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Causal Effects of World Crude Oil Prices on the Prices of Rice and Soybean Oil: An ARDL Approach

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ABSTRACT

This study was undertaken to examine the impact of world crude oil prices on the prices of rice and soybean oil. Autoregressive Distribution Lag (ARDL) method was employed to investigate both the short-run dynamic and long-run relationship. All of the data were the time series annual basis from 1970 to 2008. The results revealed that the long-run relationship between world crude oil prices and rice prices did exist. In addition, the analysis also suggested that crude oil prices formed a major factor in the operation cost for the rice production in Malaysia. Nevertheless, the impact of crude oil prices did not only affect the direct cost in rice production but it also influenced the price of other materials required for rice production such as fertilizers.

Keywords: World crude oil prices, rice prices, soybean oil prices

INTRODUCTION

Due to the sharp rise of the world crude oil prices beginning 2004, the issue of commodity prices has once again become researchers' concern (see *Fig. 1*). In more specific, they have focused on the effect of oil prices on other commodity prices (Yu, Bessler and Fuller, 2006; Baffes, 2007; Amna and Fatimah, 2008). Baffes (2007) conducted a study on the effects of the world crude oil prices changes on 35 other commodities using the annual data from the year 1960 to 2005. The results revealed that if the crude oil prices remained high, the recent commodity prices boom would likely last longer, particularly in the food commodities, fertiliser and precious metal. This is consistent with the study by Amna and Fatimah (2008) who focused on the effect of petroleum prices instead of world crude oil prices on several vegetable oil prices (including soybean oil). The results of the latest study provided strong evidence of a long run equilibrium relation between the prices of the two major commodities. Furthermore, the error correction model estimation indicated a unidirectional long run causality flowing from petroleum to each of the vegetable oil prices under their study.

Fig. 1 plots the world crude oil prices in US dollar from 1970 to 2008. The world crude oil prices had been sufficiently low in the past two decades. In 2004, however, the world crude oil prices increased sharply and eventually reached US$98.89 per barrel in 2008 (it touched USD136.32 per barrel in July 2008). The world crude oil prices will continue to affect the prices of other commodities in many

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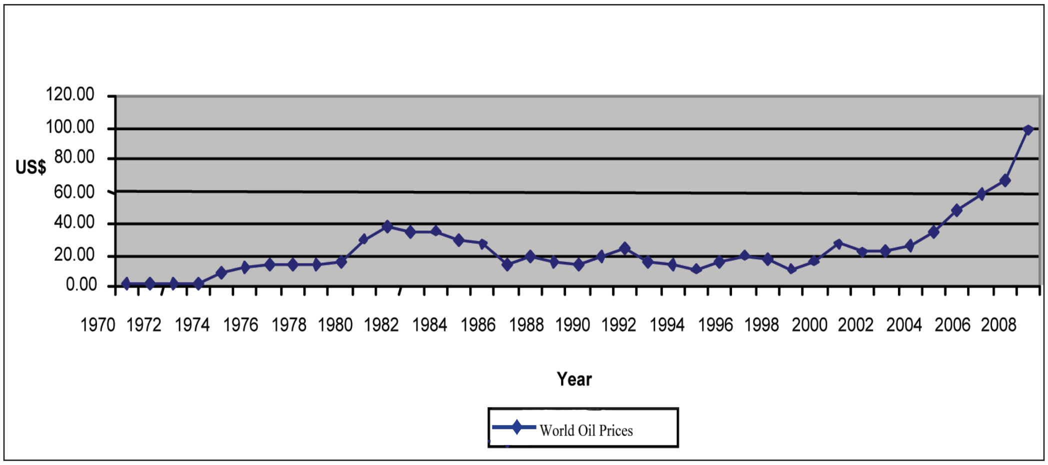


