Do Fluctuations in Crude Oil Prices Have Symmetric or Asymmetric Effects on the Real Exchange Rate? Empirical Evidence from Indonesia

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Abstract

Current research on the oil price impacts on exchange rates typically relies on the assumption that fluctuations in crude oil prices have symmetric impacts on a country's real exchange rate. Thus, the contribution of the paper is to use the nonlinear autoregressive distributed lag (ARDL) method of Shin et al. (2014) and examine whether crude oil prices are asymmetrically passed on to the real exchange rate in the case of Indonesia. We uncover that oil price changes indeed asymmetrically affect the Indonesian rupiah in the long-run; that is, the movement in the Indonesian rupiah appears to be more responsive to rising oil prices than to declining oil prices. In the short-run, however, the asymmetry of oil price changes is not observed.

JEL Classification: C22, F31, Q43
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I. Introduction

Do fluctuations in crude oil prices play a decisive role in influencing a country's real exchange movements? This is an interesting question for two reasons. First, it is the most fundamental question for macroeconomic policy. If it is established that a hike in oil prices has a beneficial effect on countries' real incomes and hence leads to an appreciation in their currencies, for example, not many countries would choose expansionary monetary policy solely aimed at deliberate currency depreciation as a mean to economic growth. The answer to this question is also interesting because, although the subject has long been a hotly debated area of empirical inquiry, the answer is not yet settled. Indeed, the oil price impacts on real exchange rate fluctuations varies depending on countries and is necessarily an empirical issue.

Since the seminal work by Krugman (1983a and 1983b), many scholars have sought to identify how real exchange rates in various countries are influenced by changes in crude oil prices. Examples include, but are not limited to, Rogoff (1991), Amano and Van Norden (1995), Amano and Van Norden (1998), Chaudhuri and Daniel (1998), Chinn (2000), Camarero and Tamarit (2002), Akram (2004), Chen and Chen (2007), Huang and Guo (2007), Narayan et al. (2008), Chen et al. (2010), Wu et al. (2012), Benhmad (2012), Mohammadi and Johan-Parvar (2012), Reboredo (2012), Czudaj and Beckmann (2013), Tiwari et al. (2013) and Jahangard et al. (2017). Chen and Chen (2007), for example, explore the oil price impacts on exchange rates in a sample of G7 countries, and reveal that the price of crude oil has a sizeable effect on real exchange rates in the long-run. Reboredo (2012), in contrast, report in identifying insignificant oil price impacts on exchange rates in the case of the EU countries.

Important but perhaps less widely recognized in the literature, however, is the possibility that oil price changes could have asymmetric impacts on a country's real exchange rate. More specifically, no matter what country is selected for the analysis of the oil price impacts on exchange rates, the implicit assumption adopted in previous works is that crude oil prices symmetrically affect a country's real exchange rate. In other words, it implies that if a 1% rise in crude oil prices appreciate (depreciate) the values of the currencies in the oil-exporting countries (oil-importing countries) by, say, x%, then a 1% decrease in crude oil prices should deprecate (appreciate) them by the same magnitude, that is, x%. Since market participants in the market for foreign exchange may react differently to increases and decreases in crude oil prices, however, such assumption does not always necessarily hold true in the real word. Furthermore, the empirical attention of the literature up until recently has been mostly paid to developed countries (e.g., G7, EU and OECD countries) with few studies investigating the issue in developing countries.[1]

In this paper, therefore, we expand the scope of the literature by empirically capturing whether the effect crude oil price changes have on real exchange rates is asymmetric in the context of a developing country, specifically Indonesia. The oil sector has traditionally contributed significantly to the economy of Indonesia through total export revenues and foreign exchange reserves. In 2017, for example, the oil sector alone accounts for nearly 20% of Indonesia's overall exports, valued at approximately US$28 billion. Hence, it would seem worthwhile to explore the oil price impacts on exchange rates in the case of Indonesia. For this purpose, we apply a nonlinear autogressive distributed lag (ARDL) approach, being developed with an original work by Shin et al. (2014), to monthly data between August 1997 and June 2017. It should be pointed out that to the best of our knowledge, Basnet and Upadhyaya (2015), Kisswani (2016), and Sultonov (2017) are the only three papers that have analyzed the oil price impacts on exchange rates for Indonesia. Basnet and

[1] For example, Mohammadi and Jahan-Parvar (2012) show that the price of crude oil significantly affects the values of the currencies in thirteen oil-exporting countries. Huang and Guo (2007) and Tiwari et al. (2013), on the other hand, conclude that oil prices have little to do with the exchange rate in China and India, respectively.

