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RESEARCH PAPER

The Impact of Economic Shocks on the Competitiveness of Leading Vegetable Oil in the International Market

Rizka Amalia Nugrahapsari[*,a], **Harianto**[b], **Rita Nurmalina**[b], **Anna Fariyanti**[b]

a. Department of Agricultural Economics, Faculty of Economics and Management, IPB University, Bogor, Indonesia; National Research and Innovation Agency, Kota Jakarta Pusat, Indonesia.
b. Department of Agribusiness, Faculty of Economics and Management, IPB University, Bogor, Indonesia.
* Corresponding author.

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Abstract
The development of the biofuel industry has increase the price of world vegetable oil, resulting in changes in competitiveness among world-leading vegetable oils. The research aims to analyze factors influencing the competitiveness of the leading vegetable oils and the impact of economic shocks on the competitiveness of the leading vegetable oils in international market. This research utilized secondary data spanning from 1990 to 2022, encompassing information from UNCOMTRADE and World Bank with the Almost Ideal Demand System model. This research used the Seemingly Unrelated Regression as estimation method for estimating coefficients. The research results showed that the price of other vegetable oils, expenditure, and the price of crude oil are factors that influence the competitiveness of palm oil. Factors that influence the competitiveness of soybean oil are palm oil prices, expenditure and population. Factors that influence the competitiveness of sunflower oil are the price of soybean oil, expenditure, crude oil prices, and population. Palm oil competitiveness benefited from the economic shocks coming from the increase in world vegetable oil prices (own price elasticity -0.670), crude oil prices (crude oil price elasticity 10.055) and income (expenditure elasticity 1.372). This research recommends that major vegetable oil exporters should formulate policies to synergize domestic and export needs. Main biofuel-producing countries need to collaborate with the leading palm oil exporting countries because, in the future, more palm oil will be used to meet domestic needs. This study contributes to the international trade strategy, competitiveness, and biofuel industry development. It also supports the existing findings.
Keywords: Biofuel, Demand System, Income Elasticity, International Trade, Price Elasticity.
JEL Classification: F10, F14, Q17.

1. Introduction

The biofuel industry's growth drives the demand for vegetable oil (Gaskell, 2015;

World Bank, 2022), motivated by the rising crude oil prices. From 2016 to 2022, crude oil prices increased at 15.49 percent anually (World Bank, 2022), promoting a shift from fossil fuels to biofuels (Lucotte, 2016). Understanding the vegetable oil market is crucial due to its role in the biofuel era and concerns about emissions (Santeramo et al., 2021). Major vegetable oil-exporting countries must decide whether to prioritize their domestic biofuel industry or export vegetable oil. They also need to choose between using domestic vegetable oil for biofuels or importing more competitively priced and higher productivity vegetable oils. These decisions significantly impact the competitiveness of vegetable oils in the global market.

The biofuel expansion leads to higher prices for vegetable oils used as raw materials (Gomes et al., 2018; Santeramo et al., 2021). This policy affects not only the primary vegetable oil used for biofuel but also other types (Thompson et al., 2010). According to the Council of Palm Oil Producing Countries (2021), the price spike in Q4 2020 indicated a demand recovery post-COVID-19 from major consumers like India and China. Sunflower oil commands the highest price, while palm oil has the lowest price (UNCOMTRADE, 2023). Rising global vegetable oil prices may prompt price-sensitive consumers to switch to palm oil due to its competitive pricing.

Competition among vegetable oils, particularly between palm and non-palm varieties like soybean and sunflower oil, is intensifying. The challenge stems from the concentration of palm oil exporting countries in the ASEAN region (Indonesia and Malaysia), while non-palm oil exporting leaders are found in the European and American regions (Argentina, Brazil, the United States, Ukraine, and Russia). Notably, the leading importers of palm oil are also the primary importers of non-palm vegetable oil, leading to market share competition. World Bank (2023) indicates an increase in global GDP, specifically in the GDP of major vegetable oil-importing countries, during the economic recovery following the COVID-19 pandemic. Global GDP per capita grew by 6% in 2021 and 3.1% in 2022. In India, GDP per capita grew by 8.18% in 2021 and 6.28% in 2022, in China by 8.35% (2021) and 3% (2022), in the Netherlands by 4.32% (2021) and 3.47% (2022), and in Turkey by 10.51% (2021) and 4.86% (2022). Several other major vegetable oil-importing countries also witnessed growth in GDP per capita. Therefore, it is crucial to investigate whether the rising global income can drive specific vegetable oils to succeed in this competitive landscape.

