-based inflation expectation components. Specifically, they found that the impact of oil price changes on inflation expectations wasmore intense when oil prices wereabove a threshold of 67 USD per barrel and weremore pervasive for the intermediate-term than for the longer term.

On the other hand, the majority of the existing literature has claimed that the relationship between oil price fluctuations and inflation is symmetric. Where the percentage change in inflation is identical from either an oil price increase or reduction. Among them, Sek*et al*. (2015) examined the effects of oil price changes on the inflation rate in two groups of countries,on data ranging from 1980 to 2010,using the autoregressive distributed lag (ARDL) technique. Their study revealed that oil price changes had a direct impact on the domestic inflation rate in agroup of low oil dependency countries, however, the impact on the domestic inflation rate of agroup of high oil dependency countries was via changes in the exporter's production costs. Dedeoglu and Kaya (2014), using the recursive VAR model, found evidence of an increasing trend in the pass-through effects of oil price fluctuations to domestic prices in Turkey. The most recent empirical evidence wasfrom Zivkov*etal.* (2019) and concerns the impact of oil price fluctuations on the inflation rates of Central and Eastern European countries. The results suggested that the transmission of fluctuations in the oil price to the rate of inflation caused relatively low effects in both Central and Eastern European countries. However, the strongest impact was found over longer time-horizons, which indicated that the indirect spillover effects of oil price fluctuationsweremore intensive.

Other than that, although most of the existing studies have demonstrated that the oil price and the inflation rate were significantly correlated, the results of their findings have not been unanimous. For example, Myersa*et al*. (2017), found that the oil price was cointegrated with the inflation rate in the long-run, however, the significance of the long-run cointegration was conditioned by permanent fluctuations in oil prices. Castro and Jiménez-Rodríguez (2017) employed a constrained vector autoregressive (VAR) model which indicated that oil price fluctuationsweresignificantly cointegrated with the producer price index in high oil consumption sectors but was not statistically cointegrated with the consumer price index. Similarly, Cunado*et al*. (2015) employed a VAR model which suggested that prices responded differently to oil price shocks. Particularly they noted that prices responded more significantly to oil price demand shocks rather than to oil price supply shocks.

The above discussions offer some insightful information on the impact of the oil price on the rate of inflation, in their respective studies. Although various estimation methods were applied in previous studies to explore the impact of the oil price on economic indicators, there is still a debate as to what extent a country's inflation rate is explained by the oil price. Besides, there is no single study which has examined the asymmetric link between the oil price and inflation in Indonesia, a country with an inflation targeting policy. Hence, this study intends to fill the gap in the literature by exploring the asymmetric impact of the oil price on the rate of inflation of Indonesia. Furthermore, most previous studies have focused on the consumer price index (CPI);

as a proxy for inflation. We argue that the CPI refers to the changes in the price level of a weighted average market basket of consumer goods and services purchased by households. Hence, for a country with an inflation targeting strategy, most of the goods that are placed in the basket are subjected to price controls or subsidies, hence it often does not reflect the true market value of the goods.Thus, this study explores to what extent oil price fluctuations affect the producer price index of Indonesia.

3.0 Methodology

3.1 Asymmetric Framework

Based on the theoretical presentation in Figure 1, we argued that the asymmetric relationship between oil price fluctuations and domestic prices can be observed from two separate models – namely; The Model in the Absence of Cost Changing Prices and The Model in the Presence of Costs to Changing Prices, as recommended by Rotemberg (1982, 1983). Both models explain the stickiness of prices which supports the foundation of the asymmetric adjustment in oil price-inflation, Due to the stickiness of prices, price adjustments due to oil price increases and reductions would not be symmetric. The hypotheses of the models areas below:

Model in the Absence of Cost Changing Prices

In this model, Rotemberg (1983), assumed that there wasno extra cost involved in changing prices. The model consents the oil price (energy) to be both an intermediate and final good.

$$Q_{it} = A_{it}\left(\frac{P_{it}}{D_t}\right)^{-b_i}\left(\frac{M_t}{P_t}\right)^{f}\left(\frac{R_t}{P_t}\right)^{k};\ \ i = 1, 2, \dots \dots n. \quad (2)$$

Where Q_{it}represents the quantity demanded of good i at time t. P_{it} is the price of good i at time t. M_t refers to the level of money balance, $R_t$is the price of a commodity (oil price, in this study) whose price is exogenous and D_t is the level of domestic prices. A_t, b_t, $f_t$and k are parameters.