Upadhyaya (2015), for example, discover that crude oil prices have little impacts on the Indonesia rupiah exchange rate. Sultonov (2017), in contrast, finds that oil prices are one of the powerful factors determining the Indonesian exchange rate. These studies, however, do not directly incorporate the asymmetry hypothesis in their analyses, thereby raising questions about the validity of the findings.

The rest of the paper is composed of 5 sections. Section II covers the theoretical framework used to guide our empirical model. Section III provides our econometric models and estimation methods. Section IV describes the data used for the empirical analysis: monthly observations from August 1997 to June 2017. Section V discusses empirical results, showing strong evidence of the long-run asymmetric effects of oil price changes on the Indonesian rupiah. Finally, Section VI makes some concluding remarks.

II. A Theoretical Framework

A simple theoretical model suggested by Chen and Chen (2007), is presented to measure the oil price impacts on the exchange rate in Indonesia. Suppose we have two countries such as home and foreign (denoted by * superscript), each of which produces two goods, traded (denoted by *T* superscript) and nontraded goods (denoted by *N* superscript). Assume that the log of consumer price indexes in both countries (p and p^*) is given by the log price levels of traded (P^{T} and $P^{\mathrm{T}*}$) and nontraded goods (P^{N} and $P^{\mathrm{N}*}$) as follows:

$$p = \lambda p^{T} + (1-\lambda) p^{N} \tag{1}$$

$$p^{*} = \lambda^{*} p^{T*} + (1-\lambda^{*}) p^{N*} \tag{2}$$

where λ and λ^*measure the expenditure shares on traded goods for the home and foreign countries, respectively. If *er* denotes the log nominal exchange rate defined as units of home currency required to buy a unit of foreign currency, the log of the real exchange rate, *rer*, is written as:

$$rer = er + p^{*} - p \quad (3)$$

where p and p^{*} represent the log price levels in the home and foreign countries, respectively. Substituting equations (1) and (2) into equation (3), we can write the real exchange rate in the home country:

$$rer = (er + p^{T*} - p^{T}) + (1-\lambda)(p^{T} - p^{N}) - (1-\lambda^{*})(p^{T*} - p^{N*}) \quad (4)$$

Suppose that the home and foreign countries have the same expenditure shares on traded goods, that is, $\lambda = \lambda^{*}$. Then, to the degree that the relative price of home traded goods ($p^{T} - p^{N}$) increases at a faster rate than the relative price of foreign traded goods ($p^{T*} - p^{N*}$), an increase in the relative price of traded goods in the home country leads to a decrease in the value of its currency. This tells us that, in the case that the home country is an oil-importing (oil-exporting) country, an increase in oil prices tends to raise the relative price of traded goods in the home (foreign) country faster than that in the foreign (home) country, thereby trigging the home (foreign) exchange rate to depreciate (appreciate).

III. The Models and Methods

In exploring the oil price impacts on exchange rates in Indonesia, we rely on the theoretical framework described above. In its simplest form, the empirical model can be expressed by:

$$rer_{t} = \beta_{0} + \beta_{1} op_{it} + \varepsilon_{it} \quad (5)$$

where the variables are in natural logarithm. The variable rer_t represents the real exchange rate between the Indonesian rupiah and the U.S. dollar, which is defined in this study that a rise in rer_t reflects a real depreciation (appreciation) of the Indonesian rupiah (the U.S. dollar). Because estimation results may be sensitive to the use of different oil prices, we employ three different types of crude oil prices such as the U.S. West Texas Intermediate (hereafter “WTI”), the British price of oil (hereafter "Brent") and the United Arab Emirates price of oil (hereafter "Dubai"). Thus, op_{it} is the price of crude oil i, where i = WTI, Brent and Dubai. Finally, ε_{it} is the error term.

