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## Article

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## Price Determination Model of World Vegetable and Petroleum

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### ABSTRACT

The increasing as non-food uses of vegetable oils especially as biodiesel and the basis of the oleo-chemical industry, making the formation of vegetable oil prices in world trade has been linked to world prices of crude oil in addition to linkages with the world price of vegetable oils competitor. The objectives of study were to analyze the linkage of the world price of crude and vegetable oil simultaneously, and examine the impact of the changes of the external factors and trade policy by the vegetable oil's exporting countries and importing countries on the world trade of vegetable oils, and particularly the production, domestic supply, domestic consumption and exports volumes of Indonesian palm oil. The study employed an econometric model and parameters were estimated using Two Stage Least Squares methods for the period 1990-2017. The study found that real price projections in the world market of 2012-2025 periods show the price fluctuations of crude oil and vegetable oil tend to have same patterns with slightly trend to increases. Although positively correlated, the percentage increase of vegetable oils price as the effect of the increasing of crude oil price is less than the percentage change of crude oil prices, except for soybean oil prices that vista vies with the percentage change of crude oil prices. The effect on percentage change of price of soybean oils is the highest and then followed by palm oil. Beside the chemical characteristics, the condition related to the limited volumes of vegetable oils world's productions and the food sector needs as a main constraints in the use of vegetable oils as crude oil substitutes. As annual crop commodities and the substitutes of seed oils, however, palm oil price has more responsive to export fluctuation then it.

**Keywords:** Price Formation, World Trade, Vegetable Oil, Petroleum

**JEL Classifications:** D43, F15, Q41, Q42

### 1. INTRODUCTION

Palm oil together with soybean oil and rapeseed oil are the three main oils produced and traded on the world market of vegetable oils and on the world market of edible oils and fats. Production of vegetable oils is generally intended for food needs, while others are used for non-food purposes (specifically the oleo chemical and biodiesel industries) and the remainder is used as animal feed. Chemically, vegetable oil has the main equation of having triglycerides with fatty acids that are bound to their arms. Given the similar composition, both for food and non-food purposes, between vegetable oils can be substituted. In addition, in the world market there is competition between producing countries for the same type of oil. As a consequence of intense competition,

fluctuations in vegetable oil prices have been found (Jayed et al., 2011; Varkkey, 2012). In the 1980s the ratio of vegetable oils for food, non-food and animal feed ranged from 80:14:6. Along with the increase in non-food use in the last 13 years, the ratio of the use of vegetable oils currently ranges from 75:20:5. The increase was driven by the increase in biodiesel use and as a substitute for the basic ingredients of the oleo chemical industry which was initially based on petroleum (Ayoub and Abdullah, 2012). Related to the above, then in the trade of world vegetable oil in addition to competition between types of vegetable oil, the formation of the world price of vegetable oil is thought to have a relationship with world oil/crude oil prices. This link can be seen from the relatively similar pattern of vegetable oil price movements and oil prices, especially since 2003. The pattern of movements in the prices of

four major vegetable oils and oil prices in the world market in 1980-2008 as presented in Figure 1.

The nature of non-renewable petroleum and the increase in world population has encouraged the use of vegetable oil as an alternative energy source and as a substitute for the basic ingredients of the oleo chemical industry which was originally based on petroleum (Murphy, 2014). Although renewable, the limited volume of world production and meeting the needs of the food sector are the main obstacles in the use of vegetable oil as a substitute for petroleum in the future (Mekhilef et al., 2011; Ayoub and Abdullah, 2012). It is known that Indonesia is one of the main producing countries for palm oil and palm oil has become a strategic commodity for the Indonesian economy. Therefore the problem arises as to how the prices of vegetable oil and petroleum are linked in the world trade in vegetable oils to the production, domestic supply, consumption and export of Indonesian palm oil.

Whereas the general objective of this research is to examine the linkages of vegetable oil prices and petroleum prices in the world trade of vegetable oils along with other external factors. The vegetable oils referred to in this study include palm oil, soybean oil, rapeseed oil and sunflower seed oil.

The exporting country and importer of vegetable oil countries used in this study are presented in Table 1. The selection of exporting countries is based on a country's export volume share of world export volumes and the country must be a producer country, while the import country selection is based on an import volume share country against the volume of world imports.

## 2. LITERATURE REVIEW

Some studies analyzed the competition between edible oil in the world market and the factors that influence the formation of vegetable oil prices have been conducted, but modeling is commonly used has not been much that unites the entire source of vegetable oil in a framework of analysis. These studies include Baharsjah (1974), Suryana (1987), Susilowati (1989), Hassouneh et al. (2012), and Susila et al. (2016).

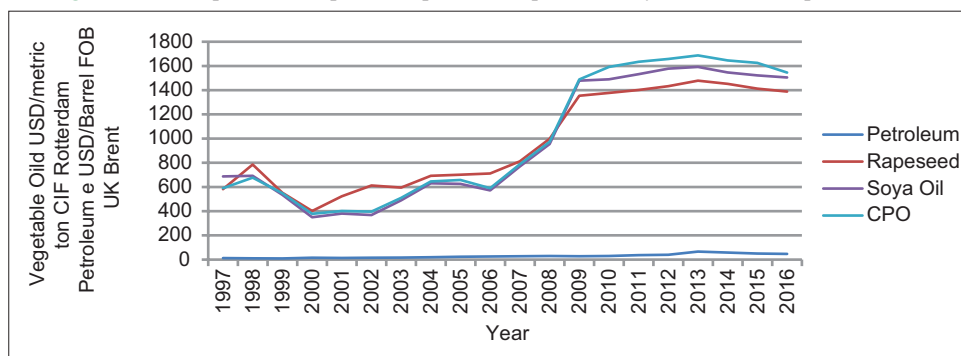
Meanwhile, several studies related to the link between the price of vegetable oil and petroleum have been carried out by Amiruddin et al. (2005), Yu et al. (2006), Awad et al. (2007), Hameed and Arshad, (2008), Helbling et al. (2008), Arianto et al. (2010), Chen et al. (2010), Yahya et al. (2011), Hassouneh et al. (2012), and Gan and Li (2014).

Baharsjah (1974) in his article entitled the domestic and international trade of Indonesian coconuts products showed that the price of exports of coconut oil with palm oil was substituted for the markets of the European Economic Community (EEC) and Japan. Whereas Suryana (1987) in his article entitled Trade Prospects of Indonesian palm oil in the international markets for fats and oils concluded that for the American market, exports have an elastic price; palm oil is complementary to coconut oil and soybean oil and is a normal item. In addition to the EEC market, Japan and Malaysia show prices are inelastic and coconut oil and soybean oil are complementary and are normal goods. From these data it can be seen that Indonesian palm oil is complementary to soybean and coconut oil in the United States, EEC, Japan and Malaysia, and price elasticity is inelastic (except America) and is normal goods.

According to Griffith and Meilke (1979), the price of various types of world vegetable oils is thought to interact with each other because of the mutual substitution between various types of vegetable oils. The same thing also allegedly happened between vegetable oil and petroleum, because of the tendency of the use of fuel made from vegetable oils. Econometric studies of vegetable oils are not easy to do because they have to aggregate many types of commodities. The best solution that can be done is to aggregate several commodities with similar price movements.

Susilowati (1989) in her research on the market of world palm oil and its relation to exports of Indonesian palm oil stated that: (1) Exports of Indonesian palm oil have elastic price elasticity and the relationship with Malaysian palm oil is mutually substituted, (2) for Malaysia's export offers have inelastic price elasticity and Malaysian and Indonesian palm oil are of a nature complement, (3) for the demand for Indonesian domestic palm oil showing that palm oil is substituted with coconut oil and is a normal item, (4) for exports to the American market, prices are inelastic, normal goods, and with coconut and soybean oil substituted, (5) for

**Figure 1:** World price development of petroleum, palm oil, soybean oil, and rapeseed oil 1997-2016



Source: World Oil, 2017<sup>1</sup>

<sup>1</sup> <https://www.oilworld.biz/t/statistics/commodities>

exports to Japan, having inelastic price elasticity, substituting soybean oil, and normal goods, and (6) for the EU market, inelastic price elasticity, normal goods, substituted with soybean oil and supplemented with rapeseed oil.

Susila et al. (2016) in the study of the domestic economic model of crude palm oil concluded: (1) CPO world prices are influenced by CPO stocks, prices with lag-one and lag-5 years before, previous year's consumption and prices of other vegetable oils, (2) Malaysian exports are influenced by stocks, population, world CPO prices and exchange rates, (3) Indonesian exports are largely influenced by stock and time for domestic consumption security, (4) on the EU market, more exports as buffer and more imports determined by CPO prices, prices of other vegetable oils and previous imports, (5) in the Chinese market, consumption is influenced by CPO prices, prices of other vegetable oils and previous period consumption, and (6) in the Pakistani market, consumption is influenced by income and population, while imports are affected by the level of consumption and income levels.

Awad et al. (2007) found that the price of oil substitution play an important role in shaping the demand for palm oil in almost all countries of the middle East and North Africa (MENA). Beside that other factors such as high palm oil discount, the 1970s world petroleum prices boom, the anti-palm oil campaign, trade embargos on Libya and Iraq, and exchange rate also proved to be important factors affecting import demand for palm oil in some MENA countries.

Yu et al. (2006) conducted a study of the relationship between the price of vegetable oil and petroleum by using weekly data from January 1999 to March 2006. The procedure used is the co-integration technique multivariate and concluded that the shock of petroleum prices did not have a significant effect on variations in the price of vegetable oils. Meanwhile Hameed and Arshad (2008) used monthly data from January 1983 to March 2008 using the Johansen co-integration method and Granger causality. The results of the study concluded that oil prices had an influence on the prices of vegetable oils. Co-integration between vegetable oils was delivered by Amiruddin et al. (2005), and concluded that soybean oil is the price leader among various vegetable oils. The data used are monthly data from January 1990 to June 2004, and examined by impulse response and variance decomposition.

Helbling et al. (2008) suggested that in addition caused by specific factors of each commodity, namely geopolitical risks, climate and weather conditions and crop failures, the increase in prices is also due to supply and demand factors that influence each other. Factors that influence the increased prices of commodities such as economic growth has driven demand for various commodities, biofuels have pushed the demand for a variety of crops that can be converted into biofuels, Response offers a slow, linkages between the various commodities and interest rates low and the depreciation of the US Dollar.

Arianto et al. (2010) in the research on palm oil price analysis, reviewed of co-integration of Oil and vegetable oil prices aimed at getting a clearer picture of the relationship between the price of vegetable oil and petroleum from the results of previous studies

conducted by Yu et al. (2006), Hameed and Arshad (2008) and Amiruddin et al. (2005). In the study, the dynamic linkages between various types of vegetable oils and petroleum are presented using the vector error correction model procedure. The data used are monthly data for the period January 1980-December 2008, namely the price data of the three most widely produced vegetable oils in the world, including palm oil, soybean oil, and rapeseed oil. Besides that it is included in the system observed is the price of petroleum. This is to examine the effect of petroleum prices on vegetable oils in the context of using vegetable oils as raw material for biodiesel. To find out the dynamics that occurred in the period of increasing commodity prices, the study was conducted on the period before the increase in commodity prices (1980-2003) and in the period of increasing commodity prices (2004-2008). The results of the study show that there is a long-term co-integration between vegetable oil and petroleum, and petroleum has a strong influence on vegetable oils, especially in periods of increasing commodity prices.

Chen et al. (2010) in his research the relationship between the oil price and global food prices concluded that increasing the processing of corn seeds as ethanol and soybean seeds as biodiesel has made the price of corn kernels and soybean seeds is significantly influenced by changes in oil prices and the interplay between the prices of corn kernels and soybean seeds.

Hassouneh et al. (2012) in his study used multivariate local linear regression and parametric error correction models to assess the relationship between prices and the price transmission pattern between food and energy prices in Spain, where the results of the study found that the prices of biodiesel, sunflower and weekly crude oil observed from November 2006 to October 2010 showed a long-term balance relationship between the three prices studied. In addition it was also found that Biodiesel is the only variable that adjusts deviations from long-term relationships. Local linear regression techniques show that the speed of adjusting biodiesel prices is faster when biodiesel is relatively inexpensive. Energy prices were also found to affect the price of sunflower oil through the dynamics of short-term prices.

Research by Gan and Li (2014) analyzed the prospects for domestic supply and demand for palm oil in Malaysia, including biodiesel demand and its ability to supply the global market by 2035. In this study, it was concluded that Malaysia has the potential to play a leading role in the food and biofuel markets the world, where domestic palm oil production is projected to rise by around 50% to 26.6 million tons by 2035. Domestic demand for palm oil for food consumption, industrial non-food use and biodiesel is expected to increase by more than 200% to 1.4 million tons in 2035, up from 0.4 million tons in 2009. Domestic demand, only a small portion (5%) of total palm oil production in 2035, with an expected export surplus of more than 25 million tons, with such surplus capacity, Malaysia will be a formidable competitor in the world vegetable and biofuel oil market.

### 3. METHODOLOGY

The study used secondary data from various sources in the period 1980-2008. The data mainly comes from (a) Oil World

Data Base, (b) International Monetary Fund (IMF), (c) World Bank, (d) Indonesian Central Bureau of Statistics (BPS), and (e) Directorate General of Plantation, Ministry of Agriculture Republic of Indonesia in 1990-2017.

The study begins by building modeling world palm oil market as a framework of analysis in the world market of vegetable oils. The main competitor oil for palm oil is defined as a type of biofuel which has (1) the same variation in use in daily life, (2) produced and traded in large quantities, and (3) as a substitute for petroleum. Based on the results of previous studies, literature and the data obtained competitor oil palm oil are soybean oil, and rapeseed oil.

The exporting and importing countries used in this study are presented in Table 1. Selection of exporting countries based on the share of a country's exports volume to the volume of world exports and the country should be a producer country, while the selection of importing countries based on the volume of imports of a country's share of the world import volume (Gan and Li, 2014). The approach is done horizontally and does not discuss in depth or vertically every competitor commodity and every country, except Indonesian palm oil.

The model diagram of the relationship between the prices of vegetable oils and petroleum in the world trade in vegetable oils as presented in Figure 2 and divided into four blocks, namely: (1) Palm oil blocks, (2) soybean oil blocks, (3) rapeseed oil blocks,

and (4) sunflower seed oil blocks. It also consists of 97 equations with details of 81 structural equations and 16 identity equations. Recapitulation of equations in models by country and Vegetable oil groups are presented in Table 2.

