DOES INDONESIA AS THE WORLD LARGEST PALM OIL PRODUCING COUNTRY DETERMINE THE WORLD CRUDE PALM OIL PRICE VOLATILITY?

SYAHRIL
Ph.D. Scholar in Economics, Universitas Syiah Kuala, Indonesia, and Lecturer of the Faculty of Economics and Business, Universitas Teuku Umar (UTU), Indonesia
syahril.juni1975@gmail.com

Raja MASBAR
Professor, Faculty of Economics and Business, Universitas Syiah Kuala, Indonesia
raja.masbar53@gmail.com

M. Shabri Abd. MAJID*
Senior Lecturer, Faculty of Economics and Business, Universitas Syiah Kuala, Indonesia.
mshabri@unsyiah.ac.id
*Corresponding author

Sofyan SYAHNUR
Senior Lecturer, Faculty of Economics and Business, Universitas Syiah Kuala, Indonesia
kabari_sofyan@unsyiah.ac.id

Abstract

This study contributes to the existing literature on the current phenomena of a higher level of world palm oil volatility by exploring the bivariate causal relationship between Indonesian and Malaysian CPO exports, the world crude and soybean oils, exchange rate, and the world CPO price volatility using the bivariate Granger causality analysis. It also attempts to explore the extent to which shocks in these variables influenced the world CPO price volatility using the impulse response functions and variance decomposition analyses over the period from January 2008 to December 2017. The study found that the world CPO price volatility is mainly Granger-caused by the changes in the real exchange rate. The Indonesian CPO export only found to have a bidirectional Granger causal relationship with the Malaysian CPO export, while the Malaysian CPO exports are Granger-caused by the world CPO price volatility, world crude oil price, and world soybean oil price. Our findings suggested that macroeconomic policy harmonization on the CPO price and production as well as exchange rate policy should be innovatively designed between Indonesia and Malaysia through the existing Council of Palm Oil Producing Countries (CPOPC) if these counties intend to gain more revenue from their CPO exports in the future.

Keywords: Dynamic causality; World CPO price volatility; World commodity markets; Macroeconomic policy harmonization; International CPO trade

JEL classification: C53, F42, L13, Q17, Q37

1. Introduction

As the largest palm oil producing country, Indonesia is the world's largest crude palm oil (CPO) exporting country (Sulaiman et al., 2011) with a share of 47.16% of the world palm oil markets (The Ministry of Plantation Industries and Commodities of Malaysia, 2015). Despite its largest market share of the world palm oil market, Indonesia has been unable to control the world CPO price since last few decades. Instead, the world CPO price is determined by the global commodity price and Indonesia is the price taker (Haron and Salami, 2015) and simply benchmarks its CPO price to the world CPO market.

Lately, agricultural products such as CPO, their prices have been more volatile than the prices of other manufactured products globally (Jacks et al., 2011). The higher level of volatility of world CPO price has been a major problem for Indonesia since the country had relied its exporting CPO price primarily on the movement of world CPO prices and its determinants. Moreover, the campaign of unhealthy palm oil that creates deforestation,

greenhouse gas emissions, and human rights violations (Corciolani et al., 2019) propagated by few parties resulted in a more instability of the world CPO price. The fierce competition between palm oil, vegetable oil, and soybean oil in the European countries (Bergmann et al., 2016), the aggressive CPO price competition between Indonesia and Malaysia as the largest and second largest oil producing countries, and the CPO price speculation in the Chinese futures market have further triggered volatility of the CPO price globally (Bohl et al., 2018).

As the largest producing palm oil country in the world, the palm oil has become one of the leading agricultural commodities in Indonesia that had contributed to national economic development (State Secretary of Indonesia, 2004). It also has been a source of income for millions of farming families that offers million of job opportunity, triggers the growth of new economic centers, and as a driver of the development of the palm oil-based downstream industry (Secretariat General of the Ministry of Agriculture, 2014). Due to the pivotal role of palm oil to the national economy of Indonesia, thus it is timely and extremely urgent to explore the determinants of the volatility of the world CPO price. To what extent the volatility of world CPO price is interlinked to the volatility of world CPO supply, the world price of soybean oil, world crude oil price, and exchange rate?. Do the shocks in the volatility of world crude oil price, world CPO supply, the world price of soybean oil, and exchange rate cause the world CPO price to become more volatile?. If yes, to what extent the shocks in these variables are responded by the changes in the world CPO price? Thus, these questions would be the main focus of our study.

