Research Paper

Impact of Crude Palm Oil prices on Indonesia's GDP during 2000-2018

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Abstract

Palm oil has been acknowledged as one of the main agriculture commodities for Indonesia export. Currently, Indonesia is the largest palm oil producer and exporter country (BPS, 2018). This research tries to analyze whether the fluctuation in the international palm oil prices have significant influence on the Indonesia GDP. After describing the role of palm oil to Indonesia GDP from 2000 to 2018, the effect relationship will be conducted through regression and vector autoregressive (VAR). From 2000 to 2017, total area for palm oil plantation in Indonesia has grown triple and CPO export has increased triple, in average is 9% to total goods export. The average ratio between CPO export to ratio is 1.03 means most of the production is for export, and 41.44% of that CPO consists of CPO purely. There is positive and high correlation between GDP and CPO export value. By bivariate regression between de-trended GDP and international palm oil price, change in price by USD1, the GDP will increase by IDR12 billion, and when it increases by 1%, the GDP will also increase by IDR8.2 trillion, vice versa when it declines. Finally, through VAR, causality relationship between palm oil price to GDP is found, and change in price by 1% will change GDP by less than 0.1% in the next first quarter.

Keywords: international palm oil price, GDP

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Impact of Crude Palm Oil prices on Indonesia's GDP during 2000-2018

Over the past years, palm oil has been acknowledged as one of the main agriculture commodities for Indonesia export. The palm oil is produced from the fruits of the palm oil tree (*Elaesis guineensis Jacq.*). Initially, commercial palm oil estates were located only in Sumatra Island, and nowadays, they can be found on other islands. This sector was getting more interest after the Asian Financial Crisis in 1997. During that period, many palm oil farmers got windfall profits because the exchange rate depreciated. Their contribution to the economy GDP is in the agricultural sector. Indonesian Central Statistics Agency (BPS), in measuring the GDP based on production, classified the methodology into nine sectors, like mining and quarrying; agriculture (including livestock), forestry, and fishery; manufacturing industries, and construction. Agriculture still has important role in Indonesia economy, and palm oil is the top contributor. Currently, Indonesia is the world's largest palm oil producer and exporter country (BPS, 2018). One of the positive aspects of this sector, according to the IMF in its Article IV Consultation on Indonesia in 2017, is that the decrease in current account deficit from 1.8% to 1.5% of GDP from 2016 to 2017 is contributed by the increase in export volumes, mainly coal and palm oil (IMF, 2018).

Palm oil sector indeed has contributed positively to the economy, and it has become one of the favorite discussions whether its role is dominant or not. In 1990, the total area utilized for palm oil plantation was 1.1 million hectare and the area nearly double in 2000 by 1.9 million hectare and increased sharply in 2017 by 12.3 million hectare. The attractiveness of palm oil plantation has encouraged many households and firms to view this sector as investment, for example in 2017, 45% of the total area for the plantation was owned by small holders (by Ministry of Agriculture regulation in 2020, maximum for each household is 4 hectare), and 49% of the total area was owned by private enterprises. It is difficult to mention whether Indonesia's economy dependency

to palm oil has increased, but the development of palm oil has grown. In 2018, Indonesia GDP nominal value was higher than in 2017, but the GDP growth rate was below the target (assumption agreed by the Government and the Parliament when formulating the budget for 2018). International commodity prices, especially palm oil was mainly suspected as the challenge why the economy could not perform well to achieve the target. Furthermore, most of the palm oil production is used for export needs, for example in 2017 was 70%. The palm oil price fluctuation in international market may give some effect to export side.

This research tries to analyze whether the fluctuations in the palm oil price internationally have significant influence on the Indonesia GDP. This paper will describe the role of the current research in other researches related to the palm oil price effect in the Indonesia economy, the historical data explanation regarding the palm oil sector and Indonesia growth, and some inferential analysis. The reason why this paper only mentions about CPO rather than palm oil in total because most the product is in CPO, which in 2017 was 83%, and the portion of CPO export value to Indonesia total export in 2017 was 10%. The export volume is increasing from year to year. Meanwhile, palm oil kernel export is relatively more stable from year to year. The method used for this research is mostly quantitative approach. The data collected is from secondary resource domestically from Indonesia and abroad. The time frame of the analysis is from 2000 to 2018. Those years are selected because it is the recovery period after Asian Financial Crisis, also the role of palm oil estates became widely recognized in Indonesia. This paper can hopefully give some insights for many stakeholders in palm oil sector about the recent relationship between international palm oil price and Indonesia economy.

Literature Review

Top influence of oil price on the economy is still the main references for the effect of commodities prices on economy. For example, in the United States, by using vector autoregressive (VAR), the oil price increases amplify the oil price shock transmission for the lag period two years (Kilian and Vigfusson, 2016). In that research, oil price shocks can explain that 3% of real GDP reduced cumulatively in the late 1970s and early 1980s, and the number increases become 5% when financial crisis took place. For the world economic growth, the effect of oil price is different between importer and exporter countries, where the correlation between oil price and economic growth is negatively correlated for importer countries, and it is positively correlated for the exporter ones (Ghalayini, 2011). Other finding in that research is there is Granger causality in the interaction between oil price changes and economic growth for the G7 countries.

From analysis of English-language research on the influence of the palm oil price on domestic economy reveals that the number of researches is not many, and most existing English-based researches are conducted by Malaysian people. Nevertheless, majority of the economic researches are focused on the issue to increase export volume. This same perspective to increase palm oil export also happens for researches conducted by Indonesian people. For example, the paper published by Amzul, 2011. By his analysis, based on input-output and social accounting matrix (flow of palm oil transactions into production factors and some institutions to capture its relationship among sectors to the economy), the palm oil sector contributes less than the animal and vegetable oil processing sector in output and value added, but in terms of employment, palm oil sector has more contribution (Amzul, 2011). The contribution described from the palm oil sector to the economy is based on accounting perspective rather than the econometrics. That research also oriented to increase export competitiveness, by also explaining the position of the

product in three countries: People's Republic of China, India, and the Netherlands. Currently, the largest importer of Indonesia palm oil is India, followed by the Netherlands.

Lastly, most researches about the effect of palm oil price on Indonesia GDP found are available in Indonesian language. The researches vary from regional level to national, and either in agricultural or economics. One of the recent related research to this paper mentions that the change of crude palm oil (CPO) price in international market will have effect to Indonesia palm oil commodity export, and to the GDP for 15 months, will increase inflation for one year, increase the money supply for 6 six months, and will negatively impact the real exchange rate for ten months from 2001 to 2013 (Azwar, 2015). However, the research does not address some endogeneity which may take place among the variables, especially palm oil production and price. From all those perspectives, this research aims to fill the existing gap and enrich the academic references in English about the influence of palm oil price on the economy of Indonesia.

Descriptive Analysis on Current Development of Palm Oil Industry in Indonesia Economy

The total area for palm oil plantation in Indonesia has grown triple from 2000 to 2017. The plantations owned by the State-Owned Enterprise—which will be called government estate, private enterprise, and smallholders. The area owned by government estate is relatively stable, and it shows some declining area from 2015. The land acquired by private and smallholders increase every year. Since 1989, private plantations have owned more land than the government estate for palm oil plantation. The smallholders' plantations have become the second largest land owner for palm oil estates since 1992. From the land-acquisition or ownership perspective, the government role in palm oil plantation is low.

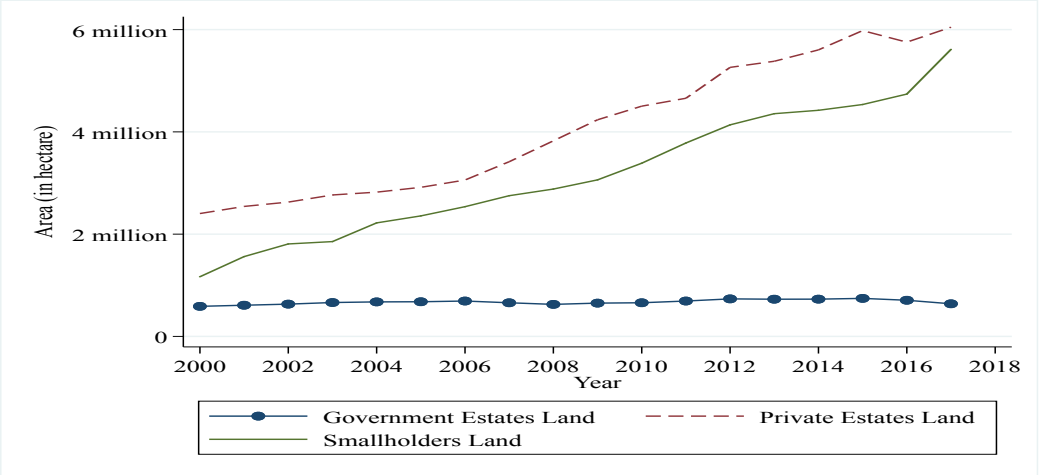

Figure 1. The area development of palm oil plantation from 2000 to 2018. Source: Indonesia Statistics Office data.

Furthermore, the share of government role for land cultivation in palm oil plantation has become lower from 2000 to 2017, by 15% to 6%. Smallholders' plantation shows increasing growth seems larger than private sector, although they have not yet exceeded its share. In the previous figure, the line slope of the smallholders one is larger than the slope of the private one from 2000 to 2017. When the palm oil price, especially the international one decline, it may affect mostly to the private plantation firms' managerial decision making and smallholders' household consumption, rather than to the government estate.

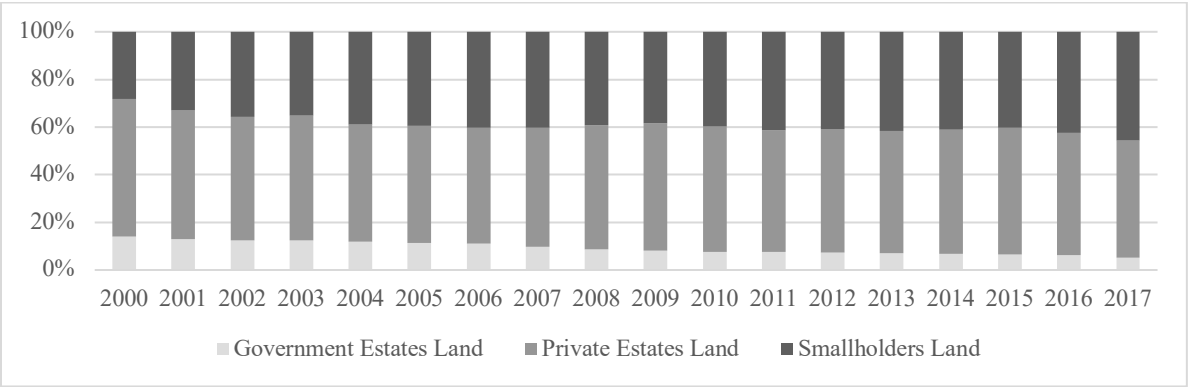

Figure 2. The share of area cultivated for palm oil plantation from 2000 to 2017. Source: Indonesia Statistics Office data.