### 3.1. Exports and Consumption of Palm Oil

#### 1. Indonesia

According to Nayantakaningtyas and Daryanto (2012), the export of Indonesian palm oil (XSI) is determined by the exports real price (HESI), percentage of rate of change of real domestic prices, Indonesia exchange rate (ERI), export price (PESI), and volume of export production and supply (SXSI), where it stated in the equation as follows:

$$XSI = a_0 HESI + a_1 RHDSI + a_2 ERI + a_3 PESI + a_4 SXSI + \epsilon_2 \quad (1)$$

Expected parameter estimated  $>0$ ;  $a_0, a_2, a_4 <0$ ;  $a_1, a_3 <0$

The export production and supply of Indonesian palm oil SXSI is equality of identity, namely the total supply of Indonesian palm oil is reduced by the consumption of Indonesian palm oil, and is formulated as follows:

$$SXSI = PRODSI + STOKSI - CSI \quad (2)$$

$$SDSI = PRODSI + STOKSI - XSI \quad (3)$$

Thus Indonesia consumption palm oil (CSI) is determined by population, world oil riel price, and lag of Indonesia consumption palm oil.

$$CSI = a_0 + a_1 HDSI + a_2 RHCOW + a_3 POPI + a_4 LCSi + \epsilon_3 \quad (4)$$

Expected parameter estimation:  $a_2, a_3 >0$ ;  $a_1 <0$ ;  $0 < a_4 <1$

#### 2. Malaysian

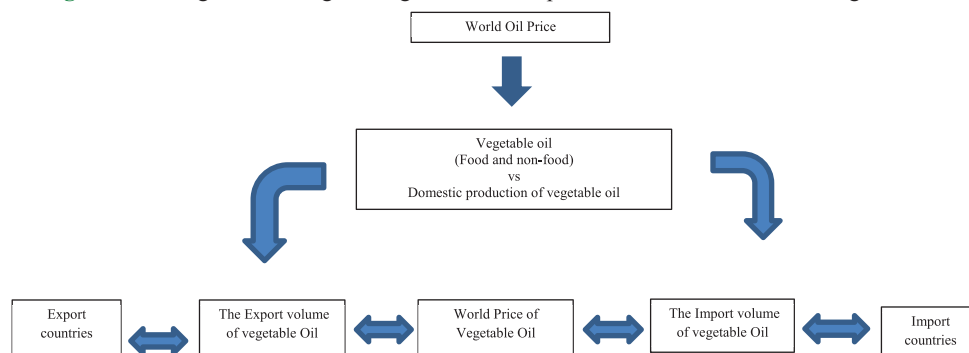
Based on Thalib et al. (2007), and Applanaidu et al. (2011), Malaysian palm oil exports (XSM) defined as the volume of exports (XSM), Malaysia's real palm oil export price (HESM), Malaysian palm oil export tax (PESM), initial stock of Malaysian palm oil (STOKSM), Malaysian palm oil production (PRODSM), and Lag of the volume of exports of Malaysian palm oil (LXSM), where they are expressed in the following equation:

**Table 1: Exporter and importer countries of vegetable oil in the world and petroleum price determination model**

Commodities	Exporter countries	Importer countries
Palm oil	Indonesia	China
	Malaysia	EU-15
	-	India
	-	Pakistan
Soybean Oil	Argentina	China
	Brazil	India
	The United States	EU-15
	-	Iran
Rapeseed Oil	Canada	The United States
	The United States	EU-15
	-	China

Source: Oil World, 2018. EU-15 includes: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and the United Kingdom

**Figure 2: Linkage model diagram vegetable oil and petroleum in the world trade vegetable oil**



Source: Chen et al., 2010; Gan and Li, 2014

**Table 2: Parameter estimation of export equations, consumption, area and productivity of palm oil produces Indonesia, Malaysia, EU, China, and India1990-2017**

Variables	Symbols	Parameters	t value		Elasticities	
					Short term	Long term
Indonesia						
Palm oil export (XSI)						
Palm oil riel export price	HESI	-453.43	-0.82	-	0.070	-
The rate of change in the real domestic price of palm oil	RHDSI	0.0083	0.19	-	0.001	-
Real exchange rate	ERI	57.94	-2.92	-	0.008	-
Export tax palm oil	PESI	0.89607	25.13	A	0.026	-
Supply of export markets for palm oil	SXSI	1.4058	1.14	A		
R <sup>2</sup> =0.987, R <sup>2</sup> . Adj.=0.984, F-stat=1.92565, DW=1.92565, dh=-						
Consumption of palm oil (CSI)						
Domestic riel price	HDSI	-0.05438	-1.31	F	0.056	0.185
The rate of change in the real world oil of price	RHCOW	961.70340	0.72	-	0.001	0.002
Poplulation	POPI	23.42292	2.55	B	1.186	3.900
Lag consumption	LCSI	0.69584	4.77	A		
Poplulation	RHCOW	961.70340	0.72	-	0.001	0.002
R <sup>2</sup> =0.987, R <sup>2</sup> . Adj.=0.985, F-stat=398.70, DW=1.98633, dh=0.05						
Malaysia palm oil export (XSM)						
Riel export price of palm oil	HESM	0.06986	0.06	-	0.003	0.005
Export tax	PESM	-6.67733	-0.21	-	0.003	0.006
Palm oil stocks	STOKSM	0.81246	1.10	-	0.094	0.176
Production	PRODSM	0.38892	2.07	C	0.469	0.877
Lag of export	LXSM	0.46543	2.10	B		
R <sup>2</sup> =0.995, R <sup>2</sup> . Adj.=0.994, F-stat=881.01, DW=2.91564, dh=-						
China palm oil import (MSC)						
Import riel price	HMSC	-0.12175	-0.23	-	0.014	-
Consumption	CSC	1.02941	38.72	A	0.955	-
R <sup>2</sup> =0.985, R <sup>2</sup> . Adj.=0.984, F-stat=763.93, DW=0.536344, dh=-						
Palm oil consumption (CSC)						
The real price of palm oil import	HMSC	-2.99543	-1.98	C	0.363	-
The real price of soya oil import	HMKC	0.17510	0.15	-	0.022	-
The real price of rapeseed oil import	HMRC	1.79444	1.12	-	0.248	-
The real price of petroleum import	HCOW	145.28	1.78	C	1.880	-
Riel GDP per capita	IPC	1.22316	8.07	A	1.256	-
Population	POPC	3.44782	1.87	C	1.042	-
R <sup>2</sup> =0.953, R <sup>2</sup> . Adj.=0.939, F-stat=-64.70, DW=1.09717, dh=-						
European union countries (EU 15)						
Import of palm oil (MSEU)						
Riel price of import	HMSEU	-0.23945	-1.45	E	0.028	0.215
Consumption	CSEU	0.39948	3.29	A	0.209	1.635
Lag of Import	LMSEU	0.87188	13.55	A		
R <sup>2</sup> =0.978, R <sup>2</sup> . Adj.=0.976, F-stat=2496.42, DW=1.57784, dh=1.14						
Consumption of palm oil						
The real price of palm oil import	HMSEU	-1.76015	-2.83	B	0.387	0.978
The real price of sun flower oil import	HMMEU	1.23679	1.94	C	0.335	0.847
The growth rate of the real world petroleum prices	RHCOW	590.79	0.49	-	0.001	0.001
Riel GDP per capita	IPEU	0.04098	1.10	-	0.430	1.088
Population	POPEU	24.40434	1.38	E	3.983	10.074
Lag of consumption	LCSEU	0.60456	3.75	A		
R <sup>2</sup> =0.967, R <sup>2</sup> . Adj.=0.959, F-stat=101.69, DW=1.79015, dh=0.94						
India						
Import of palm oil (MSID)						
The ratio of the growth rate of real import prices of palm oil to the rate of consumption of palm oil	RRHMSIDRCSID	-91.53	-0.76	-	0.016	-
Import tariff	TMSID	-180.13	-7.15	A	0.793	-
Exchange rate	ERID	-70.78	-2.67	B	0.735	-
R <sup>2</sup> =0.800, R <sup>2</sup> . Adj.=0.772, F-stat=29.28, DW=0.63000, dh=-						
Consumption of palm oil						
Riel import price	HMSID	-1.18	-0.61	-	0.157	-
Exchange rate	ERID	0.76	0.89	-	0.402	-
Population	POPID	11.43984	7.33	A	3.301	-
R <sup>2</sup> =0.787, R <sup>2</sup> . Adj.=0.758, F-stat=27.06, DW=0.38716, dh=-						

(Contd...)

**Table 2: (Continued)**

Variables	Symbols	Parameters	t value		Elasticities	
					Short term	Long term
					Pakistan	
Import of palm oil (MSP)						
Riel import price	HMSP	−0.13369	−0.91	-	0.042	0.079
Exchange rate	ERP	−9.75469	−2.08	C	0.318	0.593
Import tariff	TMSP	−39.95130	−4.01	A	0.405	0.754
The ratio of the growth rate of palm oil	RCSP	784.95960	5.85	A	0.041	0.076
Lag of import	LMSP	0.46336	3.06	A		
R <sup>2</sup> =0.969, R <sup>2</sup> . Adj.=0.961, F-stat=125.26, DW=2.81928, dh=-						
Consumption of palm oil (CSP)						
Riel Import Price	HMSP	−3.06	−1.33	E	0.102	0.181
Population	POPP	12.745	3.01	A	1.166	2.059
Lag of Consumption	LCSP	0.434	2.23	B	-s	-
R <sup>2</sup> =0.915, R <sup>2</sup> . Adj.=0.904, F-stat=79.41, DW=2.10229, dh=−1.83801						
Remarks: A: Real at level 1%		B: Real at level 5%		C: Real at level 10%		
D: Real at level 15%		E: Real at level 20%		F: Real at level 25%		

Source: Intriligator et al., 1995, and Authors, 2018

$$XSM = a_0HESM + a_1PESM + a_2STOKSM + a_3PRODSM + a_4LXSM + \epsilon_4 \quad (4)$$

Expected parameter estimation:  $a_0, a_2, a_3 > 0$ ;  $a_1 < 0$ ;  $0 < a_4 < 1$

### 3. Total world palm oil exports

Global total palm oil (XSW) exports determined by the export volume of world palm oil (XSI), and the export volume of rest of the world palm oil (XSRW), thus they stated in identity equation as follows:

$$XSW = XSI + XSM + XSRW \quad (5)$$

## 3.2. Palm Oil Imports

Referring to the import equation, in this study the import equation in certain countries ( $MS_i$ ) is influenced by the amount, of consumption ( $CS_i$ ), the price level ( $HMS_i$ ), other commodity prices and the exchange rate ( $ER_i$ ). In the modeling of palm oil imports represented by China, EU-15, and India with 2017 share of total world imports of 16.58%, 15.68%, 17.06% and 5.21% respectively (Applanaidu et al., 2011).

### 1. China palm oil imports

$$MSC = a_0 + a_1HMSC + a_2CSC + \epsilon_5 \quad (6)$$

Expected parameter estimation:  $a_1 > 0$ ;  $a_2 > 0$

$$CSC = a_0 + a_1HMSC + a_2HMKC + a_3HMRC + a_4HCOW + a_5IPC + a_6POPC + \epsilon_6 \quad (7)$$

### 2. EU countries

$$MSEU = a_0HMSEU + a_1CSEU + a_2LMSEU + \epsilon_7 \quad (8)$$

Expected parameter estimation:  $a_0 < 0$ ;  $a_1 > 0$ ;  $0 < a_2 < 1$

$$CSEU = a_0 + a_1HMSEU + a_2HMMEU + a_3RHCOW + a_4IPEU + a_5POPEU + a_6LCSEU + \epsilon_8 \quad (9)$$

Expected parameter estimation:  $a_1 < 0$ ;  $a_2, a_3, a_4 > 0$ ;  $0 < a_6 < 1$

### 3. India

$$MSID = a_0 + a_1RHMSIDRCSID + a_2TMSID + a_3ERID + \epsilon_9 \quad (10)$$

Expected parameter estimation:  $a_1, a_2, a_3 < 0$

$$CSID = a_0 + a_1HMSID + a_2IPID + a_3POPID + \epsilon_{10} \quad (11)$$

Expected parameter estimation:  $a_1 < 0$ ;  $a_2, a_3 > 0$

### 4. The world import

Thus the equation of the total import of world of palm oil (MSW) is represented by:

$$MSW = MSC + MSEU + MSID + MS \quad (12)$$

## 3.3. Price of Palm Oil

The world price of palm oil in certain countries ( $HS_i$ ) represented by prices in the Rotterdam market as a reference (McCarthy et al., 2012). The world price of palm oil ( $HS_i$ ), real world price of palm oil ( $HSW_i$ ), real world price of palm oil in the previous year ( $LHSW_i$ ), and total world palm oil imports ( $MSW_i$ ), and it is expressed in terms of the following:

$$HS = a_0 + a_1HSW + a_2LHSW + a_3MSW + \epsilon_{11} \quad (13)$$

Expected parameter estimation:  $a_1 < 0$ ;  $a_2, a_3 > 0$

The world price of palm oil (HSW) represented by the export price of palm oil in Indonesia (HESI) and Malaysia (HESM), domestic price of palm oil in Indonesia (HDSI<sub>i</sub>), import price of palm oil in China (HMSC<sub>i</sub>), the import price of palm oil in EU countries (HMEU), and import price of palm oil in India (HMSID<sub>i</sub>).

$$HSW = a_0 + a_1HESI + a_2HESM + a_3HDSI + a_4HMSC + a_5HMEU + a_6HMSID + \epsilon_{12} \quad (14)$$

Where,

$$\text{HESI} = a_0 + a_1 \text{HSv} + a_2 \text{ERI} + a_3 \text{RXSI} + a_4 \text{LHESI} + \epsilon_{13} \quad (15)$$

$$\text{HESM} = a_0 + a_1 \text{HS} + a_2 \text{ERM} + a_3 \text{XSM} + a_4 \text{LHESM} + \epsilon_{14} \quad (16)$$

$$\text{HDSI} = a_0 + a_1 \text{HESI} + a_2 \text{ERI} + a_3 \text{RTSDSI} + a_4 \text{LHDSI} + \epsilon_{15} \quad (17)$$

$$\text{HESC} = a_0 + a_1 \text{HS} + a_2 \text{TMSC} + \epsilon_{16} \quad (18)$$

$$\text{HMSEU} = a_0 + a_1 \text{HS} + a_2 \text{TMSEU} + \epsilon_{17} \quad (19)$$

$$\text{HMSID} = a_0 + a_1 \text{HS} + a_2 \text{RCSID} + a_3 \text{LHMSID} + \epsilon_{18} \quad (20)$$