There have been many studies investigated the world CPO price volatility using both qualitative and quantitative methods. For example, Go and Lau (2018) explore the relationships between prices and volumes of world CPO during the pre-crisis, during-crisis and post-crisis periods in the world futures market. Ceballos et al. (2017) investigate the short-term price volatility transmission of the major 41 domestic food products in 27 countries in Africa, Latin America, and South Asia using the multivariate generalized autoregressive conditional heteroscedasticity (GARCH) approach. Arianto et al. (2010), Cabrera and Schulz (2016), Carolina et al. (2016), and Buyung et al. (2017) examine short-term and long-term relationships between the volatility of world CPO and soybean oil and found that the prices of soybean oil and CPO are positively related as these products are substitutable. Asmara et al. (2012) investigate the volatility of world CPO prices and their impacts on the performance of Indonesia's manufacturing sector. Meanwhile, some studies explore the influence of exchange rate fluctuation on the volatilities of food and biofuel prices (Abdelradi and Serra, 2015), and CPO exports (Sarwedi, 2010; Ginting, 2013; Aprina, 2014; and Nasution, 2016).

Unlike the previous studies that investigated both short-run and long-run relationships between the CPO price, soybean oil price, exchange rate, and its interlinks to other selected macroeconomic determinants, this study empirically explore the bivariate causal relationships between the volatility of world CPO price, world CPO supply, world price of soybean oil, world crude oil price, and exchange rate using Granger causality approach. The second contribution of our study is its focus on analyzing the impact of shocks in the foreign macroeconomic determinants, namely the world CPO supply, world price of soybean oil, world crude oil price, and global exchange rate on the volatility of the world CPO price using the impulse response functions and variance decomposition approaches. Finally, unlike the previous studies that mainly focus its analysis on the global CPO market, this study mainly focuses its analysis on the volatility of the CPO price and its determinants for the case of the largest CPO producing country, Indonesia. Comparing to its largest world CPO market share, the availability of existing empirical evidence on the volatility of CPO price and its determinants for the case of Indonesia has been meager compared to the existing empirical evidence on the global CPO market. Thus this study intends to fill this gap by providing latest empirical evidence on the effects of Indonesian CPO export on the volatility of world CPO price using the monthly data over the period from January 2008 to December 2017 (120 number of observations).

The findings of this study are hoped to shed some lights for CPO producers, palm oil plantation companies, investors, and downstream palm oil industry in making their decision to risk hedging and mitigation. The findings of this study are also useful for the governments of

the CPO producer countries, particularly Indonesia in designing the international trading policy related to the CPO price and its export.

The rest of this study is structured as follows. Section 2 reviews relevant literature to the CPO price and its determinants, while Section 3 provides the data and empirically estimated models as the basis for further analyses. Section 4 discusses the findings and their implication. Finally, Section 5 concludes the study.

2. Literature Review

Price volatility is a measure of the level of undirected price changes (Gilbert and Morgan, 2013). A relatively higher price change due to a decline in supply and an increase in demand is called as price volatility. In general, price volatility shows how much and how fast a price changes over time, for example, the CPO price. Furthermore, Gilbert and Morgan (2013) also explained that price volatility is a measurement of price dispersion. Statistically, he economists commonly measure price variation or price volatility using standard deviation.

Cabrera and Schulz (2016) examine the volatility of CPO price and its relation to the price of biodiesel. As a source for biodiesel, changes in soybean oil contribute changes in the CPO price and its exports. Comparing to CPO price, the price of soybean oil in the domestic market is more responsive to changes in market dynamics (Carolina et al., 2016). The changes in the price of soybean oil cause changes in the CPO price.

Furthermore, Asmara et al. (2012) found that changes in the world crude oil price have a different influence on economic sectors. The volatility of world oil prices tends to more impact on the performance of the industrial sector than the agricultural sector. The changes in the price of crude oil directly affect the volatility of food prices through agricultural production inputs, such as fertilizer and transportation, but it indirectly affects the prices of food commodities through increasing biofuel production. As an oil importing country, Indonesia is vulnerable to food price shocks because volatility in crude oil prices would trigger fluctuations in domestic food prices.

The movement of world CPO prices is also influenced by the volume or value of CPO exports (Azizah, 2015). In her study, Azizah (2015) find that Indonesia's CPO exports to the European zone is not affected by the changes in the world CPO prices. However, the CPO export prices are positively related to export volume, meaning that if export CPO prices rise then CPO export increases (Maygirtasari and Yulianto, 2015). In contrast, an increase in domestic CPO prices causes the level of Indonesian palm oil exports to decline (Riskayanto, 2013).

Furthermore, the changes in exchange rate contribute to the higher level of volatility of food and biofuel prices (Abdelradi and Serra, 2015). Changes in the exchange rate have a positive influence on the CPO exports in the long run, but it negatively affects the CPO price in the short-run (Sarwedi, 2010). Specifically, the decline in the exchange rate of the domestic currency (depreciation) encourages more exports in the short-run, but it gradually causes the reduction of the CPO export in the long-run. However, according to Ginting (2013), the depreciation of the exchange rate has a negative influence on the Indonesian CPO export both in short- and long-run. An increase in the level of CPO prices, either directly or indirectly through the monetary sector, is proven to cause an appreciation of the real exchange rate (Aprina, 2014). The higher the growth of world CPO prices, the higher the level of inflation, and the greater the appreciation of the real exchange rate. The sharp increase in world CPO price together with the depreciation of the IDR cause the CPO producers to export as much as possible. Consequently, this leads to the shortage of the CPO to meet domestic needs that, in turns, drive the domestic prices to soar (Nasution, 2016).