Various studies have addressed the issue of vegetable oil trade in world markets (Fitrianti et al., 2019), country-specific (Shang et al., 2022), regions (Santeramo and Searle, 2019; Santeramo et al., 2021), as well as in the context between countries or regions (Bentivoglio et al., 2018; Hamulczuk et al., 2021). However, these studies have not focused on the competitive position between types of vegetable oil and how the impact of increasing vegetable oil prices, crude oil prices, and income can change the competitive position of leading vegetable oil in the international vegetable oil market. Several studies of competitiveness were conducted descriptively on sunflower oil in the world (Pilorge, 2020), and Brazilian soybean oil (Filassi and De Oliveira, 2022). Meanwhile, Paula et al. (2018) used RCA and CMS for soybean oil. These various studies have not explained the position of leading vegetable oils in global vegetable oil competition and how changes in the competitiveness of one type of vegetable oil can affect the competitiveness of other vegetable oils.

The importance of analyzing vegetable oil competitiveness is underscored by the existing research gap. This study aims to address this gap by investigating how economic shifts (increasing world price of vegetable oil, rising income, and increasing the price of crude oil) affect the competitiveness of global vegetable oils. Such insights can empower major vegetable oil exporters to devise effective strategies for enhancing their competitiveness. Santeramo et al. (2021) emphasize that efficient and effective environmentally friendly biofuel policies hinge on understanding the interplay among vegetable oils as biofuel raw materials, thus advocating for policies that foster sustainable biofuel markets by considering different vegetable oil types. This study aims to assess competition among the world's primary vegetable oils using a demand-driven approach, the factors influencing the competitiveness of these oils, and the impact of economic shocks on their competitiveness. This research, employing a demand-driven approach to evaluate global vegetable oil competitiveness, will offer novel insights by illustrating how demand dynamics for various vegetable oil types can affect the competitiveness of a single type.

In the next section, we present the theoretical background to justify the parameters' selection for the study, evaluate the current state of research topic on an international scale, and present the research innovation of this study. Section 3 provides the research objective, methodology, and data, which includes detailed equations used in this study. Results and discussions are analyzed and elaborated in Section 4. Conclusions are presented in the last section based on the study results, and to ensure that this study's objectives were fulfilled.

2. Literature Review

Numerous studies have examined the market connections among the world's primary vegetable oils: palm oil, soybean oil, sunflower oil, and rapeseed oil. These analyses were conducted by Gomes et al. (2018), Santeramo et al. (2021), and Thompson et al. (2010). Some research has focused specifically on the top three vegetable oils globally: palm oil, soybean oil, canola oil (Shang et al., 2022). Moreover, some research has focused specifically on the top two vegetable oils globally—palm oil and soybean oil—explored by Bentivoglio et al. (2018), Santeramo and Searle (2019), and Taheripour and Tyner (2020).

Factors influencing vegetable oil demand include the increase in crude oil prices, which encourages the positive development of the biofuel industry (Alam et al., 2019; Brummer et al., 2015; Gomes et al., 2018; Hamulczuk et al., 2021; Judit et al., 2017; Lajdova et al., 2017; Pal and Mitra, 2018; Santeramo et al., 2021; Schaefer et al., 2022). When biofuel entrepreneurs use certain types of vegetable oil that are in high demand as raw materials, the price of that type of vegetable oil will increase. The implication is that other entrepreneurs will switch to other types of vegetable oil so that prices will also increase (Thompson et al., 2010). In addition crude oil has an important role on agricultural production due to its high energy consumption during production dan distribution of agricultural product (Abbasian et al., 2019). The relationship between crude oil and vegetable oil can be seen from the similarities in the price fluctuation patterns of crude oil and vegetable oil (Alam et al., 2019). The positive correlation between crude oil prices and vegetable oil indicates that more vegetable oil will be used as raw material for biofuel as crude oil prices increase (Pal and Mitra, 2018). For example, US energy policy has significantly increased the responsiveness of soybean oil, canola oil and corn oil to movements in crude oil prices (Schaefer et al., 2022). However, there are also studies which based on the view that the relationship between crude oil and vegetable oil can vary according to the type of vegetable oil (Paris, 2018), and there are changes in the correlation between crude and vegetable oil over time (Lucotte, 2016).

Increasing demand for leading vegetable oils as raw materials for biofuel can create demand-driven expansion in the vegetable oil market (Santeramo et al., 2021). Palm oil demand can be linked to biofuel production growth, especially The policies of European government (Bentivoglio et al., 2018). Another factor that can influence demand for vegetable oil is income (Ahmad et al., 2022; Fitrianti et al., 2019; Ismail et al., 2022; Kea et al., 2020; Khalilian and Yuzbashkandi, 2021; Montania et al., 2021; Narayan and Bhattacharya, 2019; Purba et al., 2018).