Oil price changes could have either symmetric or asymmetric effects on the real exchange rate. The symmetric effect means that if a hike in crude oil prices pushes up the real exchange rate, then a drop in oil crude prices should push it down on the same level, and vice versa. Participants in the market for foreign exchange, however, are likely to respond differently to hikes or plunges in the price of crude oil. If this is the case, then changes in crude oil prices should have asymmetric impacts on real exchange rates. To test this hypothesis, we first need to separate crude oil price hikes from crude oil price plunges as done in Umekwe and Baek (2017).

$$op_{it}^{+} = \sum_{j=1}^{t} \Delta \ln op_{ij}^{+} = \sum_{j=1}^{t} \max(\Delta \ln op_{ij,} 0) \tag{6}$$

$$op_{it}^{-} = \sum_{j=1}^{t} \Delta \ln op_{ij}^{-} = \sum_{j=1}^{t} \min(\Delta \ln op_{ij,} 0) \tag{7}$$

The variable op_{it}^{+} measures only increase in oil prices. The variable op_{it}^{-} measures only decreases in oil prices. If op_{it} in equation (5) is replaced by op_{it}^{+} and op_{it}^{-} in equations (6) and (7), the resulting model takes the form:

$$rer_{t} = \beta_{0} + \beta_{1} op_{it}^{+} + \beta_{2} op_{it}^{-} + \varepsilon_{it} \tag{8}$$

Equation (8) is known as a long-run model. When implementing the nonlinear ARDL technique, however, excluding the short-run dynamics from estimating long-run estimates is likely to result in some parameter instability. To avoid this problem, therefore, short-run dynamics should be incorporated into estimating long-run estimates by transferring equation (8) to an error-correction model:

$$\Delta rer_t = \beta_0 + \sum_{k=1}^{p} \beta_{i1,t-k} \Delta rer_{t-k} + \sum_{k=0}^{p} \beta_{i2,t-k} \Delta op^{+}_{i,t-k} + \sum_{k=0}^{p} \beta_{i3,t-k} \Delta op^{-}_{i,t-k} + \theta_0 rer_{t-1} + \theta_1 op^{+}_{i,t-1} + \theta_2 op^{-}_{i,t-1} + \xi_{it} \quad (9)$$

Shin et al. (2014) demonstrates that the same procedures of the linear ARDL technique developed by Pesaran et al. (2001) can be correspondingly applicable to estimating the nonlinear ARDL model in equation (9). More specifically, testing for cointegration in equation (9) requires to apply the *F*-test to the lagged level variables and the *t*-test to the lagged dependent variable.[2] Since the sampling distributions of the *F*- and *t*-statistics are not normally distributed under the null, however, the critical values for both tests have been tabulated by Pesaran et al. (2001). Once the *F*-statistic (*t*-statistic) is obtained, we reject the null of $H_0 : \theta_0 = \theta_1 = \theta_2 = 0$ ($H_0 : \theta_0 = 0$) in favor of the alterative of $H_1 : \theta_0 \neq \theta_1 \neq \theta_2 \neq 0$ ($H_1 : \theta_0 < 0$) if the computed value of the *F*-statistic (*t*-statistic) is larger than the upper critical value, thereby providing evidence of cointegration. Pesaran et al. (2001) also note that the proposed testing for cointegration is valid regardless of whether the regressors (independent variables) are *I*(0) or *I*(1); in that sense, therefore, ARDL does not require unit root tests as opposed to normal cointegration methods (i.e., Johansen, 1988). Once cointegration is identified, the long-run effects and short-run dynamics can be obtained in one step by solely estimating equation (9). The long-run relationship is identified from θ_1 and θ_2 after normalizing θ_0. The short-run dynamics are associated with the coefficients of the variables in first differences (with each Δ). After estimating equation (9), the Wald test can be used for asymmetric hypothesis testing. If the obtained Wald statistic is larger than the critical value, for example, the null of no long-run (short-run) asymmetry, or $H_0 : \frac{\theta_1}{\theta_0} = \frac{\theta_2}{\theta_0}$ ($H_0 : \sum \beta_{i2} = \sum \beta_{i3}$) can be rejected, thereby providing evidence of long-run

[2] Pesaran et al. (2001) note that failure to meet the two requirements raises the possibility of degenerate cointegration relationships among the variables.

(short-run) asymmetry.

IV. Data

This study uses monthly data from August 1997 through June 2017 (239 observations). August 1997 is chosen because at that time Indonesia ended the exchange rate intervention band and moved to freely floating exchange rate regime due to the 1997 Asian financial crisis. June 2017 is the last date for which complete data are available.

Monthly nominal exchange rates are those obtained from the International Monetary Fund (IMF), in *International Financial Statistics* (IFS), and are expressed in Indonesian rupiah per U.S. dollar. The consumer price indexes (CPIs, 2010 =100) in the two countries taken from IFS are employed to compute the real exchange rate. Of crude oil prices, WTI and Brent oil spot prices are from the U.S. Energy Information Administration (EIA). Data on Dubai oil prices are from the Federal Reserve Bank of St. Louis. To obtain the real oil prices, the U.S. dollar prices are first converted to Indonesian rupiah prices, which then are deflated by the Indonesian CPI.