Finally, the volatility of the world CPO price is also affected by the changes in prices of its substitutable products such as soybean oil and other vegetable oil. Theoretically, as for the substitutable products, as the price of the CPO increases, consumers will demand more its substitutable product of soybean oil, similar to the finding of the study by Arianto et al. (2010) over the period 2004-2008 in Indonesia. Additionally, the movement of the CPO price would follow the movement of other vegetable oils because the producers of these products were competing to gain higher global market share of global vegetable oil. However, Arianto

et al. (2010) and Buyung et al. (2017) find that an increase in soybean oil price reduces the price of CPO in Indonesia during the periods 1980-2003 and 2005-2015, respectively.

The above-reviewed studies show that the volatility of the world CPO price is influenced by changes in the world CPO supply, world crude oil price, the price of its substitutable products, and the exchange rate. Thus, this study investigates the causal relationship between the variables and explore the extent to which the shocks in the determinants of the world CPO price is responded by the changes in the world CPO prices using Granger bivariate causality, the IRFs, and VDC.

3. Research Method

3.1. Data

Monthly data of world CPO price volatility (WCV), the Indonesian CPO export (ICX), the Malaysian CPO price (MCX), world crude oil price (WCP), world soybean oil price (WSP), and real effective exchange rate (RER) over the period from January 2008 to December 2017 were utilized in the study. The WCV is measured from the standard deviation of the monthly average price of world CPO based on the Rotterdam market in the USD per metric ton. The ICX and MCX are measured from the monthly average values of Indonesian and Malaysian CPO exports in the Indonesian Rupiah (IDR) and Malaysian Ringgit (MYR), respectively. The WCP and WSP are measured from monthly average prices of world crude oil and soybean oil in the USD per barrel. Finally, the RER is measured by the monthly nominal cross rate of the IDR against the USD Dollar multiplied by the ratio of the Indonesian consumer price index to the US consumer price index.

The data of the values of Indonesian CPO exports, nominal exchange cross rate of the IDR against the USD, Indonesian consumer price index, and the US consumer price index are gathered from the reports of Central Bank of Indonesia, Bank Indonesia (BI). The data on prices of the world CPO, soybean oil, and world crude oil is collected from the reports of the World Trade Organization (WTO). Finally, the data of values of Malaysian CPO exports is gathered from the reports of the Central Bank of Malaysia, Bank Negara Malaysia (BNM).

3.2. Empirical framework

To explore the causality between the variables and the impact of shocks in one variable on another variable, the following main econometric model is estimated:

$$WCV_t = \alpha_0 + \alpha_1 ICX_t + +\alpha_2 MCX_t + \alpha_3 WCP_t + \alpha_4 WSP_t + \alpha_5 RER_t + \varepsilon \quad (1)$$

where WCV is the world CPO price volatility, ICX is the Indonesian CPO export, MCX is the Malaysian CPO price, WCP is the world crude oil price, WSP is the world soybean oil price, and RER is the real effective exchange rate, (RER), α is the estimated value of each coefficient; and ε is the error correction term.

Prior to the analysis of the causal relationship, the unit root test is conducted first to ensure all variables are stationary regression. The regression findings become invalid and spurious while the non-stationary variables are used (Thomas, 1997). Basically, stationary shows that the mean, variance, and covariance of variables are constant over time. To check for the stationarity, the following standard ADF (Dickey and Fuller, 1979 and 1981) is adopted.

$$\Delta y_t = \beta_1 + \beta_2 t + \delta y_{t-1} + \gamma_i \sum_{i=1}^{m} \Delta y_{i-1} + \varepsilon_i \quad (2)$$

where Δy_t is the first difference of y, β_1 is the constant, β_2 is the predicted coefficient for a trend, δ is the predicted coefficient for lagged y, γ is the predicted coefficient for difference of the lagged y, ε is the error term, *m* is the number of lag, and *t* is the time period. In the stationary test, when the null hypothesis ($H_0: \delta = 0$) of a unit root is rejected, it indicates the variables to be stationarity and vice versa.

In the next step, the Granger causality test is conducted to explore the causal bivariate relationships between the variables within the vector autoregression (VAR) framework. The following VAR empirical models are estimated:

$$\Delta WCV_{1t} = \alpha_{10} + \sum_{i=1}^{k} \alpha_{11i}\Delta WCV_{1t-1} + \sum_{i=1}^{k} \alpha_{12i}\Delta ICX_{2t-1} + \sum_{i=1}^{k} \alpha_{13i}\Delta MCX_{3t-1} + \sum_{i=1}^{k} \alpha_{14i}\Delta WCP_{4t-1} + \sum_{i=1}^{k} \alpha_{15i}\Delta WSP_{5t-1} + \sum_{i=1}^{k} \alpha_{16i}\Delta RER_{6t-1}\varepsilon_{1it} \quad (3)$$