Source: International Monetary Fund (IFS) 2008

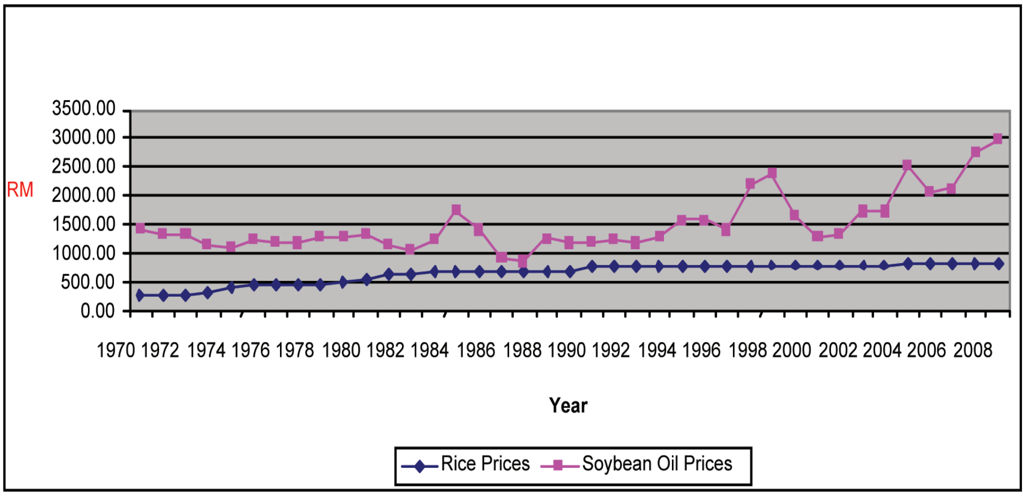
Fig. 1: Price of world crude oil for the year 1970 to 2008

ways. For example, on the supply side, the world crude oil enters the aggregate production functions of most primary commodities through various energy intensive inputs (e.g. fertilizer and fuel for agricultural commodities) and on transportation expenditures for long distances.

A rapid economic growth in developing countries has resulted in high demand for energy on electricity and industrial uses as well as for transportation fuel. Thus, increases in the world crude oil prices consequently lead to the rise in the prices of the final products. According to the World Bank (2007), global food prices have climbed by 83% since 2005 due to the increase in the prices of food commodity. It is noted that there was a dramatic increase in world crude oil prices at the end of 2008 (see *Fig. 1*). This has affected the cost of producing and transporting fertilizers and many other products which are crucial for the rice production activities. According to Doane Advisory Services (2008), high energy costs would impact the production cost in a variety of ways. Farmers use fuels to operate equipment and run irrigation wells. High energy prices, specifically the price of world crude oil, will indirectly drive up production costs through the increase in the prices of fertilizers and chemicals used in routine operations.

As shown in *Fig. 2*, the prices of rice in Malaysia and soybean oil in the Rotterdam market rose from 1970 to 2008. The prices of rice had continuously increased since 1970, from RM 265 per tonne to reach RM 823 per tonne in 2008. In addition, the prices of soybean oil also showed an upward trend from 1970 to 2008. Apparently, the increase in the world crude oil prices mentioned earlier was concurrent with the rise in the prices of rice and soybean oil in Malaysia and Rotterdam market, respectively.

The high correlation between the price of world crude oil and the prices of food commodities, such as rice and soybean oil, raises the question as to the nature of the relationship between the world crude oil prices and the prices of both commodities. Hence, this paper attempted to investigate the relationship between the world crude oil prices and the prices of both food commodities. This study was expected to provide more empirical evidences on the effects of the world crude oil prices as different approaches were used, and for this purpose, the study period was further extended to 2008, where the world crude oil prices reached a peak level as compared to the studies conducted by Yu *et al*. (2006), Baffes (2007) and Amna and Fatimah (2008).



Source: The Ministry of Plantation Industries and Commodities (various issues)

Fig. 2: The price of Malaysian rice and soybean oil in Rotterdam market for the year 1970 to 2008

MATERIALS AND METHODS

This study used the data of the world crude oil prices, and the prices of rice in Malaysia and soybean oil in the Rotterdam market; these data were gathered over the period from 1970 to 2008. The published data on these variables are available from the publications of the Ministry of Plantation Industries and Commodities (MPIC), the Department of Statistics, Malaysia, and the International Financial Statistics (IFS) online service. In more specific, this study evaluated the long-run elasticity and short-run causality as well as examined the impacts of the world crude oil prices on the prices of rice and soybean oil.

