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Article

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The Causal Relationship between Crude Oil Price, Exchange Rate and Rice Price

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ABSTRACT

This study aims to examine the causal relationship between crude oil price, IDR/EUR exchange rate, and rice price by using monthly data from January 2000 to September 2017. The result of data analysis using vector autoregressive model shows that there is no long-term relationship between crude oil price, IDR/EUR exchange rate, and the price of rice. The relationhip that happens is only in short-term one. Granger causality test result shows that the direction of relationship is from crude oil price and IDR/EUR exchange rate to rice price. The relationship between crude oil price and rice price is positive, while the relationship between IDR/EUR exchange rate and rice price is positive before the 3rd month. However, this relationship turns into negative after the 3rd month.

Keywords: Crude Oil Price, Exchange Rate, Rice Price, Vector Autoregressive Model
JEL Classifications: C58, G150, Q13, Q430

1. INTRODUCTION

Rice is the staple food for almost half of the seven billion people in the world. However, more than 90% of this rice production is consumed in Asia, where staple food for the majority of the population, including 560 million people are starving in the region. The consumption of rice in the world has been rising from year to year (Mohanty, 2013), and by 2017 rice consumption in the world reaches around 475.64 million metric tons (TSP, 2017). The country with highest rice consumer in Asia is Indonesia, followed by China and India (Mohanty, 2013). The increasement in rice consumption can cause the demand of rice to increase. This increasement in rice demand could trigger an increase world rice prices if not balanced by production increasement.

Furthermore, crude oil is one of the raw materials in production process where in agriculture field, crude oil is used to run the farming equipments such as machines and means of transportation (Rafiq et al., 2009; Adam, 2016). Hence, the rise of crude oil price can cause the rise of production cost which can lead to rise of agriculture commodities, including rice (Sugden, 2009; Baumeister and Killian, 2014; Adam et al., 2016).

Both of the commodities, crude oil and rice are export commodities for countries which have surplus in both or one of the two commodities. Crude oil and rice also become import commodities for non-producer countries where their production can not meet their domestic needs. Because foreign currency is the transaction tool in export and import activities, thus the change of exchange rate can cause the change also in crude oil price and other commodities, including rice. Harri et al. (2009) and Hatzenbuehler (2006) said that there is a causal relationship between agricultural commodity prices and exchange rates. Similarly, between the price of crude oil and the exchange rate. These relations can happen both in the short and long term.

Research on the relationship between crude oil prices, exchange rates, and prices of agricultural commodities was examined by researchers, among others: Nazlioglu and Soytas (2011), Rezitis (2015a), and Nazlioglu and Soytas (2011) examined the relation between crude oil prices, exchange rates, and agricultural commodity prices by using data in 1994–2010 period. The exchange rate was proxied with Turkey's LIRA/USD exchange rate, and the crude oil was proxied with WTI crude oil. From vector autoregressive (VAR) model analysis result, they found that there is an impact of crude oil prices and exchange rates on agricultural commodity prices (wheat, maize, cotton, soybeans, and sunflower). Rezitis (2015a) examined the relation between crude oil prices, exchange rates and prices of agricultural commodities (barley, corn, wheat, rice, and sorghum). He used data spanning from July 1998 to October 2006. Crude oil price was proxied with average crude oil prices of brent, WTI, and Dubai. The exchange rate used the narrow index of the USD exchange rate (2010 = 100) and the rice was proxied at the price of Thai rice. He found that there was a two-way relationship between the price of crude oil, the exchange rate and the price of agricultural commodities.

From the literature review above, it is found that there is a difference between the findings of: Nazlioglu and Soytas (2011), Rezitis (2015a). This difference might be caused by (1) the difference of study period in which the economic variables of a country may change due to changes in world economic conditions at different periods of time, (2) differences in the determination of research variables based on time series types: Agricultural commodities, type of crude oil (brent, WTI or Dubai), and currency exchange rate. Beside that, there are still few researchers who included price of rice as their research variables in their study.

This study aims to examine the relationship between crude oil prices, the IDR/EUR exchange rate, and rice price using data spanning from January 2000 to September 2017. To verify this relation, the VAR model is used. This study is a continuation of Adam,s research (2015) by adding the exchange rate variable in the model. A modification of analysis tool was also done from simple linear regression analysis to VAR analysis. Furthermore, the addition of exchange rate variable is intended to eliminate the bias of the research results, as stated by Ozturk and Acaravci (2010).