Accordingly, fluctuations in the oil price would change the quantity demanded of the good, or promote or discourage the demand for substitute goods, in responseto the distribution effects of fluctuations in the oil price. The domestic price (D_t), the price level of the good itself (P_t) and the production function (Q_{it}) areas follows:

$$D_t = (\prod_{i=1}^{n} P_{it})^{\frac{1}{n}} \quad (3)$$

$$P_t = D_i^{\mu} R_t^{1-\mu} \quad (4)$$

$$Q_{it} = H_t N_{it}^{g} E_{it}^{h} \quad (5)$$

Where $0<\mu_t<1$, Ni_t is the amount of labour and Ei_t is the amount of energy (oil price) employed by firm *i*at time *t* and the supply of labour is subject to the function of real wage:

$$N_{it} = A\left(\frac{W_t}{P_t}\right)^{\lambda} \quad (6)$$

Solving Equation (6) and the demand for labour implied by Equations (2) and (5). Then each firm would choose the elasticity of demand is to be equal to marginal cost

$$p_{it}^{*} = d_t + s_t + \psi_t(r_t - p_t) + \xi_t(m_t - p_t) \quad (7)$$

Subject to

$$\psi(r_t - p_t) + \xi(m_t - p_t) + S = 0 \quad (8)$$

Equation 8 reflexes the equilibrium of real money balances as a function of the real price of energy and the nominal level of money balances. Where the fixed real price of the real price of energy, real money balances are exogenous to changes in the nominal money stock. From Equations 3 and 7, the average of the domestic price d_t can be formed:

$$d_t = m_t + \bar{S} + \phi\tilde{r}_t\,; where\ \phi = \mu_{\xi}^{\psi} - (1-\mu), \bar{S} = \frac{s_t}{\xi}, \widetilde{r_t} = r_t - d_t \quad (9)$$

$\tilde{r}_t$is an alternative representationof the exogenous real price of energy, for $\tilde{r}_t$ to be inflationary, ϕ must be positive, hence, the direct impact of energy prices on the price level $(1-\mu)$ must be minimum. Which suggests that the pass-through impact hasnot been completed (stickiness in prices).

Additionally, as postulated by Rotemberg (1983), if the normal price of oil is fixed, an increase in the money balance (m_t) would lead to an increase in the price level (p_t), a decrease in the real price of energy, a rise in output (with conditions), increases the domestic price (d_t) and reduces the demand at *t*.

Model in the Presence of Costs to Changing Prices

When price changes are costly, a firm must first compute the difference between sales revenues and the costs of production by using a quadratic function of $p_{it,}$ as highlighted by Rotemberg (1982).

$$\pi\left(\frac{P_{it}}{P_t}\right) \approx \pi\left(\frac{P_{it}^*}{P_t}\right) - w_i(P_{it} - P_{it}^*)^2 \tag{10}$$

Where π represents the difference between real sales revenues and the real costs of production, w_i is a constant. Rotemberg (1982), argued that in the presence of changing costs, the effects of price changes may be captured with the quadratic cost of changing prices, asper the following equation:

$$E_t \sum_{\tau=1}^{\infty} \rho^{\tau-1}\left[\pi\left(\frac{P_{it}^*}{P_t}\right) - w_i(p_{i\tau} - p_{i\tau}^*)^2 - c_i(p_{i\tau} - p_{i\tau-1})^2\right], \tag{11}$$

With ρ is a discount factor, as indicated by Rotemberg (1983), hence, the maximisation of Equation (11) would be as follows:

$$\rho_{it} = \alpha P_{it-1} + \frac{1}{\beta\rho c}\sum_{j=0}^{\infty}\left(\frac{1}{\beta}\right)^j P^*_{\frac{it}{t}-j} \tag{12}$$

Where

$$\alpha + \beta = 1 + \frac{1}{\rho} + \frac{1}{\rho c}\,; Hence, \qquad \alpha\beta = \frac{1}{\rho} \qquad \alpha < 1;\ \beta > 1,$$

Where $P^*_{\frac{it}{t}-j}$is the value of p^*_{it+j}expected by firm *i*at time *t*. Because in the presence of cost of changing prices, firm *i* does not want to charge at *t*ia price too different from the price it charges at *t-1*.