When the land becomes increase, the total productions should increase, which is shown in the below figure for the three land-ownership categories. Nevertheless, the ratio between the production and land to display its productivity may be different for each category of estate-ownership. Private and smallholders' plantation shows positive trend of productivity, and the private one has larger ratio than the smallholders. Government estates shows volatile trend, positive in some periods and sometimes the ratio declines, for example, because the production dropped since 2015, it has declining pattern in 2016. It shows recovery signal after land area reduction in the following years.

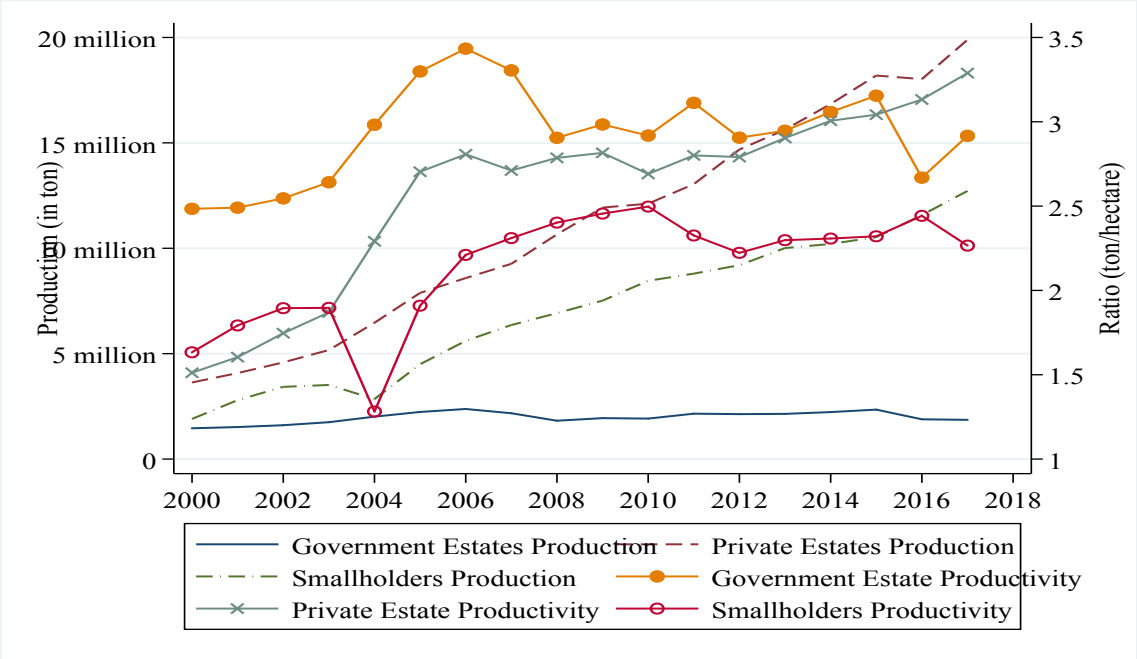

Figure 3. Palm oil production and ratio of production to land area from 2000 to 2017.

Source: Indonesia Statistics Office data.

The product from palm oil, generally can be classified as CPO and palm oil kernel. CPO is derived from the flesh of palm oil fruit, and mostly traded in liquid form as oil. Palm oil kernel is the nucleus of the palm oil. The oil from the kernel is extracted from the seed. Another main difference is that palm oil kernel is more commonly used in non-edible industry. Most of the

production output is used for export purpose. CPO dominates the palm oil industry products by more than 80% from 2000 to 2017.

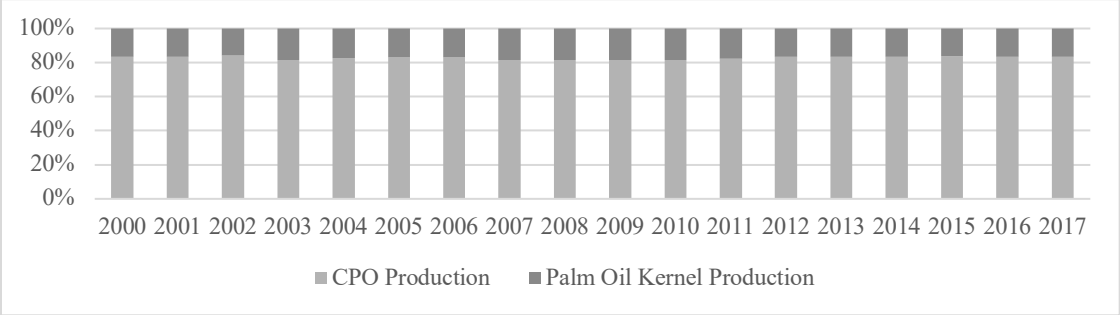

Figure 4. Composition of palm oil production from 2000 to 2017. Source: Indonesia Statistics Office data.

CPO export volume shows increasing trend over year, and Palm oil kernel one is relatively stable. For the year data ratio of export to production, it shows decreasing trend for both products. The CPO export to production ratio in some periods is more than one which indicates the interpretation that in those years, export tonnages were larger than the production volumes. Some explanations for the miss-match are by doing import, or the CPO volume has become larger due to some chemical addition process in some CPO derivative products. Despite the increase of production volume, the increase of domestic demand may be one of the reasons in the declining trend.

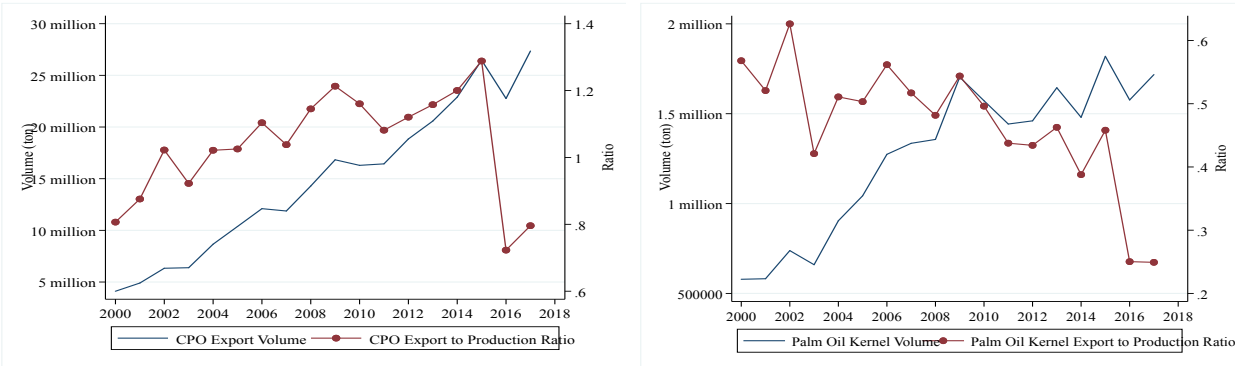

Figure 5. Palm oil product export volume and its ratio to production from 2000 to 2017. Source: Indonesia Statistics Office data.

CPO is the main export commodities in Indonesia. Other commodities after CPO are coal, and oil. The proportion of CPO to total export has exceeded 10% since 2007, and the peak was in 2012 at 13.06%. The contribution average from 2000 to 2017 is 9%. Currently, Indonesia is the largest producer and exporter country. Other major commodity, like coal, was the prime commodities from 2009 until 2013, and Indonesia was proud as the second largest exporter country (after Australia). Recently the fall of the coal commodity may still give bad impact on the economy.

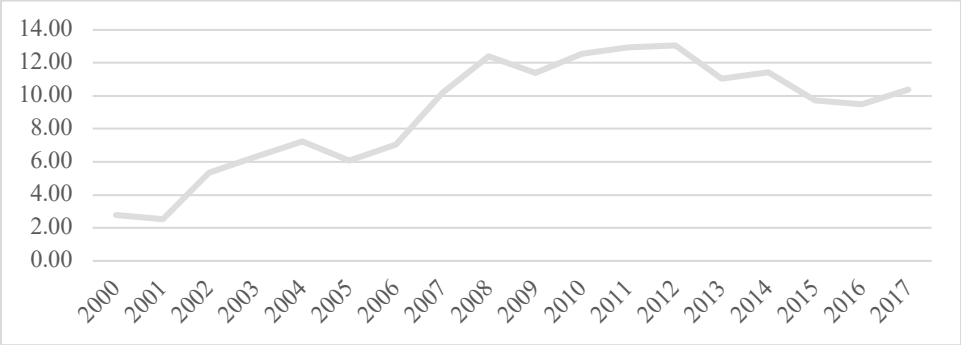

Figure 6. The contribution of CPO export value to total export. Source: Indonesia Statistics Office data, some is retrieved from Bank Indonesia website.

Indonesia economy shows the increasing trend of GDP in constant price (year 2000) from 2000 to 2018. For the GDP, the value has increased become more than double from 2000 to 2018. Nevertheless, the annual growth rate of the GDP from its previous period varies from year to year, as shown in the figure below. The growth rate is always positive, but it may be higher from the previous period, or lower from the previous one. The positive growth rate implicates that GDP value always increases for each period, but the amount increased may vary depending on the growth rate itself. For the case in 2018, the fluctuation in the growth rate is suspected from the fluctuation in the international price of palm oil, especially for quarterly GDP growth rate. Based on that information, this paper will try to capture some interaction between the international palm oil price and Indonesia GDP from 2000 to 2018.

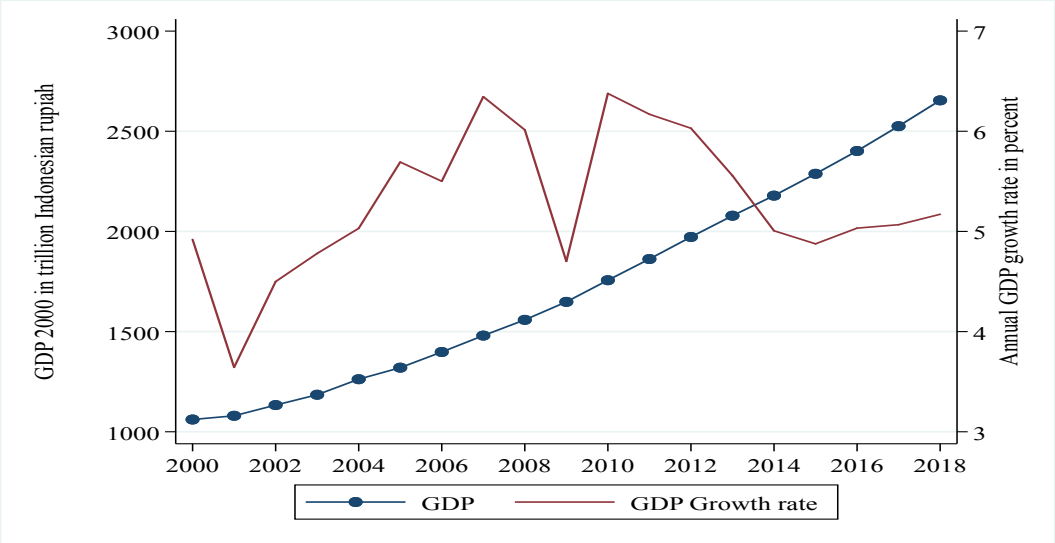

Figure 7. Indonesia GDP and annual GDP growth from 2000 to 2018. Source: FED St. Louis website.