### 3.4. Soybean Oil Export

According to Peri and Baldi (2010), and Nouri et al. (2013), the Soybean oil export in certain countries ( $\text{XK}_i$ ) represented by the price of export ( $\text{HE}_i$ ), domestic price ( $\text{HD}_i$ ), exchange rate ( $\text{ER}_i$ ), and production ( $\text{PROD}_i$ ), the equation as follows:

1. Argentina soybean oil export (XKA)

$$\text{XKA} = a_0 + a_1 \text{HEKA} + a_2 \text{HDKA} + a_3 \text{ERA} + a_4 \text{PRODKA} + \epsilon_{19} \quad (21)$$

$$\text{CKA} = a_0 + a_1 \text{RHDKA} + a_2 \text{RHCOW} + a_3 \text{POPA} + \epsilon_{20} \quad (22)$$

Thus the domestic soybean oil supply in Argentina (SDKA):

$$\text{SDKA} = \text{PRODKA} + \text{STOKKA} - \text{XKA} \quad (23)$$

2. Brazil soybean oil export (XKB)

$$\text{XKB} = a_0 + a_1 \text{HEKB} + a_2 \text{HDKB} + a_3 \text{ERB} + a_4 \text{PRODKB} + a_5 \text{LXKB} + \epsilon_{21} \quad (24)$$

$$\text{CKB} = a_0 + a_1 \text{HDKB} + a_2 \text{RRHDKBRHCOW} + a_3 \text{POPB} + a_4 \text{LCKB} + \epsilon_{22} \quad (25)$$

Thus the domestic soybean oil supply in Brazil (SDKB):

$$\text{SDKB} = \text{PRODKB} + \text{STOKKB} - \text{XKB} \quad (26)$$

3. USA soybean oil export (XKUSA)

$$\text{XKUSA} = a_0 + a_1 \text{RHEKUSA} + a_2 \text{HDKUSA} + a_3 \text{PRODKUSA} + \epsilon_{23} \quad (27)$$

$$\text{CKUSA} = a_0 + a_1 \text{RHDKUSAHCOW} + a_2 \text{HDRUSA} + a_3 \text{POPUSA} + \epsilon_{24} \quad (28)$$

Thus the domestic soybean oil supply in the USA (SDKA) will be represented by:

$$\text{SDKUSA} = \text{PRODKUSA} + \text{STOKKUSA} - \text{XKUSA} \quad (29)$$

4. Total export world soybean oil

From the (Eq. 21), (Eq. 24), (Eq. 27) and the export of soybean oil from rest of the world (XKRW), the equation of total Export World Soybean Oil (XKW) will be represented by as follows:

$$\text{XKW} = \text{XKA} + \text{XKB} + \text{XKUSA} + \text{XKRW} \quad (30)$$

### 3.5. Import Soybean Oil

Import of soybean in certain countries ( $\text{MKC}_i$ ) and consumption of soybean oil ( $\text{CK}_i$ ) represented by Price of import ( $\text{HM}_i$ ), the volume of import ( $\text{MK}_i$ ), exchange rate ( $\text{ER}_i$ ), production of soybean in certain countries ( $\text{PROD}_i$ ) (Nouri et al. 2013), the equation will be defined by:

1. China

Import (MKC) and consumption of china soybean oil (CKC) will be represented by as follows:

$$\text{MKC} = a_0 + a_1 \text{HMKC} + a_2 \text{CKC} + a_3 \text{LMKC} + \epsilon_{25} \quad (31)$$

$$\text{CKC} = a_0 + a_1 \text{HMKC} + a_2 \text{IPC} + a_3 \text{POPC} + a_4 \text{LCKC} + \epsilon_{25} \quad (32)$$

2. EU countries

Import (MKEU) and consumption of EU soybean oil (CKEU) will be represented by as follows:

$$\text{MKEU} = a_0 + a_1 \text{HMKEU} + a_2 \text{EREU} + a_3 \text{CKEU} + \epsilon_{26} \quad (33)$$

$$\text{CKEU} = a_0 + a_1 \text{HMKEU} + a_2 \text{HMREU} + a_3 \text{HMMEU} + a_4 \text{RHCOW} + a_5 \text{IPEU} + a_6 \text{LCKEU} + \epsilon_{27} \quad (34)$$

3. India

Import (MKID) and consumption of India soybean oil (CKID) will be represented by as follows:

$$\text{MKID} = a_0 + a_1 \text{HMKID} + a_2 \text{PRODKID} + a_3 \text{CKID} + \epsilon_{28} \quad (35)$$

$$\text{CKID} = a_0 + a_1 \text{HMKID} + a_2 \text{HMSID} + a_3 \text{HCOW} + a_4 \text{POPID} + a_5 \text{LCKID} + \epsilon_{29} \quad (36)$$

4. Total world import

Thus the total world import of soybean oil (MKW) can be as follows:

$$\text{MKW} = \text{MKC} + \text{MKID} + \text{MKEU} + \text{MKRW} \quad (37)$$

### 3.6. Price of Soybean

Hassounh et al. (2012), and Nouri et al. (2013) stated that the price of soybean in certain countries such Argentina, Brazil, EU, USA, China, and India  $\text{HK}_i$  will be represented by the equation of the volume of export ( $\text{XK}_i$ ), the volume of import ( $\text{MK}_i$ ), lag of soybean price ( $\text{LHK}_i$ ), exchange rate ( $\text{ER}_i$ ), and export tax ( $\text{PE}_i$ ).

1. The world price of soybean oil (HKW)

$$\text{HKW} = a_0 + a_1 \text{XKW} + a_2 \text{MKW} + a_3 \text{LHKW} + \epsilon_{30} \quad (38)$$

2. Argentina export soybean price (HEKA)

$$\text{HEKA} = a_0 + a_1 \text{HKW} + a_2 \text{PERA} + a_3 \text{XKA} + a_4 \text{LHEKA} + \epsilon_{31} \quad (39)$$

3. Brazil export soybean price (HEKB)

$$\text{HEKB} = a_0 + a_1 \text{HKW} + a_2 \text{ERB} + a_3 \text{PEKB} + a_4 \text{LHEKB} + \epsilon_{32} \quad (40)$$

4. USA export soybean price (HEKUSA)

$$\text{HEKUSA} = a_0 + a_1 \text{HKW} + a_2 \text{SEKUSA} + \epsilon_{33} \quad (41)$$

### 5. China export soybean price (HMKC)

$$HMKC = a_0 + a_1 HKW + a_2 TMKC + \epsilon_{34} \quad (42)$$

### 6. EU export soybean price (HMKEU)

$$HMKEU = a_0 + a_1 HKW + a_2 TMKEU + \epsilon_{35} \quad (43)$$

### 7. India export soybean price (HMKID)

$$HMKID = a_0 + a_1 HKW + a_2 TMKID + \epsilon_{36} \quad (44)$$

## 3.7. Domestic Price of Soybean Oil

The domestic price of soybean in certain countries ( $HDK_i$ ) will be represented by the price of export ( $HE_i$ ), domestic supply ( $SK_i$ ), and consumption ( $CK_i$ ), so the equation will be presented by as follows:

### 1. Argentina domestic price of soybean oil (HDKA)

$$HDKA = a_0 + a_1 HEKA + a_2 RSDCKA + a_3 LHDKA + \epsilon_{37} \quad (45)$$

### 2. Brazil domestic price of soybean oil (HDKB)

$$HDKB = a_0 + a_1 HEKB + a_2 SDKB + a_3 CKB + \epsilon_{38} \quad (46)$$

### 3. USA domestic price of soybean oil (HDKB)

$$HDKUSA = a_0 + a_1 HEKUSA + a_2 SDKUSA + a_3 CKUSA + \epsilon_{39} \quad (47)$$

## 3.8. Rapeseed Oil Exports

According to Nazlioglu and Soytaş (2011), and Hassouneh et al. (2012), the rapeseed oil export in certain countries ( $XR_i$ ) such Canada, and USA will be represented by export volume ( $XR_i$ ), Production of rapeseed ( $PROD_i$ ), and export volume in the previous year ( $LXR_i$ ), so the equation as follows:

### 1. Canada

$$XRCD = a_0 + a_1 RHERCD + a_2 HDRCD + a_3 PRODCD + a_4 LXRCD + \epsilon_{40} \quad (48)$$

Expected parameter estimation:  $a_0, a_2, >0; a_1 <0, 0 < a_3 < 1$

$$XCRCD = a_0 + a_1 HDRCD + a_2 HCOW + a_3 POPCD + \epsilon_{41} \quad (49)$$

Expected parameter estimation:  $a_1 <0; a_2, a_3 >0; 0 < a_4 < 1$

### 2. USA

$$XCRUSA = a_0 + a_1 HERUSA + a_2 HDRUSA + a_3 PRODUSA + \epsilon_{42} \quad (50)$$

Expected parameter estimation:  $a_0, a_2 >0; a_1 <0$

$$CRUSA = a_0 + a_1 HDRUSA + a_2 RHDRUSA + a_3 HCOW + a_4 HDKUSA + a_5 POPUSA + \epsilon_{42} \quad (51)$$

Expected parameter estimation:  $a_1, a_2 <0; a_3, a_4 >0$

Thus domestic supply of rapeseed oil in USA will be as follows:

$$SDRUSA = PRODKUSA + STOKRUSA + MRUSA - XKRUSA \quad (52)$$

### 3. Total export of rapeseed oil

The equation of total export of rapeseed oil will be as follows:

$$XRW = XRCD + XRUSA + XRWW \quad (53)$$

## 3.9. Import of Rapeseed Oil

In the modeling of rapeseed oil import countries ( $MR_i$ ) represented by the USA, EU and China, the share of total world imports ( $MRW$ ) in 2012 was 44.61, 17.68 and 11.36 (Yahya et al. 2011; Nazlioglu and Soytaş, 2011; and Hassouneh et al., 2012) respectively.

### 1. USA

$$MRUSA = a_0 + a_1 HMRUSA + a_2 STOKRUSA + a_3 CRUSA + a_4 LMRUSA + \epsilon_{43} \quad (54)$$

Expected parameter estimation:  $a_1, a_2 <0; a_3 >0; 0 < a_4 < 0$

### 2. EU

$$MREU = a_0 + a_1 HMREU + a_2 CREU + \epsilon_{44} \quad (55)$$

Expected parameter estimation:  $a_1 <0; a_2 >0$

$$CREU = a_0 + a_1 HMREU + a_2 HMSEU + a_3 HCOW + a_4 POPEU + a_5 LCUREU + \epsilon_{45} \quad (56)$$

Expected parameter estimation:  $a_1 <0; a_2, a_3, a_4 >0; 0 < a_5 < 1$

### 3. China

$$MRC = a_0 + a_1 HMRC + a_2 PRODC + a_3 CRC + a_4 LMRC + \epsilon_{46} \quad (57)$$

Expected parameter estimation:  $a_1, a_2 <0; a_3 >0; 0 < a_4 < 1$

$$CRC = a_0 + a_1 HMRC + a_2 PHMKC + a_3 IPC + a_4 POPC + a_5 LCRC + \epsilon_{47} \quad (58)$$

Expected parameter estimation:  $a_1 <0; a_2, a_3, a_4 >0; 0 < a_5 < 1$

### 4. Total world import

$$MR = MRUSA + MREU + MRC + MRWW \quad (59)$$

## 3.10. Price of Rapeseed Oil

Based on Yahya et al. (2011), the price of rapeseed oil in certain countries ( $HR_i$ ) will be represented by export of rapeseed oil ( $XR_i$ ), import of rapeseed oil ( $MR_i$ ), export price ( $HER_i$ ), eksport subsidies ( $SER_i$ ), and lag of riel export price ( $LHER_i$ ).

### 1. World of price

$$HR = a_0 + a_1 XRW + a_2 MR + a_3 LHRW + \epsilon_{48} \quad (60)$$

### 2. Canada

$$HERCD = a_0 + a_1 HRW + a_2 SERCD + a_3 XRCD + a_4 LHERCD + \epsilon_{49} \quad (61)$$

Expected parameter estimation:  $a_0, a_1 >0; a_2 <0; 0 < a_3 < 1$

### 3. USA

$$HERUSA = a_0 + a_1 HRW + a_2 SERUSA + a_3 XRUSA + \epsilon_{50} \quad (62)$$

Expected parameter estimation:  $a_0, a_1 >0; a_2 <0$

## 3.11. Import Price of Rapeseed Oil

The import of rapeseed oil in certain countries ( $HR_i$ ) will be represented by import tariff ( $TM_i$ ), and price of rapeseed oil ( $HRW_i$ ) as follows:

### 1. USA

$$HMRUSA = a_0 + a_1 HRW + a_2 TMRUSA + \epsilon_{51} \quad (63)$$

Expected parameter estimation:  $a_0, a_1 >0$

## 2. EU

$$\text{HMREU} = a_0 \text{HR} + a_1 \text{TMREU} + \epsilon_{52} \quad (64)$$

Expected parameter estimation:  $a_0, a_1 > 0$

## 3. China

$$\text{HMRC} = a_0 \text{HR} + a_1 \text{TMRC} + \epsilon_{53} \quad (65)$$

Expected parameter estimation:  $a_0, a_1 > 0$

### 3.12. Domestic Price Rapeseed Oil

Nazlioglu and Soytaş (2011), defined that the domestic price of rapeseed oil in certain countries ( $\text{HDR}_i$ ) will be defined by export price of rapeseed oil ( $\text{HER}_i$ ), production ( $\text{PROD}_i$ ), and consumption ( $\text{CR}_i$ ).

## 1. Canada

$$\text{HDRCD} = a_0 \text{HERCD} + a_1 \text{PRODCD} + a_2 \text{CRCD} + a_3 \text{LHDRCD} + \epsilon_{54} \quad (65)$$

Expected parameter estimation:  $a_0, a_2 > 0; a_1 < 0; 0 < a_3 < 1$

## 2. USA

$$\text{HDRUSA} = a_0 + a_1 \text{HERUSA} + a_2 \text{HMRUSA} + a_3 \text{SDRUSA} + a_4 \text{CRUSA} + \epsilon_{55} \quad (66)$$

Expected parameter estimation:  $a_1, a_2, a_4 > 0; a_3 < 0$

After estimating the model, this research will then do a simulation (Koutsoyiannis, 1977; Intriligator et al., 1995). The simulation in this study is intended to see the impact of a change in external factors as well as changes in the trade policies of exporting countries and major importers of vegetable oils towards the world trade in vegetable oils and in particular the production, consumption and export of Indonesian palm oil (Shamsudin and Arshad, 2000; Yahya et al., 2011; Susila et al., 2016).