The equilibrium price for firms who have rational expectations can be computed using the techniques highlighted by Rotemberg (1983). It is given by:

$$d_t = \gamma d_{t-1} + \frac{\xi}{\delta\rho c}\sum_{j=0}^{\infty}\left(\frac{1}{\delta}\right)^2\left[\bar{S} + m_{\frac{t}{\tau}+j} + \phi\tilde{r}_{\frac{t}{\tau}+j}\right] \quad (13)$$

$m_{\frac{t}{\tau}+j}$ *and* $\tilde{r}_{\frac{t}{\tau}+j}$ are the mathematical expectations of m_{t+j} and $\tilde{r}_{t+j}$. Considering that both money supply (m_t) and the relative price of energy ($\tilde{r}_t$) follow a random walk, then

$$m_t = m_{t-1} + \epsilon_t;\ V_j;\ m_{\frac{t}{\tau}+j} = m_t \quad (14)$$

$$\tilde{r}_t = \tilde{r}_{t-1} + v_t\ ;\ V_j;\ \tilde{r}_{\frac{t}{\tau}+j} = \tilde{r}_t \quad (15)$$

ϵ_t *and* v_t are independently and identically distributed (i.i.d) with mean zero and finite variance, then

$$d_t = \gamma d_{t-1} + (1-\gamma)(\bar{S} + m_t + \phi\tilde{r}_t) \quad (16)$$

Domestic price (*d*) is expected to adjust slowly if energy price increases are inflationary, then ϕ is positive and a positive shock ϵ_t, leads to a gradual increase in domestic prices. Hence,

$$q_t = \bar{A} + f(m_t - d_t) + [k\mu - d(1-\mu)]\tilde{r}_t \quad (17)$$

From Equation (17), a gradual increase in d_t induces a gradual fall of the aggregate output q_t. Besides, an increase in the relative price of energy ($\tilde{r}_t$) will eventually lead to lower domestic prices, d_t, will fall only gradually.

In conclusion, the intuition behind both models indicates that the price adjustment process may not be complete from oil price fluctuations due to the presence of the costs of changing prices. Hence, this is in parallel with our argument, where the relationship between oil price fluctuations and inflation is asymmetric.

3.2 Model

The model of this study is as follows:

$$PI = f\,(op,\ import,\ GDP) \quad (18)$$

Where *PI* is the inflation rate (producer price index), *OP* is the oil price, in local currency (Indonesian Rupiah) and Import represents the net imports of goods and services. GDP represents the GDP growth rate.

The empirical model of this study outlines the influence of the global oil price on the inflation rate of Indonesia through the asymmetric cointegration approach, as suggested by Shin *et al*. (2014). This approach uses the nonlinear autoregressive distributed lag cointegration approach (NARDL) to capture both the long-run and short-run asymmetries between the global oil price and the inflation rate. Besides, we also included the GDP.

The asymmetric long-run equation of the inflation rate is as follows:

$$PI_t = \alpha_0 + \alpha_1 OP_t^+ + \alpha_2 OP_t^- + \alpha_3 import_t + \alpha_4 GDP_t + \varepsilon_t \tag{19}$$

α_o, α_1, $\alpha_2, \alpha_3, \alpha_4$ are cointegrating vectors or are vectors of the long-run parameters to be estimated. Whereas, $OP_t^+ \, and \, OP_t^-$ are partial sums of the positive and negative changes in the *OP*.

$$OP_t^+ = \sum_{i=1}^{t} \Delta OP_t^+ = \sum_{i=1}^{t} \max(\Delta OP_i, 0) \tag{20}$$

and

$$OP_t^- = \sum_{i=1}^{t} \Delta OP_t^- = \sum_{i=1}^{t} \max(\Delta OP_i, 0) \tag{21}$$

where $OP_t = OP_0 + OP_t^+ + OP_t^-$. (22)

Based on the above formulation, the long-run relationships between the inflation rate (producer price index) and the oil price are α_1 and α_2. Where α_1 captures the long-run relationship between the inflation rate and oil price increases and α_2 captures the long-run relationship between the inflation rate and oil price reductions. By default, Equation (22) indicates that the current value of the oil price (OP_t) variable is given by the sum of its initial value and the positive and negative partial sums.