$$\Delta ICX_{2t} = \alpha_{20} + \sum_{i=1}^{k} \alpha_{21i}\Delta ICX_{1t-1} + \sum_{i=1}^{k} \alpha_{22i}\Delta WCV_{2t-1} + \sum_{i=1}^{k} \alpha_{23i}\Delta MCX_{3t-1} + \sum_{i=1}^{k} \alpha_{24i}\Delta WCP_{4t-1} + \sum_{i=1}^{k} \alpha_{25i}\Delta WSP_{5t-1} + \sum_{i=1}^{k} \alpha_{26i}\Delta RER_{6t-1}\varepsilon_{2it} \quad (4)$$

$$\Delta MCX_{3t} = \alpha_{30} + \sum_{i=1}^{k} \alpha_{31i}\Delta MCX_{1t-1} + \sum_{i=1}^{k} \alpha_{32i}\Delta WCV_{2t-1} + \sum_{i=1}^{k} \alpha_{33i}\Delta ICX_{3t-1} + \sum_{i=1}^{k} \alpha_{34i}\Delta WCP_{4t-1} + \sum_{i=1}^{k} \alpha_{35i}\Delta WSP_{5t-1} + \sum_{i=1}^{k} \alpha_{36i}\Delta RER_{6t-1}\varepsilon_{3it} \quad (5)$$

$$\Delta WCP_{4t} = \alpha_{40} + \sum_{i=1}^{k} \alpha_{41i}\Delta WCP_{1t-1} + \sum_{i=1}^{k} \alpha_{42i}\Delta WCV_{2t-1} + \sum_{i=1}^{k} \alpha_{43i}\Delta ICX_{4t-1} + \sum_{i=1}^{k} \alpha_{44i}\Delta MCX_{4t-1} + \sum_{i=1}^{k} \alpha_{45i}\Delta WSP_{5t-1} + \sum_{i=1}^{k} \alpha_{46i}\Delta RER_{6t-1}\varepsilon_{4it} \quad (6)$$

$$\Delta WSP_{5t} = \alpha_{50} + \sum_{i=1}^{k} \alpha_{51i}\Delta WSP_{1t-1} + \sum_{i=1}^{k} \alpha_{52i}\Delta WPV_{2t-1} + \sum_{i=1}^{k} \alpha_{53i}\Delta ICX_{3t-1} + \sum_{i=1}^{k} \alpha_{54i}\Delta MCX_{4t-1} + \sum_{i=1}^{k} \alpha_{55i}\Delta WCP_{5t-1} + \sum_{i=1}^{k} \alpha_{56i}\Delta RER_{6t-1}\varepsilon_{5it} \quad (7)$$

$$\Delta RER_{6t} = \alpha_{60} + \sum_{i=1}^{k} \alpha_{61i}\Delta RER_{1t-1} + \sum_{i=1}^{k} \alpha_{62i}\Delta WCV_{2t-1} + \sum_{i=1}^{k} \alpha_{63i}\Delta ICX_{3t-1} + \sum_{i=1}^{k} \alpha_{64i}\Delta MCX_{4t-1} + \sum_{i=1}^{k} \alpha_{65i}\Delta WCP_{5t-1} + \sum_{i=1}^{k} \alpha_{66i}\Delta WSP_{6t-1}\varepsilon_{6it} \quad (8)$$

To test for bivariate statistical causality, the F-statistic values of α_{ii} are referred. The rejection of the null hypothesis indicates the presence of Granger cause from one variable to another variable. From this test, four patterns of causal relationships between variables could be detected, namely: (i) a unidirectional Granger causality from the independent variable to the dependent variable; (ii) a unidirectional Granger causality from the dependent variable to the independent variable; (iii) a bidirectional Granger causality between the independent and dependent variables; and (iv) non-causal Granger relationship between the independent and dependent variables.

The lag length included in the Equations (3) to (8) is determined based on the Akaike (1969) Information Criteria (AIC). As the study uses time series analysis, the study carries out the required pre-testing to resolve the stationary properties of the data series adopting a widely unit root test of the standard Augmented Dickey-Fuller (ADF) as in the Equation (2).

Finally, based on the above VAR models, the study generate the Impulse Response Functions (IRFs) and the Variance Decomposition (VDC) to explore how the shocks of independent variables are responded by the dependent variable and to estimate the error variance of a variable to measure how much the difference between variance before and after shock. Specifically, the IRFs quantify the time profile of the impact of shocks at a specified point in time on the (expected) future values of variables in a dynamic scheme (Pesaran and Shin, 1998). This technique is well-suited in the study since it quantifies the relative strength of the diverse shocks in terms of their contributions to variations in a certain variable of interest and discovers the pattern and direction of the transmission of shocks. Thus, the duration of the influence of the shock of a variable on other variables until its effect disappears or returns back to the equilibrium point could be identified using the IRFs.