2. REVIEW OF LITERATURE

Research on the relationship between crude oil prices and agricultural commodity prices has been undertaken by earlier researchers such as: Arshad and Hameed (2009) and Chen et al. (2010). Arshad and Hameed (2009) examined the relationship between cereal prices (maize, rice and wheat) and crude oil price. Granger causality test results on the data ranging from January 1980 to March 2008 showed that there is a one-way long-term relationship of crude oil prices to cereal prices. Chen et al. (2010) examined the relationship between oil price and agricultural commodities prices (corn, soybean, and wheat). They found that changes in agricultural commodity prices were affected by the oil price.

The relationship between the exchange rate and agricultural commodities prices was examined by earlier researchers such as: Kearns (2007), Roboredo and Ugando (2014), and Hatzenbuehler et al. (2016). Kearns (2007) developed a model of relationships between exchange rates and Australian commodity export prices. Agricultural commodities (e.g., wheat, barley, rice) are included in this export commodity. Based on the data analysis result, he found that there is a correlation between the exchange rate and agricultural commodities prices. Roboredo and Ugando (2014) examined the relationship between US dollar exchange rates and agricultural commodities (corn, soy-beans, wheat and rice) where they found that there is a positive relationship between the exchange rate and the four prices of agricultural commodities. Hatzenbuehler et al. (2016) examined the relationship between the exchange rate and agricultural commodities (corn and soybean) where they found that in the short term there is a relationship between the exchange rate and the agricultural commodities prices.

Rezitis (2015b) developed this study using the data spanning from June 1983 to June 2013. In this study, the agricultural commodities were developed into 30 agricultural commodities (among others: Rice). He found that there is a long-term effect of crude oil prices and exchange rates on agricultural commodity prices. The effect of crude oil prices on agricultural commodity prices is positive, while the effect of exchange rate on agricultural commodity prices is negative. Burakov (2016) examined the relation between crude oil prices, exchange rates and agricultural commodity prices using monthly data from January 1999 to October 2015. Crude oil price was proxied with brent crude prices, exchange rate was proxied with Russian Ruble/USD and agricultural commodity prices were proxied with the price of domestic agricultural commodities (buckwheat, barley, potatoe, wheat, oats, rye and grain crops). He found that the prices of agricultural commodities and exchange rates are not sensitive to crude oil prices.

3. DATA AND METHODOLOGY

3.1. Data

The data used in this research are time series data of crude oil price (in USD per barrel), IDR/EUR exchange rate (in Indonesian rupiah per EUR), and rice price (metrics ton per quintal). These three types of data range from January 2000 to September 2017. These data were taken from Fussion Media Limited.

For the purposes of data analysis, all data is transferred into a natural logarithmic form. Crude oil price is stated as oil, IDR/EUR is stated as EXC, and rice price is stated as RIC.

3.2. Methodology

In this study, the data were analyzed by vector autoregressive (VAR) model. The VAR (p) model without trend with k stationary endogenous variable at the level or integrated of order one, I(0) (Lutkepohl, 2005; Juselius, 2006; Mills, 2015; Neusser, 2016) is as follows:

$$X_t = C + \sum_{i=1}^{p} \mathrm{A}_i X_{t-i} + \varepsilon_t \quad (1)$$

Where X_t is endougenous variable vector, C = $[C_1, C_2, C_2]'$ is constant vector, A_i coefficient matrix, and $\varepsilon_t = [\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}]'$ is white noise vector which is independently and identically distributed with $\varepsilon_t \sim IID(0, \Sigma)$ where Σ is positive definitive matrix.