In the empirical implementation, the long-run Equation (19) in an autoregressive distributed lag (ARDL) model, as per Shin *et al*. (2014), is as follows:

$$\Delta PI_t = \beta_0 + \beta_1 CPI_{t-1} + \beta_2 OP_{t-1}^{+} + \beta_3 OP_{t-1}^{-} + \beta_4 import_{t+1} + \beta_5 GDP_{t-1} + \sum_{i=1}^{p} \varphi_i \Delta CPI_{t-i} + \sum_{i=0}^{q} (\theta_i^{+} OP_{t-i}^{+} + \theta_i^{-} OP_{t-i}^{-}) + \sum_{i=0}^{r} \gamma_i \Delta import_{t-1} + \sum_{i=0}^{s} \delta_i \Delta GDP_{t-1} + \mu_t \quad (23)$$

All of the variables weredefined as above, with the addition of p, q, $r$and s which werethe lag orders. The long-run parameters in Equation (19) were derived from Equation (23), i.e. $-\beta_2/\beta_1 = \alpha_1$ and $-\beta_3/\beta_1 = \alpha_2$. Besides, $\sum_{i=0}^{q} \theta_i^{+}$ measured the short-run influences of oil price increases on the inflation rate, while $\sum_{i=0}^{q} \theta_i^{-}$measured the short-run influences of oil price reductions on the inflation rate.

The implementation of the nonlinear ARDL analysis followed the following steps. First, similarly to the ARDL error correction model, proposed by Pesaran*et al*. (2001), the NARDL model does not allow I(2) variables. The presence of I(2) variables will cause the computed F-statistics for the cointegration test to be invalid. Hence, the Augmented Dickey-Fuller (ADF) and Philips-Perron (PP) unit root tests were carried out to confirm that all of the variables were I(0) or I(1). The Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test was also included to confirm the findings obtained from the ADF and PP unit root tests. Second, Equation (23) was estimated using the standard Ordinary Least Squares (OLS) estimation method. Third, we ran the nonlinear error correction model under the NARDL model, using a two-step least squares estimation, to obtain the optimum lags for the NARDL model. Fourth, to test for cointegration under the NARDL model, the bounds testing approach, suggested by Pesaran*et al*. (2001) and Shin *et al*. (2014), was carried out to identify the presence of cointegrating variables. Next, we performed the Wald test under the restriction $-\beta_2/\beta_1 = -\beta_3/\beta_1$to examine the presence of asymmetry on the long-run impact of the oil price on the inflation rate in Indonesia. Lastly, we checked the robustness of the estimation with serial correlation and stability diagnostic tests.

The Data

Quarterly data from 1991 to 2019 were employed in the analysis. The inflation rate was represented by the producer price index *(PI)* and the data was taken from the International Monetary Fund (IMF) databank. The producer price index was chosen over the consumer price index (CPI) as the proxy for inflation in this study, based on threefactors. First, Indonesia is observing inflation targeting strategies, where Bank Indonesia is committed to maintaining price stability to keep inflation within the range of a target corridor, for instanceat 4.0±1% (2017) and 3.5±1% (for both 2018 and 2019). Hence,the general price index that is captured by the consumer price index (CPI)is exogenous from oil price fluctuations, as they may be subjected to subsidies and price control policies. Secondly, the PI focuses on the entireoutput of producers in Indonesia, which includes the goods and services purchased by producers as inputs in their operations, or as investments, and the goods and services bought by consumers from retail sellers and directly from producers. Hence, this is in parallel with our production function framework which highlights the role of oil price fluctuations in the production process flow. Lastly, in the producer price index, sales and taxes are not included inthe producer's returns, whereas,the consumer price index includes taxes and sales, hence, we felt that the PI was a better proxy for inflation, as it represents the true value of prices for goods and services.

The level of the oil price *(OP)* was taken from the World Bank Commodity Price Data (The Pink Sheet) and the exchange rate (USD to Indonesian Rupiah) was taken from the International Financial Statistics (IFS) databank. The oil price, in the local currency,wasutilisedin this study to enable us to capture the impact of oil price fluctuationson domesticoil-based production processes and variations in transportation costs, as highlighted in the production function (Figure 1). Importation,which highlights the inflow of goods and services,was included in our study to capture direct (importation of oil-based products, or inputs) and indirect (fluctuations in shipment/transportation costs) impacts of oil price fluctuations on the PI and the data was taken from the Federal Reserve Economic Data (Fred). Lastly, the GDP growth rate was included to showcase the economic activity (productivity)in Indonesia. Where, ahigher GDP growth rateindicated higher productivity and a greater efficiency level, hence, having a direct impact on the PI. The GDP data was taken from the Asian Regional Integration Centre of the Asian Development Bank. Table 1 presents the descriptive statistics of the inflation rate and the oil price, in the local currency. The standard deviations of all of the variables werehigh, which indicated that all of the variables had high variation. Figure 2 depicts the time scatter plots of both series, the PI and the oil price,and shows a positive correlation over time.