Meanwhile, the VDC measure the percentage of estimated errors of variables explained by other variables, or in other words the relative impact that one variable has on other variables. It identifies the estimated error variance of a variable to measure how much the difference between variance before and after shock. In short, the VDC can determine the magnitude of the contribution of independent variables in explaining the dependent variable when a shock occurs.

4. Findings and Discussion

Since most of the macroeconomic variables are non-stationarity (Serletis, 1992), thus to avoid from the spurious regression that results in non-robust and invalid empirical findings (Thomas, 1997), the study conduct first the test of stationarity using the standard Augmented Dickey-Fuller and Phillips-Perron (PP). The findings of stationary tests from both the ADF and PP are reported in Table 1.

Table 1. The ADF and PP tests for stationarity

Variable	Level		First Difference	
	ADF	PP	ADF	PP
WPV	-2.8731	-2.4745	-7.4330***	-7.4547***
ICX	-0.4837	-0.8938	-13.6072***	-39.1431***
MCX	-0.4298	-0.4887	-14.7422***	-14.9041***
WCP	-2.6503	-2.1510	-6.1975***	-6.1017***
WSP	-2.6179	-2.2321	-7.3331***	-7.2844***
RER	-2.1190	-2.2388	-10.2131***	-10.5786***

Note: The figures show the p-values of the ADF and PP tests. *** indicates significance at the 1% level.

As illustrated in Table 1, the study found that all variables (i.e., WPV, ICX, MCX, WCP, WSP, and RER) were non-stationarity at the level, *I*(0) both using the ADF and PP tests. Thus, to ensure for their stationarity, all variables are tested their stationarity at the first difference. The tests showed that all variables become stationarity after taking their first difference, *I*(1) both using the ADF and PP tests. These findings showed that for further analyses of causal bivariate relationships and impact of shocks in one variable on another variable, the *I*(1) variables should be used to arrive at the robust and valid empirical findings.

After confirming all data were stationarity at the *I*(1), in the next step, the study determine the optimal lag-length to be included in the model using the lag-length criterion of Likelihood Ratio (LR), Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwartz Information Criterion (SIC), and Hannan-Quinn Information Criterion (HQ). Referring to these lag-length criteria, the lag-length of 4 is found to be the optimal lag-length included in our estimated model. Thus, for further analyses, the lag-length of 4 is incorporated in the estimated model.

As stated earlier, to explore the causal bivariate relationship between the variables, the Pairwise Granger causality test based on the VAR framework is conducted. The findings of the bivariate causal relationships are reported in Table 2.

As observed from Table 2, the study found that the world CPO price volatility is only Granger-caused by the real exchange rate (RER) and Granger caused the Malaysian CPO export (MCX) and world crude oil price (WCP). These proved that the world CPO price volatility caused the changes in the Malaysian export and drive the world crude oil price to change, while the changes in real effective exchange are found to be the only factors Granger caused the world CPO price volatility. As the world economy moving towards more integrated into the globalization era (Karim and Majid, 2009, 2010; Kassim et al., 2011; and Majid and Kassim, 2009, 2010), thus any changes in the real exchange rate would cause the price of the world CPO to become more volatile. This further indicates that to stabilize the world CPO price it is extremely important to ensure the stability of the exchange rate globally.

Table 2. The bivariate Granger causal relationships between the variables

Null Hypothesis	F-Statistic	Prob.	Null Hypothesis	F-Statistic	Prob.
ICX ≠ WPV	0.3912	0.6772	ICX ≠ WSO	0.2688	0.7648
WPV ≠ ICX	1.4759	0.2330	RER ≠ ICX	1.9603	0.1456
MCX ≠ WPV	0.1608	0.8517	ICX ≠ RER	0.7159	0.4910
WPV = MCX	5.2431***	0.0067	WCP = MCX	8.3110***	0.0004
WCP ≠ WPV	0.2982***	0.7428	MCX ≠ WCP	0.0501	0.9511
WPV = WCP	5.1704	0.0071	WSP = MCX	6.9755***	0.0014

Null Hypothesis	F-Statistic	Prob.	Null Hypothesis	F-Statistic	Prob.
WSP ≠ WPV	0.2350***	0.7909	MCX ≠ WSP	0.9404	0.3935
WPV ≠ WSP	1.6188	0.2027	RER ≠ MCX	0.6936	0.5019
RER = WPV	4.9809	0.0085	MCX ≠ RER	0.2439	0.7840
WPV ≠ RER	1.7751	0.1742	WSP ≠ WCP	1.4664	0.2352
MCX = ICX	2.9338	0.0573	WCP ≠ WSP	0.1674	0.8460
ICX = MCX	2.7503	0.0682	RER = WCP	4.5554	0.0125
WCP ≠ ICX	0.4605	0.6321	WCP = RER	7.2389	0.0011
ICX ≠ WCP	2.1631	0.1198	RER = WSP	4.6648	0.0113
WSP ≠ ICX	0.65783	0.5200	WSP ≠ RER	2.0035	0.1397

Note: = indicate the presence of bivariate Granger causal relationship, while ≠ indicates the absence of bivariate Granger causal relationship. ***, **, and *indicate significance at the 1%, 5%, and 10% levels, respectively.

