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Modelling of the Dynamics of Relationship between World Crude Oil Prices and Indonesia's Trade Balance: An LVAR Analysis

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Abstract
This paper aims to examine the long-term dynamics of relationship between world crude oil prices and Indonesia's trade balance, and establish a model of the relationship dynamics. The data used were the monthly data covering the period from January 2004 to October 2014, and were analyzed by using the LVAR (p, q) causal model proposed by Agung (Time series data analysis using eview. Singapore : John Wiley & Son, 2009). Results of data analysis demonstrated a significant long-term dynamic relationship between world crude oil prices and Indonesia's trade balance. The relationship between those two variables was negative, i.e., if the prices of world crude oil increase, the trade balance decreases.
Keywords : Crude oil price, trade balance, LVAR analysis

1. Introduction

Oil has become a commodity that is necessary for every country in building its economy. Industries require oil as raw material, in addition to other raw materials, to produce goods that can be traded, both domestically and abroad. The need for oil has caused non-oil producing countries to import oil from other countries. Some countries which produce oil but have a limited production quotas, such as Indonesia, also have to import oil to meet the needs of their domestic industries.

An increase in oil prices can therefore affect the economy of a country. High oil price volatility can exert instability into the economy of both oil importing and exporting countries (Gokce, 2013). The instability condition, however, differs between oil-importing and oil-exporting countries (Abdelazis et al., 2008). For oil importing countries, the rise in oil prices could raise the cost of imports, causing import expenditure to rise (Qiangian, 2011). Meanwhile, high oil prices could raise the cost of production and lower export's competitiveness (Qiangian, 2011; Trung et al., 2008). In other words, an increase in oil prices increases imports and lower exports, which in turn can reduce the trade balance (Qiangian, 2011), or even may worsen the current account balance (Abdelazis et al. 2008; Chortareas et al., 2011). In an oil-exporting countries, a rise in world oil prices improves the trade balance, leading to a higher current account surplus (Adebiyi et al., 2009).

An increase in world oil prices, such as the WTI oil which rose up from US $ 34.31 per barrel in January 2004 to US $ 133.88 per barrel in June 2008 (www.tonto.eia.gov) has usually been followed by the falling value of the trade balance of several oil-importing countries. The trade balance of the United States, for example, has also fell, resulting in a higher deficit value of the country's trade balance. In the interval from August 2004 to July 2006, the US trade deficit rose from US $ 14 billion to US $ 26 billion, or the US trade balance in 2006 got lower than it was in the previous year (Cavallo, 2006). Likewise, Indonesia's trade balance also fell from US $ 1,700,201,152.00 in January 2004 to US $ 707,883,430.00 in June 2008 (www.bps.go.id).

Macroeconomic conditions and shocks of oil price have sparked many researchers' interest, especially in the field of economics. A number of research on the macroeconomic effects of oil price shocks, particularly on oil importing countries, have been conducted. However, these studies, e.g. Hamilton (2005), Jayaraman and Lau (2011), and Gokce (2013), have primarily focused on the relationship between oil price shocks and economic growth. There was only very few studies in the literature, among others Schubert (2009) and Le and Chang (2013), which addressed the relationship between oil prices and trade balance.

This paper aims to examine the long-term dynamics of the relationship between price of crude oil and Indonesia's trade balance, and establish a modelling of its dynamics relationship by using the LVAR causal model proposed by Agung (2009). The dynamics of the relationship is looked at from a one-way perspective, that is, from crude oil prices towards Indonesia's trade balance. In this analysis of relationship, time lag becomes important since the relationship between the two variables, i.e. world crude oil prices and trade balance, does not occur immediately, but requires a certain time lag.

This paper is organized into five sections. Section 1 is the introduction. Section 2 reviews the literature, both theoretically and empirically, on the relationship between oil prices and trade balance. Section 3 presents the data and methods. Section 4 describes the estimated results. Section 5 gives the conclusion.

2. Review of Literature

Trade balance is defined as the difference between a country's imports and its exports. For oil-importing countries, their imports represent the number of oil and non-oil imports, whereas for oil-exporting countries, their exports refer to the number of oil and non-oil exports.

In theory, the relationship between oil prices and trade balance works through two channels, namely trade and finance. Trade channel works through changes in the quantity and price of goods import and export, whereas finance channel works through external portfolio positions and asset price changes in response to shock demand and oil supply (Kilian et al. 2009). The effectiveness of the transmission of each of these channels depends on three factors: the level of economic development of a given country, its status as either a developing or developed country, and its role of either an oil-importing or oil-exporting country (Bao, 2014). This study focused on the trade channel.