If all the endogenous variables are integrated of order one (1) and cointegrate, then equation (1) can be stated in a vector of error correction model (VECM) (p-1) as follows:

$$D(X_t) = C + \Pi X_{t-1} + \sum_{i=1}^{p-1} \Gamma_i D(X_{t-i}) + \varepsilon_t \quad (2)$$

Where $\Pi = \sum_{(i=1)}^{p} A_i - I$ with I identity matrix, and $\Gamma_i = -\sum_{j=i+1}^{p} A_i$. Coefficient Π is called as long-term matrix coefficient, and Γ_i is called as short-term matrix coefficient (Juselius, 2006). Furthermore, if all endougenous variables do not cointegrate, then (2) becomes the VAR (p-1) model (Tsay, 2014; Mills, 2015) as follows:

$$D(X_t) = C + \sum_{i=1}^{p-1} \Gamma_i D(X_{t-i}) + \varepsilon_t \quad (3)$$

Endougenous variables in this research are *RIC*, *OIL* dan *EXC*, thus vector X_t in equation (1), (2), and (3) is $X_t = RIC_t, OIL_t, EXC_t$', so $k = 3$. To estimate the VAR (p) model, or the VECM (p-1) model, hence the first step to do is determining the length of time lag using Akaike Information Criteria (AIC). Second step is testing stationerity or integration order of each endogenous variable (RIC, OIL, and EXC). Integration order test used is Augmented Dickey-Fueller (ADF) which was developed by Dickey and Fuller (1981) and Phillips-Perron test which was developed by Phillips and Perron (1988). Acoording to these two tests, one variable is integrated of order *d (I(d))*, if the P-value of test statistics is smaller than its critical values (1%, 5% or 10%). If all endogenous variables are integrated of order one, I(1), then the third step is to test the cointegration between RIC, OIL and EXC variables using Johansen cointegration test developed by Johansen (1988). The Johansen cointegration test uses a trace test or max-eigen test). The trace test uses the trace statistics as follows:

$$\eta_r = -T \sum_{i=r+1}^{k} \log(1+\lambda_i), r = 0,1,\ldots,k-1$$

Where λ_i states the biggest eigen value from matriks Π. In trace test the null hypotheses is verified H_r: There is *r* cointegration equation opposites alternative hyphoteses H_{r+1}: There is *k*+1 cointegration equation. Max-eigen test statistics is as follows:

$$\xi_r = \log(1+\lambda_i), r = 0,1,\ldots,k-1$$

In max-eigen test, eigen value was tested with the null hyphoteses H_r: There is *r* cointegration equation versus alternative hyphoteses H_{r+}: There is *r*+1 cointegration equation.

The last step is estimating the VAR model or the VECM model. If in this estimation there are significant coefficients from endougenous variables found, then it will be continued with Granger causality test. Then, continued with Inpuls Response Function (IRF) test to acknowledge the impact of one variable change to other variables change. Varians decomposition test also be done to determine the contribution of each variable.

4. RESULTS AND DISCUSSION

4.1. Stationary Test

The estimation results of the ADF test and the PP test are summarized in Table 1. Based on the statistical values of the ADF test and the PP test in Table 1 shows that the crude oil price (OIL), the IDR/EUR (EXC) exchange rate, and the rice price (RIC) are not stationary at the level, but stationary at the first diference. Thus, OIL, EXC and RIC are integrated of order one, I(1).

4.2. Cointegration Test

Because of all the variables are integrated of order one, I(1), then the next step is to perform a cointegration test using the Johansen cointegration test. The estimation results of the Johansen cointegration test are summarized in Table 2. It appears in Table 2 that the statistical values of the trace test and the max-eigen test are smaller than their critical values at the 5% significance level. This means there is no long-term cointegration relationship between crude oil prices, the IDR/EUR exchange rate and the price of rice.

4.3. Causal Relationship Test

The estimation results of the criteria values for determining the length of the lag time is summarized in Table 3. According to the AIC criterion, the minimum time lag length of the VAR model in the level is p = 2.

Since all the endogenous variables of this research are integrated of order one, I(1) and not cointegrated, then the estimated VAR model is the VAR (p-1) model, so the length of the time lag is

Table 1: ADF test and PP test

Variabel	ADF test statistic		PP test statistic	
	Constant	Constant and tren	Constant	Constant and tren
OIL	−1.807	−1.614	−1.805	−1.455
D (OIL)	−11.686*	−11.711*	−11.679*	−11.687*
EXC	−2.227	−3.010	−2.194	−2.915
D (EXC)	−15.027*	−15.043*	−15.173*	−15.257*
RIC	−1.846	−2.246	−1.635	−2.028
D (RIC)	−9.409*	−9.399*	−17.176*	−17.167*