After knowing the GDP—especially in the constant price—always increases over years, the next necessary step is to conduct contribution/proportional analysis of palm oil sector, especially CPO. Palm oil contributes to the GDP (the next data used is current price perspective) from export side (based on expenditure approach), and from the plantation crops subsector (based on production sector). One of the other reasons using current price data is because the price effect has not yet omitted in the observed variables, like CPO export value. In 2018, the Government targeted in the budget assumption that the economy (GDP) would grow at 5.4% year on year from 2017, but the realization was only 5.17%. In the quarterly period, the slow GDP growth in Q1 at 5.06% (below the expected 5.1%) was contributed by many factors, and one of them was the decline in the CPO price.

The GDP classification by BPS as previously mentioned for agriculture, forestry, and fishery sector can be further classified into agriculture, livestock, hunting, and agricultural services; forestry and logging; and fishery. The plantation is positioned under the agriculture,

livestock, hunting, and agricultural services. The nominal value of the contribution can be seen in the following graph.

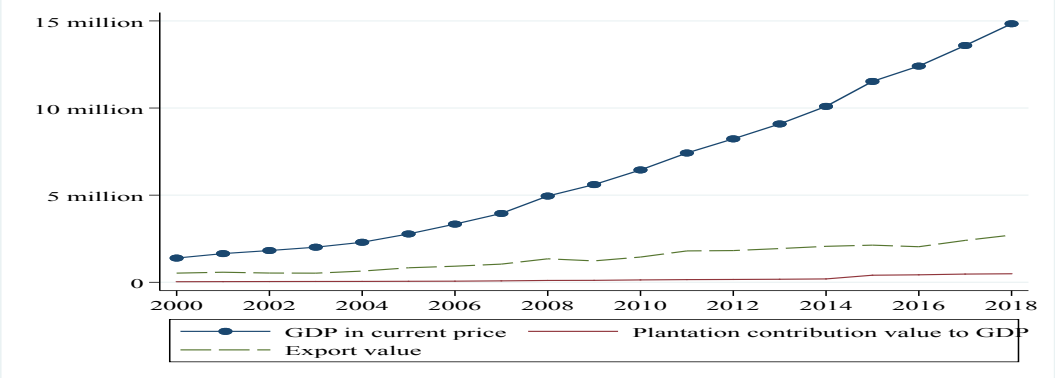

Figure 8. The contribution of export and plantation sector in GDP (current price). Source: Indonesia Statistics Office data, retrieved from Bank Indonesia website.

Nominally, the plantation sector and export relatively stable, which in the proportion perspective, their contribution become smaller. For example, export to the GDP on average is 24.77% with the maximum point of 37% in 2000. From this perspective, the contribution palm oil over the years should be illustrated in the proportion, as in the following graph. Also, the figure includes new variables, which is CPO export value proportion.

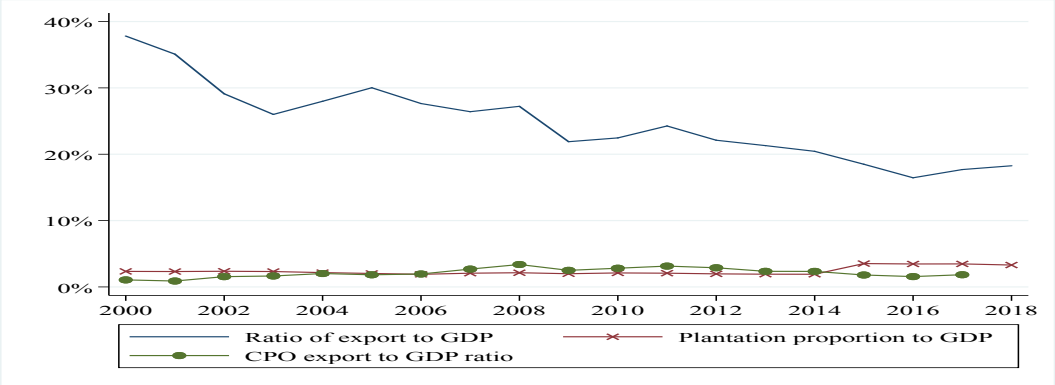

Figure 9. The ratio proportion of plantation sector, export, and CPO export to GDP over years. Source: Indonesia Statistics Office data, some are retrieved from Bank Indonesia website.

Although the trend shows that CPO export ratio is around 1 to 2% to GDP as the whole, The highest proportion shown during the observation period is in 2011 (3.14%) and the lowest one is in 2001 (0.89%), with the average of 2.12%. One of the interesting findings about the graph about is the ratio of CPO export value to GDP exceed the trend of plantation sector contribution to GDP from 2004 to 2014. The CPO export value in 2008, 2011, and 2012 exceeded the plantation sector contribution. During that period, most of the CPO produced is mostly traded as export commodities. The trend has reversed since 2014, probably it is because domestic demand for industry supply-chain material increases. Also, in 2014, the Government once imposed export levies USD50 for each ton volume to the CPO export. On average, the percentage of plantation sector contribution to GDP is higher than the CPO export, and the value is 2.39%.

From the correlation test perspective, GDP in current price, export, and all the observed variables during the period 2000 to 2018 are positively correlated. The coefficients for each two variables tested can be found in the table below.

Table 1.

Coefficient of correlation of Indonesia GDP in current price, export value, plantation sector contribution, and CPO export value during 2000 to 2018

No.	Correlation	Coefficient
1.	GDP-export value	0.9602
2.	GDP-plantation sector	0.9500
3.	GDP-CPO export value	0.9021
4.	Plantation sector-CPO export value	0.7232

Note: Source: FED St. Louis website, and Indonesia Statistics Office data, some are retrieved from Bank Indonesia website

From the descriptive analysis perspective, the contribution of CPO export in Indonesia economy, specifically GDP seems small, only 1-2% of the GDP, and it has positive coefficient of correlation with the GDP.

Interaction between International Palm Oil Price and Indonesia GDP

This is the start of inferencing analysis part. The first step is conducting bivariate simple regression by only using two variables. This regression aims at studying the relationship of variables, in terms of how the dependent variable with changes in the independent variable. This research only emphasizes on the impact (inferential purpose) rather than the other use of regression for prediction. The assumption in this analysis is that the relationship between the two variables are in the linear function. The common equation for this analysis is:

$$y_i = \beta_0 + \beta_1 x_i + \varepsilon_i$$

In that equation, y_i is the dependent variable, and x_i is the independent one. While, $\beta_0$and β_1 are the parameter of the regression and ε_i is the random error term. The data used for this regression part will be monthly data.

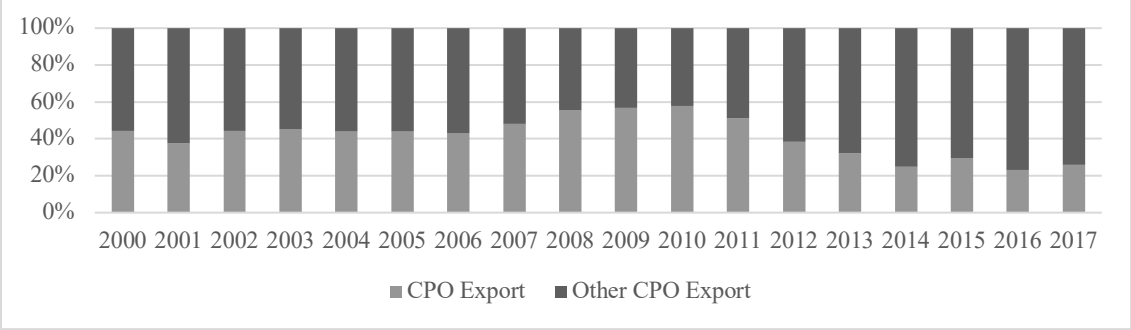

Figure 10. Composition of Indonesia CPO Export from 2000 to 2017. Source: Indonesia Statistics Office data.

In international trade, Indonesia CPO is classified into two commodities based on the Harmonized Standard (HS) System, which are CPO (HS 151110000) and Other CPO (HS 151119000). In the previous years, the portion of CPO (HS 151110000) commodity in the CPO export was nearly 50% of the trade volume. Recently, the proportion has declined, but the average is still high by 41.44% from 2000 to 2017. In my opinion, the CPO (HS 151110000) commodity

can represent the CPO. For the regression analysis ahead, all CPO export data which will be used is the HS 151110000 only. One of the considerations is because they have different HS, tariff rates may be charged differently, and this research want to ignore the tariff which may influence export. Here is the result of bivariate regression relationship between some palm oil and CPO data variables that will be used further. The international price (of palm oil) defined in this research is the data from Malaysia Palm Oil Futures (first contract forward) which is retrieved from the IMF database. The variables of change of the previous variables are obtained by applying natural logarithm function to the existing original data, which is commonly called as level data.

Table 2

Palm oil data bivariate regression result properties

No.	Dependent variable	Independent variable	Regression Coefficient	Robust standard error	Probability not to reject null hypothesis	Goodness of fit
1.	Export volume	Production	-.0091041	.0408899	0.824	0.0003
2.	Change in export volume	Change in production	.0897955	.1356018	0.509	0.0030
3.	Export volume	International price	227.9559	98.98409	0.023	0.0379
4.	Change in international price	Change in export volume	.2342176	.1279929	0.07	0.0266

Note: Source: Indonesia Statistics Office data and the IMF database.

Change in USD1 in the international palm oil price will increase the export volume become 228 ton, and the 1% change of the export volume will have impact on 0.23% change of the international price. However, there is one uncommon finding in this bivariate regression, the relationship between CPO export volume and palm oil total production is negative, and not statistically significant, in both ways. In this paper, the level of confidence used is 95% to declare

whether it is statistically significant or not. Ideally, export should be some proportion of the production volume, but this is not proven by the regression properties. The relationship of CPO export volume and international price of palm oil is statistically significant, but in both ways, which means some endogeneity issue may happen.

Further analysis is necessary if the price of palm oil is affected by the supply of Indonesian palm oil. The relationship between the international price of palm oil and production volume will be checked using temperature as the instrumental variable. Temperature is chosen rather than other weather indicator like rainfall intensity, because nationally the average temperature in Indonesia is same. The rainfall condition varies among regions and islands in Indonesia, the national average may not reflect the regional one where there are many palm oil plantations. The temperature data is retrieved from the World Bank database. The instrumental variable purposes to isolate part of production supply that does not influence the international price of palm oil. The equation for this analysis is:

$$y_i = \beta_0 + \beta_1 x_i + \varepsilon_i$$

$$x_i = \pi_0 + \pi_1 Z_i + \nu_i$$

The test will assume that from the supply side, the supply of palm oil (production volume) in Indonesia as the largest producer and exporter country whether has effect or not to the price. Dependent variable is international price of palm oil. At the same time, the production of palm oil is influenced by the temperature. For the instrumental variable to be considered as valid, it is supposed to fulfill the conditions that the instrument is relevant which is given when the correlation between instrumental variable and independent variable is not zero ($Corr\ (Z_i X_i) \neq 0$), then the instrument exogeneity condition when the correlation between instrumental variable and the model error term should be zero ($Corr\ (Z_i \varepsilon_i) = 0$.

