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Does RSPO certification affects the amount of CO_2 emission in Indonesia?

Y S Hilmi* **and A W Utami**

Department of Agricultural Socio-economics, Faculty of Agriculture, Universitas Gadjah Mada, Indonesia

Corresponding author: yahya.shafiyuddin.h@mail.ugm.ac.id

Abstract. As the most giant Crude Palm Oil (CPO) producer, Indonesia faces environmental issues. In 2004, the adoption of Roundtable Sustainable Palm Oil (RSPO) aimed at reducing the negative effect created by the palm oil industries. This study examined the impact of RSPO certification in the Indonesian palm oil industries on the amount of CO_2 as one component of GHG emissions. This study used time series data from 1981 to 2016, collected from the World Bank, the Tree Crop Estate Statistics of Indonesia, and UnComtrade. Vector Error Correction Model (VECM), with the amount of CO_2 emissions in Indonesia as the dependent variables, was run against the area used to produce CPO, the amount of CPO produced by Indonesia, the CPO price of Indonesia, and the dummy variable that is RSPO certification. The results show that the model has both short and long-term equilibrium relationships. While the RSPO certification as a dummy variable is not associated with the amount of CO_2 emissions in Indonesia.

1. Introduction

The use of palm oil has boomed over the last decade, both for food and non-food, as well as biofuel. Palm oil was used for biofuel as they belong to the renewable energy compared to fossil fuel [1]. Indonesia has surpassed Malaysia in the production of palm oil since 2006 and became the world leader of palm oil production that contributes to 48% of total world palm oil production [2]. The great demand from other countries has led to the expansion of the palm oil industry in Indonesia. In the past 20 years, 95% of the Indonesian oil palm production area was in Sumatra and Kalimantan [3].

However, the expansion carried out by the palm oil industry is inseparable from converting the forest land to be used as plantation land, although this is still many arguments regarding the forest conversion from the palm oil industry. Several studies found that the expansion of the palm oil industry was done by burning the natural forest [4]. Jelsma et al [5] in their paper said that the impacts in terms of forests loss and fragmentation caused by the expansion of palm oil plantations would produce CO2 emission and freshwater pollution

Another issue is the increased surface temperature because of the massive expansion in the industry. The increased use of synthetic fertilizer, especially in the immature phase of oil palm, added with the degraded land cover over the country. The temperature, as one of the variables of climate, can be a factor in climate change [4].

Environmental issues related to deforestation to the loss of biodiversity have become a global issue, and the palm oil industry has no exception. This condition started the emergence of RSPO, which was established by the EU in 2004 [6]. The RSPO certification, which is a voluntary-based certification, has begun to be adopted in Indonesia since 2008. Therefore, this study aims to examine the effect of the adoption of RSPO certification in Indonesia on the amount of CO2 emissions produced

2. Data sources and methods

This study uses secondary data to make an empirical analysis from the amount of CO2 emission as the dependent variable (which is explained by the area used to produce CPO), the amount of CPO produced by Indonesia, and the CPO price of Indonesia, and RSPO certification as the dummy variable. Time series data with annual periods from 1981 to 2016 were collected from the World Bank, the Tree Crop Estate Statistics of Indonesia, and UnComtrade. The number of observations is 36 samples and already passed the diagnostic test.

This research examines the effect of the adoption of RSPO certification on the amount of CO2 emission produced in Indonesia. The other independent variables were included, which are the area used to produce CPO, the amount of CPO produced by Indonesia, and the CPO price of Indonesia. This study uses the amount of CO2 emission as it is one indicator for the Environmental Performance Index (EPI) of Indonesia 2015-2019. The amount of CO2 emission data was collected from the World Bank. The CPO area and the amount of CPO produced by Indonesia data were collected from the Tree Crop Estate Statistics of Indonesia. At the same time, the CPO price of Indonesia was collected from UnComtrade. This study uses the RSPO certification as a dummy variable. The certification started to establish in Indonesia from 2008 onwards.

VECM analysis is required several tests to ensure that the VECM is fit and can be adequately interpreted. The tests need to be done before obtaining VECM outputs are 1) conduct stationarity test using the unit root test analysis, 2) determine the optimum lag length, 3) conduct cointegration test, and 4) analyze the VEC model. The study begins with testing the stationarity of data using Augmented Dickey-Fuller (ADF) at the same degree (level) to obtain the data with the variance that is not too large and have a tendency to approach the average value [7]. After the data is stationary, it is necessary to determine the optimum lag (order) length for the Vector Autoregressive (VAR) model that can be estimated based on the Akaike Information Criterion (AIC) criteria. It is also worth noting that in this step, the stability test to the VAR model is carried out. The results of the stability test can be explained in two forms, namely tabulation and graph forms. The tabulation form describes the modulus values, and the graph form represents points distributed in a circle. The modulus value with an average value smaller than one illustrates that the model is stable; meanwhile, the inverse root of the AR characteristic polynomial graph describes the stable model by the dispersion of points in a circle. Before testing out the cointegration in the VAR model, these two steps, determine the optimum lag length and conduct stability test, must be done first. The cointegration test needs to be carried out to determine a relationship between variables; thus, the model can be included in the VECM if there is cointegration.