Simulation of external factors includes changes in world oil prices. Simulations of the trade policies of exporting countries and the major importing countries of vegetable oils include changes in export taxes, import tariffs and exchange rates.

## 4. DISCUSSION

### 4.1. World Palm Oil Performance

The world trade in palm oil is seen from producer and consumer countries as oligopoly (Lamers et al., 2008). Indonesia and Malaysia are the main producers and exporters of palm oil with the cumulative share of both countries around 89% of total exports on the world market for palm oil. China, India, EU-15 and Pakistan are the four main importing countries with a cumulative share of around 52.65% of total imports the world of palm oil.

### 4.2. Palm Oil Exports

Table 2 showed the performance of Indonesia's palm oil exports. Indonesia's palm oil exports (XSI) are influenced by export prices (HESI), the rate of change in domestic prices (RHDSI), exchange rates (ERI), export taxes (PESI) and Indonesian palm oil supply for export markets (SXSI). All exogenous variables are able to

explain the diversity of Indonesian palm oil exports by 99% and all variables have a real effect simultaneously.

Judging from the calculated value, the export of Indonesian palm oil is significantly affected by Indonesia's palm oil supply for the export market and export tax. The variable supply of Indonesian palm oil for the export market has a positive effect on exports. Enhancement an offer volume of 1% will increase exports by 0.89%. The short-term elasticity value approaches unitary elastic, which is equal to 0.95. The supply of Indonesian palm oil for the export market is the difference between the total Indonesian palm oil supply and oil consumption Indonesian palm oil (CSI). The total supply of Indonesian palm oil is the sum of the initial year stock (STOKSI) and Indonesian palm oil production (PRODSI).

Another variable that significantly affects the export of Indonesian palm oil is the export tax (PESI), but it has a negative influence. An increase in export tax of 1% will reduce the export volume of Indonesian palm oil by 58 thousand tons, from the average export volume in 1990 - 2017 amounting to 3.6 million tons, or around 1.61%. Other exogenous variables, namely the export prices of Indonesian palm oil (HESI) and exchange rates (ERI) have a positive influence on exports, while the variable rate of change in domestic prices (RHDSI) has a negative influence on exports. The three exogenous variables do not have a large impact on the export of Indonesian palm oil and are statistically significant at the level of >25%.

The consumption of Indonesian palm oil (CSI) is influenced by the variable domestic price of Indonesian palm oil (HDSI), the rate of change in petroleum prices (RHCOW), population numbers (POPI) and consumption lag (LCSI). All exogenous variables are able to explain the diversity of Indonesian palm oil consumption by 99% and all variables have a real effect simultaneously. Judging from the calculated value, Indonesia's palm oil consumption is mainly influenced by the lag of consumption, the population and domestic price of Indonesian palm oil respectively at the level of 1%, 5%, and 25%.

The Indonesian population exogenous variable (POPI) has a positive effect on consumption. Each additional population of 1000 people will increase consumption by 23.42 tons/year, from the average consumption volume in 1990-2017 of 2.35 million tons/year, or about 1%. Consumption of palm oil is responsive to population changes, especially in the long term which has a value of elasticity 3.3 times greater than the value of short-term elasticity. This phenomenon is related to the diversification of palm oil products which are relatively small in consumption and make the influence of Indonesia population more dependent on the population itself (Amirudddin et al., 2005; Nayantakaningtyas and Daryanto, 2012). Types of use in consumption Indonesian palm oil are dominated as a raw material for national cooking oil. About 77% of the volume of consumption of Indonesian palm oil is for the supply of raw materials for national cooking oil (Buyung et al., 2017).

The domestic price variable (HDSI) has a negative influence on consumption, while the variable rate of change in world oil prices (RHCOW) has a positive influence on consumption. However,

Indonesia's palm oil consumption is unresponsive to changes in these two variables. Like the influence of population (POPI) on consumption (CSI), this phenomenon is related to palm oil as the main raw material for national cooking oil and the relatively small diversification of products in consumption, including the processing of palm oil as a petroleum substitute product (Mekhilef et al., 2011). In addition, it is also influenced by trade policies implemented by the Indonesian government to guarantee the availability of domestic palm oil supplies.

Table 2 presented how the performance of Malaysian palm oil exports in 1990-2017 was presented, where exports of Malaysian palm oil (XSM) were affected by the export prices of Malaysian palm oil (HESM), export taxes (PESM), Malaysian palm oil stocks (STOKSM), production (PRODSM) and export lag (LXSM). All exogenous variables are able to explain the diversity of exports of Malaysian palm oil by 99% and all variables have a real effect together. Judging from the t-count value, the export of Malaysian palm oil is influenced by the lag of exports and production of Malaysia palm oil respectively at the level of 5% and 10%.

The value of short-term and long-term elasticity of all exogenous variables is inelastic. For the export price variable, this condition is in accordance with the results of Suryana (1987) and Sulistyanto and Akyuwen (2011) who concluded that the export response of Indonesian and Malaysian crude palm oil is inelastic towards price changes. This phenomenon is related to palm oil as a result of plantation commodities with characteristics of having a long production life and a production cycle (Hameed and Arshad, 2008). The influence of Malaysian palm oil production on exports of Malaysian palm oil is relatively greater than other exogenous variables. This condition is related to the balance between the volume of production and the need for consumption of Malaysia. If it is known that the percentage of consumption to Malaysian palm oil production volume is around 18%<sup>2</sup> or in other words there is still a relatively large remaining production for export activities.

In addition as a result of agricultural commodities, the Malaysian government policies that encourage the production volume settings Malaysian palm oil (information: Such as granting replanting incentive scheme 2002-2006) and the development of downstream industries processing crude palm oil to make the effect of changing production to Malaysia's exports is inelastic. This phenomenon also explains the effect of changes in the stock and export taxes on the export of Malaysian inelastic (Talib et al., 2007; Hameed and Arshad, 2008).

China is the first largest importer of palm oil with a share in the 2000-2008 periods of around 18% of total world imports<sup>3</sup>. The performance of Chinese palm oil imports and consumption in 1990-2017 is presented in Table 2. Imports of Chinese palm oil (MSC) are influenced by import prices (HMSC) and Chinese palm oil consumption (CSC). All exogenous variables are able to explain the diversity of China's palm oil import is 98% and all variables have a real effect together. Judging from the calculated

value, the import of Chinese palm oil is significantly affected by consumption. In addition, in the short term the response of China's palm oil imports to changes in consumption is relatively unitary elastic.

The consumption of Chinese palm oil (CSC) is significantly affected by China's palm oil import prices, world oil prices, population (POPC) and China's per capita income level (IPC). While the import prices of Chinese soybean oil (HMKC) and prices of Chinese rapeseed oil (HMRC) imports have no significant effect on Chinese palm oil consumption. In the short term, China's palm oil consumption is responsive to changes in world oil prices, changes in the level of income per capita and population. According to Jayed et al. (2011), the phenomenon is related to the main use of palm oil in China in the non-food sector including the processing of palm oil as a petroleum substitution product.

Imports of palm oil by EU-15 countries are mainly used for the needs of the non-food sector, including as an energy source for alternative substitutes and basic ingredients of the oleo-chemical industry which was originally based on petroleum (Parisi and Ronzon, 2016). In addition to being used alone, the results of processing palm oil are partly exported to other countries on the European continent. The balance between consumption and re-export of total imports is around 60:40 with an increasing trend of re-exports. The performance of imports and consumption of EU-15 palm oil are presented in Table 2.

The import of EU-15 palm oil (MSEU) is influenced by the import price variable (HMSEU), EU-15 palm oil consumption (CSEU) and import lag (LMSEU). All exogenous variables are able to explain the diversity of EU-15 palm oil imports by 98% and all variables have a real effect together. Judging from the t-count value, EU-15 palm oil imports are significantly affected by EU-15 palm oil consumption (CSEU) and import lag (LMSEU) at the level of 1% and price import (HMSEU) at the level of 20%. In the short term EU-15 palm oil imports are not responsive to all exogenous variables, but are responsive to changes in EU-15 palm oil consumption in the long run.

Consumption of EU-15 palm oil (CSEU) is significantly affected by EU-15 palm oil import prices (HMSEU), EU-15 sun oil import prices (HMSEU), population numbers (POPEU) and consumption lags. The per capita income level (IPEU) and the growth rate of petroleum prices do not significantly affect EU-15 palm oil consumption. All exogenous variables are able to explain the diversity of EU-15 palm oil imports by 92% and all variables have a significant effect simultaneously. In the short term, consumption of EU-15 palm oil is only responsive to population changes. In the long run, EU-15 palm oil consumption is responsive to population changes and relatively unitary elastic to changes in the level of per capita income and import prices for palm oil.

India is the second largest importer of palm oil after China (Hameed and Arshad, 2008; Varkkey, 2012). The main use of palm oil in India is in the food sector. The performance of Indian palm oil imports and consumption is presented in Table 2. Imports of Indian palm oil (MSID) are influenced by the ratio of Indian palm oil real

2 <https://www.oilworld.biz/t/statistics/commodities>

3 <https://www.oilworld.biz/t/statistics/commodities>

import price growth rates to the rate of consumption of Indian palm oil (RRHMSIDRCSID), Indian palm oil import tariffs (TMSID) and exchange rate (ERID). All exogenous variables are able to explain the diversity of Indian palm oil imports by 80% and all variables have a significant effect simultaneously. Judging from the calculated value, the import of Indian palm oil is significantly affected by Indian palm oil import tariffs and exchange rates. However, in the short term imports of Indian palm oil are not responsive to changes in all exogenous variables. Consumption of Indian palm oil (CSID) is significantly affected by population (POPID). Palm oil import price (HMSID) and exchange rate (ERID) variables have no significant effect on the consumption equation of Indian palm oil. All exogenous variables are able to explain the diversity of Indian palm oil consumption by 79% and all variables have a real effect together. In the short term, consumption of Indian palm oil is responsive to population changes.

### 4.3. Palm Oil Prices

Performance of world prices, export prices and domestic prices of exporting countries and the import prices of palm oil from importing countries in the model are presented in Table 3. The world prices of palm oil (HSW) equation is influenced by world exports of palm oil (XSW), world imports of palm oil (MSW) and lag the world price of palm oil (LHSW). All exogenous variables are able to explain the diversity of the world price of palm oil by 24% and all variables simultaneously have a significant effect on the level of 15%. In the short term, the world price of palm oil is relatively unitary to changes in world exports of palm oil, but is not responsive to changes in imports. In the long term, Nazlioglu and Soytaş (2011) explained that the response of the world price of palm oil to changes in world imports of palm oil is relatively responsive to changes in world exports of palm oil, but is not responsive to changes in imports.

These phenomena include: (1) World palm oil production and exports are dominated by Indonesia and Malaysia with the cumulative share of the two countries reaching 85% of total world production and total world exports, (2) in general the main oil importing countries oil palm does not have domestic production of palm oil, but is a producer country of three other vegetable oils.

The export prices of Indonesian palm oil (HESI) are influenced by the world price of palm oil (HSW), the exchange rate (ERI), the export growth rate of Indonesian palm oil (RXSI) and the lag in the export price of Indonesian palm oil (LHESI). All exogenous variables are able to explain the diversity of Indonesian palm oil export prices by 99% and all variables simultaneously have a significant effect. In the short term, the export price of Indonesian palm oil is not responsive to changes in all exogenous variables. In the long run, the export prices of Indonesian palm oil are not responsive to changes in the world price of palm oil.

The domestic price of Indonesian palm oil (HDSI) is influenced by the export prices of Indonesian palm oil (HESI), exchange rates (ERI), the ratio of Indonesia's total palm oil supply to the total demand for Indonesian palm oil (RTSDSI) and lag of domestic coconut oil prices Indonesian palm oil (LHDSI). All exogenous variables are able to explain the diversity of the export price of

Indonesian palm oil by 97% and all variables have a real effect together. The effect of changes in the export price of Indonesian palm oil to the domestic price of Indonesian coconut oil is relatively greater than the effect of changes in other exogenous variables, then followed by the influence of changes in exchange rates and the effect of changes in Indonesian palm oil supply to the total demand for Indonesian palm oil.

The export price of Malaysian palm oil (HESM) is influenced by the world price of palm oil (HSW), exchange rate (ERM), exports of Malaysian palm oil (XSM) and lags the price of Malaysian palm oil exports (LHESM). All exogenous variables are able to explain the diversity of the export price of Malaysian palm oil by 83% and all variables have a real effect together. The export price of Malaysian palm oil is responsive to changes in the world price of palm oil (Hameed and Arshad, 2008). This phenomenon is related to the balance between consumption and export of Malaysian palm oil to production around 18:82.

Based on t-statistic values, the prices of imported Chinese palm oil, EU-15, India and Pakistan are significantly affected by the world price of palm oil. Import tariffs have no significant effect, except for the influence of Chinese palm oil import tariffs on Chinese palm oil import prices. In general, all exogenous variables are included in each equation the import prices of each importing country are able to explain the diversity of import prices in the range of 65% -99%, and all variables give influence real together. The response of import prices to changes in world prices for palm oil and changes in import tariffs mainly occurred in China, followed by India, EU-15 and Pakistan. This phenomenon is related to the position of China and India as the two largest importing countries of palm oil (Hameed and Arshad, 2008; Varkkey, 2012).

### 4.4. World Soybean and rapeseed Oil Performance

Based on Mekhilef et al. (2011), soybean oil is the largest produced and the second largest oil traded on the world market in vegetable oils and in the world market for biofuels. A distinctive feature in the world trade in soybean oil is the main importing country is generally the main producer of soybean oil and imports are carried out to cover the shortage between the volume of domestic production and consumption. The use of soybean oil is relatively wide compared to three other vegetable oils, both in food stocks, in the oleo-chemical industry and as an alternative fuel source for petroleum (Gan and Li, 2014)

Argentina, Brazil and the United States are the three main exporter countries with a cumulative share of more than 85% of total exports on the world market for soybean oil. EU-15, China, India and Iran are the four main importing countries with a cumulative share of around 48.1% of total world imports of soybean oil (Janssen and Rutz, 2011).