Table 3

Instrumental variable (temperature) regression result properties at the regression of international price of palm oil on palm oil production

No.	Indicator/Test	Variable: Level data		Variable: change (logarithm) data	
		Bivariate	Multivariate	Bivariate	Multivariate
1.	Durbin (score)	5.6404	.000714	4.50357	.180661
2.	Probability not to reject null hypothesis of Durbin endogeneity test	0.0176	0.9787	0.0338	0.6708
3.	Wu-Hausman test	5.75826	.000693	4.55668	.175427
4.	Probability not to reject null hypothesis of Wu-Hausman endogeneity test	0.0178	0.9790	0.0347	0.6760
5.	First stage F-test	27.1863	27.7897	25.0464	27.9101
6.	Probability not to reject null hypothesis of weakness of instrumental variable	0.000	0.000	0.000	0.000

Note: Source: reproduced from Indonesia Statistics Office data and the IMF database.

From the properties above, the use of temperature as instrumental variable is strong, either when the variable is at level, or at logarithm. It means that either temperature is statistically significant influencing the palm oil production, or the change in the temperature is statistically significant to influence the change of palm oil production. The condition of instrument relevant condition is fulfilled for both situations. However, the indicator of Wu-Hausman and Durbin show that endogeneity issue still remains, which means that instrument exogeneity condition cannot be fulfilled. Both the level and logarithm (change) variables regressions have the same situation. Based on the result, the presence of endogeneity is still bias. The instrumental variable, either temperature may have some correlation with the model error term, or the change of temperature may have some correlation with its model error term. Further interpretation is that the temperature and its change may have some relationship with other factors other than the palm oil production and the change of palm oil production, that contribute to the international price of palm oil and the

change of international price. The model only satisfies the relevant condition. In order to conduct appropriate analysis about the influence of international palm oil price on Indonesia GDP, the test that can deal with some endogeneity issues should be chosen.

As additional analysis shown above, other perspective is replicating the model by using additional independent variables (it becomes multivariate regression) to solve the endogeneity, without making problem in the relevancy condition. For example, if adding the international price of soybean, the result of the model test will be as in the above table. Soybean is used because it is the second largest used vegetable oils after the palm oil. The two goods can be assumed as substitution goods which react to the price change. Also, multicollinearity issue from adding additional variable (through regressing it with the error term of the bivariate or by conducting correlation test) does not take place. Nevertheless, the result is not same for the logarithm regression analysis. By adding another independent variable which the change of international soybean price into the analysis, the bias result of endogeneity still occurs. The endogeneity issue cannot be resolved by the simply adding independent variables.

Another way through regression analysis to show the relationship between international price of palm oil and Indonesia GDP is by comparing both graphs. However, the data of quarterly GDP in constant price has the increasing trend, but the international palm oil price data fluctuates based on the market situation. It is necessary to remove the trend part of GDP, to compare the seasonality part of GDP data and the movement of international palm oil price for each quarter. To get the cyclical component, the trend is removed using Baxter-King method which is based on weighted moving averages with specific formula. The cyclical component result will be directly produced by the processing software. The below graph shows that similar pattern occurs for the both variable. The pattern becomes more visible after 2007.

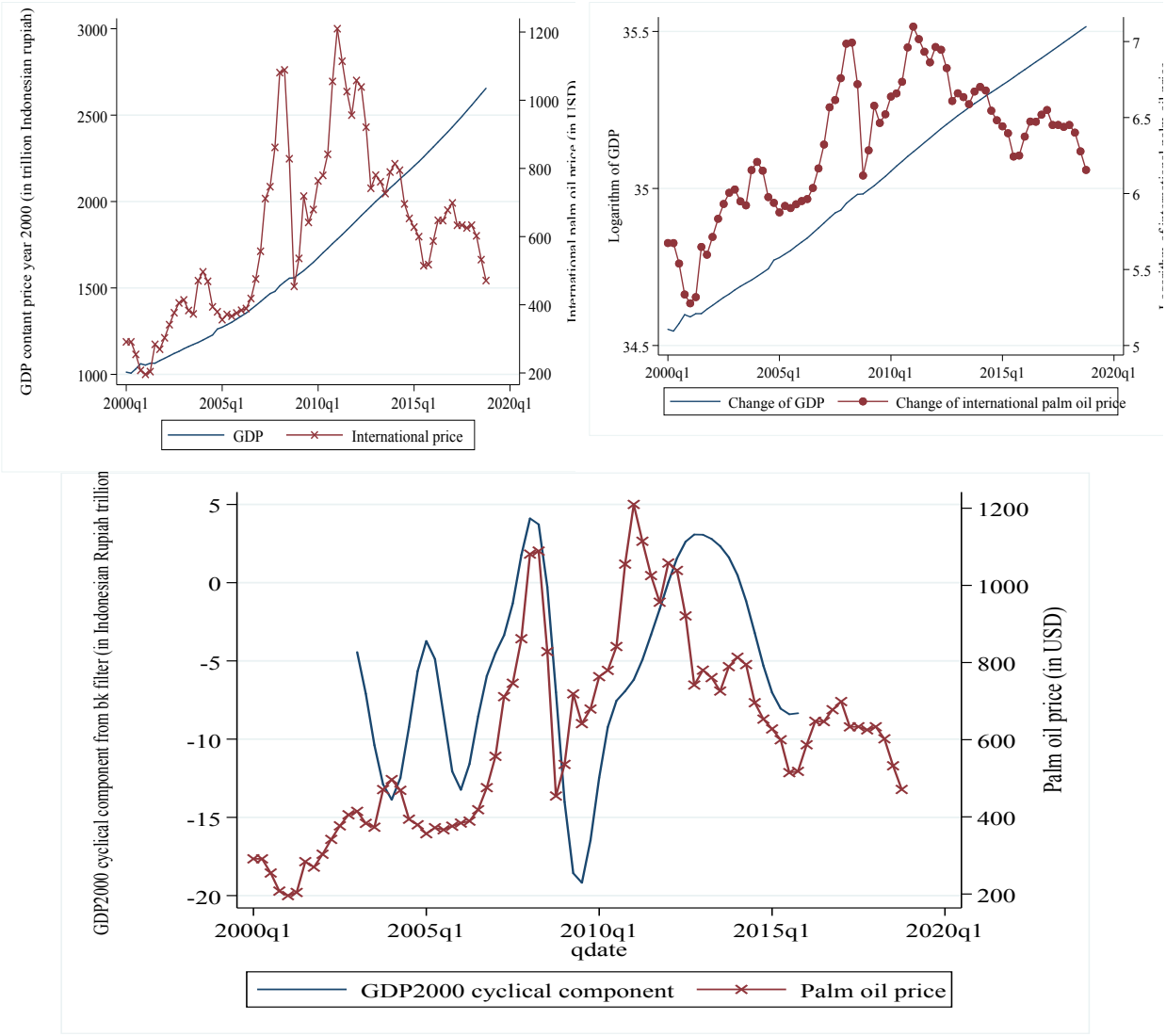

Figure 11. Comparison of the pattern of palm oil price movement and GDP before at level and logarithm data (above) and after (below) removing the trend component. Source: FED St. Louis website and the IMF database.

By using bivariate regression where GDP cyclical component as the dependent variable, the influence of price and the change of price are statistically significant on GDP, as shown in the following table. Nevertheless, the influence of price and the change of price are not statistically significant on the change in GDP cyclical component. If the international palm oil price change USD1, the GDP will change by the local currency Indonesia rupiah IDR12 billion, and when the price changes, increase by 1%, the GDP will also increase by IDR8.2 trillion. The parameters are

in the positive value, means the change will be in the same direction: if the price declines, it will make the GDP decrease, from the period of 2000 to 2017.

Table 4

Bivariate *regression combination of cyclical component of GDP on international palm oil price*

No.	Indicator/Test	GDP on Price	Change of GDP on Price	GDP on Change of Price	Elasticity
1.	Regression Coefficient	1.27e+10	-.002531	8.20e+12	-2.340616
2.	Robust standard error	2.52e+09	.0037552	1.60e+12	3.338931
3.	Probability not to reject null hypothesis	0.000	0.516	0.000	0.499
4.	Goodness of fit	0.2609	0.0643	0.2507	0.0673

Note: Source: FED St. Louis website and the IMF database.

Because endogeneity can make bias in the regression analysis, it will be better to choose analysis which it will not become issue, like VAR. By this test, the nature of variable which previously are dependent and independent changes become all endogenous. In the VAR method, the general equation will be as follows:

$$y_t = b_0 + B_1 y_{t-1} + B_2 y_{t-1} + \cdots + B_p y_{p-1} + \varepsilon_t$$

All the variables are in the form of $n \times 1$ vector, $y_t = (y_{1t}, y_{2t}, \ldots, y_{nt})'$. Which in the form of matrix, the equation will be (for *n* variable and *t* time) as follow.

$$b_0 = \begin{bmatrix} \beta_{10} \\ \beta_{20} \\ \vdots \\ \beta_{n0} \end{bmatrix}, B_1 = \begin{bmatrix} \beta_{11}^{(1)} & \beta_{12}^{(1)} & \cdots & \beta_{1n}^{(1)} \\ \vdots & & \ddots & \vdots \\ \beta_{n1}^{(1)} & \beta_{n1}^{(1)} & \cdots & \beta_{nn}^{(1)} \end{bmatrix}, \ldots, B_p = \begin{bmatrix} \beta_{11}^{(p)} & \beta_{12}^{(p)} & \cdots & \beta_{1n}^{(p)} \\ \vdots & & \ddots & \vdots \\ \beta_{n1}^{(p)} & \beta_{n1}^{(p)} & \cdots & \beta_{nn}^{(p)} \end{bmatrix}, \varepsilon_0 = \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \vdots \\ \varepsilon_{nt} \end{bmatrix}$$

In this part, it will be compared the result by using the bivariate VAR and multivariate one by adding palm oil export volume and palm oil production. Those two variables are considered having the endogeneity issues that has occurred in the previous tests, also export is part of GDP from the expenditure approach. The export data which will be used is the volume, because if using the value, some adjustment for inflation (either price level or exchange rate) is necessary to be conducted. The endogenous variable in the left-hand side is GDP, and endogenous variable in the

right-hand side is international price of palm oil, production, and export. The analysis will be conducted either for the variable in the level data and for the both changes (logarithm) data for the change of GDP and change of international palm oil price.

Before conducting the VAR test, it is to check the stationarity condition of all the observed variables. VAR result may be bias when one of the variables has unit roots. If the variables are not stationer at the level data (original), they must be differenced to make it become stationer. One of the popular methods to test stationarity is using Dickey-Fuller. The software result of this test for the observed variables, and the first differencing level is shown in the below table. At level data, either for level data or for logarithm data, the only stationer variable is palm oil export, which means it does not need further differencing process.