V. Empirical Results

Before estimating equation (9), it is important to understand that although the ARDL can be employed regardless of whether regressors (independent variables) are $I(0)$ or $I(1)$, it cannot be valid when regressors are $I(2)$ and/or the dependent variable is $I(0)$. For this reason, we begin this section with testing for unit roots in the variables. Table 1 contains the resulting test known as the Dickey-Fuller generalized least squares (DF-GLS) test for a unit root. The DF-GLS tests in levels, with a time trend included, give that all the test statistics are above -2.353. The 10% critical value is -2.570; therefore, we cannot reject a unit root at the 10% significance level. In first differences, however, the test statistics for the unit root tests are well below the 10% critical value and we can reject a unit root for all the variables. This thus leads us to conclude that all the variables are *I*(1).

With strong proof that none of independent variables are *I*(2) and the dependent variable is *I*(1), we now rely on the *F*- and *t*-tests to uncover evidence of cointegration among the variables. The computed *F*-statistics on the lagged level variables for WTI, Brent and Dubai are 6.337, 6.604 and 6.838, respectively, which are well above the 5% critical value of 4.85, and the null of no cointegration is strongly rejected. In addition, the *t*-statistics on the lagged dependent variable for WTI, Brent and Dubai are -3.997, -3.923 and -4.001, respectively. Because the 5% critical value is -3.530, we can reject the null at the 5% level. Together, this is reasonably strong proof of cointegration among the selected variables.

We are now in a position to estimate equation (9) to determine whether oil price changes have symmetric or asymmetric effects on the real exchange rate for Indonesia. To achieve this goal, we first impose a maximum lag order of six months on the variables in first differences and search the optimal model specification in each of three cases using the Akaike Information Criterion (AIC).[3] For WTI and Brent (Dubai), for example, the estimated orders of an *ARDL* (y, x_1, x_2) model in the three variables (rer_t , op^+_{it}, op^-_{it}) are decided by seeking across the 7^3 = 343 ARDL models, spanned by y = 0, 1, …, 6, and x_i = 0, 1, …, 6, i =1, 2, using the AIC. This search results in the choice of an *ARDL* (6, 6, 1) specification for WTI and Brent and of an *ARDL* (6, 5, 1) specification for Dubai, respectively, with estimated coefficients of the long- and short-run relationships. Table 2 gives the long-run results. Table 3 contains the findings of the short-run dynamics and error-correction coefficients.

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[3] Since the validity of the ARDL approach is crucially relied on the assumption that the error term does not contain serial correlation, it is important to include the appropriate lag order in equation (9). When used six lag lengths in this study, the Lagrange Multiplier (LM) statistics display that we cannot reject the null and there is little evidence of serial correlation in the error terms (Table 3).

Let us first consider the long-run results contained in Table 2. In the log-log model (also known as the constant elasticity model), each of the coefficients gives the estimated percentage change in the real exchange rate, given one percent change in the corresponding independent variable.[4] The results show that the coefficients of increases (op_{it}^{+}) and decreases (op_{it}^{-}) in three oil prices are very significant and have all negative signs. This hints that a rise (decline) in the price of crude oil causes the real exchange rate to decrease (increase), thereby appreciating (deprecating) the Indonesian rupiah in the long-run. Notice that the coefficients on op_{it}^{+} and op_{it}^{-} across models reveal different magnitudes. For example, a 1% increase in the prices of WTI, Brent and Dubai appreciate the Indonesian rupiah by 0.182%, 0.144%, and 0.165%, respectively. A 1% decline in the prices of WTI, Brent and Dubai, on the other hand, depreciate the Indonesian rupiah by 0.143%, 0.107% and 0.126%, respectively. Thus, the effect of falling crude oil prices on the Indonesian rupiah is outweighed by the impact of rising oil prices, thereby seemingly supporting long-run asymmetric responses of the real exchange rate to oil price changes. In fact, the Wald test confirms this observation. The Wald test statistics across models are at least above 7.734, and this is the outcome of χ_1^2. The 5% critical value is 3.84. This rejects the null hypothesis of no long-run asymmetry at the 5% level, providing strong evidence of long-run asymmetry effects.