Table 4 showed that the Argentine soybean oil (XKA) exports are influenced by the export prices of Argentine soybean oil (HEKA), the domestic price of Argentine soybean oil (HDKA), the exchange rate and Argentine soybean oil production (PRODKA). All exogenous variables are able to explain the diversity of soybean oil exports

**Table 3: Estimated results of world price equations, export prices and domestic prices of Exporters and prices of imported palm oil importers, 1990-2017**

Variables	Symbols	Parameters	t value		Elasticities	
					Short term	Long term
Indonesia						
The real world price of crude palm oil (HSW)						
World exports	XSW	-0.02120	-0.71	-	0.977	1.859
World imports	MSW	0.02331	0.77	-	1.095	2.084
Real exchange rate	LHSW	0.47444	2.31	B		-
Export tax palm oil	PESI	0.89607	25.13	A	0.026	-
R <sup>2</sup> =0.237, R <sup>2</sup> . Adj.=0.132, F-stat=2.27, DW=1.61426, dh=-						
The price of real exports of palm oil (HESI)						
World riel price	HSW	0.74513	9.76	A	0.878	1.054
Indonesia riel exchange rate	ERI	-0.00176	-0.82	-	0.032	0.039
The rate of export growth	RXSI	-11.06980	-0.65	-	0.004	0.004
Lag of exports	LHESI	0.16741	1.81	C		
R <sup>2</sup> =0.9994, R <sup>2</sup> . Adj.=0.993, F-stat=937.12, DW=1.43310, dh=1.64						
The domestic price of palm (HDSI)						
Riel export price of palm oil	HESI	4.66236	2.17	B	0.493	0.704
Indonesia riel exchange rate	ERI	0.15708	2.15	B	0.305	0.436
The ratio of the total supply of total demand	RTDSDI	-464.243	-0.41	-	0.106	0.151
Lag of domestic price	LHDSI	0.30071	2.26	B		
R <sup>2</sup> =0.970, R <sup>2</sup> . Adj.=0.964, F-stat=177.07, DW=1.8174, dh=0.63						
Malaysia export price of palm oil (HESM)						
World riel price	HSW	0.85516	8.03	A	0.957	1.929
Riel exchange rate	ERM	-14.06760	-0.49		0.102	0.135
Export	XSM	-0.00528	-1.70	D	0.140	0.185
Lag of export price	LHESM	0.24496	2.51	B		
R <sup>2</sup> =0.825, R <sup>2</sup> . Adj.=0.792, F-stat=24.74, DW=2.34565, dh=1.02						
Import prices of palm oil China (HMSC)						
The world real price	HSW	0.85498	18.01	A	0.915	-
Tariff	TMSC	2.07163	2.92	A	0.085	-
R <sup>2</sup> =0.993, R <sup>2</sup> . Adj.=0.992, F-stat=1705.07, DW=1.051652, dh=-						
Import prices of palm oil European countries (HMSEU)						
The real world price	HSW	0.74637	8.80	A	0.724	-
Tariff	TMSEU	1.44446	0.46	-	0.046	-
R <sup>2</sup> =0.781, R <sup>2</sup> . Adj.=0.762, F-stat=41.07, DW=1.473455, dh=-						
Import prices of palm oil India (HMSID)						
The world riel price	HHSW	0.66574	5.19	A	0.707	2.114
The growth rate of consumption	RCSID	23.18987	0.67	-	0.002	0.005
Lag import price	LHMSID	0.21873	1.75	C		
R <sup>2</sup> =0.691, R <sup>2</sup> . Adj.=0.649, F-stat=16.41, DW=1.07785, dh=-						
Import prices of palm oil Pakistan (HMSP)						
The world riel price	HSW	0.68999	6.04	A	0.689	1.034
Lag of import Price	LHSMP	033423	3.08	A	-	
R <sup>2</sup> =0.968, R <sup>2</sup> . Adj.=0.965, F-stat=358.48, DW=2.05282, dh=-0.16						
Remarks: A: Real at level 1%	B: Real at level 5%		C: Real at level 10%			
D: Real at level 15%	E: Real at level 20%		F: Real at level 25%			

Source: Intriligator et al., 1995, and Authors, 2018

Argentina is 99% and all variables have a real influence together. Judging from the statistical value, the export of Argentine soybean oil is significantly affected by the volume of production and consumption of Argentine soybean oil. Argentine soybean oil exports are responsive to changes in production, while changes to other exogenous variables do not have a large impact on Argentine soybean oil exports.

The consumption of Argentine soybean oil (CKA) is influenced by the growth rate of Argentine soybean oil (RHDKA) prices, the growth rate of world oil prices (RHCOW) and the Argentine population (POPA). All exogenous variables included in the equation are able to explain the diversity of Argentine soybean oil consumption by 64% and all variables have a real effect together.

In the short term, Argentine soybean oil consumption is responsive to population changes (Lamers et al., 2008), whereas changes in other exogenous variables do not have a large impact on Argentine soybean oil consumption.

The table also point out that Brazil is the second largest soybean oil exporter. About 60% of Brazil's soybean oil production is absorbed by the domestic market and the remaining 40% is intended for the export market. The performance of Brazilian soybean oil exports and consumption is presented in Table 4. Brazilian soybean oil exports (XKB) are influenced by the export prices of Brazilian soybean oil (HEKB), domestic prices Brazilian soybean oil (HDKB), exchange rate (ERB), production (PRODKB) and lag of export of Brazilian soybean oil (LXKB).

**Table 4: Simulation of Estimation 2012-2025**

Endogenous variables	Baseline	SIM 1		SIM 2		SIM 3	
		Predicted	% Δ	Predicted	% Δ	Predicted	% Δ
HSW	532.10	533.90	0.34	522.00	-1.90	527.60	-0.85
HKW	699.70	706.80	1.01	698.90	-0.11	699.40	-0.04
HRW	826.50	831.00	0.54	823.70	-0.34	825.40	-0.13
HDSI	4921.00	4931.10	0.21	4863.00	-1.18	5086.80	3.37
HESI	451.40	453.00	0.35	442.50	-1.97	445.50	-1.31
PRODSI	4.12	24745.40	0.19	24418.30	1.13	24851.20	0.62
SDSI	9121.60	9123.10	0.02	8478.40	-7.05	9116.10	-0.06
CSI	7205.70	7204.20	-0.02	7214.70	0.12	7181.10	-0.34
XSI	17436.80	17483.40	0.27	17801.00	2.09	17596.10	0.91
XSW	40200.50	40247.00	0.12	40563.80	0.90	40359.70	0.40
MSW	38162.60	38247.20	0.22	38254.40	0.24	38199.50	0.10
XKW	14601.60	14601.60	0.00	14601.70	0.00	14601.60	0.00
MKW	13199.80	13276.00	0.58	13190.70	-0.07	13196.00	-0.03
XRW	4953.10	4949.60	-0.07	4955.50	0.04	4953.90	0.02
MRW	4694.80	4731.50	0.58	4672.00	-0.49	4685.60	-0.20

Source: Intriligator et al., (1995), Authors (2018)

All exogenous variables are able to explain the diversity of exports of Brazilian soybean oil by 91% and all variables have a real effect together. Brazil's soybean oil exports are responsive to changes in production and consumption, while changes to other exogenous variables do not have a large impact on Brazil's soybean oil exports.

The consumption of Brazilian soybean oil (CKB) is influenced by domestic prices (HDKB), the ratio of the growth rate of Brazil's domestic soybean oil prices to the growth rate of world oil prices (RRHDKBRHCOW), the Brazilian population and consumption lag. All exogenous variables included in the equation are able to explain the diversity of Brazil soybean oil consumption by 96% and all variables have a significant effect simultaneously. In the short term, consumption of Brazilian soybean oil is not responsive to changes in all exogenous variables. In the long run, Brazil's soybean oil consumption is responsive to changes in the Brazilian population (Griffin and Scandiffio, 2009).

The United States is the largest producer of soybean oil, but only about 10% of production is intended for the export market. The performance of exports and consumption of US soybean oil is presented in Table 4. The United States soybean oil (XKUSA) exports are influenced by the growth rate of US soybean oil (RHEKUSA) export prices, United States soybean oil domestic prices (HDKUSA) and production (PRODKUSA). All exogenous variables are able to explain the diversity of exports of US soybean oil by 14% and all variables simultaneously have a significant effect on the level of 35%. In the short term, US soybean oil exports are relatively more responsive to changes in US soybean oil production compared to changes in export prices and changes in domestic prices (Gan and Li, 2014).

The consumption of US soybean oil (CKUSA) is influenced by the relative price between the domestic prices of US soybean oil and the world price of petroleum (RHDKUSAHCOW), the price of United States rapeseed oil (HDRUSA) and the population of the United States (POPUSA). All exogenous variables included in the equation are able to explain the diversity of consumption of US soybean oil by 99% and all variables have a real effect together.

However, in the short term consumption of US soybean oil is not responsive to changes in all exogenous variables.

Meanwhile Table 4 showed China is the second largest soybean producer after the United States (Mekhilef et al., 2011; Gan and Li, 2014). Imports are primarily intended to cover the shortfall between domestic production and consumption. The performance of imports and consumption of Chinese soybean oil are presented in Table 4. Imports of Chinese soybean oil are influenced by import prices, soybean oil consumption and import lag. All exogenous variables are able to explain the diversity of imports of Chinese soybean oil by 90% and all variables have a real effect together. Imports of Chinese soybean oil are only responsive to changes in consumption of Chinese soybean oil in the long term.

The consumption of Chinese soybean oil is influenced by the import prices of Chinese soybean oil (HMKC), the level of Chinese per capita income (IPC), the Chinese population (POPC) and the consumption lag (LCKC). All exogenous variables included in the Chinese soybean oil consumption equation are capable explain the diversity of consumption by 98% and all variables have a real effect simultaneously. In the short term, consumption of Chinese soybean oil is not responsive to changes in all exogenous variables. In the long run, China's soybean oil consumption is responsive to changes in China's population.

Countries included in the EU-15 (on Table 4) are generally soybean oil producers. Like China, import activities are intended to cover shortages between domestic production and consumption. The performance of imports and consumption of EU-15 soybean oil is presented in Table 4. Imports of EU-15 soybean oil (MSEU) are influenced by import prices (HMKEU), exchange rates (EREU) and EU-15 soybean oil consumption (CKEU). All exogenous variables are able to explain the diversity of EU-15 soybean oil imports by 83% and all variables have a real effect together. Judging from the statistics, EU-15 soybean oil imports are only significantly affected by consumption. In the short term EU-15 soybean oil imports are responsive to changes in EU-15 soybean oil consumption.

EU-15 soybean oil consumption (CKEU) is influenced by import prices of soybean oil (HMKEU), rapeseed oil import prices (HMRC), import prices of sunflower seed oil (HMMEU), growth rate of world oil prices (RHCOW), per capita income level (IPEU) and consumption lag (LCKEU). All exogenous variables are able to explain the diversity of EU-15 palm oil imports by 99% and all variables have a real effect together. Consumption of EU-15 palm oil is relatively more responsive to changes in per capita income levels of the EU-15, then to changes in import prices of soybean oil, followed by a response to changes in import prices of rapeseed oil and to changes in prices of imported sunflower seed oil (Murphy, 2014).

India is one of the top 5 soybean oil producing countries with the United States, China, Argentina and Brazil. Soybean oil imports are primarily intended to cover the shortfall between domestic production and consumption. The performance of imports and consumption of Indian soybean oil are presented in Table 4. Whereas, the imports of Indian soybean oil (MKID) are influenced by import prices (HMKID), production (PRODKID) and consumption of Indian soybean oil (CKID).

All detailed variables are able to explain the diversity of imports of Indian soybean oil by 98% and all variables have a real effect together. Based on the t-statistic value, the import of Indian soybean oil is significantly affected by production and volume of consumption, but is only responsive to changes in consumption. Consumption of Indian soybean oil is affected by import prices of Indian soybean oil (HMKID), Indian palm oil import prices (HMSID), prices of world oil (HCOW), Indian population (POPID) and consumption lag (LCKID). All exogenous variables included in the Indian soybean oil consumption equation are able to explain the diversity of consumption by 92% and all variables have a significant effect simultaneously. In the short term, consumption of Indian soybean oil is only responsive to changes in world oil prices, whereas in the long term, consumption of Indian soybean oil is responsive to changes in world oil prices and to population changes.

The world price of soybean oil (HKW) is affected by world exports of soybean oil (XKW), world imports of soybean oil (MKW) and the world price of soybean oil in previous year (LHKW). All exogenous variables are able to explain the diversity of world soybean oil prices by 46% and all variables give a real joint effect. World soybean oil prices are relatively more responsive to changes in world exports compared to changes in world soybean oil imports.

In general, export prices and import prices are significantly affected by world soybean oil prices. All exogenous variables included in each endogenous variable equation have a joint significant effect, except for the Brazilian export price of soybean oil (HEKB) which has a significant effect at the level of 10%. Domestic prices in exporting countries are generally influenced by export prices and consumption at the level of 10-15%.

Import tariffs have a significant effect on the import price equation for Indian soybean oil. Based on the value of elasticity, the export price response to changes in world prices of soybean oil mainly

occurs in Argentina related to the absorption of export markets about 90% of Argentina's soybean oil production. The number of responses to export prices for changes in world prices for soybean oil then occurred in the United States even though export volume ranked third after Argentina and Brazil. This phenomenon is related to the export subsidy policy by the United States government. In importing countries, the import price response to changes in world soybean oil prices mainly occurs in Iran, followed by India, EU-15 and China.

According to Carter et al. (2007), rapeseed oil is the third largest vegetable oil produced and traded on the world market of vegetable oils and in the world market for biofuels. In addition to food sector, the main use of rapeseed oil in producing countries and major importing countries is as an alternative fuel source for petroleum (remarks: biodiesel). As with soybean oil, a distinctive feature in the world trade in rapeseed oil is that the main importing countries are generally the main producer of soybean oil and imports are carried out to cover shortages between the volume of domestic production and consumption (Carter et al., 2007; Parisi and Ronzon, 2016).

Canada and the United States are the two largest exporters with cumulative shares from both countries of around 73.1% of total exports on the world market for rapeseed oil. In terms of production, Canada is the third largest producer country after China and India, while the United States is one of the top 10 producing countries, including Japan, Mexico, Pakistan and EU 15. The United States is not only an exporter also acts as the main importer country along with the EU-15 and China with a cumulative share of the three around 70.22% of the total world imports of rapeseed oil. Imports made by the United States are more intended for consumption, while domestic production of US rapeseed oil is aimed more at the export market. The United States and Canada impose rapeseed oil export subsidies (Yu et al., 2006; Sorda et al., 2010).