Schubert (2009) develops a standard model of the relationship between oil prices and trade balance of small open countries. In this model, labor and imported oil work as production inputs. Based on the model calibration, Schubert (2009) concludes that after the price of oil rises, the trade balance falls. Furthermore, the effect of oil prices on the trade balance is found to be greater than the effect of labor. Backus et al. (1994) constructed a model of the relationship between trade balance and the terms of trade in industrialized countries where oil is used as inputs in the production of goods. In calibrating the model they find that the trade balance serves as a function of the terms of trade. This means that the effect of oil price shocks on the trade balance occur through variations of the terms of trade. Backus and Crucini (2000) redevelop a model, previously constructed by Backus et al. (1994), on the relationship between oil prices and trade balance. Calibration of this model leads to a conclusion that a shock of oil price increase has a negative effect on the terms of trade of oil-importing countries.

Aghevli and Sassanpour (1982) constructs a model of the relationship between oil prices, output, and trade balance of oil-exporting countries. The basic framework of the model is as follows. In oil-producing countires, the majority of trade benefits is gained from oil exports. The domestic expenditure on trade goods and non-trade goods triggers an increase in imports, output, and the prices of both trade and non-trade goods. Furthermore, an increase in the prices of non-trade goods causes an increase in import demands, which in turn increases economic growth towards a point where a stability of imported goods prices is achieved at a higher price rates. A simulation that tested this model and used Iranian data taken from the period of 1960-1077 indicates that oil price increase triggers the rate of domestic inflation, economic growth, and at the same time decrease the country's non-oil trade balance.

Tsen (2009) examined the effect of the oil price shock and the terms of trade on the trade balance in Asian countries: Japan, Hong Kong, and Singapore. The research was conducted in the period from 1960 to 2006. The results of the VAR analysis demonstrate that the effect of terms of trade on the trade balance differs from country to country. The effect of permanent shock of oil prices rise cause the terms of trade to fall, whereas the effect of oil price rise occurs with a temporary ambiguity. In general, the variations of terms of trade and oil price shock (either permanent or temporary) affect the trade balance, both in the short and in the long run. Rafiq et al. (2009) studied the impact of crude oil price volatility on macroeconomic indicators (output, employment, interest rate, fiscal deficit, and trade balance) in other Asian countries, i.e. Thailand, from the first quarter of 1993 to the fourth quarter of 2006. By employing a VAR analysis to examine the impacts, the researchers found that, according to the quarter-period data, oil price has an impact on all of the macroeconomic indicators.

Fowowe and Iwayemi (2011) studied the effect of oil price shock on macroeconomic variables: GDP, government spending, inflation, real exchange rate, and the trade balance in Nigeria. They took a sample of quarterly data from the first quarter of 1985 to the fourth quarter of 2007. In analysing the data, the VAR model and Granger causality test are used to examine the direct effect. The results showed that the oil price only affects the trade balance. The influence of oil prices on trade balance in the period of 1970-2008 was further investigated by Effiong et al. (2011). While also involving quarterly data, they analyze the data by using the Structured VAR (SVAR). The results showed that there is a correlation between oil prices and trade balance. Furhtermore, decomposition analysis of variance indicated that approximately 15.77% of the variation of trade balance dynamics was caused by oil price shocks.

A study by Pekkurnaz and Ozlale (2010) used a structural VAR models to examine the relationship between oil prices and trade balance in Turkey during the periode of September 1999 to September 2009. The test results using monthly data indicate that oil prices significantly affect the trade balance, particularly in the short term.

Qiangian (2011) conducted a research on the effect of fluctuations on international oil prices on

China's economy. Analyzing monthly data in the period of October 1999 to October 2008, the economic variables in the study were the real GDP, industry, domestic output, money supply M2, the volume of imports and exports, the CPI index, and the exchange rate. Data analysis is conducted by using the VECM. The results show that there is a long-term equilibrium relationship amongst oil prices and output, the CPI index (consumen price index), net exports (trade balance), and money supply. Wu et al. (2013) also studied the effect of oil price on the bilateral trade balance of China and G7 countries (Canada, France, Germany, Italy, Japan, UK, and US) within the period of 1975-2010. The study involved some variables other than oil price, namely: income, exchange rate, and import-weighted distances. The result of data analysis which used the panel smooth transition regression (PSTR) indicated that Chinese bilateral trade balance responded significantly on the changes of these fundamental variables: income, oil price, and import-weighted distances.

Hasan and Zaman (2012) investigated the effect of rising oil prices on the trade balance of Pakistan in the period 1975-2010. Employing the ARDL approach to analyze data, the results showed that there was a negatively significant correlation between oil prices and the trade balance. An increase in the crude oil prices by 1% results in the falling value of the trade balance by 0.342%.

Le and Cang (2013) studied the effect of oil prices on the trade balance in the countries: Malaysia (oil exporters), Singapore, and Japan (oil importers). The study was conducted in the period January 1999 to November 2011. The trade balance of the three countries was denominated in United States (USD). The oil prices selected were the price of Dubai crude oil. All data used were monthly data. Test results using Granger causality test show that crude oil prices affect the countries' trade balance both in the short term and in the long term.