The co-integration techniques, such as by Engle and Granger (1987) or Johansen (1988) and Johansen and Juselius (1990), have commonly been used in the empirical economics to study the existence of long-run equilibrium relationship levels between the variables. These methods involve a pre-testing step for unit roots to determine the order of the integration of the variables in the model. In particular, the methods required that all the variables undertaken in the study to be integrated in the same order of one, that is, I(1). In practice, however, not all the variables have a unit root. Some variables are stationary in level I(0), while others may have two unit roots, I(2), or are stationary in second differences. If the orders of integration of the variables undertaken the study are different, it will cast doubt on the accuracy and validity of the estimation results obtained from the co-integration testing procedures.

However, Engle and Granger (1987) pointed out that if the time series was non-stationary, one could then include lagged dependent and independent variables using a sufficiently complex dynamic specification, such as an Autoregressive Distributed Lag (ARDL) model to allow the regressors to have different orders of integration. As such, in this study, the ARDL bound testing approach proposed by Pesaran *et al*. (2001) was used to allow the regressors to have different orders of integration, either I(1) or I(0), in estimating the functions. The bound test, which is based on the estimation of an Unrestricted Error Correction Model (UECM), is applicable irrespective of whether the underlying regressors are purely I(0), I(1) or is mutually co-integrated. Furthermore, the ARDL model is more robust and performs better with a small sample size compared to the standard co-integration methods (Pesaran and Shin, 1999).

The variables used in this study include world crude oil prices (lnCOP), prices of rice (lnRP) and prices of soybean oil (lnSBOP) in the natural logarithmic form. Meanwhile, the dependent variables are the prices of rice and soybean oil. There are two ARDL functions, as follows:

a. The ARDL model for the function of rice prices

$$\Delta \text{lnRP}_t = \beta_0 + \beta_1 \text{lnRP}_{t-1} + \beta_2 \text{lnCOP}_{t-1} + \sum_{i=0}^{p} \alpha_3 \, \Delta \text{lnRP}_{t-i} + \sum_{i=0}^{p} \theta_4 \, \Delta \text{lnCOP}_{t-i} + \varepsilon_t \quad (1)$$

b. The ARDL model for the function of soybean oil prices

$$\Delta \text{lnSBOP}_t = \beta_0 + \beta_1 \text{lnSBOP}_{t-1} + \beta_2 \text{lnCOP}_{t-1} + \sum_{i=0}^{p} \alpha_3 \, \Delta \text{lnSBOP}_{t-i} + \sum_{i=0}^{p} \theta_4 \, \Delta \text{lnCOP}_{t-i} + \varepsilon_t \quad (2)$$

Where, lnRP_t, lnSBOP_t, and lnCOP_t are as mentioned above, and Δ denotes the first difference operator, *ln* represents natural logarithmic transformation, β_0 is the intercept and ε_t is a white noise error term.

There are two steps involved in testing the co-integration relationship for both equations. First, the two models were estimated using Ordinary Least Square (OLS) technique. Second, the null hypothesis of the no-cointegration H_o: $\beta_1 = \beta_2 = 0$ was tested against the alternative of H_1: $\beta_1 \neq \beta_2 \neq 0$ by means of *F*-test. Two sets of critical value bound for the *F*-statistics were generated by Narayan (2005). If the computed *F*-statistic fell below the power bound critical value, the null hypothesis of the no-cointegration could be rejected. On the contrary, if the computed *F*-statistic was above the upper bound critical value, the null hypothesis was therefore rejected, implying that there was a long-run co-integration relationship between the variables in the model. Nevertheless, if the calculated value was within the bound, the inference was therefore inconclusive.