Interestingly, the Indonesian CPO export (ICX) only found to have a bidirectional Granger causal relationship to the Malaysian CPO export (MCX), while other variables were found no significant effect on the Indonesian CPO export. As the major competitive trading partner, Malaysia is the second largest producer CPO country after Indonesia, thus any changes of CPO export in these countries would cause the world CPO supply, which in turns, affect their CPO exports. This finding further implies that to gain greater benefits from their CPO exports, these two largest CPO producing countries should engage in a more cooperative way of determining their CPO supply. In addition, ass Indonesia is a more isolation economy from the rest of the world (Majid et al., 2008, 2009, 2018), thus the changes in other variables have no significant effect on the Indonesian CPO export.

Unlike the Indonesian CPO export (ICX), the Malaysian CPO export (MCX) is Granger caused by the world CPO price volatility (WPV), world crude oil price (WCP) and world soybean oil price (WSP). This indicated that the Malaysian CPO export is more exposed to world commodity prices. The Malaysian effort to embark its palm oil industry into renewable energy, thus the changes in the Malaysian export would affect the world crude oil price (Abdulrazik et al., 2017). These findings further imply that to promote the values of CPO export, Malaysian government could design its owned specific macroeconomic stabilization policy, as the findings suggested the significant influences of the Malaysian CPO export on the world commodity markets.

Furthermore, the study documented that the world crude oil price (WCP) is Granger caused by the world CPO price volatility (WCV), indicating the significant role of changes in world CPO price in determining the world oil price. Since the palm oil is one of the renewable energy sources (Loh, 2017; and Giwa et al., 2017), thus increase in the world CPO and other agricultural commodity prices would cause the rise in world crude oil price (Nazlioglu and Soytas, 2012). In addition, the study documented a bidirectional causal relationship between the world crude oil price (WCP) and world soybean oil price (WSP) with the real effective exchange rate (RER), similar to our earlier findings on the significant causes of exchange rate on the price of world CPO. These findings further confirmed the important role of the exchange rate in determining the stability of world commodity price (Yang et al, 2017; and Alley, 2018). Thus, managing the stability of the exchange rate is the most crucial strategy in stabilizing the world commodity markets. Macroeconomic harmonization among the country in the globe is extremely important for stabilization of the world economy, including the world CPO market.

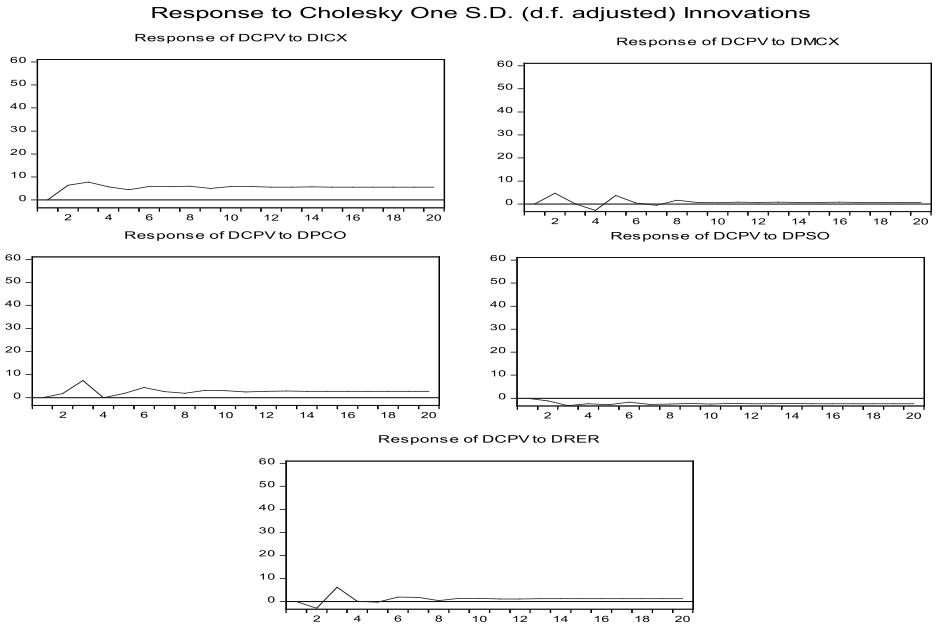
After discussing the findings from the Granger bivariate causalities among the variables, the study now presents and discusses how the variable is responded to the shocks in other variables using the Impulse Response Functions (IRFs) and Variance Decomposition (VDC) analyses. Figure 1 reported the findings from the IRFs based on one standard deviation for a 20-month time horizon.

Referring to Figure 1, the study found that, in the first period, the shocks in the Indonesian CPO exports (ICX) have no effect on the world CPO price volatility (WPV). However, in the

next periods, the shocks in the Indonesian CPO export caused the world CPO price volatility for a few months before its return to the equilibrium point. This finding is in line with the finding by Buyung et al. (2017), who found that an increase in the world CPO price encouraged the exporting countries to increase their exports to gain higher benefits from international trading activities.