Increasing the income of India and the Netherlands has the greatest influence on palm oil prices (Zaidi et al., 2022). Abbasian et al. (2019) highlights the important connection between the ratio of financial instruments to GDP and international trade in the Middle East countries. Demographic factors, especially population, can significantly influence the demand for vegetable oil. Gaskell (2015) highlights the crucial role of population in driving the demand for palm oil. From the demand side, Kiani et al. (2017) research results emphasizes that consumers' willingness to pay for renewable energy sources is also determined by how consumers view the importance of environmental sustainability.

Numerous studies have examined consumption pattern using AIDS model, among others by Anindita et al. (2022); Ceylan (2019); Forgenie et al. (2023); Hina et al. (2022); Khalilian and Yuzbashkandi (2021); Kharisma et al. (2020); Kutortse (2022); Onyeneke, et al. (2020); Rathnayaka et al. (2019); Selvanathan et al. (2023); and Siddique et al. (2020). These research analyzes the demand for a particular commodity in a particular country and has not utilized the AIDS model to describe competition. The AIDS model can also be used to analyze competitiveness, one of which is competition of leading exporting countries of dairy products in the Brazilian market (Arancibia and Guiguet, 2020) and competition of Pakistan, India and USA in Chinese cotton yarn market (Khan et al., 2023). This research uses the almost ideal demand system (AIDS) model to examine the demand behavior for each of the world's main types of vegetable oil, as well as how the demand for one type of vegetable oil influences the demand for other types of vegetable oil, so as to describe the competition between vegetable oils.

Numerous studies have examined the price relationships among different types of vegetable oil, the relationship between the price of vegetable oil and crude oil, and the interplay of income, population, and demand for specific vegetable oils. The objective of this research is to augment existing studies by analyzing the competition between various types of vegetable oils using a demand-driven approach, factors that influence the competitiveness of each major type of vegetable oil and the repercussions of economic shocks, such as escalating prices of vegetable oils, crude oil, and income, on the global competitiveness of vegetable oils. Given the global shift towards biofuels and away from fossil raw materials, investigating the competitiveness among vegetable oils is exceedingly vital, as it could reshape their competitive standing as raw materials. Understanding the competition among vegetable oils from the demand side can help explain how consumer preferences influence the competitiveness of a particular type of vegetable oil. Incorporating crude oil price variables into the AIDS model of competition among vegetable oils also helps provide an overview of how biofuel development affects the competitiveness of vegetable oil. Moreover, this research is instrumental in aiding major vegetable oil exporting countries in devising policies to enhance their vegetable oils competitiveness.

3. Methods and Materials

This research utilized secondary data spanning from 1990 to 2022, encompassing information on import value (UNCOMTRADE), import quantity (UNCOMTRADE), real price of crude oil (World Bank), and population (World Bank). The data consisted of annual figures for prominent vegetable oils traded globally, specifically palm oil, soybean oil, and sunflower oil. The selection of these three types of leading vegetable oil was based on their significant market share and consistent availability over the years. The research employed the HS codes for crude palm oil (151110), soybean oil (150710), and sunflower oil (151211). According to UNCOMTRADE (2023) data, the trade in vegetable oils was primarily dominated by sunflower oil (28.77%), followed by soybean oil (21.98%), coconut oil (12.41%), and palm oil (12.04%) in 1990. The dominance of palm oil in the international vegetable oil trade continued to grow, reaching its peak in 2022 with the largest share (28.92%), followed by sunflower oil (27.86%) and soybean oil (20.40%).

The rest of the world's vegetable oil referred to in this research is the average of vegetable oils other than palm oil, soybean oil and sunflower oil. The HS code of these other vegetable oils include 150810 (peanut oil), 150910 (olive oil), 151221 (cottonseed oil), 151311 (coconut oil), 151511 (linseed oil), 151521 (corn oil), 151411 (canola oil), 151530 (castor oil), 151550 (sesame oil). Table 1 shows the value and share of world vegetable oil trade in 1990 and 2022.

This research utilized the Almost Ideal Demand System (AIDS) model, a framework developed by Deaton and Muellbauer. This model is characterized by its capacity to present a first-order approach to a demand system, where budget share is a linear function of the logarithm of total income. Moreover, it adheres accurately to the axioms of commodity selection behavior and can aggregate consumer behavior without relying on a linear Engel curve. The AIDS model enables the testing of homogeneity and symmetry restrictions through linear resistance to fixed parameters, and it facilitates precise and reflective estimation of elasticities (Deaton and Muellbauer, 1980).