Bao (2014) examined the effect of oil price shocks on Vietnam's trade balance in the period of the first quarter of 1999 to the fourth quarter of 2011. The results of ARDL analysis indicated that there was a negative relationship among oil prices, exchange rate and trade balance. In the long run, a 1% increase in the crude oil prices and exchange rates has caused the country's trade balance to drop by 0.12% and 0.79%. In the short term, the variables of oil price and exchange rate were positively correlated with the trade balance.

Tiwari et al. (2014) examined the relationship between oil prices and Indian's trade balance from January 1980 to December 2011. Using the wavelet analysis to analyze the monthly data, the study demonstrated that oil prices responded negatively to the trade balance.

3. Data and Methodology

3.1 Data

This study examines the dynamics of the relationship between crude oil prices and Indonesia's trade balance from January 1, 2004 to October 31, 2014. The data of crude oil price selected was the spot price of crude oil by West Texas Intermediate (WTI), published by the US Energy Information Administration (EIA), and obtained for free from http://tonto.eia.gov.

The data Indonesia's export and import were acquired from the Central Bureau of Statistics of the Republic of Indonesia through its website www.bps.go.id. Upon obtaining the data, Indonesia's trade balance data was determined by calculating the excess of exports minus imports by using the Microsoft Office Excel application program. Both crude oil data and trade balance data were monthly data.

The data of WTI crude oil prices were expressed in units of USD per barrel. The data of Indonesia's trade balance data were in terms of USD.

3.2 Methodology

Econometric analysis tool that is used to examine the dynamics of the relationship between oil prices and the trade balance is an LVAR (p, q) causal model proposed by Agung (2009). Modelling of the dynamics of the relationship between crude oil prices and the trade balance is expressed by the following equation

$$y(t) = a_0 + \sum_{i=1}^{p} a_i y(t-i) + \sum_{j=0}^{q} b_j x(t-j) + \varepsilon(t) \qquad (1)$$

where *x(t)* denotes the price of crude oil at time *t*, and *y(t)* represents the value of the trade balance at time *t*. According to Agung (2009), the variables in the model (1) can employ the original data or data of transformation results. Model (1) can give a wide range of specific forms, among others:

$$y(t) = a_0 + b_m x(t-m) + \varepsilon(t) \qquad (2)$$
$$y(t) = a_0 + b_0 x(t) + b_m x(t-m) + \varepsilon(t)$$
$$y(t) = a_0 + a_k y(t-k) + b_m x(t-m) + \varepsilon(t)$$

where $0 \le k \le p$ and $0 \le m \le q$, t time, p and q time lag, and $\varepsilon(t)$ error term. Enders (2004) provides an alternative which is a special form of model (1), namely $y(t) = a_0 + \sum_{i=1}^{p} a_i y(t-i) + z_t$ where z_t can be one or more of the rates of $\sum_{j=0}^{q} b_j x(t-j) + \varepsilon(t)$. Here z_t is called forcing process.

Model (1) requires *x(t)* and *y(t)* to be stationary. Granger and Newbold (1974) says that the model (2) can yield spurious regression estimation, that is, the regression shows that b_m parameters of the model (2) is significant, whereas the coefficient of determination R^2 is greater than the Durbin Watson statistic (DW). Therefore, according Rosadi (2012), a non-spurious regression is characterized by a criterion stating that the value of the coefficient of determination R^2 is smaller than the value of the DW statistic.

The dynamics of the long-term relationships is determined by estimating the parameter regression of model (1) based on time series data in the interval between January 2004 and October 2014. In order to examine the relationship, a stationary test is firstly conducted, followed by a test on the regression prameter, where *p* and *q* time lag are determined on the basis of a criteria of Akaike Information Criterion (AIC).

Data Stationary Test is conducted by using the Augmented Dickey-Fuller test (ADF), which examines the significance of the parameters ρ_i $(i = 1, 2)$ of the regression equation (3) and (4).

$$D(x(t)) = \alpha_1 + \delta_1 t + \rho_1 x(t-1) + \sum_i^m \emptyset_i D(x(t-i)) + \varepsilon_1(t) \qquad (3)$$

$$D(y(t)) = \alpha_2 + \delta_2 t + \rho_2 y(t-1) + \sum_j^n \varphi_j D(y(t-j) + \varepsilon_2(t) \qquad (4)$$

where $\alpha_1, \alpha_2,\ \delta_1, \delta_2, \rho_1, \rho_2, \emptyset_i\ (i = 1, 2, .., m),\ \varphi_j(j = 1, 2, \dots, n)$ is the regression parameter, $\varepsilon_1(t)$ and $\varepsilon_2(t)$ error term, $D(x(t)) = x(t) - x(t-1)$ signifies the variables at first difference level. Stasionary test is conducted by refering to the following hypothesis

$H_o : \rho_i = 0$; meaning that x and y have unit root (non-stationary)

$H_1 :\ \rho_i \neq 0$; meaning that x and y have no unit root (stationary)

Widarjono's criterion (2009) for stationary testing postulates that if the absolute value of ADF-statistic is higher than the absolute value of ADF-critique, then x and y are stationary. Other than that, they are not stationary.