RESULTS AND DISCUSSION

This section presents and discusses the empirical analysis of the relationship between both the ARDL models as mentioned in the methodology part. The complete analysis involved the bound test to analyse the short-run and long-run relationships. The methods which were adopted in the previous literature mainly concentrated on cases where the underlying variables were integrated of order I(1) (Pesaran *et al*., 2001). Meanwhile, the ARDL approach has some advantages over the other approaches. First, the series used do not have to be I(1) (Pesaran and Pesaran, 1997). Second, even with a small sample, more efficient co-integration relationships can be determined (Ghatak and Siddiki, 2001). Finally, Laurenceson and Chai (2003) stated that the ARDL approach could overcome the problems which resulted from non-stationary time series data. If non-stationary problem was not properly handled, it would lead to spurious regression coefficients which are biased towards zero.

Both models for the bound test co-integration relationships are revealed in Table 1. The bound test is important to test the existence of the relationship level between a dependent variable and a set of regressors, particularly when it is not known with certainty whether the underlying regressor are trend or first-difference stationary (Pesaran *et al*., 2001). There is evidence of co-integrating relationship in model number one, i.e. between the prices of world crude oil and prices of rice. This is proven by the computed *F*-statistic (5.58) which lies above the upper bound critical value at 5% level of significance. However, the model for the relationship between the prices of world crude oil and the prices of soybean oil provides no evidence of co-integration. In other words, the increase in world crude oil prices has significantly impacted the prices of rice in Malaysia but not the prices of soybean oil in Rotterdam. This could probably be due to the difference in the trends of the prices for both the commodities (*Fig. 2*). The rice prices continuously increased during the period of the study, whereas the prices of soybean oil decreased several times.

TABLE 1
The bound test results for long-run relationship

The critical value of the F-statistic: intercept and no trend						
	90% level		95% level		99%level	
T40	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
	3.21	3.73	3.94	4.52	5.59	6.33
Types of commodity			Calculated F-statistic			
Rice prices			5.58**			
Soya bean oil prices			3.23			

Notes: ** Significant at 5 percent. The critical values were taken from Narayan (2005)

After analysing the bound test for co-integration, the next step was to estimate the coefficient for the long-run relationships. The lagged length (ρ) in Eq. (1) and Eq. (2) were determined by Schwartz Bayesian Criteria (SBC) following the suggestion of Pesaran and Pesaran (1997). The SBC indicated $\rho = 2$ as the most appropriate lagged length for both the equations. The results of the long-run test revealed that only the prices of rice were positive (0.16) and significantly (at 10 percent level) affected by the prices of world crude oil (Table 2). This is consistent with the finding of the study by Chaudhuri (2001) whereby the prices of the primary commodity and the prices of world crude oil will co-integrate in the long run. The result also implies that as the price of world crude oil increase, the prices of rice will also increase. When this occurs, Malaysia has to face not only the price hike in the local crude oil due to the rise in the prices of world crude oil but also in the price of staple food, i.e. the price of rice. Unlike the prices of rice, however, the price of world crude oil do not significantly impact the price of soybean oil in the long run. This is consistent with the finding of the study by Yu *et al*. (2006). Even when the price of world crude oil reached its highest peak in 2008, the impact on the price of soybean oil remained insignificant. One may argue that this could be attributed to the sample period used by Yu *et al*. (2006), which was only until 2006. In the present study, nevertheless, the data were collected up to 2008. Hence, this shows that the result is robust as the present study made use of different methods or approaches and sample period as compared to that of Yu *et al*. (2006). As mentioned earlier, this study used the ARDL method to perform the regression analysis. On the contrary, Yu *et al*. (2006) used the Johansen and Juselius co-integration method.

Finally, the results presented in Table 3 reveal the error correction representation for the selected ARDL model for the prices of rice and soybean oil. This is also known as the short-run dynamic coefficient estimation. Both models indicated that there are insignificant relationships (at 10 percent level) between the price of world crude oil and the price of rice, as well as between the price of world crude oil and the price of soybean oil in the short-run, despite the sign effect for both models are positively correlated, with coefficient 0.02 and 0.08, respectively. One possible explanation for this is that short-term changes in world crude oil prices could be absorbed by the Malaysian Government. This is due to its position as one of the crude oil producers in the world. Thus, if there are any changes in the world crude oil prices in the short-term period, the transportation cost will be marginally affected but it will not impact the prices of commodity.