Table 1. Import Value and Share of World Vegetable Oil Trade in 1990 and 2022

Type of Vegetable Oil	1990		2022	
	Import Value (US$)	Share (%)	Import Value (US$)	Share (%)
Peanut oil	41,343,766	3.07	654,209,165	1.38
Olive oil	136,174,318	10.11	43,184,887	0.09
Cottonseed oil	15,446,864	1.15	19,169,023	0.04
Coconut oil	167,124,086	12.41	1,774,029,587	3.74
Linseed oil	33,040,128	2.45	197,979,355	0.42
Corn oil	54,985,546	4.08	0	0.00
Soybean oil	295,949,414	21.98	9,686,090,327	20.40
Palm oil	162132169	12.04	13,732,688,753	28.92
Sunflower oil	387422782	28.77	13,230,006,516	27.86
Canola oil	0	0.00	6,621,346,252	13.94
Castor oil	38,952,387	2.89	1,204,607,296	2.54
Sesame oil	14,085,401	1.05	322,194,974	0.68

Source: UNCOMTRADE (2023).

The AIDS model is used to analyze competition between the world's leading vegetable oils (palm oil, soybean oil, and sunflower oil). The estimation method for estimating coefficients (parameters) in the linear AIDS (LA/AIDS) model used the Seemingly Unrelated Regression (SUR) method with the following basic model:

$$Si = \alpha_i + \sum_{i=1}^{n} \gamma_{ij}\ lnp_j + \beta i\ ln\left(\frac{M}{P^*}\right) + \sum \theta i\ lnZ + e_i \tag{1}$$

Dimana:

S = Export share of vegetable oil i in the world

P = Price of vegetable oil i

M = Total import value

P* = Geometric mean price index stone = ∑wi.pi

Z = Other variables that affect trade

The vegetable oil demand model was as follows:

$$\begin{aligned} S_{PO} = \alpha_1 + \gamma_{11}\ ln\,P_{PO} & \\ + \gamma_{12}\ ln\,P_{SO} & \\ + \gamma_{13}\ ln\,P_{SFO} & \\ + \gamma_{14}\ ln\,P_{RW} + \beta_1\ ln\left(\frac{M}{P^*}\right) + \theta_1\ ln\,PCO & \\ + \theta_2\ ln\,POP + e_1 & \end{aligned} \tag{2}$$

$$S_{SO} = \alpha_2 + \gamma_{21}\ ln\, P_{PO} + \gamma_{22}\ ln\, P_{SO} + \gamma_{23}\ ln\, P_{SFO} + \gamma_{24}\ ln\, P_{RW} + \beta_2\ ln\left(\frac{M}{P^*}\right) + \theta_1\ ln\, PCO + \theta_2\ ln\, POP + e_2 \quad (3)$$

$$S_{SFO} = \alpha_3 + \gamma_{31}\ ln\, P_{PO} + \gamma_{32}\ ln\, P_{SO} + \gamma_{33}\ ln\, P_{SFO} + \gamma_{34}\ ln\, P_{RW} + \beta_3\ ln\left(\frac{M}{P^*}\right) + \theta_1\ ln\, PCO + \theta_2\ ln\, POP + e_3 \quad (4)$$

where:

S_i	=	Export share of vegetable oil i in the world
P_i	=	Price of vegetable oil i (US$/Kg)
M	=	Total value of vegetable oil import (US$)
P^*	=	Geometric mean price index stone = $\sum w_i.p_i$
PCO	=	Real-world crude oil price (US$/barrel)
POP	=	Population (Billian people)
e_i	=	*Error*
i	=	PO=palm oil, SO=soybean oil, SFO=sunflower oil, RW= the rest of the world's vegetable oil

Moschini (1995) suggests using a corrected stone price index that uses a log-linear version of the Laspeyres index as follows:

$$lnP^* = \sum_{i=1}^{n} S_i \ln \frac{P_{it}}{P_t^0} \quad (5)$$

The above equations are constrained using homogeneity and symmetry conditions. The model inherently accommodates aggregation, representing one of the benefits of the AIDS model. Data processing for the AIDS model used the STATA 14 application. The regression coefficients in the model was determined by using the Seemingly Unrelated Regression (SUR) method. This research used elasticity values of the AIDS parameters to describe the impact of economic shocks on the competitiveness of world vegetable oils.