Canada is the largest exporter of rapeseed oil even though it is the third largest rapeseed oil producer after China and India (Sorda et al., 2016). About 65% of Canadian rapeseed oil production is intended for the export market and the rest is absorbed by the domestic market. The performance of Canadian rapeseed oil exports and consumption is presented in Table 1. Canadian rapeseed oil exports (XRCD) are influenced by the growth rate of rapeseed oil export prices

Canada (RHERCD), domestic prices (HDRCD), production (PRODRCD) and lag of Canadian rapeseed oil (LXRCD) exports. All exogenous variables are able to explain the diversity of Canadian rapeseed oil exports by 98% and all variables have a real effect together. Judging from the t-count value, Canadian rapeseed oil exports are significantly affected by the production volume and lag of Canadian rapeseed oil exports. In the long run, Canadian rapeseed oil exports are responsive to changes in production, while changes to other exogenous variables do not have a large impact on Canadian rapeseed oil exports.

The consumption of Canadian rapeseed oil (CRCD) is influenced by domestic prices of Canadian rapeseed oil (HDRCD), world oil

prices (HCOW), Canadian population (POPCD) and consumption lag (LCRCD). All exogenous variables included in the equation are able to explain the diversity of Canadian rapeseed oil consumption by 76% and all variables have a real effect together. In the short term, Canadian rapeseed oil consumption is not responsive to changes in all exogenous variables. In the long run, Canadian rapeseed oil consumption is responsive to changes in world oil prices.

In addition to being the second largest rapeseed oil exporter, the United States also acts as the largest importer country (Nouri et al., 2013). Imports made by the United States are more intended for consumption, while domestic production of US rapeseed oil is more aimed at the export market. Like Canada, the United States imposes rapeseed oil export subsidies (Nouri et al., 2013).

US rapeseed oil exports (XRUSA) are influenced by prices of US rapeseed oil (HERUSA), domestic prices (HDRUSA) and United States rapeseed oil (PRODRUSA). All exogenous variables are able to explain the diversity of exports of United States rapeseed oil by 88% and all variables have a significant effect simultaneously. US rapeseed oil exports are relatively more responsive to changes in US rapeseed oil production than changes in export prices and domestic prices.

US rapeseed oil consumption (CRUSA) is influenced by the price of US rapeseed oil (HDRUSA), the relative price of domestic prices of US rapeseed oil on world oil prices (RHDRUSAHCOW), soybean oil domestic prices (HDKUSA) and the United States population (POPUSA). All exogenous variables included in the equation are able to explain the diversity of US rapeseed oil consumption by 89% and all variables simultaneously have a significant effect. The consumption of rapeseed oil in the United States is responsive to population changes, while other exogenous variables do not have a large impact on consumption.

The United States, besides acting as a rapeseed oil exporter, also acts as an importer country (Carter et al., 2007). It was previously known that US rapeseed oil exports were preferred over domestic production, while imports were more intended to fulfill domestic consumption. The performance of United States rapeseed oil imports is presented in Table 4. Imports of US rapeseed oil (MRUSA) are influenced by import prices (HMRUSA), stocks (STOKRUSA), consumption (CRUSA) and lags of US rapeseed oil imports (LMRUSA). All explanatory variables are able to explain the diversity of imports of United States rapeseed oil by 98% and all variables give a real effect simultaneously. The import of rapeseed oil in the United States is relatively more responsive to changes in consumption compared to changes in import prices and US rapeseed oil stocks.

While the countries included in the EU-15 are generally rapeseed oil producers. Import activities are intended to cover shortages between domestic production and consumption. The performance of imports and consumption of EU-15 rapeseed oil is presented in Table 4. Imports of EU-15 rapeseed oil (MREU) are affected by import prices (HMREU) and consumption of EU-15 rapeseed oil (CREU). All exogenous variables are able to explain the

diversity of EU-15 rapeseed oil imports by 74% and all variables have a significant effect simultaneously. Judging from the t-count value, the import of EU-15 rapeseed oil is significantly affected by consumption and is responsive to changes in consumption.

The consumption of EU-15 rapeseed oil (CREU) is affected by EU-15 (HMREU) rapeseed oil import prices, EU-15 palm oil import prices (HMSEU), world oil prices, population and lag of EU-15 rapeseed oil consumption (LCREU). All exogenous variables are able to explain the diversity of EU-15 palm oil imports by 94% and all variables have a significant effect simultaneously. Consumption of EU-15 palm oil is only responsive to population changes, while changes in the price of EU-15 rapeseed oil import prices and EU-15 palm oil import prices and changes in world oil prices do not have a major impact on EU-15 rapeseed oil consumption.

Meanwhile, China is the largest rapeseed oil producer. As with rapeseed oil imports by EU-15 countries, more imports are intended to cover shortages between domestic production and consumption of Chinese rapeseed. China's rapeseed oil (MRC) imports are influenced by import prices (HMRC), production (PRODRC), consumption (CRC) and lags in Chinese rapeseed oil imports (LMRC). All exogenous variables are able to explain the diversity of Chinese rapeseed oil imports by 51% and all variables have a real effect together. Based on the calculated value, China's rapeseed oil imports are significantly affected by the volume of consumption and production and are responsive to changes in both.

The consumption of Chinese rapeseed oil (CRC) is influenced by the import prices of Chinese rapeseed oil (HMRC), the import price of Chinese soybean oil (HMKC), the level of per capita income (IPC), population (POPC) and lag of Chinese rapeseed oil consumption (LCRC). All exogenous variables included in the Chinese rapeseed oil consumption equation are able to explain the diversity of consumption by 99% and all variables have a real effect simultaneously. China's rapeseed oil consumption is responsive to population changes, and is not responsive to changes in other exogenous variables.

The performance of world prices, export prices and exporters' domestic prices as well as rapeseed oil import prices of importing countries in the model are presented in Table 4. World prices of rapeseed oil (HRW) are influenced by world exports of rapeseed oil (XRW), world imports of rapeseed oil (MRW), trends and lags in world prices of rapeseed oil (LHRW). All exogenous variables are able to explain the diversity of the world price of rapeseed oil by 61% and all variables simultaneously have a significant effect. In contrast to the world price of palm oil and the world price of soybean oil, the world price of rapeseed oil is relatively more responsive to changes in world imports of rapeseed oil compared to changes in world exports.

Export prices are significantly affected by world prices of rapeseed oil and domestic prices in exporting countries are significantly affected by export prices. In addition to world prices, trade barriers applied by importing countries generally have a significant effect on import prices. The response of export prices to changes in world prices for rapeseed oil mainly occurs in the United States compared

to Canada. In importing countries, the response of import prices to changes in world prices for rapeseed oil is mainly in the EU-15 followed by the United States and China.

#### 4.5. The Forecast of Vegetable and Palm Oil in World Market

The movement of real prices of palm oil, soybean oil, and rapeseed oil on the world vegetable oil market for the period 2003-2008 and the 2012-2025 forecasts are presented in Figure 3. Whereas the trade balance for vegetable oils in the world market in 2003-2008 and the 2012-2025 forecast is presented in Figure 4 (note: World trade balance is the difference between world export volume and world import volume).

The projection of the fourth real price of vegetable oil and the price of petroleum in the world market for the period 2012-2025 tends to have a pattern of price movements similar to a small rising trend (Parisi and Ronzon, 2016). The biggest increase in price trends is owned by the world price of soybean oil, followed by world prices of rapeseed oil, world prices of sunflower seed oil and world prices of palm oil with the trend of the smallest price increase.

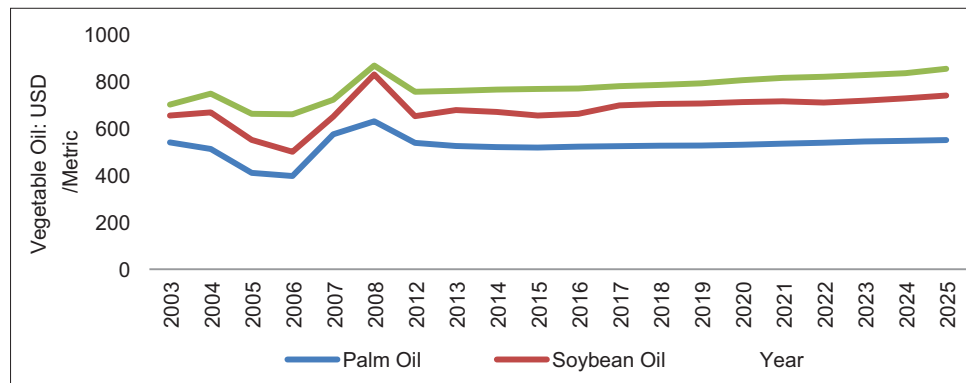
The development of the fourth world price of vegetable oils above is influenced by the results of forecasting the world price of petroleum and other external factors (note: Forecasting methods of exogenous variables using STEPAR trend 2 method with SAS 9.1.) Which then affects the consumption of each vegetable oil in each

country and finally affect the balance of world exports and imports of each vegetable oil?

Based on Figure 4, for the 2012-2025 periods, the fourth trade balance of vegetable oil is projected to be in a surplus position. The average trade surplus for 2012-2025 for palm oil is 2.04 million tons/year or 5.07% of the average world export volume of palm oil at 40.20 million tons/year, for soybean oil is 1.4 million tons/year or 9.60% of the average volume world export of soybean oil by 14.6 million ton/year, and for rapeseed oil by 258.34 thousand tons/year or 5.22% from the average volume of world export of rapeseed oil at 4.95 million tons/year.

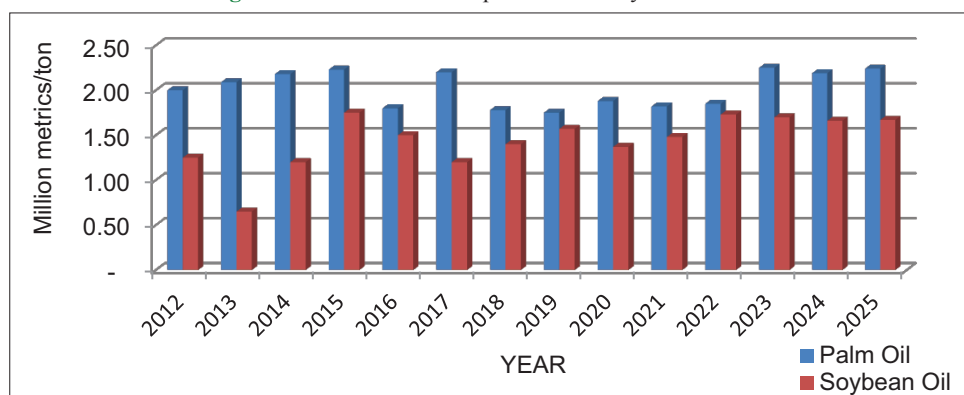
The formation of world prices for each vegetable oil is further affected by the response of world prices of vegetable oils to changes in exports and imports world. Based on the world price equation for vegetable oils, it is known that each vegetable oil has a different response to changes in world exports and imports. The results showed that: (1) In the formation of world prices for each vegetable oil is relatively more responsive to changes in world imports than changes in world exports, (2) the response of world prices to the world's largest export changes is owned by the world price of palm oil, followed by the world price of soybean oil and the world price of rapeseed oil, and (3) the response of world prices to changes in world imports is the largest owned by world prices of palm oil, followed by prices the world of soybean oil and world prices of rapeseed oil. The movement of the trade

**Figure 3:** Real price movement palm oil, soybean oil, and rapeseed oil in the world market forecasts year years 2003-2008 and 2012-2025



Source: World Oil, 2017; Authors, 2018

**Figure 4:** Balanced of trade palm oil and soybean oil in 2012-2025



Source: Wolrd oil, 2017; Authors, 2018

balance and real prices on the world market for vegetable oils for each oil are presented in Figures 5-8 (Remarks: The 2009-2011 period was not analyzed).

#### 4.6. Policy Simulation

##### 1. SIM 1: Petroleum prices rose 1%

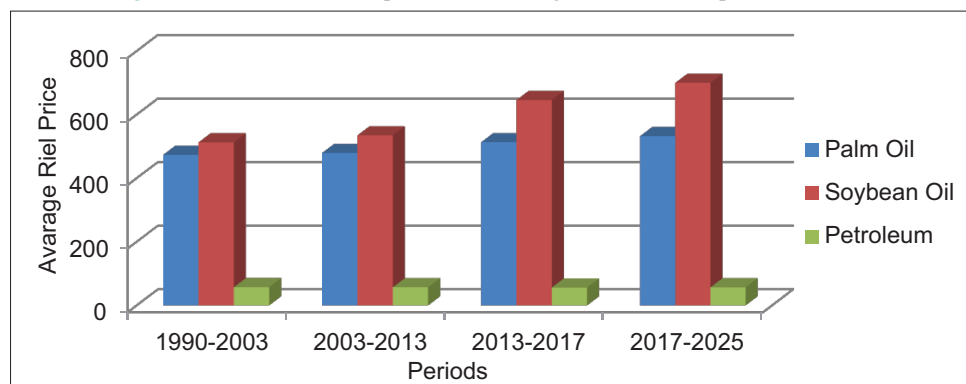
The increase in world oil prices (Scenario 1) generally drives an increase in vegetable oil consumption in both exporting and importing countries, which in turn is followed by an increase in world vegetable oil prices. However, the increase in world prices for vegetable oil is relatively smaller than the increase in world oil prices. The world price of soybean oil has the greatest impact from the increase in world oil prices, followed by rapeseed oil prices and palm oil prices. In addition to the chemical characteristics that affect the coverage of the three uses of vegetable oil as petroleum substitution in everyday life, in general the limitations of the world production volume of vegetable oil and meeting the needs of the food sector are the main obstacles in the use of vegetable oil as a substitute

(Chen et al., 2010). For the Indonesian palm oil industry, the increase in world prices for palm oil due to the increase in world oil prices has made export prices and domestic prices of Indonesian palm oil rise (Arianto et al., 2010). Increased productivity and export prices of palm oil pushed up export volumes. The increase in export prices made domestic prices rise which was followed by a decrease in the volume of domestic consumption of Indonesian palm oil.