*1% significant. ADF: Augmented Dickey-Fueller, PP: Phillips-Perron

Table 2: Johansen cointegration test

Null hypothesis	Trace test		Max-Eigen test	
	Statistic test value	Critical value 5%	Statistic test value	Critical value 5%
r=0	27.549	42.915	16.586	25.823
r≤1	10.963	25.872	7.520	19.387
r≤2	3.443	12.518	3.443	12.518

Table 3: Information criterias statistic values

Lag	AIC	SC	HQ
0	−0.101118	−0.052155	−0.081309
1	−7.905092	−7.709238*	−7.825857
2	−7.983151*	−7.640405	−7.844490*
3	−7.935326	−7.445690	−7.737239

*Indicates lag order selected by the criterias. AIC: Akaike Information Criteria p-1 = 1. The estimation results of VAR (1) in the first difference and the Granger causality test are summarized in Table 4.

It appears at the bottom of Table 4, the residual of VAR (1) model has a constant variance (homocedastic) and does not contain autocorrelation. Furthermore, in the second column of Panel A, it appears that the coefficient values of the variables D(RIC(-1)) and D(OIL(-1)) are significant 1%, while the coefficient D(EXC(-1)) significant 5%. The coefficient values of the variables D(OIL(-1)) and D(EXC(-1)) are positive. Thus, there is a short-term relationship between the price of crude oil, the exchange rate and the price of rice. This relationship is positive, since the coefficient values D(OIL(-1)) and D(EXC(-1)) are positive.

In various literatures, it is known that after the estimation of VAR model is done, then it is also continued with the test of causality. In fact, the direction of the relationship can already be determined from the test results of the significance coefficients of the endogenous variables VAR(1) in Table 4 in Panel A above. Thus, this Granger causality test is an advanced test to reinforce the test results of the coefficient significance of the endogenous variables in which the test statistic used is the Wald test statistics based on the distribution function χ^2. The P-values of the test statistics are shown in Table 4 in Panel B where the P-values of the statistic χ^2 are <5%. In conclusion that in the short-term, there is a one-way relationship of crude oil prices and exchange rates to rice prices.

A further search was to examine the impact of that causality relation. The IRF test result of the impact of changes in crude oil prices and the IDR/EUR exchange rate is illustrated by Figure 1. It is shown in Figure 1, that the response of the price of rice to the price of crude oil is positive. Meanwhile, the response of the rice price to the IDR/EUR exchange rate changed from positive into negative. This mark change occurs after the 3rd month. Furthermore, the response of the price of rice to crude oil prices and the IDR/EUR exchange rate is stable after the 5th month.

4.4. Discussion

The first finding of this study is that the relationship between crude oil prices and rice prices occurs only in the short term. This relation is a one-way and positive relation of crude oil price to the rice price. The increasement in rice price in the January to September 2017 period is a positive response to the rise in crude oil prices. This positive response is because crude oil is the raw material of rice production as proposed by Sugden (2009) and Baumeister and Killian (2014). Empirically, the result of this study is in accordance with the results of the research from Arshad and Hameed (2009) where they found that crude oil price affects the price of cereal commodities (such as rice prices) not only in short-term periods, but this effect also occurs in long-term period.

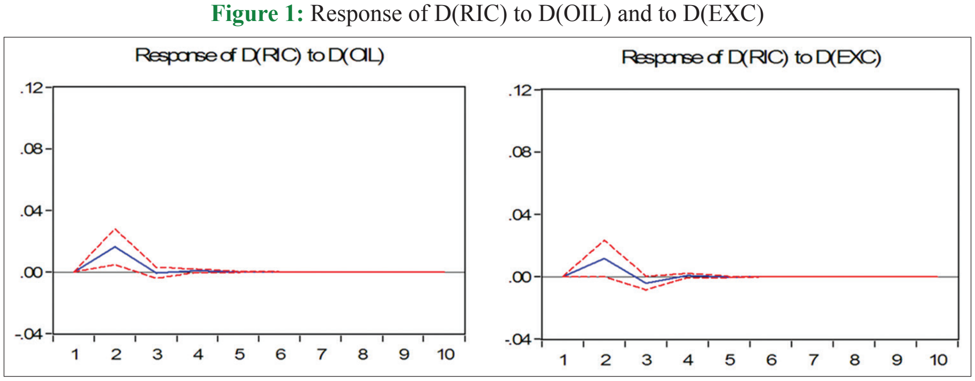
The second finding is about the relationship between the IDR/EUR exchange rate and the price of rice. This relationship also occurs only in the short term from the IDR/EUR exchange rate to the price of rice. The nature of this relationship changes from positive relation to the negative one. The positive relation lasted only from January 2000 to the end of the 3rd month or the end of March 2000. That is, the rise in the exchange rate of IDR/EUR has driven the rise in rice prices in this period. Nevertheless, the rise in the exchange rate of IDR/EUR was no longer dominantly pushing up the price of rice in the period of March 2000 to January 2007. Of course, the increase of rice price in the period of March