The elasticity values in this research were: (1) own price elasticity, (2) cross-price elasticity, and (3) expenditure elasticity. These elasticities are calculated based on the following formula (Rifin, 2010):

Own price elasticity	: $e_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{s_i} - \beta_i \left(\frac{s_j}{s_i}\right)$	(6)
Cross price elasticiy	: $e^*_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{s_i} + s_j$	(7)
Expenditure elasticity	: $\eta_i = 1 + \frac{\beta_i}{w_i}$	(8)

where:

δ = knocker delta (where $\delta ij = 1$ and $\delta ij = 0$ for i is not equal to j)

$\hat{y}_{ij}$ = parameter for the export price of vegetable oil i

β_i = Parameter for the value of expenditure on vegetable oil i

s_i = Share vegetable oil i

s_j = Share of another type of vegetable oil

The own-price elasticity was calculated using the uncompensated or Marshallian formula (6). The cross-price elasticity was determined using the compensated or Hicksian formula (7) to depict competition among leading vegetable oil oil exporters. The expenditure elasticity was represented by formula (8). To assess the impact of changes in the price of crude oil on leading vegetable oil competitiveness position, elasticity value was calculated following the approach outlined (Kautsoyiannis, 1977):

$$E = \frac{\partial Y_t}{\partial Xi_t} \frac{\text{Xi}}{Y} = \beta \frac{Xi}{Y} \quad (9)$$

where:

E : Short-term elasticity

β : Estimated parameter value for explanatory variable i

X_i : Mean value of explanatory variable i

Y : Mean value of endogenous variable

4. Results and Discussion

4.1 Factors Influencing the Competitiveness of World Vegetable Oil

The AIDS model estimation results were used to investigate factors influencing the vegetable oils demand for in international market. The estimation results of the global vegetable oil AIDS model are presented in Table 2. The R-square value of the palm oil equation was 81.3 percent. This value means that the variation in the proportion (share) of palm oil imports could be explained by the independent variables in the model, amounting to 81.3 percent, while the remaining 18.7 percent was explained by other independent variables outside the model. The R-square value of the soybean oil equation was 60.5 percent. This value means that the variation in the proportion (share) of soybean oil imports could be explained by the independent variables in the model of 60.5 percent, while the remaining

39.5 percent was explained by other independent variables outside the model. The R-square value of the sunflower oil equation was 92.07 percent. This value means that the variation in the proportion (share) of sunflower oil imports could be explained by the independent variables in the model amounting to 92.07 percent, while the remaining 7.93 percent was explained by other independent variables outside the model.

Table 2. The Estimation Results of AIDS Model for Leading Vegetable Oil

Variable	Palm Oil	Soybean Oil	Sunflower Oil
Constant	-1.446	-0.426	1.845
Palm oil price	0.098	-0.081***	0.034
Soybean oil price	-0.051	0.012	0.150*
Sunflower oil price	0.103	-0.009	-0.028
Other vegetable oil price	-0.301*	-0.002	0.032
Expenditure	0.087*	0.089*	-0.148*
Crude oil price	0.041**	-0.009	-0.035*
Population	-0.069	-0.614*	0.809*
RMSE	0.034	0.026	0.012
R Square	0.813	0.606	0.921
P-Value	0.000	0.000	0.000

Source: Research finding.

Note: * significant at 1%, ** significant at 5%, *** significant at10%.

Apart from a high R-square value, other measures of the goodness of the model were a small RMSE value (close to 0) and the significance of the F statistical p-value. The three equations had small RMESE values (close to 0), namely 0.034 for the palm oil equation, 0.026 for the soybean oil equation and 0.012 for the sunflower oil equation. The P-value F statistic obtained was significant at the 1 percent real level. This value means that the independent variables together could explain the dependent variable, namely the variable proportion (share) of imports of leading vegetable oil.

Variables that had a significant influence on the market share of palm oil were the price of other vegetable oils, expenditure and the price of crude oil. The variables that significantly influence the share of soybean oil were palm oil prices, expenditure and population. The variables that significantly influence the share of sunflower oil were the price of soybean oil, expenditure, crude oil prices and population.

4.2 Impact of Economic Changes on the Competitiveness of World Vegetable Oils

The results of price and expenditure elasticity of demand for leading vegetable oils are presented in Table 3. Table 3 shows that the own price elasticity of soybean oil was -1.040 (elastic), meaning that a 1 percent increase in the price of soybean oil can reduce soybean oil share by 1.040 percent. The price elasticity of palm oil was -0.670 (inelastic), meaning that a 1 percent increase in the price of palm oil can reduce the palm oil share by 0.670 percent. The own price elasticity of sunflower oil was -1.024 (elastic), meaning that an increase in the price of sunflower oil by 1 percent can reduce sunflower oil by 1.024 percent.