##### 2. SIM 2: Zero palm oil export tax

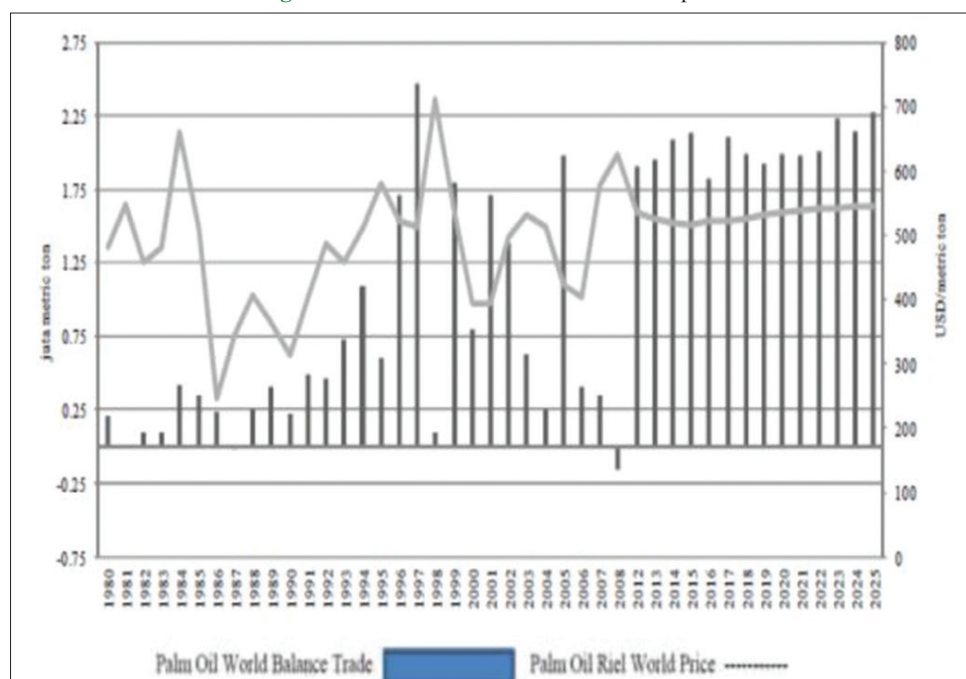
Elimination of export tax of Indonesian palm oil boosted Indonesia's palm oil exports, but lowers the domestic supply of palm oil in Indonesia (Sulistiyanto and Akyuwen, 2011). The impact of the increase in exports of Indonesian palm oil on the world market for palm oil is a decline in the world price of palm oil and followed by a decline in the world price of three other vegetable oils. The decline in the world price of palm oil is transmitted to the decline in export prices and domestic prices of Indonesian palm oil. This showed that the effect of elimination of the export tax on the increase in the export

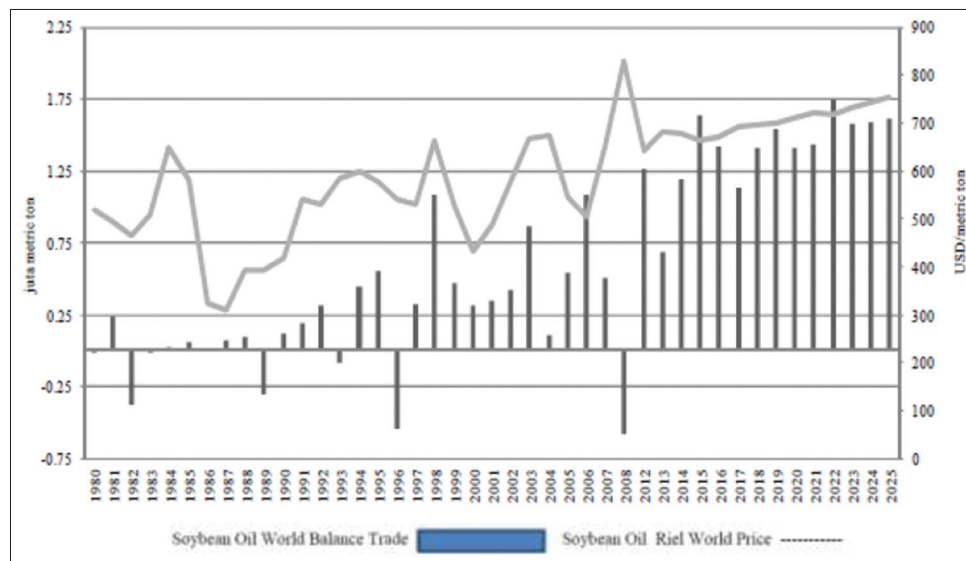
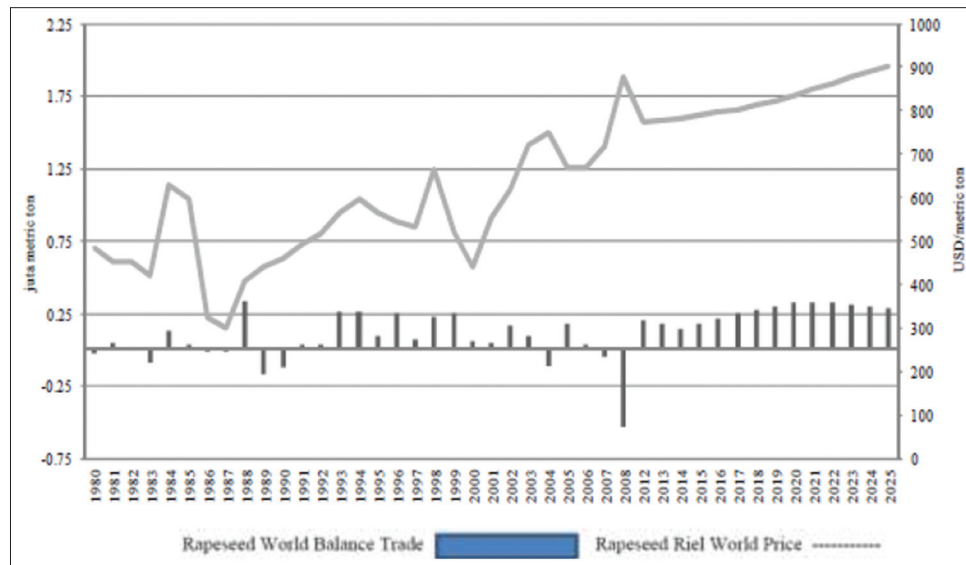
**Figure 5:** The estimation of petroleum and vegetable oil world price 1990-2025



Source: World Oil, 2017; Authors, 2018

**Figure 6:** Palm oil balance trade and world price



**Figure 7:** Soybean oil balance trade and world price**Figure 8:** Rapeseed oil balance trade and world price

Source: World oil (2017); Authors, 2018

price of Indonesian palm oil is smaller than the effect of the decline in the world price of palm oil on the export prices of Indonesian palm oil (Susila et al., 2016; Buyung et al., 2017). Something similar happened to Indonesia's domestic palm oil prices, namely the impact of the decline in the number of domestic supplies was relatively smaller compared to the impact of the decline in the export price of Indonesian palm oil (Suryana, 1987). The decline in domestic prices has led to an increase in Indonesian palm oil consumption. As a result of the decline in export prices and domestic prices, it resulted in the three business actors which were subsequently followed by a decline in Indonesian palm oil production.

3. SIM 3: Depreciation of the Rupiah against the USD by 8%  
The results of Scenario 3, where 8% depreciation of the rupiah against the US dollar caused a decline in the export prices of Indonesian palm oil, but on the other hand there was an increase in the domestic price of Indonesian palm oil.

The increase in domestic prices was followed by a decline in consumption, and as a result boosted Indonesia's palm oil exports. The increase in Indonesia's palm oil exports pushed up world exports which eventually led to a decline in the world price of palm oil (Arianto et al., 2010; Susila et al., 2016; Buyung et al., 2017). On the world market vegetable oils, a decline in world prices for palm oil are followed by a decline in world prices of soybean and rapeseed oil.

## 5. CONCLUSION

Based on the explanation in the previous discussion, then there are several conclusions such as the influence of world prices of petroleum and competitor vegetable oils on one type of vegetable oil transmitted through consumption (substitution effect) which then influences the trade balance on world markets. The trade balance on the world market further affects world prices. World

prices, exchange rates and trade policies further affect export prices and import prices, while domestic prices in exporting countries are affected by export prices. Domestic prices in the exporting country and import prices in the importing country will then affect the consumption of one type of vegetable oil.

While, based on the world price formation equation of each vegetable oil it is known that the third world price of vegetable oil is relatively more responsive to changes in world imports than changes in world exports. The world price of palm oil has the greatest response to changes in world imports, followed by world prices of soybean oil and world prices of rapeseed oil. The world price of palm oil has the greatest response to changes in world exports, followed by world prices of soybean oil and world prices of rapeseed oil.

On the other hand, the increase in world oil prices generally led to an increase in the consumption of four types of vegetable oils, which affected the trade balance of vegetable oils on the world market which was finally followed by the increase in world vegetable oil prices. However, the increase in world vegetable oil prices is relatively smaller than the increase in world oil prices, except for world soybean oil prices which experience a percentage increase in prices which is relatively the same as the percentage increase in world oil prices. World price Soybean oil has a greater impact than the increase in world oil prices compared to the impact received by the price of two other vegetable oils, followed by prices of rapeseed oil and palm oil. In addition to chemical characteristics that affect the coverage of the utilization of all four vegetable oils as Petroleum substitution in everyday life, in general the limited volume of world vegetable oil production and meeting the needs of the food sector are the main obstacles in the use of vegetable oil as a substitute for petroleum.

The substitution effect of palm oil is relatively more influential on rapeseed oil consumption, and is followed by consumption of soybean oil. The substitution effect of rapeseed oil is relatively more influential on soybean oil consumption, and is followed by the consumption of palm oil. The effect of soybean oil substitution is relatively more influential on rapeseed oil consumption, followed by palm oil consumption.

Forecasts real prices of vegetable oils and petroleum prices in the world market for the period 2012-2025 tended to have a pattern of price movements equal to a small rising trend. The largest price increase trend is owned by the world price of soybean oil, followed by rapeseed oil world price and the world price of palm oil with the smallest price increase trend.

The third trade balance of vegetable oils for the period 2012-2025, is projected to be in surplus position. The average trade surplus for 2012-2025 for palm oil is 2.04 million tons/year or 5.07% of the average world export volume of palm oil at 40.20 million tons/year, for soybean oil is 1.4 million tons/year or 9.60% of the average volume world export of soybean oil is 14.6 million tons/year, and rapeseed oil is 258.34 thousand tons/year or 5.22% of the world volume of rapeseed oil exports of 4.95 million tons/year.

Meanwhile, the forecast for Indonesian palm oil production for the period 2012-2025 shows a trend of increasing production by 2.39%/year. Whereas, the pace of consumption growth and the rate of development of Indonesia's palm oil exports are 3.09%/year and 2.15%/year respectively. This condition is relatively different from the conditions in 2013-2018. In 2013-2018 the average rate of increase in Indonesian palm oil production was around 12.75%/year with the rate of consumption growth and the rate of development of Indonesia's palm oil exports in a row of 5.23%/year and 18.42%/year. This shows that the domestic market will play an important role in supporting the development of the Indonesian palm oil industry in the future, namely in supporting price stability and guaranteed marketing of production.

From the market side, Indonesia still has the opportunity to develop the palm oil industry. In addition to the domestic market, the demand for palm oil and its derivative products is expected to continue to increase, both for food and non-food products along with the increasing trend in oil prices. Demand developments are expected to come from China, India and the European Union.

## REFERENCES

- Amiruddin, M.N., Abrahman, A.K., Shariff, F. (2005), Market potential and challenges for the Malaysian palm oil industry in facing competition from other vegetable oils. *Oil Palm Industry Economic Journal*, 5(1), 17-27.
- Applanaidu, S.D., Arshad, F.M., Shamsudin, M.N., Hameed, A., Awad, A. (2011), An econometric analysis of the link between biodiesel demand and Malaysian palm oil market. *International Journal of Business and Management*, 6(2), 35-45.
- Arianto, M.E., Daryanto, A., Arifin, B., Nuryartono, N. (2010), Analisis harga minyak sawit, tinjauan kointegrasi harga minyak nabati dan minyak bumi. *Jurnal Manajemen dan Agribisnis*, 7(1), 1-15.
- Awad, A., Arshad, F.M., Shamsudin, M.N., Yusof, Z. (2007), The palm oil import demand in Middle East and North African (MENA) countries. *Journal of International Food and Agribusiness Marketing*, 19(2-3), 143-169.
- Ayoub, M., Abdullah, A.Z. (2012), Critical review on the current scenario and significance of crude glycerol resulting from biodiesel industry towards more sustainable renewable energy industry. *Renewable and Sustainable Energy Reviews*, 16(5), 2671-2686.
- Baharsjah, S. (1974), The Domestic and International Trade of Indonesian Coconut Products Doctoral Dissertation. North Carolina: North Carolina State University.
- Buyung, S.N., Masbar, R., Nasi, M. (2017), The analysis of factor affecting CPO export price of Indonesia. *European Journal of Accounting Auditing and Finance Research*, 5(7), 17-29.
- Carter, C., Finley, W., Fry, J., Jackson, D., Willis, L. (2007), Palm oil markets and future supply. *European Journal of Lipid Science and Technology*, 109(4), 307-314.
- Chen, S.T., Kuo, H.I., Chen, C.C. (2010), Modeling the relationship between the oil price and global food prices. *Applied Energy*, 87(8), 2517-2525.
- Gan, P.Y., Li, Z.D. (2014), Econometric study on Malaysia's palm oil position in the world market to 2035. *Renewable and Sustainable Energy Reviews*, 39, 740-747.
- Griffin, W.M., Scandiffio, M.I.G. (2009), Can Brazil replace 5% of the 2025 gasoline world demand with ethanol? *Energy*, 34, 655-661.
- Griffith, G.R., Meilke, K.D. (1979), Relationships among North American fats and oils prices. *American Journal of Agricultural Economics*,