The error correction model, denoted as ECM (-1) in Table 3, was found to be negatively and statistically significant for both the prices of rice and soybean oil models. The ECM

TABLE 2
The estimates for the long-run elasticities

Prices of rice			
Regressor	Coefficient	Standard error	P-value
Intercept	6.16***	0.31	0.00
Crude oil prices	0.16*	0.09	0.09
Prices of soybean			
	Coefficient	Standard error	P-value
Intercept	6.39***	0.57	0.00
Crude oil prices	0.32	0.19	0.11

Notes: *** Significant at 1 percent, * Significant at 10 percent

TABLE 3
The estimates for the short-run elasticities

Rice prices			
Regressor	Coefficient	Standard error	P-value
Intercept	0.92***	0.22	0.00
Crude oil prices	0.02	0.02	0.18
Error correction model (-1)	-0.15***	0.04	0.00
Soybean oil prices			
	Coefficient	Standard error	P-value
Intercept	1.61*	0.88	0.08
Crude oil prices	0.08	0.05	0.11
Error correction model (-1)	-0.25*	0.13	0.06

Notes: * Significant at 10 percent, *** Significant at 1 percent

indicates the speed of adjustment process to restore the equilibrium following a disturbance in the long-run equilibrium relationship. A negative and significant error correction term implies how quickly the variables will return to the equilibrium. For instance, the model for the price of rice implies that 15% (ECM coefficient = -0.15) of the disequilibrium of the previous year's shocks are able to readjust to the long-run equilibrium in the current year. Similarly, the model for the price of soybean oil implies that 25% (ECM coefficient = -0.25) of the disequilibrium of the previous year's shocks are able to readjust to the long-run equilibrium in the current year. It is important to note that the model of the price of soybean oil is better than the model of the price of rice. This is because the model for the price of rice would take 7 years to readjust to the long-run equilibrium. However, the model for the prices of soybean oil only took 4 years to readjust to the long-run equilibrium.

CONCLUSIONS

In this paper, two models which focused on the impacts of the price of world crude oil on the prices of both rice and soybean oil were examined. The first model analysed the relationship between the price world crude oil and the price of rice in Malaysia. The second model investigated the relationship between the price of world crude oil and the price of soybean oil in the Rotterdam market. Due to the growing interest on the rise and fluctuation of the world crude oil prices, it would potentially increase the need for policy makers to remodel the agriculture-related policies. Therefore, this paper aimed to investigate the presence of the long-run relationship between the price of crude oil and the prices of the commodity, particularly on the prices of rice and soybean oil.

Both models used the ARDL approach which had been developed by Pesaran and Pesaran (1997) and Pesaran *et al.* (2001). The results of the ARDL bound testing confirmed the presence of co-integration in the model for the price of rice, but not in the price of soybean oil. Over the long-run, it is noted that only the price of rice is affected. This also means that the linear combinations of the variables are stationary and therefore, the prices tend to move towards this equilibrium relationship in the long-run. This finding is supported by the study of Chaudhuri (2001) who demonstrated that the prices of the real primary commodity and the prices of the real crude oil are indeed co-integrated. Nevertheless, in line with the study by Yu *et al.* (2006), the findings of the present study do not provide a strong evidence for the long-run relationship between the price of world crude oil and the price of soybean oil. This may reflect the robustness of the results obtained in this study. Even though different analysis approaches were used compared to the study conducted by Yu *et al*. (2006), the results remain similar. This suggests that the present prices of world crude oil have no influence on the price of soybean oil. In addition, the results also reveal that the prices of world crude oil do not affect the prices of rice and soybean oil in the short run.

These findings clearly demonstrate the implications of the world crude oil prices on the agriculture sector, particularly for the production of rice. Since Malaysian rice producers are price takers, high production costs which are resulted from the increase in the world crude oil prices would significantly reduce their profit margin. These situations will become worse if they do not receive any subsidies or incentives from the government. On the other hand, no implication was observed for the world crude oil prices on the price of soybean oil. This finding suggests that soybean oil producers do not have to worry about the fluctuation of world crude oil prices. In addition, it is known that palm oil could influence the price of soybean oil as it is a substitute for soybean oil (Amna and Fatimah, 2008).

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