If the characteristics of the data obtained are co-integrated, then the VECM can be used. Being known as restricted VAR, VECM is a VAR model with cointegration constraints. As there is a cointegration relationship in the VEC model when there is an extensive range of short-term dynamic fluctuation, VECM expressions can restrict the long-term behavior of the endogenous variables and be convergent to their cointegration relation. The VEC models used in this study are as follows:

$$Log(CO_2)^d_{ti} = \beta_0 + \beta_1 Log(AREA_{ti}) + \beta_2 Log(PRICE_{ti}) + \beta_3 Log(PROD_{ti}) + \beta_4 RSPO_{ti} + \mu_t$$

Where $Log(CO_2)^d_{ti}$ is the amount of CO_2 emission produced by Indonesia (metric per capita), $Log(AREA_{ti})$ is the CPO area of Indonesia (Hectare), $Log(PRICE_{ti})$ is CPO price of Indonesia (US$/Tonnes), $Log(PROD_{ti})$ is the amount of CPO produced by Indonesia (Tonnes), and $RSPO_{ti}$ is the dummy variable for the adoption of RSPO certification in Indonesia, which is 0 for the time before the adoption and 1 for the time after the adoption.

3. Results and discussion

3.1. Stationarity test

VECM require variables that are stationary in the first difference (I) test at 0.05 alpha. Table 1 shows that four out of five variables used in this study are not static in the 0 levels, thus need to be tested in the first difference level (I). The results are all the unit-roots from variables tested in the first difference level are smaller than 0.05 alpha, meaning all of the variables are stationary in the first difference level.

Table 1. Results for the stationary test using Augmented-Dickey Fuller (ADF) on alpha 0.05

Variable	Level		1st Difference	
	ADF	Probs	ADF	Probs
LOG(CO_2)	-1.162154	0.6787	-6.417315	0.0000*
LOG(AREA)	-3.523352	0.0131	-3.977420	0.0042*
LOG(PRICE)	-1.939897	0.3110	-5.770701	0.0000*
LOG(PROD)	-2.164558	0.2224	-6.128313	0.0000*
RSPO	-0.717137	0.8294	-5.830952	0.0000*

* Significant at 0.05 alpha

3.2. Optimum lag length

After all the variables are stationary at the first difference level, the next step is to determine the length of the lag (order) used in the analysis. The lag length in this study was carried out using the Akaike Information Criterion (AIC) test criteria.

Table 2. Determine Lag Intervals for Endogenous with Lag Length Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	104.6585	NA	1.78e-08	-6.494094	-6.309064*	-6.433779*
1	115.0864	17.49199	2.58e-08	-6.134605	-5.209452	-5.833028
2	137.2632	31.47682*	1.83e-08	-6.533111	-4.867836	-5.990273
3	159.0513	25.30226	1.47e-08*	-6.906534*	-4.501137	-6.122435
4	171.9335	11.63554	2.47e-08	-6.705386	-3.559866	-5.680025

Here the lag intervals for the endogenous variable can be seen in Table 2. The optimum lag length based on the AIC criteria has the smallest value among the other lags. Based on Table 2, the AIC test criterion has the optimum lag at the third-order marked with an asterisk (*). After the optimum lag has been obtained and the new VAR model is re-established, it needs to be tested. The test ensures that the model used is stable by checking the modulus and should be less than 1. Table 3 shows that the modulus on the model is less than 1. That is to say, the third lag order is appropriate, and the established VAR model is stable to be used in the next step.

Table 3. Results for the VAR stability test

Root	Modulus
-0.084408 - 0.835287i	0.839541
-0.084408 + 0.835287i	0.839541
0.186279 - 0.619599i	0.646995
0.186279 + 0.619599i	0.646995
0.640746	0.640746
-0.210617 - 0.511052i	0.552751
-0.210617 + 0.511052i	0.552751
-0.321373	0.321373

3.3. Cointegration test

After the optimum lag in the model is known, the next step is the cointegration test. This step aims to ensure whether there are short-term and long-term equilibrium relationships in the model. If the model is significantly co-integrated, then the VECM can be estimated. This study uses Johansen cointegration test method, which compares both trace statistic value and max eigenvalue to the critical value.

Based on Table 4, the results reject the null hypothesis, which is not having co-integrated equation(s), under the 0.05 alpha both in trace and maximum eigenvalue test. Both tests indicate that there is one co-integrating equation and might be a long-term equilibrium relationship. The presence of cointegration relationships means that VECM can be further conducted.