- 61(2), 335-341.
- Hameed, A.A.A., Arshad, F.A. (2008), The Impact of the Petroleum Prices on Vegetable Oil Prices: Evidence from Cointegration Test. In: Proceedings of the 3<sup>rd</sup> International Borneo Business Conference, IBBC. p504-514.
- Hassouneh, I., Serra, T., Goodwin, B.K., Gil, J.M. (2012), Non-parametric and parametric modeling of biodiesel, sunflower oil, and crude oil price relationships. *Energy Economics*, 34(5), 1507-1513.
- Helbling, T., Mercer-Blackman, V., Cheng, K. (2008), Riding a wave. *Finance and Development*, 45(1), 10-15.
- Intriligator, M., Bodkin, R., Hsiao, C. (1995), *Econometric Methods. Techniques and Applications*. 2<sup>nd</sup> ed. New York: Pearson.
- Janssen, R., Rutz, D.D. (2011), Sustainability of biofuels in Latin America: Risks and opportunities. *Energy Policy*, 39(10), 5717-5725.
- Jayed, M.H., Masjuki, H.H., Kalam, M.A., Mahlia, T.M.I., Husnawan, M., Liaquat, A.M. (2011), Prospects of dedicated biodiesel engine vehicles in Malaysia and Indonesia. *Renewable and Sustainable Energy Reviews*, 15(1), 220-235.
- Koutsoyiannis, A. (1977), *Theory of Econometrics; an Introductory Exposition of Econometric Methods*. New York: Barnes and Noble Books; 1977.
- Lamers, P., McCormick, K., Hilbert, J.A. (2008), The emerging liquid biofuel market in Argentina: Implications for domestic demand and international trade. *Energy Policy*, 36(4), 1479-1490.
- McCarthy, J.F., Gillespie, P., Zen, Z. (2012), Swimming upstream: Local Indonesian production networks in “globalized” palm oil production. *World Development*, 40(3), 555-569.
- Mekhilef, S., Saidur, R., Safari, A., Mustafa, W.E.S. (2011), Biomass energy in Malaysia: Current state and prospects. *Renewable and Sustainable Energy Reviews*, 15(7), 3360-3370.
- Murphy, D.J. (2014), The future of oil palm as a major global crop: Opportunities and challenges. *Journal of Oil Palm Research*, 26(1), 1-24.
- Nayantakaningtyas, J.S., Daryanto, H.K. (2012), Daya saing dan strategi pengembangan minyak sawit di Indonesia. *Jurnal Manajemen and Agribisnis*, 9(3), 194-201.
- Nazlioglu, S., Soytas, U. (2011), World oil prices and agricultural commodity prices: Evidence from an emerging market. *Energy Economics*, 33(3), 488-496.
- Nouri, J., Lotfi, F.H., Borgheipour, H., Atabi, F., Sadeghzadeh, S.M., Moghaddas, Z. (2013), An analysis of the implementation of energy efficiency measures in the vegetable oil industry of Iran: A data envelopment analysis approach. *Journal of Cleaner Production*, 52, 84-93.
- Parisi, C., Ronzon, T. (2016), A Global View of Bio-based Industries: Benchmarking and Monitoring their Economic Importance and Future Developments. Publications Office of the European Union, JRC Working Papers, No. JRC103038.
- Peri, M., Baldi, L. (2010), Vegetable oil market and biofuel policy: An asymmetric cointegration approach. *Energy Economics*, 32(3), 687-693.
- Shamsudin, M.N., Arshad, F.M. (2000), Short Term Forecasting of Malaysian Crude Palm Oil Prices, Paper.
- Sorda, G., Banse, M., Kemfert, C. (2010), An overview of biofuel policies across the world. *Energy Policy*, 38(11), 6977-6988.
- Sulistiyanto, A.I., Akyuwen, R. (2011), Factors Affecting the Performance of Indonesia's Crude Palm Oil Export. Singapore: International Conference on Economics and Finance Research, IACSIT Press.
- Suryana, A. (1987), Trade Prospects of Indonesian Palm Oil in the International Markets for Fats and Oils. Ann Arbor, MI: University Microfilms.
- Susila, W.R., Abbas, B.S., Hadi, P.U., Priyambodo, A., Lubis, S.O. (2016) Model ekonomi minyak sawit mentah dunia. *Jurnal Agro Ekonomi*, 14(2), 21-43.
- Susilowati, S.H. (1989), Pasar Minyak Sawit Dunia dan Kaitannya Dengan Ekspor Minyak Sawit Indonesia. Doctoral Dissertation, Thesis. Bogor: Institut Pertanian Bogor.
- Talib, B.A., Jani, M.F.M., Mamat, M.N., Zakaria, R. (2007), Impact assessment of liberalizing trade on Malaysian crude palm oil. *Oil Palm Industry Economic Journal*, 7(1), 9-17.
- Varkkey, H. (2012), The growth and prospects for the oil palm plantation industry in Indonesia. *Oil Palm Industry Economic Journal*, 12(2), 1-13.
- Yahya, M.H., Shaari, A.H., Huridi, M.H. (2011), Investigating Relationship between Crude Palm Oil And Crude Oil Prices Co-integration Approach. In: 2<sup>nd</sup> International Conference on Business and Economic Research, Proceeding, No. 2011-281. Conference Master Resources.
- Yu, T.H.E., Bessler, D.A., Fuller, S.W. (2006), Cointegration and Causality analysis of World Vegetable Oil and Crude Oil Prices, Paper. No. 379-2016-21814.

## APPENDIX

Variables		Symbols	Parameters	t value	Elasticities		Variables		Symbols	Parameters	t value	Elasticities		
					Short term	Long term						Short term	Long term	
Argentina							Canada							
Soybean oil exports (XKA)							Export of Rapeseed Oil (XRCD)							
Real export price		HEKA	0.16354	0.44	-	0.015	-	The Growth of Riel Export Price	RHECRD	5.1237	0.04	-	0.0001 0.0002	
Real Domestic Price		HDKA	-0.4167	-0.78	-	0.027	-	Domestic Price	HDRCD	-0.326	-2.56	B	0.202 0.346	
Real Exchange rate		ERA	10.7632	0.29	-	0.006	-	Production	PRODRCR	0.5831	4.09	A	0.843 1.44	
Production		PRODKA	0.90919	38.32	A	1.07	-	Lag of Export	LXRCD	0.4148	2.88	A		
R2 = 0.996		R2. Adj = 0.996	F-stat = 1447.53	DW = 1.30475		dh = -		R2 = 0.984		R2. Adj = 0.981	F-stat = 339.59	DW = 1.09184 dh = 3.41		
Consumption (CKA)							Consumption of Rapeseed Oil (CRCD)							
The rate of real domestic price		RHDKA	-41.438	-0.23	-	0.008	-	Domestic Price	HDRCD	-0.007	-0.05	-	0.009 0.047	
Production		RHCOW	131.349	0.11	-	0.001	-	World Riel Petroleum Price	HCOW	4.0627	0.47	-	0.512 2.53	
Population		POPA	66.6807	6.11	A	4.769	-	Population	POPCD	1.1314	0.2	-	0.082 0.407	
R2 = 0.636		R2. Adj = 0.586	F-stat = 12.82	DW = 0.337257		dh = -		Lag of Consumption		LCRCD	0.7976	6.26	A	
R2 = 0.755		R2. Adj = 0.708	F-stat = 16.17	DW = 1.41834		dh = 1.95								
Brazil							USA							
Export (XKKB)							Export of Rapeseed Oil (XRUSA)							
Real Export Price		HEKB	0.2297	0.58		0.061	0.069	Riel export Price	HERUSA	0.067	0.14	-	0.273 -	
Stocks		HDKB	-0.4163	-0.89	-	0.062	0.071	Domestic Price	HDRUSA	-0.057	-0.13	-	0.263 -	
Production		PRODKB	0.44095	4.88	A	1.087	1.231	Production	PRODUSA	0.4316	6.56	A	0.989 -	
Lag of Export		LXKB	0.11675	0.71	-			R2 = 0.878		R2. Adj = 0.862	F-stat = 55.34	DW = 1.69325 dh = -		
R2 = 0.905		R2. Adj = 0.886	F-stat = 42.50	DW = 1.69325		dh = 1.43		Consumption of Rapeseed Oil (CRUSA)						
Consumption (CKB)							Domestic Price							
Real Domestic Price		HDKB	-0.917	-0.61	-	0.02	0.065	HDRUSA	-0.793	-0.6	-	0.662 -		
The rate of increase in the domestic price ratio of the real against the real rate of increase in world prices of petroleum		RRHDKBKR HCOW	-2.176	-2.72	B	0.002	0.006	Domestic Price of Soybean	HDKUSA	0.2991	0.67	-	0.227 -	
Population		POPB	11.5053	1.98	C	0.629	1.986	The USA's rapeseed relative price to world riel Petroleum Price	RHDRUS AHOCOW	-6.575	-0.08	-	0.098 -	
Lag of consumption		LCKB	0.68321	3.8	A			Population	POPUSA	16.702	12.19	A	5.249 -	
R2 = 0.961		R2. Adj = 0.954	F-stat = 130.52	DW = 1.78403		dh = 1.39		R2 = 0.891		R2. Adj = 0.871	F-stat = 49.03	DW = 0.81984 dh = -		
USA							USA							
Export (XKUSA)							Import of Rapeseed Oil (MRUSA)							
The growth rate of real soybean oil prices exports		RHEKUSA	65.1056	0.21	-	0.001	-	Import Riel Price	HMRUSA	-0.06	-0.65	-	0.05 -	
Riel Domestic Price		HDKUSA	-0.2797	-0.56	-	0.217	-	Stocks	STOKRUS	-0.521	-1.1	-	0.044 -	
Production		PRODUSA	0.07796	1.88	C	0.741		Consumption	CRUSA	0.6441	7.18	A	0.81 -	
R2 = 0.139		R2. Adj = 0.021	F-stat = 1.18	DW = 1.72575		dh = -		Lag of Import		LMRUSA	0.2301	1.66	D	
Consumption (CKUSA)							R2 = 0.978							
The rate of increase in the domestic price ratio of the real against the real rate of increase in world prices of petroleum		RRHDKUS AHOCOW	70.39	-0.55	-	0.11	-	R2. Adj = 0.974	F-stat = 231.31	DW = 1.54670 dh = 1.62975				
Domestic Price		HDRUSA	0.71	0.27	-	0.078	-							
Population		POPUSA	25.79	5.31	A	0.202	-							
R2 = 0.986		R2. Adj = 0.984	F-stat = 544.94	DW = 1.9807		dh = -								
China							European Union							
Soybean oil import (MKC)							Import of Rapeseed Oil (MREU)							
Import price		HMKC	0.29663	-0.74	-	0.09	0.222	Import Riel Price	HMREU	-0.729	-0.83	-	0.245 -	
Consumption		CKC	0.34625	2.09	B	0.566	1.392	Consumption	CREU	0.9866	6.86	A	1.17 -	
Lag Import		LMKC	0.59331	3.22	A		-	R2 = 0.742		R2. Adj = 0.719	F-stat = 33.07	DW = 0.718025 dh = -		
R2 = 0.900		R2. Adj = 0.887	F-stat = 69.29	DW = 1.86206		dh = 1.02		Consumption Of Rapeseed Oil (CREU)						
Consumption (CKC)							Riel Import Price of Rapeseed OHMREU							
Import Price		HMKC	-0.1697	0.53	-	0.032	0.155		-0.592	-0.72	-	0.168	1.842	
Riel GDP		IPC	0.01455	0.21	-	0.022	0.107	Riel Import Price of Palm Oil	HMSEU	0.769	0.91	-	0.183 2.011	
Population		POPC	1.8444	1.86	C	0.812	3.991	World Riel Petroleum Price	HCOW	15.219	0.52	-	0.351 3.849	
Lag of Consumption		LKCK	0.79655	4.46				Population	POPEU	10.893	0.91	-	1.928 21.169	
R2 = 0.976		R2. Adj = 0.971	F-stat = 209.48	DW = 2.31416		dh = -1.95		Lag of Consumption of Rapeseed LCREU		0.9089	5.34	A		
R2 = 0.939		R2. Adj = 0.924	F-stat = 61.62	DW = 2.40866		dh = -2.10								
European Union							China							
Import (MKEU)							Import of Rapeseed (MRC)							
Riel Import		HMKEU	-0.303	-0.35	-	0.201	-	Riel Import Price	HMRC	-0.021	-0.6	-	0.061 0.085	
Exchange rate		EREU	-91.323	-0.71	-	78	-	Production	PRODRC	-0.448	-3.08	A	3.127 4.395	
Consumption		CKEU	0.7022	2.19	B	1.279	-	Consumption	CRC	0.4571	3.14	A	9.886 13.895	
R2 = 0.831		R2. Adj = 0.809	F-stat = 37.73	DW = 0.26645		dh = -		Lag of Import		LMRC	0.2885	1.7	D	
Consumption (CKEU)							R2 = 0.515							
Riel Import price		HMKEU	-0.7705	-0.9	-	0.281	0.449	R2. Adj = 0.422	F-stat = 5.57	DW = 1.726645 dh = 1.39				
Riel Import price of Rapeseed		HMREU	0.616	1.11	-	0.255	0.408	Riel Import Price of Rapeseed OHMRC						
Riel Import of Sun oil		HMMEU	0.504	0.69	-	0.217	0.346		-0.004	-0.01	-	0.0005 0.001		
Growth of Petroleum Price		RHCOW	1400.69	1.34	E	0.002	0.003	Riel Import Price of Soybean Oil	HMKC	0.2575	0.72	-	0.031 0.049	
Population		POPEU	0.0264	2.56	B	0.44	0.704	Riel GDP Per capita	IPC	0.1147	2.19	B	0.112 0.175	
Lag of consumption		LCKEU	0.37434	2.09	B			Population	POPC	6.4368	3.32	A	1.847 2.897	
R2 = 0.994		R2. Adj = 0.992	F-stat = 560.10	DW = 1.566835		dh = 2.85		Lag of Import		LCRC	0.3626	1.84	C	
R2 = 0.999		R2. Adj = 0.998	F-stat = 354.87	DW = 1.88205		dh = -								
India														
Import (MKID)														
Riel Import Price		HMKID	-0.0786	-0.56	-	0.034	-							
Production		PRODKID	-0.9604	-10.5	A	0.934	-							
Consumption		CKID	0.98603	20.95	A	1.914	-							
R2 = 0.976		R2. Adj = 0.973	F-stat = 298.23	DW = 2.54498		dh = -								
Consumption (CKEU)														
Riel Import price		HMKID	-0.6829	-1.49	E	0.151	0.533							
Riel Import of Palm Oil		HMSID	0.4144	0.7	-	0.093	0.327							
Petroleum World Price		HCOW	57.0726	1.04	-	1.349	4.764							
Population		POPID	1.5708	1.31	F	0.757	2.672							
Lag of consumption		LCKID	0.7168	3.49	A									
R2 = 0.920		R2. Adj = 0.900	F-stat = 46.07	DW = 2.04925		dh = -								

Source: Intriligator et al., 1995, and Authors, 2018