The cross price elasticity of soybean oil was negative with palm oil, namely -0.104 (complement), but positive with sunflower oil, namely 0.119 (substitution), and other vegetable oils, namely 0.359 (substitution). An increase in palm oil prices of 1 percent can reduce the share of soybean oil by 0.104 percent. An increase in the price of sunflower oil by 1 percent can increase soybean oil share by 0.119 percent. An increase in the price of other vegetable oils can increase soybean oil's share by 0.359 percent.

Table 3. Price and Expenditure Elasticities of Leading Vegetable Oil

Share	Price elasticity				Expenditure Elasticity
	Soybean Oil	**Palm Oil**	**Sunflower Oil**	**Other Vegetable Oil**	
Soybean oil	-1.040	-0.104	0.119	0.359	1.375
Palm oil	0.023	-0.670	0.598	-0.916	1.372
Sunflower oil	1.180	0.447	-1.024	0.570	0.074

Source: Research finding.

The cross-price elasticity of palm oil exhibited a positive correlation with soybean oil, specifically 0.023 (indicating substitution), and with sunflower oil, at 0.598 (also indicating substitution). Conversely, the elasticity was negative with other vegetable oils, specifically -0.916 (indicating complement). A 1 percent increase in soybean oil price resulted in a 0.023 percent increase in palm oil share. Similarly, a 1 percent increase in sunflower oil price led to a 0.598 percent increase in palm oil share. Conversely, a 1 percent increase in other vegetable oils price resulted in a 0.916 percent decrease in palm oil share.

The cross price elasticity of sunflower oil was positive with soybean oil, namely 1.180 (substitution), palm oil, namely 0.447 (substitution) and other vegetable oils, namely 0.570 (substitution). A 1 percent increase in soybean oil price can increase sunflower oil share by 1.180 percent. A 1 percent increase in the price of palm oil can increase sunflower oil share by 0.447 percent. A 1 percent increase in other vegetable oils price can increase sunflower oil share by 0.570 percent.

The elasticity of soybean oil expenditure was 1.375, meaning that an increase in world expenditure of 1 percent will increase soybean oil share by 1.375 percent. The elasticity of palm oil expenditure was 1.372, meaning that an increase in world expenditure of 1 percent will increase the share of palm oil by 1.372 percent. The expenditure elasticity for sunflower oil was 0.074, meaning that an increase in world income of 1 percent will increase sunflower oil share by 0.074 percent.

The price elasticity of crude oil for palm oil was 10.05, meaning that an increase in crude oil price by 1 percent will increase palm oil share by 10.05 percent. The price elasticity of crude oil for soybean oil was -2.14, meaning that an increase in crude oil prices of 1 percent will reduce the soybean oil share by 2.14 percent. The price elasticity of crude oil for sunflower oil was -12.68, meaning that a 1 percent increase in the price of crude oil will reduce sunflower oil by 12.68 percent. Table 4 shows the effect of crude oil shock on the leading vegetable oil competitiveness in international trade.

Table 4. Impact of Changes in Crude Oil on the Competitiveness of Leading Vegetable Oil

Share	Crude Oil Price Elasticity
Palm oil	10.055
Soybean oil	-2.146
Sunflower oil	-12.679

Source: Research finding.

4.3 Discussion

As a vegetable oil with the largest share in the world vegetable oil trade, palm oil price can influence the competitiveness of world soybean oil. On the other hand, soybean oil with the third largest share in world vegetable oil trade, can influence the competitiveness of sunflower oil, with the second largest share in world vegetable oil trade. Even though palm oil is the leading vegetable oil with the largest share, the competitiveness of palm oil is also influenced by the prices of other vegetable oils. This proves that there is interconnectedness in the vegetable oil market.

The price elasticity of palm oil is inelastic, while soybean oil and sunflower oil are elastic. This situation is favorable for palm oil because world demand for palm oil is not responsive to changes in palm oil prices. Palm oil prices are the most competitive. Even though there has been an increase in the price of palm oil, the price of palm oil is still lower when compared to other vegetable oils. Figure 1 shows the development of world vegetable oil prices.