** Insert Table 1and Figure 2**

4.0 Empirical results

Similarly to the ARDL error correction model, as proposed by Pesaran*et al*. (2001), the NARDL model does not allow I(2) variables. Hence, we employed the Advanced Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests on each variable to confirm that no I(2) variables were involved in the analysis. Additionally, the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test was also included to confirm the findings obtained from the ADF and PP unit root tests. The results of the tests are reported in Table 2. The ADF, PP and KPSS unit root tests were in agreement that the inflation rate and the oil price were integrated at order 0 or order 1. The absence of I(2) variableswas vital, as such data would have invalidated the computed F-statistics for testing cointegration. The absence of I(2) variables, allowed us to proceed to perform the NARDL model estimation, as suggested by Pesaran*et al*. (2001).

** Insert Table 2**

The cointegration tests on the oil price-inflation nexus equation were performed by regressing Equation (23) with the OLS estimation method and the non-linear error correction model (ECM), under the setting of the NARDL model, through the two-step least squares method, to arrive at the model's final specification. Table 3summarises the results of the model specification. In the NARDL framework, the existence of long-run cointegration can be tested with bounds testing F-statistics, as suggested by Shin *et al.* (2014), to compare with the critical values provided by Pesaran*et al*. (2001), for observations greater than 100. If the calculated F-statistics are greater than the upper bound critical value, then there is evidence of cointegration. From the results presented in Table 4, the *F-statistics*that were reported were significant at the 10 percent significance level, thus, rejecting the null hypothesisof non-cointegration. Additionally, the *p-value* of the long-run asymmetry test was less than 0.01. Thus, indicating that there was an asymmetry in the long-run impact of the oil price on the inflation rate of Indonesia.

** Insert Table 3 and 4**

The results presented in Table 4 are not the long-run coefficients, to obtain the long-run coefficients, we divided the negative coefficient of each of the explanatory variables by the coefficient of the *PI* (-1). The long-run coefficients of the explanatory variables are presented in Table 6. The long-run coefficients presented in Table 5indicate that a 1 per cent increase in the oil price rate led to a 0.4436 per cent increase in the inflation rate (positive relationship), and a 1 per cent decrease in the oil price led to a 0.2137 per cent decrease in the inflation rate (positive relationship as well). Therefore, the inflation rate responded more significantly to a positive change, rather than to a negative change, in the oil price (as shown in Figure 3 - NARDL Multiplier Graph). Besides, the pass-through effect of the oil price to the inflation rate was not complete, as a 1per cent increase in the oil price was associated with only a 0.26per cent increase in the inflation rate. The incomplete pass-through effect could be due to the inflation targeting policy observed in Indonesia, as an example, President Joko Widodo ordered energy prices to be kept flat in 2018 and 2019 by increasing fuel subsidies (TheStar, 2019). Nevertheless, as highlighted in the theoretical background, the impact of the oil price on the producer price index remains significant, transportation charges and production inputs imported from overseas are still subject to the effects of oil price fluctuations. However, surprisingly, the coefficients obtained fromthe import variable were not significant at the conventional significance level, whereas the GDP growth rate was significant and inversely associated with the PI. This indicates that a higher GDP growth rate leads to a lower producer price indexin Indonesia. This could be explained from the perspective of the production approach, where higher productivity reflects a higher efficiency level, thus, leading to a lower producer price index. However, the insignificance of imports on the producer price index indicates that further research on the roles of imports on the producer price index of Indonesia is needed.

Additionally, we included the Bruesch-Godfrey serial correlation LM statistics for autocorrelation, up to order 4, to serve as the diagnostic statistics to justify the adequacy of the model specification. Theresuts are presented in the right panel of Table 4. We also present, in Figure4, the CUSUM and CUSUM of squares statistics diagrams for testing the structural stability of the model. From the results that unfold in Table 4, both coefficients confirmed the absence of autocorrelation. The diagrams of the CUSUM and CUSUM of squares indicate that the test statistics were within the 5% confidence interval bands, suggesting that there was no structural instability in the residuals.