Table 5

Result of stationarity test of the variables

No.	Variable	Level data		Logarithm data	
		Test-statistics Z(t)	MacKinnon approximate p-value for Z(t)	Test-statistics Z(t)	MacKinnon approximate p-value for Z(t)
1.	GDP	8.857	1.0000	0.662	0.9890
2.	First difference in GDP	-5.629	0.0000	-10.825	0.0000
3.	Palm oil price	-1.794	0.3836	-1.736	0.4128
4.	First difference in palm oil price	-5.901	0.0000	-6.279	0.0000
5.	Palm oil production	-2.061	0.2604	-2.381	-2.381
6.	First difference in palm oil production	-8.375	0.0000	-8.243	0.0000
7.	Palm oil export	-4.840	0.0000	-4.787	0.0001

Note: Source: FED St. Louis website, the IMF database, and Indonesia Statistics Office data.

When all the variables satisfy the stationer condition, the second step in VAR is choosing the lag. Common methods which are suggested, especially by software, are likelihood ratio, final prediction error (FPE), Akaike's information criterion (AIC), Schwarz's Bayesian information criterion (SBIC), and the Hannan and Quinn information criterion (HQIC). The result of the tests,

for both bivariate and multivariate one, is shown in the table below. From the recommendation for the level data (GDP, international palm oil price, palm oil production, and export volume), the lag for bivariate is 2 and for multivariate is 4. For the multivariate, the lag is selected based on comparing the result of all tests, and most tests advise 4. Meanwhile, for the logarithm data (change of GDP, change of international price of palm oil, change of palm oil production, and change of palm oil export), the lag recommendation is 4, and it is same with the lag recommendation result at the level data. The analysis of data in this part is conducted from quarterly data, for example, if the lag recommendation is 4, it can be interpreted as 4 quarters or 1 year in the future.

Table 6

Result of lag recommendation

No.	Test	Level data		Logarithm data	
		Bivariate	Multivariate	Bivariate	Multivariate
1.	Likelihood ratio	2	4	3	4
2.	FPE suggestion	2	4	3	4
3.	AIC suggestion	2	4	3	4
4.	SBIC suggestion	2	1	2	0
5.	HQIC suggestion	2	2	0	0

Note: Source: FED St. Louis website, the IMF database, and Indonesia Statistics Office data.

The third step is by conducting the VAR test itself. All endogenous variables are tested based on their recommended lag, 2 for bivariate at level data 3 for bivariate at logarithm data, and 4 for multivariate. The result from bivariate VAR at level data declares that effect difference in GDP is statistically significant for itself. The result for bivariate VAR at logarithm data displays that the effect is not statistically significant neither for change of GDP on the change of GDP 3 quarters ahead, nor the change of price on the change of GDP. Meanwhile, for the multivariate VAR, the result of difference in GDP and difference in palm oil price are statistically significant on the difference in GDP in the 4 quarters in the future for the level data, but not for the logarithm data.

Table 7

Probability result that endogenous variables influence other variables

No.	Variable	Level data		Logarithm data	
		Bivariate	Multivariate	Bivariate	Multivariate
1.	GDP on GDP	0.000*	0.000*	0.716	0.012*
2.	GDP on palm oil price	0.555	0.017*	0.411	0.181
3.	GDP on palm oil production	-	0.422	-	0.623
4.	GDP on palm oil export	-	0.958	-	0.718
5.	Palm oil price on GDP	0.150	0.731	0.206	0.046*
6.	Palm oil price on palm oil price	0.035*	0.739	0.358	0.424
7.	Palm oil price on production	-	0.283	-	0.191
8.	Palm oil price on export	-	0.755	-	0.678
9.	Production on GDP	-	0.225	-	0.154
10.	Production on palm oil price	-	0.717	-	0.570
11.	Production on production	-	0.008*	-	0.011*
12.	Production of export	-	0.325	-	0.676
13.	Export on GDP	-	0.018*	-	0.503
14.	Export on palm oil price	-	0.658	-	0.697
15.	Export on production	-	0.835	-	0.782
16.	Export on export	-	0.028*	-	0.099

Note: *statistically significant result. Source: FED St. Louis website, the IMF database, and Indonesia Statistics Office data.

The interpretation of the statistically significant result of the VAR analysis above is that for the bivariate VAR for level data, the GDP of the current period will influence the GDP in the 2 quarters in the future, and the palm oil price in current period will influence itself in the 2 quarters in the future. For the multivariate VAR in the level data, the GDP and palm oil price in the current period will influence the GDP in the 4 quarters (1 year) in the future, also the palm oil production in the current period will influence the production in the next 4 quarters, the GDP and palm oil export in the current period will influence the palm oil export in the next 4 quarters. There is not any significant result for bivariate VAR for the logarithm level data. For the multivariate VAR of the logarithm data, the change in the GDP in the current period will influence the change of GDP and the change of palm oil international price in the 4 quarters in the future, also the change of

production in the current period will influence the change of production in the 4 quarters in the future.

Further posttest is necessary to assess the recommendation from VAR result, and one of those is through Granger causality. For the bivariate model, Granger casualty result is not statistically significant in both level and logarithm variables. The statically significant result for the multivariate model occurs for both level and logarithm variables. For the level one, Granger causality relationships are statistically significant between the difference in international palm oil price and difference in GDP, also between CPO export volume and difference in GDP. In the logarithm one, it is statistically significant that between the change in the GDP and the change of international palm oil price. Granger casualty implies the two-way interaction between the variables which influence each other, for the certain lag observed. The probability result from the VAR table and Granger causality table for the statistically significant result are same. The result in the Granger causality eliminates the causality which occurs through one variable the unilaterally among different period.

Table 8

Probability result of Granger causality that implies statistically significant result

No.	Variable	Multivariate VAR	
		Level	Logarithm
1.	GDP on palm oil price	0.017	-
2.	Export volume on GDP	0.018	-
3.	Palm oil price on GDP	-	0.046

Note: Source: FED St. Louis website, the IMF database, and Indonesia Statistics Office.

The final step in VAR analysis to understand the impact is by conducting the impulse response function. The table result of IRF analysis displays the same probability result as in the VAR table previously. This result, graph, will illustrate the effect on certain variable when shock (respective variable change) is given. Below is the result for the bivariate models.

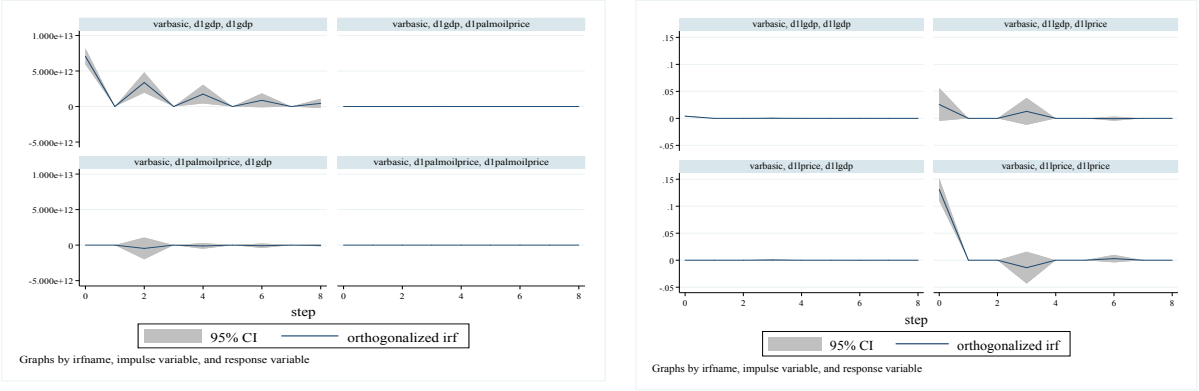

Figure 12. IRF graph from bivariate VAR at level data (left) and logarithm (right).

Source: reproduced from FED St. Louis website, the IMF database, and Indonesia Statistics Office.

For the bivariate VAR, in the level data, the IRF result of palm oil price effect to GDP is not available, but here is the interpretation of all shown graph. When the GDP changes, it will affect itself continuously, and the value is always greater than 0. The effect will die out at period 7, or the seventh quarter. The GDP change effect stabilizes every 2 quarters, and it is statistically significant. Also, at the level data, when the GDP declines in the first period, it will give effect to the palm oil price, but it may be increase in price or decrease in price, then it becomes zero in the third period. The effect occurs each two quarters, it will die out in the seventh quarter, but it is not statistically significant. At the logarithm data, the percent change of palm oil price to the percent change GDP will decline in the first period, increase again in the third period, and becomes zero in the fifth quarter. The effect repeatedly occurs each two quarters and will die out in the seventh quarter. Also, the percent change of palm oil price will affect itself, and the effect will die out after the seventh quarter. Both effects in the logarithm data are not statistically significant, which by the figure, the effect may be positive or negative (1% change of the palm oil price may make GDP change from -0.01% to 0.05% in the first quarter, 0 in second quarter).

Considering that the IRF graph result which is statistically significant is only one, the effect of GDP to itself, it may not answer the question from this research. However, the IRF graph result from the effect percent change of palm oil price to percent change of GDP may relate to the research question, but it is difficult to exactly conclude whether the its increase will increase or decrease the percent change of GDP, vice versa.