In addition, the study found that the shocks in the Malaysian CPO export caused a one standard deviation changes in the world CPO price. Although during the first period, the shocks in the Malaysian CPO price did not cause the world CPO price volatility, but in a few months later, the world CPO price has been become more volatile due to the shocks in the Malaysian CPO exports. During the second-, third-, fifth-, and six-month period it has a positive response, while starting from the third-to the fourth-month and during the sixth-month period, the response was negative. However, during the seventh-month period onwards, the changes in the world CPO prices responded positively to the Malaysian CPO exports.

Figure 1. Responses of world CPO price volatility to the shocks in other variables



Furthermore, the study documented that the shocks in the world crude oil price (WCP) only caused the changes in the world CPO price starting from the second month period. During the second- and the third-month period the changes in world crude oil price responded positively by the changes in the world CPO price and then it turned back to the equilibrium point. However, the world CPO price has again responded positively to the changes in the world crude oil price after the fourth-month period onwards. This is due to the fact that palm oil is one of the renewable energy sources, thus any changes in the world crude oil prices would be positively responded by an increase in the world CPO price.

Finally, the shocks in the world soybean oil prices (WSP) and real exchange rate (RER) caused the world CPO price to become more volatile starting from the second-month period onwards. This could be due to the success of the black campaign by the vegetable oil producing countries on the negative externality caused by the palm oil plantation and industry which resulted in the reduction of world market demand for palm oil. This finding is in harmony with our previous finding on the negative effect of the world price of soybean oil on the world CPO prices. Unlike the shocks in the world soybean oil price that has an adverse effect on the world CPO price over the 20-month time horizon, the shocks in the real exchange rate have a mixed effect on the world CPO price volatility. In the second period, shocks in the real exchange rate are negatively responded by the world CPO price, while during the fourth to the fifth period it turned back to the equilibrium position.

To support our findings based on the IRFs, we further conduct the Variance Decomposition (VDC) analysis to find out how much the shocks in independent variables could explain the changes in the dependent variable. The findings of the VDC are reported in Table 3. Table 3 showed that the changes in the world CPO price is predominantly explained

by its owned shocks (98.57%), while the shocks in other variables only explained less than 2% of the world CPO price volatility [i.e., the Indonesian CPO export (1.73%), the world crude oil price (0.85%), real exchange rate (0.70%), the Malaysian CPO export (0.42%), and the world soybean oil price (0.28%)].

Table 3. Variance in the dependent variable due to the independent variables' shocks

Variable	WPV		ICX		MCX		WCP		WSP		RER	
WPV	(2)	98.57	(9)	3.23	(2)	2.48	(10)	26.42	(10)	62.89	(5)	4.80
ICX	(10)	1.73	(1)	98.57	(5)	1.77	(3)	1.06	(5)	1.86	(10)	4.10
MCX	(5)	0.42	(10)	9.66	(1)	97.84	(4)	0.17	(5)	0.93	(6)	0.94
WCP	(3)	0.85	(9)	2.59	(10)	0.30	(1)	83.27	(10)	10.61	(10)	13.11
WSP	(10)	0.28	(7)	3.75	(3)	2.98	(3)	0.25	(1)	33.77	(1)	10.64
RER	(3)	0.70	(5)	6.07	(8)	0.26	(3)	0.81	(2)	1.07	(1)	87.17

Note: (.) indicates the period with the highest value.

Furthermore, the shock in the Indonesian CPO export is also explained primarily by its owned shocks by 98.57%, while the shocks in other variables only explained between 2.59% to 9.66% changes in the Indonesian CPO export. However, the shocks in the Malaysian CPO export (9.66%) is found to explain the largest changes in the Indonesian CPO export, finding further supported our earlier findings on the important role of Indonesia and Malaysia in determining changes in the world CPO price through their CPO supply as these countries are the two largest CPO producing countries in the world.

Similarly, the changes in the Malaysian CPO export is also primarily explained by its owned shocks by 97.87%, while the shocks in other variables could only explain about 0.26% to 2.98% changes in the Malaysian CPO export. Although the shocks in the world crude oil price are dominantly explained by its owned shocks by 83.27%, but the changes in the world CPO price explained 26.42% changes in the world crude oil price. The shocks in other variables could only explain less than 1% changes in the world crude oil price. This finding further confirmed the crucial role of palm oil as a raw material for renewable energy. To ensure the stability of world CPO price, thus it could be materialized through the use of palm oil as a source of renewable energy. Following the Indonesian government's success in implementing the B20 palm oil program, the government agenda to implement the B100 program since August 2018 to anticipate the decline in the world CPO price should be taken seriously.