Insert Table 5 and Figure 3 and 4

4.1 Robustness checking

To verify the robustness of our analysis, and to confirm that the producer price index was the right indicator for the rate of inflation for a country implementing an inflation targeting policy, the impact of the oil price on the consumer price index (CPI) was included in this study and the estimations are presented in Tables6, 7 and 8. Table 6summarises the results of the model specification, whereas,Table 7 reports the long-run cointegration, and asymmetric test findings and the Bruesch-Godfrey serial correlation LM test. Lastly, the long-run coefficients of the explanatory variables are presented in Table 8.

Insert Table 6

The results presented in Table 7 were consistent with the estimation results obtained by the producer price index (PI)-oil price nexus. The oil price and the consumer price index (CPI) were found to be significantly integrated into the long-run at the 10 per cent significance level. However, the *p-value* of the long-run asymmetry test was more than 0.10. Thus, indicating that there was no asymmetry in the long-run impact of the oil price on the consumer price index. The finding is in parallel with the inflation targeting policy of Indonesia, where the consumer price index is controlled by Bank Indonesia to sustain at the 3.5±1% level. Hence, the impact of oil price fluctuations will not matter tothe consumer price index. On the other hand, the long-run coefficients of the explanatory variables, as presented in Table 8, indicated that the import variable was not significant at the conventional significance level, whereas the GDP growth rate was significant. This is identical to the finding of the producer price index-oil price nexus.

Insert Table 7 and 8

4.2 Discussion

This section presents the main implications of the results obtained from the empirical analysis and robustness checking.

From the results, which aresummarised in Table 4, oil prices were found to be significantly cointegrated with the rate of inflation,as measured by the producer price index, hence, suggesting that the oil price is a significant determinant of the inflation rate, even in a country that is observingan inflation targeting policy. Additionally, the oil price was found to be asymmetrically correlated with the inflation rate in Indonesia, suggesting that the inflation rate in Indonesia reacts differently to upward and downward fluctuationsinthe oil price. More specifically, as reported in Table 5, a 1 percent increase in the oil price tended to increase the rate of inflation of Indonesia by 0.4436 percentage points, whereas, a 1 percent decrease in the oil price tended to decrease the inflation rate by 0.2137 percentage points. This finding suggested that the general price level reacted with more sensitivity to increases, rather than to reductionsinthe oil price.

The results from the robustness checking highlighted that the oil price was integrated with the consumer price index of Indonesia, but no asymmetric cointegration was found. Hence, suggesting that the oil price was a significant determinant of the consumer price index. We argued that, under the inflation targeting policy and heavy fuel subsidies (47 trillion rupiahs in 2017 and 46.9 trillion rupiahs in 2018, (Financial Ministry of Indonesia, 2019)) of the Indonesian government, that the consumer price index was not expected to be sensitive to oil price fluctuations. This can be explained by the definition of the CPI itself, where the CPI is a measure that examines the weighted average of prices of a basket of consumer goods and services, such as transportation, food, and medical care. Hence, in the presence of fuel subsidies, the direct impact of oil price fluctuationswas being absorbed by the government through these subsidies. However, as presented in the theoretical background, the oil price can affect general price levels in various ways. Thus, it would be misleading for us to conclude that the oil price was not a significant determinant of the inflation rate in Indonesia. Hence, for countries with inflation targeting policies, the Producer Price Index (PI),which measures the average change over time in the selling prices received by domestic producers of goods and services, should be the rightful proxy for the rate of inflation, instead of the CPI.

5.0 Conclusion

Recognising that oil price fluctuations may impact general prices in several ways. This paper adopted the NARDL model, as proposed by Shin *et al*. (2014), to capture the presence of asymmetric cointegration between the inflation rate (proxied by the producer price index) and the oil price in Indonesia. The empirical results indicated that there was significant evidence of asymmetric effects of the oil price on the rate of inflation in the Indonesian economy. More specifically, an increase in the oil price tended to lead to an increase in the inflation rate with a greater deviation, while an oil price reduction would lead to a decrease in the inflation rate, with a lower deviation. Therefore, the rate of inflation responded more to positive changes, rather than to negative changes in the oil price.

On the other hand, the oil price was not a significant determinant of the consumer price index. Hence, suggesting that the consumer price index was not anappropriate variable to proxy as the inflation rate for a country that was observing an inflation targeting policy,as well as providing heavy fuel subsidies. The impact of oil price fluctuationswas absorbed by the government through subsidies, thus, the domestic price level, which is captured by the CPI,would not varymuch. Theoretically, oil price fluctuations varytransportation costs and input prices from overseas and will affect the producer price index. Hence, the producer price index is a more appropriate variable to proxy the inflation rate of a country which is observing an inflation targeting policy,as well asproviding heavy fuel subsidies.