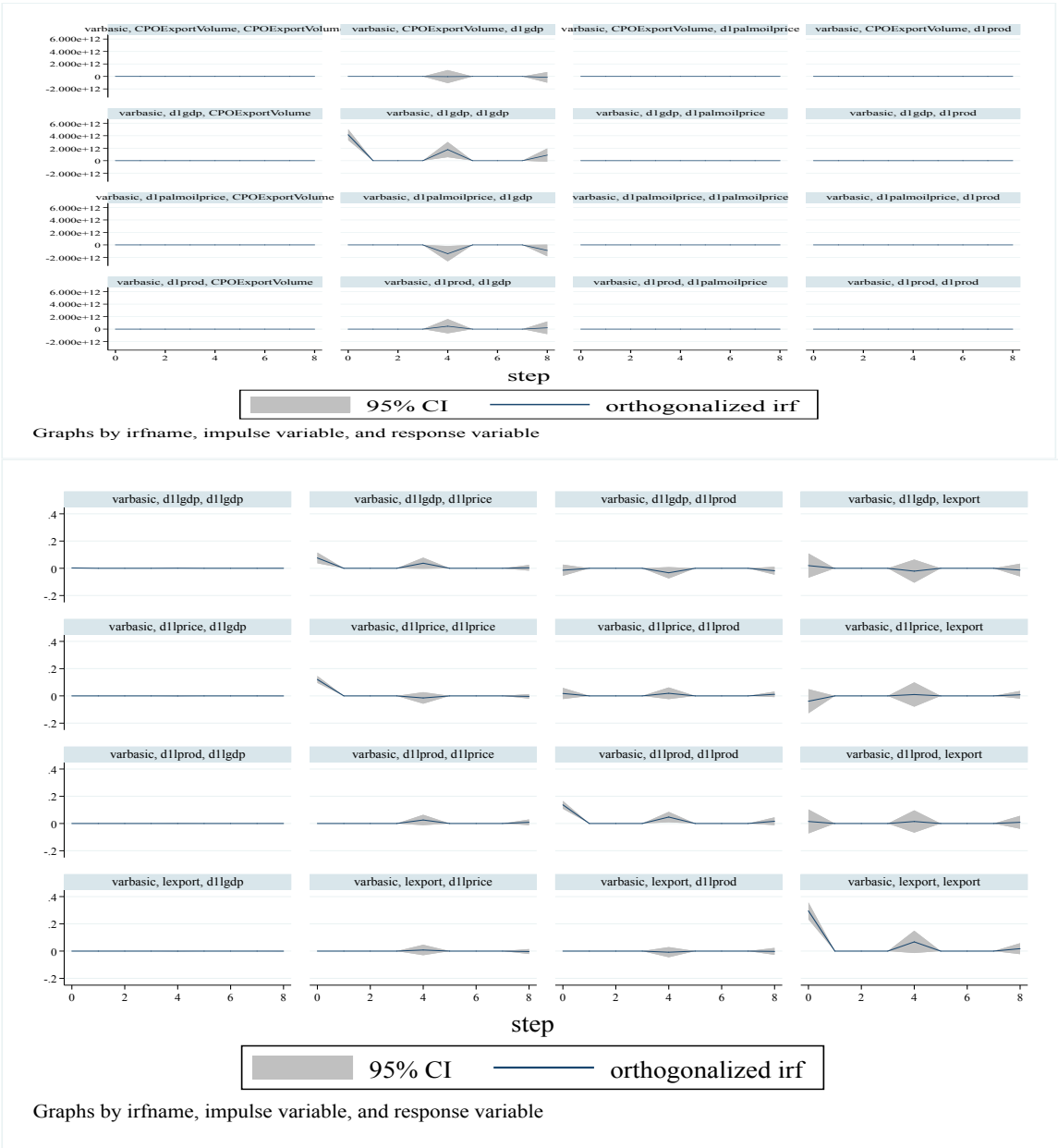

Figure 13. IRF graph from multivariate VAR at level data. Source: FED St. Louis website, the IMF database, and Indonesia Statistics Office data.

For the multivariate model in level data, the effect of change of palm oil price to GDP is not shown by the IRF result. Because there are many graph results, the analysis and interpretation are only conducted for the graph which explain the effect of international palm oil price to GDP. In the above graph, the relationship is represented in the upper part, column three and the second row from above. The graph does not show the impact of palm oil price change to the GDP, despite the previous test in VAR and Granger causality show that its change is statistically significant to affect the GDP. One of the possibility reasons is the Y-axis in the graph are shown in trillion Indonesia rupiah, meanwhile the change in the international price of palm oil is not that much (less than USD50).

The lower part of the figure illustrates the impulse-response relationship when all variables are made in the logarithm form. The graph which relates most with the research question is located in the first row and second column from left, which shows the effect when the percent change of international palm oil price to the percent change of GDP. When the price change by 1%, GDP will increase less than by 0.1% in the first quarter and decline become 0 in the next quarter, but the effect will come again to make GDP increase less than by 0.05% and die out in the fifth quarter. The effect has same direction that means if the change is minus, the effect on the change of the GDP will be minus. The relationship becomes clearer rather than the bivariate VAR because the equation includes CPO export and palm oil production. As shown in the above figure, when the percent export change, it will increase the percent change of GDP and decrease the percent change of price in the first quarter, but it will decrease percent change of GDP and increase the percent change of price in the fourth quarter, finally die out in the fifth quarter. Nevertheless, the interaction between change of international price affected by change in GDP is significant by the VAR and Granger causality, but the IRF does not show the graph.

The consistent results among VAR test, Granger causality, IRF for two different variables are only between international palm oil price with GDP and change of GDP with change of international palm oil price. Nevertheless, the effect is not fully for 4 lags consecutively as recommended by VAR test, but in the first quarter and from the third to the fifth one. Through IRF, the effect will die out in the second quarter after 5 quarters.

Conclusion and Recommendation

Palm oil sector in Indonesia has grown positively from 2000 to 2017 which was shown by many increasing indicators like total area for palm oil plantation in Indonesia has grown triple, production has increased more than six times, and CPO export has increased triple, in average is 9% to total goods export. From the graph of land used for palm oil plantation if the growth is constant, there will some tendency that in the future the smallholders' total area for may exceed the private plantation. The major product from palm oil is CPO by more than 80% and mainly produced as export commodity, the average ratio between CPO export to ratio is 1.03 means most of the production is for export, and 41.44% of that CPO consists of CPO purely. The correlation between GDP and CPO export value is positive and displays high coefficient number (0.9).

From the regression analysis, endogeneity issues arise from the relationship of international palm oil price with palm oil production in Indonesia. Export volume is also influenced significantly by the international palm oil price, but not by the national production. There is an interesting finding on the relationship between CPO export volume and palm oil production, that it is not statistically significant. After goods and services being produced, some part of them supposed to be traded to the rest of the world as export, but that case is not found within this research using bivariate regression. After removing the trend, the regression analysis of GDP cyclical component

on international palm oil price shows significant result, which means that the price influences the GDP. If price change positively by USD1, the GDP will increase by IDR12 billion, and when it increases by 1%, the GDP will also increase by IDR8.2 trillion, vice versa when it declines.

By further analysis using VAR method, the effect of international palm oil price fluctuation to Indonesia GDP is statistically significant while using the multivariate VAR. There is causality relationship between palm oil price to GDP if the price change by 1%, GDP will increase by less than 0.1% in the first quarter and decline become 0 in the second quarter, but the effect will come again to make GDP increase less than by 0.05% and die out in the fifth quarter. From VAR and Granger causality result, the change of international palm oil price is affected by the change in Indonesia GDP, but the IRF does not provide the graph. Either bivariate or multivariate VAR suggests that the change in the GDP will affect the GDP itself.

For stakeholders in the palm oil sector, they should aware about the effect which cause by that commodity price fluctuation. For private sector, usually they are more flexible to mitigate the risk by some hedging mechanism, like having future contracts. For government, it is better to consider the timing whether the to include international price of palm oil (like other commodities like oil) as surveillance indicator. Also, some data shows that the ratio of production to total area (tonnage/hectare) for government estate is the most fluctuated one. It is important to make the ratio become more stable, proportional between the production to total area, or the government may further reduce its share and leave this sector to the private sector. From academic perspective, further research and better modelling in CPO should be explored for the exact impact in the future. Another aspect for research improvement is by the perspective of regionalism for some largest provinces which CPO is their main commodity, probably their regional GDP will be affected more than the Indonesian national GDP by the price change.

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Additional Tables

Table 1

The Proportion of CPO to GDP over years

Year	Yearly Nominal GDP	Sectoral: Plantation	Expenditure: Goods Export	CPO Export value		Percent of Goods Export to GDP	Percent of CPO Export to Export	Percent of Plantation to GDP	Percent of CPO Export to GDP
	in billion Indonesia Rupiah (IDR)				in thousand USD	in percent			
2000	1389769.9	32491.4	525422.3	14678.3	1087278.0	37.81	2.79	2.34	1.06
2001	1646322.0	38171.5	577510.0	14592.2	1080906.0	35.08	2.53	2.32	0.89
2002	1821833.4	43037.9	530393.3	28247.5	2092404.0	29.11	5.33	2.36	1.55
2003	2013674.6	46753.8	523580.8	33137.5	2454626.0	26.00	6.33	2.32	1.65
2004	2295826.2	49630.9	642297.5	46464.0	3441776.0	27.98	7.23	2.16	2.02
2005	2774281.1	56433.7	832757.5	50709.8	3756283.0	30.02	6.09	2.03	1.83
2006	3339216.8	63401.4	922962.4	65038.2	4817642.0	27.64	7.05	1.90	1.95
2007	3950893.2	81664.0	1043361.8	106226.6	7868640.0	26.41	10.18	2.07	2.69
2008	4948688.4	105960.5	1346960.9	167070.2	12375569.0	27.22	12.40	2.14	3.38
2009	5606203.4	111378.5	1227221.9	139962.9	10367621.0	21.89	11.40	1.99	2.50
2010	6446851.9	136048.5	1447923.9	181831.0	13468966.0	22.46	12.56	2.11	2.82
2011	7419187.1	153709.3	1800027.8	233026.8	17261248.0	24.26	12.95	2.07	3.14
2012	8230925.9	162542.6	1819787.3	237629.3	17602168.0	22.11	13.06	1.97	2.89
2013	9087276.5	174638.4	1935442.5	213824.5	15838850.0	21.30	11.05	1.92	2.35
2014	10094928.9	192921.5	2063575.9	235774.2	17464754.0	20.44	11.43	1.91	2.34
2015	11526332.8	405291.5	2131563.4	207701.2	15385275.0	18.49	9.74	3.52	1.80
2016	12406774.1	428782.6	2040317.3	193951.2	14366754.0	16.45	9.51	3.46	1.56
2017	13588797.3	471307.8	2403487.9	249927.1	18513121.0	17.69	10.40	3.47	1.84
2018	14837357.5	489249.0	2709251.0			18.26		3.30	

Note: The CPO export value in the source is presented in thousand USD. Assumption FX rate: US dollar 1: Indonesia rupiah 13,500. Source: Indonesian Statistics Office, retrieved from the website and Bank Indonesia's website.

Table 2

Lag selection for VAR analysis

```
. varsoc d1gdp d1palmoilprice

   Selection-order criteria
   Sample:  2001q2 - 2018q4                        Number of obs      =        71
```

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-2626.76				4.9e+29	74.0496	74.0749	74.1133
1	-2599.83	53.867	4	0.000	2.6e+29	73.4035	73.4796	73.5948
2	-2577.83	43.999*	4	0.000	1.6e+29*	72.8965*	73.0233*	73.2152*
3	-2576.09	3.4788	4	0.481	1.7e+29	72.9602	73.1376	73.4064
4	-2573.59	4.9865	4	0.289	1.7e+29	73.0026	73.2308	73.5763

```
   Endogenous:  d1gdp d1palmoilprice
    Exogenous:  _cons

. varsoc d1gdp d1palmoilprice d1prod CPOExportVolume

   Selection-order criteria
   Sample:  2007q2 - 2017q4                        Number of obs      =        43
```

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-2857.19				7.3e+52	133.078	133.139	133.242*
1	-2837.14	40.096	16	0.001	6.1e+52	132.89	133.192	133.709
2	-2807.97	58.339	16	0.000	3.4e+52	132.278	132.821*	133.752
3	-2794.12	27.699	16	0.034	3.9e+52	132.378	133.163	134.508
4	-2767.34	53.56*	16	0.000	2.6e+52*	131.876*	132.903	134.661

```
   Endogenous:  d1gdp d1palmoilprice d1prod CPOExportVolume
    Exogenous:  _cons
. varsoc d1lgdp d1lprice

   Selection-order criteria
   Sample:  2001q2 - 2018q4                        Number of obs      =        71
```

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	345.507				2.2e-07	-9.67625	-9.6509	-9.61251*
1	349.225	7.4372	4	0.115	2.2e-07	-9.66832	-9.59228	-9.47711
2	358.059	17.667	4	0.001	1.9e-07	-9.80447	-9.67774*	-9.48579
3	363.597	11.077*	4	0.026	1.8e-07*	-9.84781*	-9.67039	-9.40165
4	364.51	1.8262	4	0.768	2.0e-07	-9.76086	-9.53274	-9.18722

```
   Endogenous:  d1lgdp d1lprice
    Exogenous:  _cons

. varsoc d1lgdp d1lprice d1lprod lexport

   Selection-order criteria
   Sample:  2007q2 - 2017q4                        Number of obs      =        43
```

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	231.039				3.0e-10	-10.56	-10.4995*	-10.3961*
1	251.47	40.862	16	0.001	2.5e-10	-10.766	-10.464	-9.94688
2	270.291	37.643	16	0.002	2.2e-10	-10.8973	-10.3535	-9.42278
3	287.171	33.76	16	0.006	2.3e-10	-10.9382	-10.1528	-8.80838
4	309.126	43.909*	16	0.000	1.9e-10*	-11.2152*	-10.1881	-8.43

```
   Endogenous:  d1lgdp d1lprice d1lprod lexport
    Exogenous:  _cons
```

Note: Retrieved from STATA result. Source: FED St. Louis website, the IMF database, and Indonesia Statistics Office.

