Vector error correction model relationship between three vegetable oil products

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Abstract. International price of palm oil fluctuated frequently. It is predicted that the international price of palm oil is affected by the other vegetable oil prices. Soybean oil, rapeseed oil and palm oil are the three most important vegetable oil in the world. These commodities compete but on the other hand the world prices are moving in the same direction. This paper analyzes the relationship of these three prices in the short-run and long-run. The method utilizes in the analysis is the vector error correction model (VECM) followed by Impulse Response and Variance Decomposition. The data used is monthly data from January 2003 until December 2020. The results indicate that in the short-run, only the lag of each vegetable oil prices affects their own price. Meanwhile, in the long-run the three prices have long-run relationship or in other words the prices are cointegrated. Using variance decomposition and impulse response shows that soybean oil price has more effect on rapeseed and palm oil prices. Therefore, it can be concluded, the fluctuation of rapeseed and palm oil prices will be affected by the price fluctuation of soybean oil price

1. Introduction

The three largest vegetable oil produced in the world are soybean, palm and rapeseed oil, respectively. Soybean oil contributed 32.52%, palm oil 31.68% and rapeseed 12.48% of the world vegetable oil in the world in 2018 [1]. In terms of export quantity, palm oil is the largest vegetable oil exported with 41.64% in 2019, meanwhile soybean oil is the third largest with 12.83% and rapeseed oil is the fifth largest vegetable oil exported with 9.87% [1]. Besides in terms of production and export, the price of the three vegetable oils is closely related (Figure 1) [2]. Indonesia, as the largest producer of palm oil, is very affected from this price fluctuation. Therefore, by analyzing the relation between the three vegetable oil prices, the price fluctuation can be anticipated.

Vegetable oils compete in the world market. It can be competition with the same vegetable but from different countries or between vegetable oils. Rifin [3] revealed that Indonesia and Malaysia’s palm oil compete or substitute each other in India and China’s market. The same case also in the world market [4].
Many scholars have analyzed the price relation between vegetable oils. Rifin [4] revealed that palm oil and soybean oil in the world market are substitute in the long-run not in the short-run. Alias and Othman [5] and Hasan and Balu [6] analyze the long-run relation between palm oil and soybean price. The authors revealed that there exists a long-run relation between the two prices or both prices are cointegrated. In addition, the authors also found that there a bi-directional relation between the two prices. In the case of Indonesia’s palm oil, Fitrianti et al. [7] found that the price of Indonesia’s palm oil was affected by Malaysia’s palm oil price, soybean oil price and rapeseed oil price. Azam et al. [8] found that four vegetable oil prices (soybean, rapeseed, palm and sunflower oil) have similar movement along the years. The authors also found that soybean oil is the leader among the four vegetable oils. The same result also found by In and Inder [9] and Owen [10] for eight vegetable oil prices. Besides with the other vegetable oils, vegetable oil price is also having a long run relation with other variable such as crude oil [11], exchange rate [12] and biofuel policy [13]. Different results found by Owen, Chowdury and Garrido [14] which found no long-run relationship between vegetable oils in the world market. The difference between the other articles is that this paper focus on the three price variables without using other non-price variables and used more recent data. The objective of this article is to analyze the relationship between three main vegetable oils prices in the short-run and long-run

2. Materials and methods
The data utilized in this article is the price data of three vegetables oils from the World Bank. The data is a monthly data from January 2003 until December 2020. The VECM model is used in order to analyze the long-run relation between the three vegetable oils using EViews 9 software. The VECM model assumes that all the variables are endogenous [15]. The model is as follows:

\[
\Delta \ln SO_t = \alpha_0 + \sum_{i=1}^{m} \alpha_{1i} \Delta \ln SO_{t-i} + \sum_{i=1}^{m} \alpha_{2i} \Delta \ln RO_{t-i} + \sum_{i=1}^{m} \alpha_{3i} \Delta \ln PO_{t-i} + \alpha_4 ECT_{t-1} + \mu_t \\
\Delta \ln RO_t = \beta_0 + \sum_{i=1}^{m} \beta_{1i} \Delta \ln SO_{t-i} + \sum_{i=1}^{m} \beta_{2i} \Delta \ln RO_{t-i} + \sum_{i=1}^{m} \beta_{3i} \Delta \ln PO_{t-i} + \beta_4 ECT_{t-1} + \epsilon_t \\
\Delta \ln PO_t = \gamma_0 + \sum_{i=1}^{m} \gamma_{1i} \Delta \ln SO_{t-i} + \sum_{i=1}^{m} \gamma_{2i} \Delta \ln RO_{t-i} + \sum_{i=1}^{m} \gamma_{3i} \Delta \ln PO_{t-i} + \gamma_4 ECT_{t-1} + \nu_t 
\]

where:
- SO = international price of soybean oil (USD/tons)
- RO = international price of rapeseed oil (USD/tons)
- PO = international price of crude palm oil (USD/tons)

All price data will be converted into logarithmic form.
After calculating the VECM model, impulse response analysis and variance decomposition analysis will be conducted. Impulse response analyze the response of an endogenous variable to a shock of an exogenous variable. Meanwhile variance decomposition analyze which price is responsible of the fluctuation of the price.

3. Results and discussion

The first step in running the VECM model is to test the stationarity of all the variables. The test is conducted using the Augmented Dickey Fuller (ADF) test and the result can be found in Table 1. The result of the ADF test shows that all of the variables are stationary at the first level or I(1) indicated by the probability in first difference form all below 0.05.

| Variables          | Level t-statistic | Level Prob | First difference t-statistic | First difference Prob |
|--------------------|-------------------|------------|-----------------------------|------------------------|
| Ln Soybean oil price | -2.33             | 0.16       | -9.57                       | 0.00                   |
| Ln Rapeseed oil price | -2.57             | 0.10       | -9.88                       | 0.00                   |
| Ln Palm oil price   | -2.33             | 0.16       | -9.57                       | 0.00                   |

The next step is to test whether the three vegetable oil prices have long-run relation or cointegrated. The method utilized is Johansen Cointegration. The result indicated in Table 3 shows that using trace statistic and max eigen statistic could not reject H₀ (Prob below 0.05) that there is no cointegration or in other words it exists one cointegrating equation.

| H₀ | Eigen value | Trace statistic | Prob | Max-Eigen Statistic | Prob |
|----|-------------|-----------------|------|---------------------|------|
| r=0| 0.11        | 33.89           | 0.00 | 24.86               | 0.00 |
| r=1| 0.04        | 9.03            | 0.17 | 8.72                | 0.13 |
| r=2| 0.00        | 0.31            | 0.64 | 0.31                | 0.64 |

After knowing the existence of cointegration, the next step is calculating the vector error correction model (VECM). The model consists of two equation, long-run and short-run regression. The long-run relation is basically the cointegrating equation which is as follows

\[ \text{LSO}_{t-1} = 0.35 \text{LRO}_{t-1} + 0.66 \text{LPO}_{t-1} 
\]

\[ (5.22) \quad (9.48) \]

The long-run relation shows that rapeseed price and palm oil price have positive and significant effect indicated by the high t-stat in the bracket. Since the equation is in the logarithmic form, therefore the coefficient is the elasticity. Meanwhile in the short-run, soybean and palm oil price only affected by its own lag price meanwhile rapeseed oil price besides its own lag price, it is also affected by the soybean oil price. The low R² in the model indicates that there are other variables that affected the prices. The paper focus on the relation of the three prices, therefore the other variables such as crude oil [11], exchange rate [12] and biofuel policy [13], can be ignored. Similar result found by Hassan and Balu [6] for the case of palm oil, the authors found that in short-run palm oil price do not affected by other vegetable oil prices. Meanwhile different result found by Alias and Othman [5] for soybean oil and palm oil prices which found bi-directional relation between the two prices. These can be caused by the different time of analysis.
Table 3. Short-run relation between three vegetable oil prices.