As previously pointed out, the inflation rate responds more to positive changes in the oil price which indicates that the speed of adjustment in price increases is faster than when the oil price drops. This suggests that the benefits of oil price reductions are not fully passed down to consumers, which is in parallel with Rotemberg (1983)'s price stickiness hypothesis. Thus, our first policy implication is that policymakers should pay more attention to combat profiteering. Policymakers should enforce strict regulations and penalties on companies/producers who make or seek to make an excessive or unfair profit. For example, the government could reduce or prevent profiteering through an "Anti-Profiteering Act".

Additionally, the GDP growth rate was found to be negative and significantly associated with the producer price index, which indicates that a growing GDP rate,associated with high productivity and efficiency levels,has a corrective effect on the inflation ratein Indonesia.Giventhat Indonesia's total estimated population is approximately 273million people, the world's fourth most populous nation, with the development of human capital also seen as a key factor for Economic Growth, development and competitiveness, (World Economic Forum, 2017), policymakers should prioritisehuman capital development and initiate programmes, such as;improving the levels of education, health, and social protection

Lastly, with depleting domestic oil reserves incombination with increased domestic oil demand, Indonesia has turned into a net oil importer, since the year 2004. Hence, the Indonesian government should not continue to rely on non-renewable energy sourcesand should explore the potential of renewable energy sources, such as solar and geothermal energy. This would, at the same time, both enhance the green credentials of the country, whilst reducing the effects of fluctuationsin the oil price on the economy of the country. Besides, Indonesia, with its 18,037 islands, has an estimated total potential for offshore wind energy of 9.3GW, according to the International Renewable Energy Agency (IRENA). To date, the World Bank has approved $150 million in loans for Indonesia to scale up investments in geothermal energy by reducing the risks of early-stage exploration. The loan is accompanied by $127.5 million in grants from the Green Climate Fund and the Clean Technology Fund, two institutions supporting climate-friendly development (World Bank. 2019). Thus, policymakers should gradually reduce the existing fuel subsidies,whilst increasing government spending to develop renewable and sustainable energy industries. Lastly, policy attention should also be directed to increasing production efficiency through research and development and innovations. Theoretically, an increase in efficiency will shift the production frontier to the right and will lead to a reduction in unit production costs (Sickles and Zelenyuk, 2019). This should be able to act as a buffer to the impact of oil price fluctuations.

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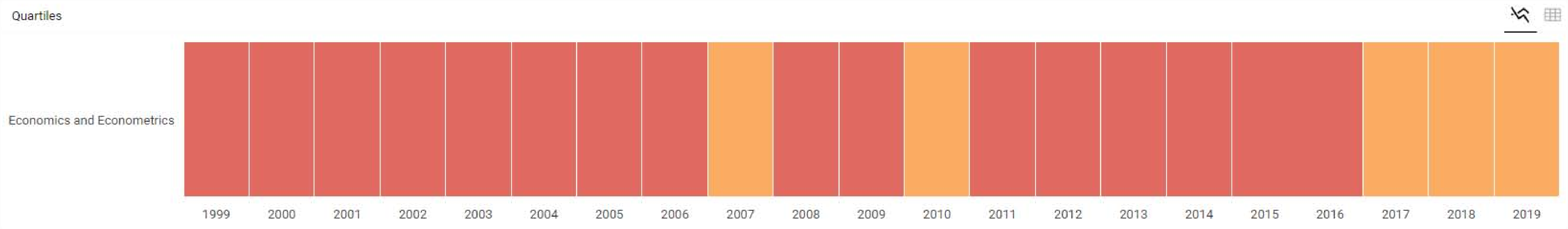

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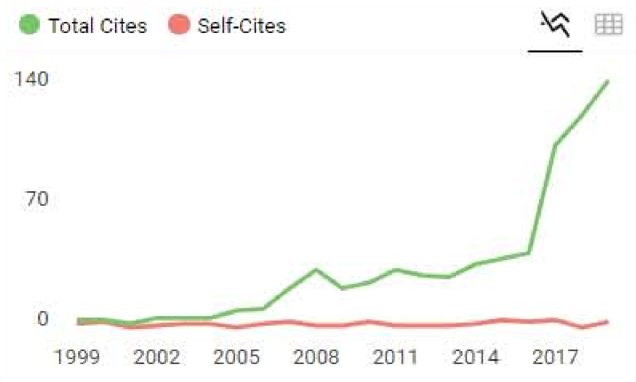