We now cover the error-correction model given in Table 3. These coefficients provide evidence on the short-run dynamics that may exist among the real exchange rate and crude oil prices. All five lagged changes in the real exchange rate are very significant, justifying the choice of six lag lengths for the analysis. The error-correction coefficients (ec_{t-1}) across models are negative and very significant, further confirming the existence of cointegration. The regression

[4] This is also called the constant elasticity model because the coefficient is the estimated elasticity of the dependent variable with regard to the corresponding independent variable (Wooldridge, 2015).

passes such key diagnostic tests as serial correlation (LM) and functional misspecification (RESET) tests. In addition, such stability tests as cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) reveal that the estimated coefficients are steady during the 1997-2017 period. Thus, our model specification and statistical testing seem to be well justified.

As in the long-run case, our primary interest here is in what happens to the coefficients on oil price increase (op_{it}^{+}) and decreases (op_{it}^{-}) in the short-run. When first looking at the coefficients of oil price decreases, a decline in three oil prices is estimated to depreciate the Indonesian rupiah contemporaneously, and the estimates are all statistically significant at the 10% level. In the case of WTI, for example, Δop_{t}^{-} = -0.105, indicating the 0.105% contemporaneous depreciation of the Indonesian rupiah given a 1% decrease in the price of WTI. The estimated coefficients of oil price increases, in contrast, give mixed results. In the case of Brent, for example, although Δop_{t-2}^{-} and Δop_{t-3}^{-} have negative coefficients, only Δop_{t-3}^{-} is statistically different from zero, with t = -3.767, this is -0.217, suggesting that a 1% increase in the price of Brent causes the Indonesian rupiah to appreciate by 0.217% after two months. For Δop_{t}^{-}, Δop_{t-1}^{-}, Δop_{t-4}^{-} and Δop_{t-5}^{-}, however, the coefficients are positive but only Δop_{t}^{-} is very significant with the coefficient of 0.145, indicating the 0.145% contemporaneous depreciation of the Indonesian rupiah given a 1% increase in the price of Brent. As in the long-run case, the different magnitudes of the coefficients coupled with different signs in Δop_{it}^{+} and Δop_{it}^{-} may seem to indicate short-run asymmetry effects; but to be convinced of an effect, we must remember to compute the Wald statistic. Based on the outcome of a χ_{1}^{2} random variable, the Wald test statistics across models are well below the 5% critical value, and so we cannot reject the null of no short-run asymmetry, thereby providing little evidence of the short-run asymmetry effects.

It is important to note that the declined in Indonesia's oil production coupled with expanded domestic demand have turned Indonesia into a net importer for crude oil since 2003. As a result, Indonesia has suspended its membership of the Organization of Petroleum Exporting Countries (OPEC) since 2009. Before ending this section, therefore, it is useful to investigate what happens to the Indonesian rupiah if we incorporate Indonesia's shift from net oil exporter to net importer into our modeling process. To do this, we add a dummy variable to equation (9); it takes on the value unity from January 2003 onward, when Indonesia became a net oil importer. The results show that the dummy variable is statistically insignificant across models, so there is no evidence that this change of status has been a substantial effect on the Indonesian rupiah since 2003; hence, we eliminate the dummy variable from the final model.

VI. Concluding Remarks

In this paper, we seek to contribute to the debate over crude oil prices and real exchange rates by asking: "Are the effects of crude oil price shocks on the real exchange rate symmetric or asymmetric in Indonesia?" To address this question adequately, we use three different prices of crude oil such as WTI, Brent and Dubai and examine whether they are asymmetrically passed on to the Indonesian rupiah in the long- and short-run. After implementation of the nonlinear ARDL methodology that is developed with an original work by Shin et al. (2014), we discover overwhelming evidence that oil price changes asymmetrically impact the Indonesian rupiah in the long-run; that is, the movement in the Indonesian rupiah is more responsive to oil price hikes than to oil price plunges. In the short-run, however, the asymmetry of oil price changes is not observed.

An important implication from our findings is that, when quantifying the oil price impacts on the Indonesian rupiah exchange rate, analysts need to incorporate the (long-run) asymmetry of oil price fluctuations; otherwise, the empirical models are likely to be misspecified, thereby providing misleading results. Another important implication is that given the long-run relationship between oil prices and the Indonesian rupiah, any government policies implemented by overlooking the movement in the world oil market could lead to undesirable outcomes such as trade imbalances and welfare losses.