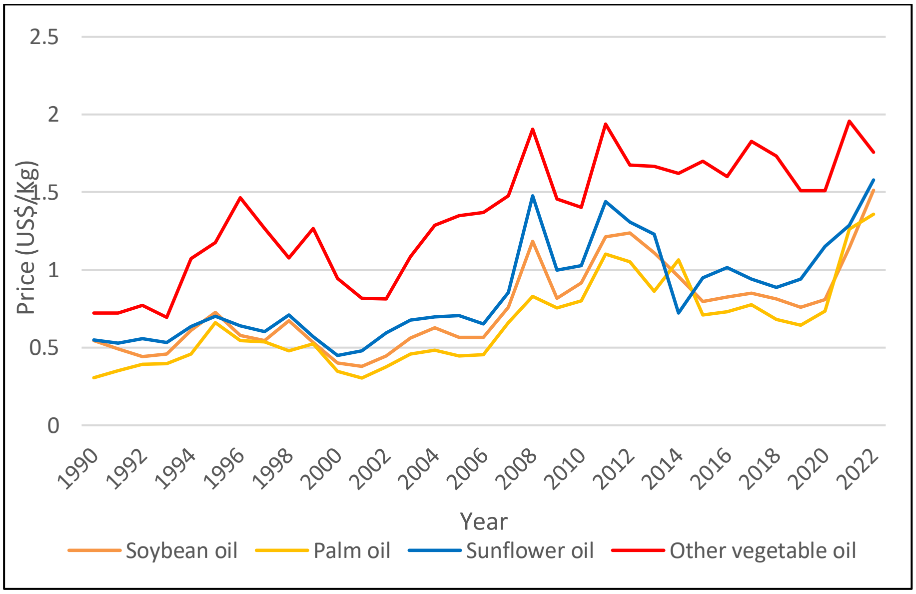

Figure 1. Price of World Leading Vegetable Oil
Source: UNCOMTRADE (2023).

Table 5 explains the relationship between vegetable oils based on cross-price elasticity values. The research results showed that competition between types of vegetable oils is sometimes two-way. The two-way competitive relationship only occurs between palm oil and sunflower oil and between soybean oil and sunflower oil. Palm oil is a complement to soybean oil, whereas soybean oil is a competitor to palm oil. Soybean oil's competitiveness decreases when the price of palm oil increases, while palm oil's competitiveness decreases when the price of other vegetable oils increases. The results of this research strengthen the results of research by Santeramo and Searle (2019) that an increase in the price of soybean oil can encourage an increase in the supply of palm oil. It is also in line with the research results of Bentivoglio et al. (2018) which show that in the long term, the price of soybean oil has a positive and significant effect on Indonesian palm oil production.

The elasticity of expenditure for soybean oil was 1,375, palm oil was 1,372, and sunflower oil was 0,074. Vegetable oils that will benefit most from the increase in world income are soybean oil and palm oil. The research results of Zhao et al. (2021) show that soybean oil has the highest vitamin E content when compared to sunflower oil and palm oil. Soybean oil also has a high level of suitability for human fatty acid needs. So, it is recommended for consumption. However, the productivity of soybean oil is lower compared to palm oil, while increasing income can increase the need for the use of oleochemical-based ingredients in the food industry, pharmaceuticals, shortening, and cosmetics. Palm oil requires 2.42 m^2 to produce 1 kg of oil, soybean oil requires 10.52 m^2, and sunflower oil requires 17.66 m^2 (Ministry of Foreign Affairs of the Republic of Indonesia, 2020). Therefore, increasing world income encourages an increase in the competitiveness of soybean oil as a vegetable oil that has a better level of suitability in meeting human fatty acid needs, and palm oil as a vegetable oil with the highest productivity.

Table 5. The Relationship among Leading Vegetable Oil Based on Cross-Price Elasticity

Share	Type of Relationship			
	Soybean Oil	**Palm Oil**	**Sunflower Oil**	**Other Vegetable Oil**
Soybean oil	-	complement	competitive	competitive
Palm oil	competitive	-	competitive	complement
Sunflower oil	competitive	competitive	-	competitive

Source: Research finding.

The price elasticity of crude oil towards the share of vegetable oil is 10.05 for palm oil, -2.14 for soybean oil, and -12.68 for sunflower oil. It means that an increase in crude oil prices can increase the competitiveness of world palm oil but reduce the competitiveness of world soybean oil and sunflower oil. US Energy Information Administration (2023) data shows that the three leading exporting countries of soybean oil are the leading producers of biofuel, namely Brazil, the USA, and Argentina. The leading exporting countries of palm oil, which are the leading producers of biofuel, are Indonesia and Thailand. The biofuel production of the leading exporter of soybean oil is greater than that of the leading exporter of palm oil. The development of the biofuel industry in the leading exporting countries of soybean oil and sunflower oil has caused more vegetable oil to be used for domestic needs. So, this has resulted in the decrease of exports of crude vegetable oil. The increase in crude oil prices causes a greater decline in the competitiveness of sunflower oil compared to soybean oil. The biofuel industry of the main exporting countries of soybean oil, namely Brazil and the USA, has already developed, while the biofuel industry of the main exporting countries of sunflower oil is starting to grow, namely Argentina and Franc. The main exporter of sunflower oil, namely Ukraine, also produces biofuel even though it is not a major producer. Table 6 shows the world's leading producers of biofuels.