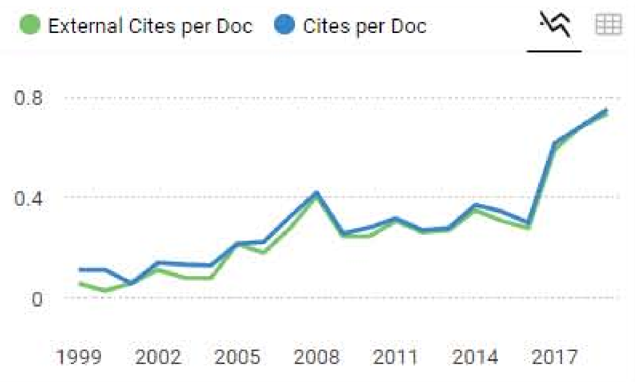

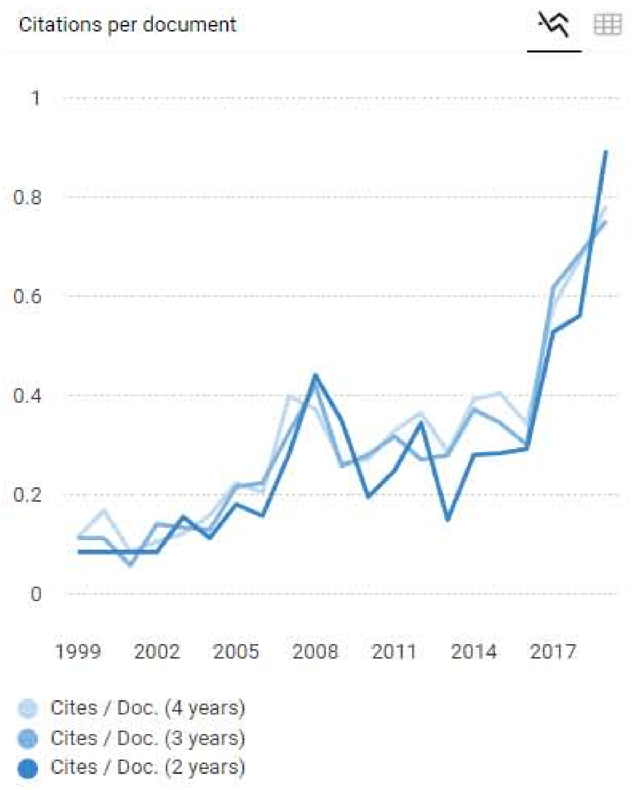

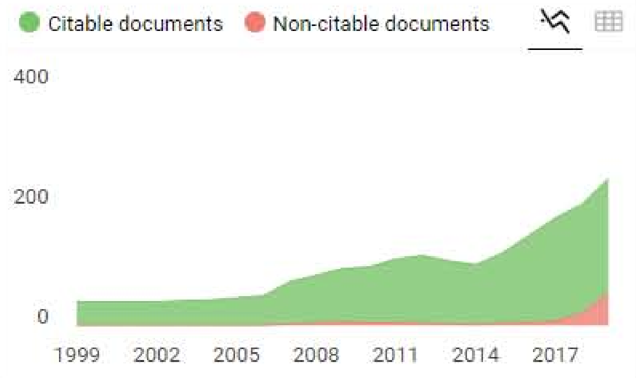

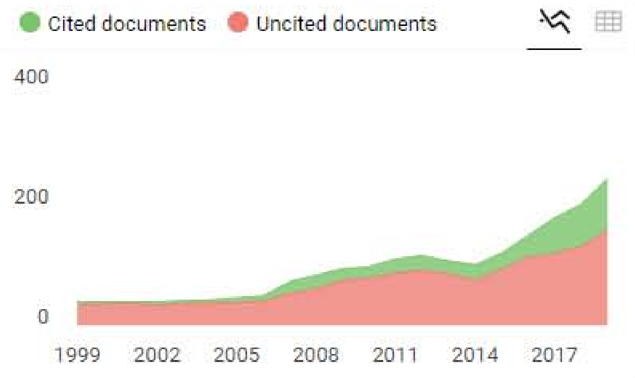

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