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Table 1. Results of unit root tests

Variable	Level	First difference	Decision
Exchange rate	-1.955 (2)	-6.126** (2)	I(1)
WTI^{+}	-1.455 (1)	-7.745** (1)	I(1)
WTI^{-}	-2.353 (1)	-8.251 (1)	I(1)
$Brent^{+}$	-0.600 (1)	-5.779** (2)	I(1)
$Brent^{-}$	-2.636 (1)	-8.595** (1)	I(1)
$Dubai^{+}$	-1.411 (1)	-8.203** (1)	I(1)
$Dubai^{-}$	-2.248 (1)	-8.113** (1)	I(1)

Note: ** demarcates rejection of the null hypothesis at the 5% level. The 5% critical value for the DF-GLS with trend is -2.890. Numbers inside parentheses are lag lengths, which are selected by the Schwert Information Criterion.

Table 2. Long-run coefficient estimates of nonlinear ARDL equations

	i = WTI	*i* = Brent	*i* = Dubai
$(\text{Oil prices})_i^+$	-0.182 (-3.479)**	-0.144 (-2.631)**	-0.165 (-3.418)**
$(\text{Oil prices})_i^-$	-0.143 (-2.314)**	-0.107 (-1.634)*	-0.126 (-2.122)**
Constant	9.720 (73.025)**	9.693 (58.204)**	9.708 (68.320)**
F-statistic	6.337**	6.604**	6.838**
t-statistic	-3.997**	-3.923**	-4.001**
Wald-*L*	8.098**	7.734**	10.988**

Notes: Parentheses are the *t*-statistics. The upper critical values of the *F*-statistic and *t*-statistic at the 5% significance level is 4.85 and -3.53, respectively. Wald-L is the Wald tests for long-run asymmetry. This test is based a chi^2 distribution with one degree of freedom. The critical value at the 5% (10%) significance level is 3.84 (2.71). ** and * demarcate significance at the 5% and 10% levels, respectively.

Table 3. Equilibrium correction forms of nonlinear ARDL equations

	i = WTI	i = Brent	i = Dubai
$ec_{i,t-1}$	-0.130 (-3.950)**	-0.124 (-3.730)**	-0.130 (-4.004)**
Δ(exchange rate)$_{i,t-1}$	0.250 (3.924)**	0.264 (4.153)**	0.269 (4.277)**
Δ(exchange rate)$_{i,t-2}$	0.087 (1.799)**	0.112 (2.354)**	0.110 (2.317)**
Δ(exchange rate)$_{i,t-3}$	-0.132 (-2.982)**	-0.144 (-3.216)**	-0.139 (-3.122)**
Δ(exchange rate)$_{i,t-4}$	0.012 (0.259)	0.002 (0.050)	0.003 (0.074)
Δ(exchange rate)$_{i,t-5}$	0.238 (5.355)**	0.235 (5.361)**	0.245 (5.678)**
Δ (Oil prices)$^{+}_{i,t}$	0.066 (0.940)	0.145 (2.168)**	0.133 (1.912)*
Δ (Oil prices)$^{+}_{i,t-1}$	-0.020 (-3.190)**	0.064 (1.090)	0.082 (1.292)
Δ (Oil prices)$^{+}_{i,t-2}$	-0.079 (-1.292)	-0.078 (-1.338)	-0.097 (-1.546)
Δ (Oil prices)$^{+}_{i,t-3}$	-0.144 (-2.343)**	-0.217 (-3.767)**	-0.224 (-3.588)**
Δ (Oil prices)$^{+}_{i,t-4}$	0.078 (1.258)	0.086 (1.441)	0.149 (2.355)**
Δ (Oil prices)$^{+}_{i,t-5}$	0.114 (1.848)*	0.099 (1.706)*	
Δ(Oil prices)$^{-}_{i,t}$	-0.105 (-1.868)*	-0.143 (-2.747)**	-0.139 (-2.701)**
LM	0.083 [0.773]	0.061 [0.804]	0.004 [0.952]
RESET	1.212 [0.271]	0.408 [0.523]	0.267 [0.605]
Wald-S	0.620	3.049	0.999

Notes: $ec_{i,t-1}$ represents an error-correction term. Parentheses are the *t*-statistics. Brackets are the p-values. LM and RESET represent the Lagrange multiplier test of serial correlation and Ramsey's test or functional form, respectively. Wald-S is the Wald tests for short-run asymmetry. This test is based a chi^2 distribution with one degree of freedom. The critical value at the 5% (10%) significance level is 3.84 (2.71). ** and * demarcate significance at the 5% and 10% levels, respectively.