Interestingly, the changes in the price of world soybean oil are explained more by the shocks in the world CPO price (62.89%), followed by the shocks in its own variable (33.77%), the world crude oil price (10.61%), the Indonesian CPO export (1.86%), the real exchange rate (1.07%), and the Malaysian CPO export (0.93%). The large contribution of the changes in world CPO prices in explaining the shock in the world soybean oil price was due to these commodities is substitutable to each other. However, this finding indicated the superior of palm oil to soybean oil due to its potential sustainability and low production costs as compared to the soybean oil production. Thus, the campaign to the discrimination of palm oil from other types of vegetable oil has been more of the agenda of business politics.

Finally, the changes in the exchange rates is dominantly explained by its own shocks (87.17%), while the shocks in other variables, i.e., the world crude oil price, the world soybean oil price, the world CPO price, the Indonesian CPO export, and the Malaysian CPO export explained the changes in the exchange rate by 13.11%, 10.64%, 4.80%, 4.10%, and 0.94%, respectively. These findings further confirmed our earlier findings that the world economy is very much dependent on the stability of crude oil prices as the most important source of energy. The recent higher volatility of world crude oil price has adversely impacted the Indonesian economy, especially due to the instability of the world CPO prices and the IDR.

As the largest palm oil producing country, Indonesia would not enjoy higher benefits from its CPO export unless the Indonesian government could design proper strategy to stabilize the domestic crude oil price, managing the stability of the IDR, and enhance more macroeconomic policy harmonization with its neighboring country of Malaysia as the second largest palm oil producing country. Combining the CPO exports of Indonesia and Malaysia, these countries could capture 87% of the world palm oil market share (The Ministry of

Plantation Industries and Commodities of Malaysia, 2015). Having a macroeconomic policy harmonization between the countries, Indonesia and Malaysia could easily enjoy greater benefits from international palm oil trading activity that consequently contribute more towards their sustainable development.

5. Conclusions and Recommendations

The recent phenomena of the higher level of the world CPO price volatility influence the value of the CPO export of Indonesia as the world's largest palm oil producing country that captures 47.16% of the world palm oil markets (Sulaiman et al, 2011). The ability of Indonesia to control over the world CPO price would maximize its revenue from international trading activities. This study provided the latest empirical evidence on the bivariate causal relationship between Indonesian and Malaysian CPO exports, the world crude and soybean oils, exchange rate, and the world CPO price volatility using the bivariate Granger causality analysis. It also attempted to explore the extent to which the shocks in the Indonesian and Malaysian CPO exports, the world crude and soybean oils, and exchange rate influenced the world CPO price volatility using the Impulse Response Functions (IRFs) and Variance Decomposition (VDC) analyses over the period from January 2008 to December 2017.

The study found that the world CPO price volatility is only Granger-caused by the changes in the real exchange rate, while other variables were found to have no significant effect. The shocks in the exchange rate are responded differently by the world CPO price volatility, depending on whether the exchange rates were depreciating or appreciating. On the other hand, the world CPO price volatility Granger caused the Malaysian CPO export and world crude oil price. Interestingly, the Indonesian CPO export only found to have a bidirectional Granger causal relationship to the Malaysian CPO export as these two countries contributed 87% to the world palm oil markets. The shocks in the Indonesian CPO export is positively responded by the world CPO price volatility and world crude oil prices, while the shock in the world price of soybean oil is negatively responded by the world CPO prices. Moreover, the Malaysian CPO exports are Granger-caused by the world CPO price volatility, world crude oil price, and world soybean oil price. The world crude oil price is Granger caused by the world CPO price volatility. Finally, the study found a bidirectional causal relationship between the world crude oil price and world soybean oil price with the real effective exchange rate, indicating the important role of exchange rate in determining the stability of world commodity price.

Our findings suggested that to gain greater benefits from its CPO export, Indonesia should engage in a more cooperative way in determining their CPO prices and supply with Malaysia as the second largest palm oil producing country after Indonesia. Macroeconomic policy harmonization on the CPO price and production as well as exchange rate policy should be innovatively designed between Indonesia and Malaysia through the existing Council of Palm Oil Producing Countries (CPOPC) if these counties intend to gain more revenue from their CPO exports in the future. Additionally, maintaining higher domestic CPO prices is needed as it could promote the palm oil-based downstream industry to diversify palm oil-based products of high economic value. More efforts should be done to implement advanced technologies to utilize palm oil as a major source of renewable energy. Following the success in implementing the B20 palm oil program, the B100 palm oil agenda that has been introduced since August 2018 should be implemented seriously to anticipate the decline in the world CPO price. Thus, more efforts should be done to implement advanced technologies to utilize palm oil as the major source of renewable energy

To provide more comprehensive findings on the world CPO price volatility, further studies on this issue might incorporate not only the economic determinants of the CPO price and production, but also cover political, social, environmental, legal, and technological factors both from the demand-side and supply-side perspectives. Both short run and long run non-linear relationships between the world CPO price and production and its economic, political, social, environmental, legal, and technological determinants could also provide a broader picture and enriched empirical evidence on the recent phenomenon of the higher level of volatility of the world palm oil price.

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