Tabel 4: VAR (1) model in first difference and Granger causality test

Independent variable and constant	Dependent variable		
	D (RIC)	D (OIL)	D (EXC)
Panel A: VAR (1) model			
D (RIC(-1))	−0.207 (0.002)*	0.0806 (0.269)	−0.036 (0.223)
D (OIL(-1))	0.173 (0.006)*	0.2085 (0.002)	−0.014 (0.617)
D (EXC(-1))	0.316 (0.048)**	−0.209 (0.226)	−0.034 (0.625)
C	0.003 (0.595)	0.003 (0.687)	0.004 (0.117)
Panel B: VAR Granger causality			
D (RIC)	-	[0.267]	[0.222]
D (OIL)	[0.006]*	-	[0.617]
D (EXC)	[0.046]**	[0.225]	-

P-valuet of statistic-t in ( ) and P value of statistic- χ^2 in [ ]. *.**are significant 1% and 5%. P value of LM test is 0.4443, P value of White test is 0.1407. VAR: Vector autoregressive

Figure 1: Response of D(RIC) to D(OIL) and to D(EXC)



Source: Own processing

2000 to January 2017 could be affected by factors other than crude oil price. This requires further research. Empirically, the result of this study is in line with the result of researches from Kearns (2007) and Roboredo and Ugando (2014). However, Roboredo and Ugando (2014) found a positive relation between exchange rates and rice price during the sampling period.

In accordance with the Granger causality test, crude oil price and the IDR/EUR exchange rate simultaneously affect the price of rice. The result of variance decomposition analysis shows that the effect of crude oil price and the IDR/EUR exchange rate on the price of rice is relatively small (6.06%) where the effect of crude oil price is greater than the effect of IDR/EUR exchange rate. Furthermore, these findings are consistent with the findings of Rezitis (2015) and Rezitis (2015a).

5. CONCLUSION

The purpose of this study is to investigate the causal relationship between crude oil price, IDR/EUR exchange rate and rice price. Crude oil price data, IDR/EUR exchange rate and the price of rice used are monthly data which span from January 2000 to September 2017. To analyze the relationship, the VAR model is used, while to determine the direction of causality relation, Granger causality test is used.

Since all endogenous variables of the VAR model are integrated of order one, I(1), then before causality relation test is done between the variables, the cointegration test was done first using Johansen cointegration test. From the results of this cointegration testing, it is found that there is no long-term cointegration between crude oil prices, the IDR/EUR exchange rate and the price of rice. Thus, the estimation of VAR model is performed on the VAR model in the first diference. The VAR model estimation result and the Granger causality test show that there is a one-way short-term relation from the price of crude oil and the exchange rate to the price of rice. The short-term relationship between crude oil prices and rice prices is positive. Meanwhile, the relationship between exchange rate and rice price was positive before the 3rd month and negative after the 3rd month.

REFERENCES

Adam, P. (2015), A model of the Dynamics of the Relationship between the Prices of World Crude Oil and the Prices of Rice. Proceeding of the Celebes International Conference on Divercity at Wallacea's Line (CICWDL). pp453-458. Available from: https://www.papers.ssrn.com/sol3/papers.cfm?abstract_id =2985817.

Adam, P. (2016), The response of bank of Indonesia's interest rates to the prices of world crude oil and foreign interest rates. International Journal of Energy Economics and Policy, 6(2), 266-272.