| Variable  | ΔLSO | t-stat | ΔLRO | t-stat | ΔLPO | t-stat |
|-----------|------|--------|------|--------|------|--------|
| ΔLSO\(_{t-1}\) | 0.30 *** | 2.50 | 0.13 ** | 2.14 | 0.25 | 1.50 |
| ΔLSO\(_{t-2}\) | -0.02 | -0.13 | 0.18 | 1.52 | 0.09 | 0.55 |
| ΔLRO\(_{t-1}\) | -0.01 | -0.14 | 0.19 * | 1.71 | -0.16 | -1.19 |
| ΔLRO\(_{t-2}\) | 0.05 | 0.50 | -0.23 ** | -2.32 | -0.08 | -0.61 |
| ΔLPO\(_{t-1}\) | 0.06 | 0.74 | -0.04 | -0.49 | 0.34 *** | 3.17 |
| ΔLPO\(_{t-2}\) | -0.05 | -0.60 | -0.01 | -0.12 | -0.10 | -0.96 |
| ECT\(_{t-1}\) | -0.20 *** | -3.13 | -0.13 ** | -2.08 | 0.01 | 0.07 |
| R\(^2\) | 0.21 | 0.19 | 0.16 | ** | ** | ** |

Note: ***, **, * significant at 1%, 5% and 10%, respectively

In order to analyze the dynamic relation between the three vegetable oil prices, impulse response analysis is conducted. Impulse response analyze the response of an endogenous variable after a shock in the exogenous variable. For soybean oil price, shock of its own price will have more effect compare to shock in rapeseed and palm oil prices. For rapeseed oil price, a shock on soybean oil price has more affect compare to its own price and palm oil prices. This is similar to the findings in the short-run model where soybean oil price has significant effect on the rapeseed oil price. Lastly, for palm oil price, a shock in soybean oil price has more effect on palm oil price compare to its own price and rapeseed oil price.

From the impulse response analysis, it can be concluded that a shock in soybean oil price (LSO) will affected its own price, rapeseed (LRO) and palm oil prices (LPO) directly even after the first month. Therefore, changes in soybean oil price will likely to change rapeseed and palm oil prices as well.

Figure 2. Impulse response of three vegetable oil prices.
The last analysis is the variance decomposition which decomposes the variance of the price on its own and other variables. In the case of soybean oil price (LSO), the contribution of other prices in its variance is relatively small (Figure 3a). During the first period, all of the variance is contributed by its own price and after 10 month the contribution of rapeseed and palm oil price is relatively small, less than 20%. For rapeseed oil price (LRO), besides its own price, the variance is contributed by the soybean oil price (Figure 3b). Meanwhile, the contribution of palm oil is relatively small. Lastly, variance of palm oil price (LPO) is dominated by its own price although soybean oil price has almost 40% contribution (Figure 3c). From the analysis, it can be concluded that the price fluctuation of rapeseed and palm oil is also contributed by soybean oil price since soybean oil is the largest vegetable oil produced [1]. Meanwhile, fluctuation of soybean oil price mainly caused by its own price. This is similar to the conclusion made by Azam et al. [8] that soybean oil price affected the other vegetable oil prices compared to the other vegetable oils.

4. Conclusions
Soybean, rapeseed and palm oil prices have a long-run relation or cointegrated, not the case in the short-run. Soybean oil price has more impact on rapeseed and palm oil price. A shock in soybean price will have immediate effect on the other two vegetable oils. From the analysis, it can be concluded that for rapeseed and palm oil producing countries must aware by the change of price in soybean oil. The change
of soybean price will be directly affected both rapeseed and palm oil prices on the first month and still for the several months to come.

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