Table 6. The Production of World-Leading Biofuel Producers

Country	Year 1990		Year 2021	
	Production (Mb/d)	**Share (%)**	**Production (Mb/d)**	**Share (%)**
Indonesia	0	0	164	6.25
Thailand	0	0	51	1.94
Argentina	0	0	51	1.94
Brazil	203	79.60784	569	21.68
USA	49	19.21569	1129	43.03
Netherland	0	0	36	1.37
France	0	0	44	1.68
China	0	0	98	3.73
Germany	0	0	70	2.67
India	0	0	54	2.06

Source: US Energy Information Administration (2023).

The increase in palm oil competitiveness due to the increase in crude oil prices can indicate two things. First, the development of the biofuel industry in the leading exporting countries of palm oil has been slower than the leading exporting countries of soybean oil and sunflower oil. Second, according to Balat (2011), palm oil has the highest contribution to biofuel production, which is 4.736 liters/ha, while sunflower oil is 952 liters/ha, and soybean oil is 6.32 liters/ha. Therefore, an increase in world crude oil prices can increase world demand for palm oil as a raw material for biofuel. US Energy Information Administration (2023) data shows that several leading importing countries of palm oil are leading producers of biofuel, namely India, the Netherlands, Germany, China, Franc. Even though it is not a major importer, US also continuously imports palm oil. Besides, palm oil has the most competitive price compared to other vegetable oils as a raw material for biofuel.

As Santeramo and Searle (2019) stated, the increasing demand for soybean oil as a biofuel raw material in the US can increase the price of soybean oil. The impact of increasing palm oil imports as a result of increasing soybean oil prices is greater than the impact of increasing soybean oil production as a result of increasing soybean oil prices. Therefore the US biofuel policy can contribute to increasing the area of oil palm. Almost the same thing also happens in the EU, where the biofuel development policy in the EU creates competition between rapeseed oil produced in the EU and imported palm oil, which has a lower price as a raw material for biofuel (Bentivoglio et al., 2018).

The consequence of increasing the competitiveness of palm oil due to increasing crude oil prices is increasing competition between food and energy needs, especially in palm oil exporting countries. Pal and Mitra (2018) explained that fluctuations in crude oil prices cause fluctuations in food prices, where crude oil prices are positively correlated with food prices (Judit et al., 2017). The important role of crude oil volatility is also emphasized by Sayadi et al. (2022) in the industry market and by Bala and Chin (2020) in economic growth.

5. Conclusion

The relationship between leading vegetable oils can be seen from how palm oil price significantly influences the competitiveness of world soybean oil, soybean oil price significantly influences the competitiveness of sunflower oil, and other vegetable oils price significantly influence the competitiveness of palm oil. Expenditure significantly affects soybean oil, palm oil and sunflower oil competitiveness. Crude oil prices significantly influence the competitiveness of palm oil and sunflower oil, while population significantly influences the competitiveness of soybean oil and sunflower oil.

The increase in world vegetable oil prices, crude oil prices and income have different influences on each of the leading vegetable oil. The increase in world vegetable oil prices benefits the competitive position of palm oil because the own price elasticity for palm oil is inelastic (-0.670). The relationship between vegetable oils is somewhat competitive. Palm oil is a complement to soybean oil (cross price elasticity of soybean oil was -0.104 with palm oil), but not vice versa (cross price elasticity of palm oil was 0.023 with soybean oil). Increasing world income benefits the competitiveness of soybean oil (elasticity of soybean oil expenditure was 1.375) and palm oil (elasticity of palm oil expenditure was 1.372). The increase in crude oil prices benefits palm oil's competitive position (crude price elasticity of palm oil was 10.055) because soybean oil and sunflower oil are used to meet the needs of the domestic biofuel industry.

Research finding conclude that global economy changes can have a significant impact on the competitiveness of vegetable oils. Understanding the competitiveness of vegetable oils provides valuable insights into the sustainability of biofuel development. The leading exporting countries of palm oil need to improve their palm oil quality, while the leading exporting countries of soybean oil need to increase their productivity to be able to win the competition. The world demand for palm oil as a vegetable oil with the highest productivity in producing biofuel increases along with increases in crude oil prices, resulting in increasing competition between food and energy needs, especially in palm oil exporting countries. The development of the world biofuel industry needs to pay attention to the availability of palm oil because the biofuel industry of the leading exporting countries of palm oil is emerging so that in the future, more palm oil will be destined for the domestic needs of the leading exporting countries of palm oil.

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