Adam, P., Rianse, U., Harafah, L.M., Cahyono, E., Rafiy, M. (2016), A model of the dynamics of the effect of world crude oil price and world rice price on Indonesia's inflation rate. AGRIS on-line Papers in Economics and Informatics, 8(1), 3-12.

Arshad, F.M., Hameed, A.A.A. (2009), The long run relationship between petroleum and cereals prices. Global Economy and Finance Journal, 2(2), 91-100.

Baumeister, C., Kilian, L. (2014), Do oil price increases cause higher food prices? Economic Policy, 9(80), 691-747.

Burakov, D. (2016), Oil prices, exchange rate and prices for agricultural commodities: Empirical evidence from Russia. AGRIS on-line Papers in Economics and Informatics, 8(2), 33-47.

Chen, S.T., Kuo, H.I., Chen. C.C. (2010), Modeling the relationship between the oil price and global food prices. Applied Energy, 87, 2517-2525.

Dickey, D.A., Fuller, W.A. (1981), Likelihood ratio statistics for autoregressive time series with a unit root. Econometrica: Journal of the Econometric Society, 49(9), 1057-1072.

Harri, A., Nalley, L., Hudson, D. (2009), The relationship between oil, exchange rates, and commodity prices. Journal of Agricultural and Applied Economics, 41(2), 501-510.

Hatzenbuehler, P.L., Abbott, P.C., Kenneth, A.F.K. (2016), Agricultural commodity prices and exchange rates under structural change. Journal of Agricultural and Resource Economics, 41(2), 204-224.

Johansen, S. (1988), Statistical analysis of cointegration vectors. Journal of Economic Dynamics and Control, 12, 231-254.

Juselius, K. (2006), The Cointegrated VAR Model: Methodology and Applications. New York: Oxford University Press Inc.

Kearns. J. (2007), Commodity currencies: Why are exchange rate futures biased if commodity futures are not? The Economic Record, 83, 60-73.

Lutkepohl, H. (2005), New Introduction to Multiple Time Series Analysis. Berlin: Springer.

Mills, T.C. (2015), Time Series Econometrics: A Concise Introduction. New York: Palgrave Macmillan.

Mohanty, S. (2013), Trend in global rice consumption. Rice to Day, 12(1), 44-45. Available from: https://www.id.scribd.com/document/119860372/RT-Vol-12-No-1-Rice-facts#fullscreen=1.

Nazlioglu, S., Soytas, U. (2011), World oil prices and agricultural commodity prices: Evidence from an emerging market. Energy Economics, 33, 488-496.

Neusser, K. (2016), Time Series Econometrics. Switzerland: Springer International Publishing.

Ozturk, I., Acaravci, A. (2010), CO_2 emissions, energy consumption and economic growth in Turkey. Renewable and Sustainable Energy Reviews, 14, 3220-3225.

Phillips, P.C.B., Perron, P. (1998), Testing for a unit root in time series regression. Biometrika, 75(2), 335-346.

Rafiq, S., Salim. R., Bloch, H. (2009), Impact of crude oil price volatility on economic activities: An empirical ınvestigation in the Thai economy. Resources Policy, 34, 121-132.

Rezitis, A.N. (2015a), The relationship between agricultural commodity prices, crude oil prices and US dollar exchange rates: A panel VAR approach and causality analysis. International Review of Applied Economics, 29(3), 403-434.

Rezitis, A.N. (2015b), Empirical analysis of agricultural commodity prices, crude oil prices and US dollar exchange rates using panel data econometric methods. International Journal of Energy Economics and Policy, 5(3), 851-868.

Roboredo, J.C., Ugando, M. (2014), US dollar exchange rate and food price dependence: Implications for portfolio risk management. North American Journal of Economics and Finance, 300, 300-300.

Sugden, C. (2009), Responding to high commodity prices. Asian-Pasific Economic Literature, 25(1), 79-105.

The Statistica Portal (TSP). (2017), Total Global Rice Consumption 2008-2017. Available from: https://www.statista.com/statistics/255977/total-global-rice-consumption.

Tsay, R.S. (2014), Multivariate Time Series Analysis with R and Financial Applications. New Jersey: John Wiley & Sons Inc.