Table 3

VAR and Granger result for bivariate analysis

```
. var d1gdp d1palmoilprice, lags(2)

Vector autoregression

Sample:  2000q4 - 2018q4                        Number of obs     =         73
Log likelihood =  -2690.921                     AIC               =   73.88825
FPE            =   4.21e+29                     HQIC              =   73.96327
Det(Sigma_ml)  =   3.57e+29                     SBIC              =    74.0765

Equation           Parms      RMSE     R-sq      chi2     P>chi2
------------------------------------------------------------------
d1gdp                  3     7.2e+12   0.2664   26.50782   0.0000
d1palmoilprice         3     88.0673   0.0891   4.437593   0.1087
------------------------------------------------------------------
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
d1gdp						
d1gdp						
L2.	.4918176	.0955467	5.15	0.000	.3045494	.6790857
d1palmoilprice						
L2.	-5.46e+09	9.24e+09	-0.59	0.555	-2.36e+10	1.26e+10
_cons	1.16e+13	2.22e+12	5.24	0.000	7.29e+12	1.60e+13
d1palmoilprice						
d1gdp						
L2.	-1.68e-12	1.17e-12	-1.44	0.150	-3.97e-12	6.08e-13
d1palmoilprice						
L2.	-.2379498	.1129566	-2.11	0.035	-.4593407	-.0165589
_cons	40.319	27.15063	1.49	0.138	-12.89526	93.53325

```
. vargranger

  Granger causality Wald tests
```

Equation	Excluded	chi2	df	Prob > chi2
d1gdp	d1palmoilprice	.34895	1	0.555
d1gdp	ALL	.34895	1	0.555
d1palmoilprice	d1gdp	.	0	.
d1palmoilprice	ALL	.	0	.

```
. var d1lgdp d1lprice, lags(3)

Vector autoregression

Sample:  2001q1 - 2018q4                        Number of obs     =         72
Log likelihood =   338.4305                     AIC               =   -9.23418
FPE            =   3.35e-07                     HQIC              =  -9.158651
Det(Sigma_ml)  =   2.83e-07                     SBIC              =  -9.044458

Equation           Parms      RMSE     R-sq      chi2     P>chi2
------------------------------------------------------------------
d1lgdp                 3     .004163   0.0115   .8404727   0.6569
d1lprice               3     .135996   0.0314   2.332789   0.3115
------------------------------------------------------------------
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
d1lgdp						
d1lgdp						
L3.	.0338657	.0930475	0.36	0.716	-.1485041	.2162356
d1lprice						
L3.	.0028925	.0035177	0.82	0.411	-.0040022	.0097871
_cons	.0122703	.0012883	9.52	0.000	.0097452	.0147954
d1lprice						
d1lgdp						
L3.	3.841543	3.039963	1.26	0.206	-2.116674	9.79976
d1lprice						
L3.	-.1057048	.1149282	-0.92	0.358	-.3309599	.1195504
_cons	-.0368899	.0420912	-0.88	0.381	-.1193872	.0456074

```
. vargranger

  Granger causality Wald tests
```

Equation	Excluded	chi2	df	Prob > chi2
d1lgdp	d1lprice	.67609	1	0.411
d1lgdp	ALL	.67609	1	0.411
d1lprice	d1lgdp	1.5969	1	0.206
d1lprice	ALL	1.5969	1	0.206

Note: Retrieved from STATA result. Source: FED St. Louis website, the IMF database, and Indonesia Statistics Office.

Table 4

VAR and Granger result for multivariate analysis

```
. var d1gdp d1palmoilprice d1prod CPOExportVolume, lags(4)

Vector autoregression

Sample:  2007q2 - 2017q4                        Number of obs     =         43
Log likelihood =  -2839.188                     AIC               =   132.9855
FPE            =   6.71e+52                     HQIC              =   133.2876
Det(Sigma_ml)  =   2.64e+52                     SBIC              =   133.8047

Equation           Parms      RMSE     R-sq      chi2     P>chi2
------------------------------------------------------------------
d1gdp                  5     4.4e+12   0.2997   18.40419   0.0010
d1palmoilprice         5     117.423   0.0361   1.512762   0.8244
d1prod                 5      854194   0.1948   10.40484   0.0341
CPOExportVolume        5      517205   0.2229   12.33445   0.0150
------------------------------------------------------------------
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
d1gdp						
d1gdp L4.	.5911261	.1416766	4.17	0.000	.3134451	.868807
d1palmoilprice L4.	-1.45e+10	6.08e+09	-2.39	0.017	-2.64e+10	-2.60e+09
d1prod L4.	587915.2	732475.2	0.80	0.422	-847710	2023540
CPOExportVolume L4.	-57550.7	1100013	-0.05	0.958	-2213537	2098436
_cons	1.12e+13	4.22e+12	2.65	0.008	2.91e+12	1.95e+13
d1palmoilprice						
d1gdp L4.	1.29e-12	3.76e-12	0.34	0.731	-6.07e-12	8.65e-12
d1palmoilprice L4.	.0535914	.1611202	0.33	0.739	-.2621985	.3693813
d1prod L4.	.0000208	.0000194	1.07	0.283	-.0000172	.0000589
CPOExportVolume L4.	9.12e-06	.0000292	0.31	0.755	-.0000481	.0000663
_cons	-49.55435	112.0077	-0.44	0.658	-269.0854	169.9767
d1prod						
d1gdp L4.	-3.32e-08	2.73e-08	-1.21	0.225	-8.68e-08	2.04e-08
d1palmoilprice L4.	424.8039	1172.066	0.36	0.717	-1872.403	2722.011
d1prod L4.	.3723397	.1413013	2.64	0.008	.0953943	.6492852
CPOExportVolume L4.	-.2088845	.2122028	-0.98	0.325	-.6247943	.2070253
_cons	1272531	814797.7	1.56	0.118	-324442.9	2869505
CPOExportVolume						
d1gdp L4.	-3.92e-08	1.65e-08	-2.37	0.018	-7.16e-08	-6.73e-09
d1palmoilprice L4.	314.5831	709.6736	0.44	0.658	-1076.352	1705.518
d1prod L4.	.0177913	.0855564	0.21	0.835	-.1498962	.1854789
CPOExportVolume L4.	.2827281	.1284865	2.20	0.028	.0308991	.534557
_cons	2309109	493351.4	4.68	0.000	1342158	3276060

```
. var d1lgdp d1lprice d1lprod lexport, lags (4)

Vector autoregression

Sample:  2007q2 - 2017q4                        Number of obs     =         43
Log likelihood =   241.5287                     AIC               =  -10.30366
FPE            =   3.95e-10                     HQIC              =  -10.00158
Det(Sigma_ml)  =   1.55e-10                     SBIC              =  -9.484496

Equation           Parms      RMSE     R-sq      chi2     P>chi2
------------------------------------------------------------------
d1lgdp                 5     .002714   0.1317   6.522046   0.1634
d1lprice               5     .151746   0.1081    5.21158   0.2663
d1lprod                5     .147732   0.2029   10.94805   0.0272
lexport                5     .318026   0.0745   3.460609   0.4839
------------------------------------------------------------------
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
d1lgdp						
d1lgdp L4.	.4458871	.1765545	2.53	0.012	.0998466	.7919276
d1lprice L4.	-.0042634	.0031881	-1.34	0.181	-.0105119	.0019851
d1lprod L4.	.0012413	.0025281	0.49	0.623	-.0037138	.0061963
lexport L4.	-.0004286	.001187	-0.36	0.718	-.0027551	.0018979
_cons	.013486	.0171112	0.79	0.431	-.0200514	.0470233
d1lprice						
d1lgdp L4.	19.68092	9.871417	1.99	0.046	.3332952	39.02854
d1lprice L4.	-.142369	.1782503	-0.80	0.424	-.4917331	.2069952
d1lprod L4.	.1848411	.1413514	1.31	0.191	-.0922026	.4618848
lexport L4.	.0275497	.0663687	0.42	0.678	-.1025307	.15763
_cons	-.6624898	.9567114	-0.69	0.489	-2.53761	1.21263
d1lprod						
d1lgdp L4.	-13.6847	9.610326	-1.42	0.154	-32.52059	5.151196
d1lprice L4.	.098548	.1735357	0.57	0.570	-.2415757	.4386718
d1lprod L4.	.3488808	.1376128	2.54	0.011	.0791647	.618597
lexport L4.	-.0270418	.0646133	-0.42	0.676	-.1536816	.0995981
_cons	.5870696	.9314072	0.63	0.528	-1.238455	2.412594
lexport						
d1lgdp L4.	-13.85493	20.68828	-0.67	0.503	-54.40321	26.69336
d1lprice L4.	.1454677	.3735727	0.39	0.697	-.5867214	.8776568
d1lprod L4.	.0818565	.296241	0.28	0.782	-.4987652	.6624781
lexport L4.	.2296142	.139094	1.65	0.099	-.0430051	.5022335
_cons	11.27598	2.005053	5.62	0.000	7.346147	15.20581

```
. vargranger

  Granger causality Wald tests
```

Equation	Excluded	chi2	df	Prob > chi2
d1gdp	d1palmoilprice	**5.7048**	**1**	**0.017**
d1gdp	d1prod	**.64423**	**1**	**0.422**
d1gdp	CPOExportVolume	**.00274**	**1**	**0.958**
d1gdp	ALL	**5.9187**	**3**	**0.116**
d1palmoilprice	d1gdp	**.**	**0**	**.**
d1palmoilprice	d1prod	**1.1506**	**1**	**0.283**
d1palmoilprice	CPOExportVolume	**.09766**	**1**	**0.755**
d1palmoilprice	ALL	**1.2789**	**2**	**0.528**
d1prod	d1gdp	**1.4745**	**1**	**0.225**
d1prod	d1palmoilprice	**.13136**	**1**	**0.717**
d1prod	CPOExportVolume	**.96897**	**1**	**0.325**
d1prod	ALL	**2.2556**	**3**	**0.521**
CPOExportVolume	d1gdp	**5.6023**	**1**	**0.018**
CPOExportVolume	d1palmoilprice	**.1965**	**1**	**0.658**
CPOExportVolume	d1prod	**.04324**	**1**	**0.835**
CPOExportVolume	ALL	**6.1573**	**3**	**0.104**

```
. vargranger

  Granger causality Wald tests
```