Table 4. Johanssen cointegration test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None*	0.646149	61.30620	47.85613	0.0017
At most 1	0.342614	27.02317	29.79707	0.1011
At most 2	0.275706	13.18019	15.49471	0.1084
At most 3	0.073964	2.535791	3.841466	0.1113
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None*	0.646149	34.28304	27.58434	0.0059
At most 1	0.342614	13.84297	21.13162	0.3781
At most 2	0.275706	10.64440	14.26460	0.1730
At most 3	0.073964	2.535791	3.841466	0.1113

3.4. The short and long-terms effect of RSPO certification to the CO_2 emissions

Engle-granger's ECM model is valid if the error correction term (ECT) is marked negative and statistically significant [8]. Based on Table 5, the ECT coefficient value is -0.700888 and is significant at 0.10 alpha, meaning that the model is valid. The coefficient value of ECT can determine how quickly the balance can be recovered. The ECT value of 0.700888 implies the proportion of its balance and the development of CO_2 emission in the preceding period adjusted for the current period of 70.08%.

Table 5. Johanssen cointegration test

Variables	Short-term		Long-term	
	Coefficient	t-statistics	Coefficient	t-statistics
LOG(CO_2 (-1))	0.383345	-	-	-
LOG(AREA (-1))	-1.359187	-3.07179***	-0.632132	-5.25718***
LOG(PRICE (-1))	0.026859	0.31136	-0.377640	-6.32403***
LOG(PROD (-1))	0.889404	2.41404**	0.413690	2.98318***
RSPO (-1)	-0.062851			
ECT	-0.700888			
C	0.116925			
R-squared	0.529489			
Adj. R-squared	0.315621			
F-statistic	2.475769**			

*** Significant at the 0.01 alpha
** Significant at the 0.05 alpha
* Significant at the 0.10 alpha

Table 5 shows that this model has the adjusted R-squared valued at 0.315621. It means that 31.56% of the variation of the dependent variable, which is the amount of CO_2 emissions, can be explained by the independent variables used in this model. Table 5 also shows that the F-statistics value is 2.475769 and is significant at 0.05 alpha. It can be interpreted that the amount of CO_2 emissions as the dependent variable can be affected by the independent variables simultaneously.

The result of the VECM estimation can be interpreted as in the long-term, all variables in the previous period, which are the area used to produce CPO, CPO prices of Indonesia, and the amount of CPO produced by Indonesia affect the amount of CO_2 emissions in Indonesia. While in the short-term, the area used to produce CPO and the amount of CPO produced by Indonesia are significantly affect the amount of CO_2 emissions in Indonesia.

Based on the data used in this study, the VECM estimation results on the area used to produce the CPO variable are significantly both in the short and long-term equilibrium. Both in the short and long-term, it has a negative sign of coefficient means that the increase of 1 unit of the area to produce CPO will reduce the amount of CO_2 emission. This finding is opposite to what Obidzinski [9] has found. He said that the activities held by palm oil industries such as forest conversion and plantation development are the significant sources of GHG emissions, which contributes 15% to 25% of global carbon emissions. One of the GHG emissions is CO_2. Purnomo et al [10] said that CO_2 could be reduced by removing the amount of existing oil palm plantations on peatlands and swapping them with mineral soil lands. The opposite findings in this study might because the amount of CO_2 emissions that had been examined were the total amount of CO_2 emissions produced by industrial activities. It means that the CO_2 emissions were not only made by the activities of the palm oil industry.

On the other hand, the variable of CPO produced by Indonesia has a positive sign of coefficient both in the short and long-term periods to the amount of CO_2 emissions. The use of fertilizers and pesticides or other chemicals, especially in the early phase of palm oil trees, might be contributing to the CO_2 emissions. The use of the chemical substance, especially Urea fertilizer in the immature stage, is widely known as the essential factor for the rest of the plant's life.

The CPO price of Indonesia has a negative sign in the long-term period. Tey et al [11] said that the CPO price is a significant factor in the early mover advantage in RSPO certification. The indirect effect is to the amount of CO_2 emission produced; it might get reduced if the CPO price is decreasing. The industry will lose interest in increasing the production of CPO because of the price they will receive.

The RSPO certification as the dummy variable has no significant effect on the amount of CO_2 emission produced with the t-statistics of -1.22364. It indicates no difference in the amount of CO_2 emission before and after the RSPO certification was established in Indonesia. This finding might be crucial as the RSPO certification is aimed at the more sustainable palm oil; thus, it shall have importance regarding the CO_2 emissions produced every year. It might happen because the CO_2 emission data is not precisely the amount of CO_2 emission produced by palm oil industries but the aggregate from all industrial activities.

4. Conclusions

This study examined the effects of RSPO certification on the amount of CO2 emissions in Indonesia using the vector error correction model (VECM). The results demonstrate that the model has both short- and long-term equilibrium relationships explained from the Johanssen cointegration test. From the VECM estimation results, it can be seen that the amount of CO_2 emissions is not associated with the RSPO certification as the dummy variable; thus, the adoption of RSPO certification does not have any impacts on the dependent variable.

The results of this study can provide information for the palm oil stakeholders in which the sustainability of the industry is the main focus, whether for the economic, social, or environmental aspects. Regarding the results, further research might use the amount of CO2 emissions, which are calculated only from palm oil industry activities, to get better results.

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