To examine the causal relationship between crude oil prices and the trade balance, the parameters of the regression equation model (1) are estimated based on the following formulated hypotheses

H_o: $b_i = 0,\ \forall i = 1, 2, 3, \dots, q$ (there is no relationship)

H_1: $\exists i, \ni\ b_i \neq 0, i = 1, 2, \dots, q$ (there is a relationship)

Significance test is done by using test p-value of t-student statistics and F-statistics. Rosadi (2012) proposes a criteria for testing the relationship, that is, if the parameters of the regression model (1) is significant, in that the *p-value* is lower than the significance level α, then there is a dynamic relationship between crude oil prices (*x*) and the trade balance (*y*).

Econometric application program used to estimate the regression parameters is the *Eview-6.0*. Outputs of this application program include the statistical value of p-value for each value of t-statistics and F-statistic, the value of AIC, the coefficient of determination R^2, and the value of the DW statistic. In the outputs of this application program, the notation *x(t-m)* is expressed by *x(m)* where *m* is time lag, and the first difference notation of variable *x* at time *t,* i.e., *D*(*x*(*t*)) is expressed by *D*(*x*).

4. Estimation Result

As shown by Table-1, the absolute value of ADF-statistic 5.674506 is higher than the absolute value of the ADF-critic for all of the significance levels (1%, 5%, and 10%). This indicates that the price of crude oil is stationary at the first difference level *D*(*x*(*t*)).

Table-1: Stationary Statistical Test of World Crude Oil Prices Variables (x)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.674506	0.0000
Test critical values:	1% level	-3.484198	
	5% level	-2.885051	
	10% level	-2.579386	

*MacKinnon (1996) one-sided p-values.

Table-2 shows that the absolute value of 13.46879 ADF-statistic is higher than the absolute value of the ADF-critic for all of the significance levels (1%, 5%, and 10%), thereby the trade balance data time series is stationary at the first difference level *D*(*y*(*t*))

Table-2: Stationary Statistical Test of Trade Balance Variables (y)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-13.46879	0.0000
Test critical values:	1% level	-3.482453	
	5% level	-2.884291	
	10% level	-2.578981	

*MacKinnon (1996) one-sided p-values.

Based on the result of stationary test, the relationship between crude oil prices and the balance of trade is examined at the level of the first difference. Table 3 shows the results of estimation, where the *p*-value *t*-statistic of variable $D(x(t\text{-}3))$ 0.0298 is less than 5%. In this case, the dynamic of the relationship between crude oil prices and trade balance is significant. The relationship between the two variables is negative, i.e., if crude oil prices rise, the trade balance lower down. This applies the other way around, when crude oil prices fall, the trade balance rise. The dynamic model of the long-term relationship between the two variables is expressed through the equation below.

$$y(t) = y(t-1) - 0.660368D(y(t-1)) - 0.327563D\big(y(t-2)\big) - 25880617D(x(t-3)) \quad (5)$$

It can be seen from model (5) that the dynamics of the relationship between crude oil prices and Indonesia's trade balance occurs at the time lag in the third month.

Table-3 : Statistical Test of the Relationship between World Crude Oil Prices (x) and Trade Balance (y)

Dependent Variable: D(y)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(y(-1))	-0.660368	0.083764	-7.883717	0.0000
D(y(-2))	-0.327563	0.083788	-3.909405	0.0002
D(X(-3))	-25880617	11775079	-2.197915	0.0298

R-squared	0.351141	Akaike info criterion	43.95005
Durbin-Watson stat	1.942290	S.D. dependent var	1.03E+09

5. Conclusion

This study has investigated the dynamics of the relationship between crude oil prices and Indonesia's trade balance over the period of January 2004 to October 2014. The data of world crude oil prices and the trade balance are not stationary at level (the estimation results are not given here) but they are stationary at the first difference level (ADF statistical tests are shown in Table-1 and Table-2).

Test results using LVAR causal model analysis show that there is a relationship between crude oil prices and the country's trade balance. The relationship is negative and one-directional, from crude oil prices towards the trade balance. In this case, if the price of world crude oil increases, the trade balance of Indonesia decreases. On the other hand, if the price of the world crude oil decreases, then Indonesia's balance. These results of analysis confirm the results reported by Hasan and Zaman (2012), Wu et al. (2013), Bao (2014), and Tiwari et al. (2014).

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