Equation	Excluded	chi2	df	Prob > chi2
d1lgdp	d1lprice	**1.7883**	**1**	**0.181**
d1lgdp	d1lprod	**.24107**	**1**	**0.623**
d1lgdp	lexport	**.13037**	**1**	**0.718**
d1lgdp	ALL	**1.9139**	**3**	**0.590**
d1lprice	d1lgdp	**3.9749**	**1**	**0.046**
d1lprice	d1lprod	**1.71**	**1**	**0.191**
d1lprice	lexport	**.17231**	**1**	**0.678**
d1lprice	ALL	**5.0314**	**3**	**0.170**
d1lprod	d1lgdp	**2.0277**	**1**	**0.154**
d1lprod	d1lprice	**.32249**	**1**	**0.570**
d1lprod	lexport	**.17516**	**1**	**0.676**
d1lprod	ALL	**2.3447**	**3**	**0.504**
lexport	d1lgdp	**.4485**	**1**	**0.503**
lexport	d1lprice	**.15163**	**1**	**0.697**
lexport	d1lprod	**.07635**	**1**	**0.782**
lexport	ALL	**.64958**	**3**	**0.885**

Note: Retrieved from STATA result. Source: FED St. Louis website, the IMF database, and Indonesia Statistics Office.

Table 5

IRF result for bivariate analysis

```
. varbasic d1gdp d1palmoilprice, lags(2)

Vector autoregression

Sample:  2000q4 - 2018q4                        Number of obs     =         73
Log likelihood =  -2690.921                     AIC               =   73.88825
FPE            =   4.21e+29                     HQIC              =   73.96327
Det(Sigma_ml)  =   3.57e+29                     SBIC              =    74.0765

Equation           Parms      RMSE     R-sq      chi2     P>chi2
------------------------------------------------------------------
d1gdp                  3     7.2e+12   0.2664   26.50782   0.0000
d1palmoilprice         3     88.0673   0.0891   4.437593   0.1087
------------------------------------------------------------------
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
d1gdp						
d1gdp						
L2.	.4918176	.0955467	5.15	0.000	.3045494	.6790857
d1palmoilprice						
L2.	-5.46e+09	9.24e+09	-0.59	0.555	-2.36e+10	1.26e+10
_cons	1.16e+13	2.22e+12	5.24	0.000	7.29e+12	1.60e+13
d1palmoilprice						
d1gdp						
L2.	-1.68e-12	1.17e-12	-1.44	0.150	-3.97e-12	6.08e-13
d1palmoilprice						
L2.	-.2379498	.1129566	-2.11	0.035	-.4593407	-.0165589
_cons	40.319	27.15063	1.49	0.138	-12.89526	93.53325

```
. varbasic d1lgdp d1lprice, lags(3)

Vector autoregression

Sample:  2001q1 - 2018q4                        Number of obs     =         72
Log likelihood =   338.4305                     AIC               =   -9.23418
FPE            =   3.35e-07                     HQIC              =  -9.158651
Det(Sigma_ml)  =   2.83e-07                     SBIC              =  -9.044458

Equation           Parms      RMSE     R-sq      chi2     P>chi2
------------------------------------------------------------------
d1lgdp                 3     .004163   0.0115   .8404727   0.6569
d1lprice               3     .135996   0.0314   2.332789   0.3115
------------------------------------------------------------------
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
d1lgdp						
d1lgdp						
L3.	.0338657	.0930475	0.36	0.716	-.1485041	.2162356
d1lprice						
L3.	.0028925	.0035177	0.82	0.411	-.0040022	.0097871
_cons	.0122703	.0012883	9.52	0.000	.0097452	.0147954
d1lprice						
d1lgdp						
L3.	3.841543	3.039963	1.26	0.206	-2.116674	9.79976
d1lprice						
L3.	-.1057048	.1149282	-0.92	0.358	-.3309599	.1195504
_cons	-.0368899	.0420912	-0.88	0.381	-.1193872	.0456074

Note: Retrieved from STATA result. Source: FED St. Louis website, the IMF database, and Indonesia Statistics Office.

Table 6

IRF result for multivariate analysis

```
. varbasic d1lgdp d1palmoilprice d1prod CPOExportVolume, lags(4)

Vector autoregression

Sample:  2007q2 - 2017q4                        Number of obs     =         43
Log likelihood =  -2839.188                     AIC               =   132.9855
FPE            =   6.71e+52                     HQIC              =   133.2876
Det(Sigma_ml)  =   2.64e+52                     SBIC              =   133.8047

Equation           Parms      RMSE     R-sq      chi2     P>chi2
------------------------------------------------------------------
d1gdp                  5     4.4e+12   0.2997   18.40419   0.0010
d1palmoilprice         5     117.423   0.0361   1.512762   0.8244
d1prod                 5      854194   0.1948   10.40484   0.0341
CPOExportVolume        5      517205   0.2229   12.33445   0.0150
------------------------------------------------------------------

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
d1lgdp       |
      d1gdp  |
         L4. |   .5911261   .1416766     4.17   0.000     .3134451    .868807
             |
d1palmoilprice |
         L4. |  -1.45e+10   6.08e+09    -2.39   0.017    -2.64e+10   -2.60e+09
             |
       d1prod |
         L4. |   587915.2   732475.2     0.80   0.422      -847710    2023540
             |
CPOExportVolume |
         L4. |  -57550.7    1100013    -0.05   0.958    -2213537    2098436
             |
       _cons |   1.12e+13   4.22e+12     2.65   0.008     2.91e+12   1.95e+13
-------------+----------------------------------------------------------------
d1palmoilprice |
      d1gdp  |
         L4. |   1.29e-12   3.76e-12     0.34   0.731    -6.07e-12   8.65e-12
             |
d1palmoilprice |
         L4. |   .0535914   .1611202     0.33   0.739    -.2621985    .3693813
             |
       d1prod |
         L4. |   .0000208   .0000194     1.07   0.283    -.0000172    .0000589
             |
CPOExportVolume |
         L4. |   9.12e-06   .0000292     0.31   0.755    -.0000481    .0000663
             |
       _cons |  -49.55435   112.0077    -0.44   0.658    -269.0854    169.9767
-------------+----------------------------------------------------------------
d1prod       |
      d1gdp  |
         L4. |  -3.32e-08   2.73e-08    -1.21   0.225    -8.68e-08    2.04e-08
             |
d1palmoilprice |
         L4. |   424.8039   1172.066     0.36   0.717    -1872.403    2722.011
             |
       d1prod |
         L4. |   .3723397   .1413013     2.64   0.008     .0953943    .6492852
             |
CPOExportVolume |
         L4. |  -.2088845   .2122028    -0.98   0.325    -.6247943    .2070253
             |
       _cons |   1272531    814797.7     1.56   0.118    -324442.9    2869505
-------------+----------------------------------------------------------------
CPOExportVolume |
      d1gdp  |
         L4. |  -3.92e-08   1.65e-08    -2.37   0.018    -7.16e-08   -6.73e-09
             |
d1palmoilprice |
         L4. |   314.5831   709.6736     0.44   0.658    -1076.352    1705.518
             |
       d1prod |
         L4. |   .0177913   .0855564     0.21   0.835    -.1498962    .1854789
             |
CPOExportVolume |
         L4. |   .2827281   .1284865     2.20   0.028     .0308991    .534557
             |
       _cons |   2309109   493351.4     4.68   0.000      1342158    3276060
------------------------------------------------------------------------------
```

```
. varbasic d1lgdp d1lprice d1lprod lexport, lags (4)

Vector autoregression

Sample:  2007q2 - 2017q4                        Number of obs     =         43
Log likelihood =   241.5287                     AIC               =  -10.30366
FPE            =   3.95e-10                     HQIC              =  -10.00158
Det(Sigma_ml)  =   1.55e-10                     SBIC              =  -9.484496

Equation           Parms      RMSE     R-sq      chi2     P>chi2
------------------------------------------------------------------
d1lgdp                 5     .002714   0.1317   6.522046   0.1634
d1lprice               5     .151746   0.1081    5.21158   0.2663
d1lprod                5     .147732   0.2029   10.94805   0.0272
lexport                5     .318026   0.0745   3.460609   0.4839
------------------------------------------------------------------

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
d1lgdp       |
      d1lgdp |
         L4. |   .4458871   .1765545     2.53   0.012     .0998466    .7919276
             |
d1lprice     |
         L4. |  -.0042634   .0031881    -1.34   0.181    -.0105119    .0019851
             |
       d1lprod |
         L4. |   .0012413   .0025281     0.49   0.623    -.0037138    .0061963
             |
lexport      |
         L4. |  -.0004286    .001187    -0.36   0.718    -.0027551    .0018979
             |
       _cons |    .013486   .0171112     0.79   0.431    -.0200514    .0470233
-------------+----------------------------------------------------------------
d1lprice     |
      d1lgdp |
         L4. |   19.68092   9.871417     1.99   0.046     .3332952    39.02854
             |
     d1lprice |
         L4. |  -.142369    .1782503    -0.80   0.424    -.4917331    .2069952
             |
       d1lprod |
         L4. |   .1848411   .1413514     1.31   0.191    -.0922026    .4618848
             |
lexport      |
         L4. |   .0275497   .0663687     0.42   0.678    -.1025307     .15763
             |
       _cons |  -.6624898   .9567114    -0.69   0.489    -2.53761     1.21263
-------------+----------------------------------------------------------------
d1lprod      |
      d1lgdp |
         L4. |  -13.6847    9.610326    -1.42   0.154    -32.52059    5.151196
             |
     d1lprice |
         L4. |   .098548    .1735357     0.57   0.570    -.2415757    .4386718
             |
       d1lprod |
         L4. |   .3488808   .1376128     2.54   0.011     .0791647     .618597
             |
lexport      |
         L4. |  -.0270418   .0646133    -0.42   0.676    -.1536816    .0995981
             |
       _cons |   .5870696   .9314072     0.63   0.528    -1.238455    2.412594
-------------+----------------------------------------------------------------
lexport      |
      d1lgdp |
         L4. |  -13.85493   20.68828    -0.67   0.503    -54.40321    26.69336
             |
     d1lprice |
         L4. |   .1454677   .3735727     0.39   0.697    -.5867214    .8776568
             |
       d1lprod |
         L4. |   .0818565    .296241     0.28   0.782    -.4987652    .6624781
             |
lexport      |
         L4. |   .2296142    .139094     1.65   0.099    -.0430051    .5022335
             |
       _cons |   11.27598   2.005053     5.62   0.000     7.346147    15.20581
------------------------------------------------------------------------------
```

Note: Retrieved from STATA result. Source: FED St. Louis website, the IMF database, and Indonesia Statistics Office.