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Oil Price Shocks and Sectoral Outputs: Empirical Evidence from Malaysia

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Abstract

This article examines the oil price-output nexus for the case of Malaysia between the years 1970 to 2014. Autoregressive Distributed Lag (ARDL) modeling approach is adopted to investigate long-run relationships among oil-price and real aggregate GDP as well as the real outputs of agriculture, manufacturing, industrial and service sectors. The outcomes of linear ARDL cointegration analysis fails to reveal any long-run relationship among the variables. Subsequently, all models are re-estimated by deploying the nonlinear ARDL approach to cointegration. The evidence of nonlinear long-run relationship is found for oil price and the Malaysian manufacturing and industrial outputs. Notably, the long-run parameter estimates reveal that oil price increase enhances outputs significantly, whereas oil price decrease has significant negative impact on these two sectoral outputs. It is suggested in this article that policy-makers need to consider the nonlinear effect of oil price shocks to formulate policy which is able to maintain favorable environment that enhances economic growth.

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1. Introduction

The 1973 oil shock's recession had resulted in one of the longest post-war recessions. This had brought to a renewed research focus for the investigation of oil price and macroeconomy relations. The interest of understanding about causes and consequences of oil price changes grasp attention among economists as movements in oil values were likely to cause macroeconomic problems among countries. Those important studies that highlighted this issue were Pierce and Enzler (1977), Mork and Hall (1980), Darby (1982), Gisser and Goodwin (1986), Burbidge and Harrison (1984), Bruno and Sachs (1981, 1985). These were among the earliest studies and they generally claimed an inverse relationship between oil price increase and aggregate economic activity. The supply side effect of oil price increase, which reduces quantity demanded for energy input for production, provides one important theoretical explanation on such inverse relationship. Other than that, during positive oil price shock, transfer of wealth happens from net oil importing countries to net oil exporting countries. Oil producing countries earns more revenue from sales of input during high oil price and net oil importing countries spends more for purchase of energy input.

The nonlinear relationship between oil price shock and real economic activity can be attributed to the changes in aggregate demand and supply. When there is positive oil price shock or an increase in oil price, aggregate demand may fall (in net oil importing countries) because of income transfers from net oil importing countries to net oil exporting countries. While from the supply side, positive oil price shock leads to a drop in demand for energy inputs in net oil importing countries and relative fall in production. This phenomenon shows that productivity from any amount of production factors such as capital and labor may fall. A fall in the factor productivity suggests lower wages and it leads to increase in the natural rate of unemployment amid accelerating inflation of an economy. Other than that, uncertainties due to oil price fluctuation may lead to a production fall due to reallocation of resources at the sectoral level and reduction in investment (see, for instance, Brown and Yüucel, 2002, for further details). All these factors suggest that changes in oil price exert impact on output of a country in an asymmetrical fashion, which can be better estimated by nonlinear instead of linear modeling approach. In the light of this backdrop, this study aims to investigate the effects of oil price on Malaysian aggregate and disaggregate outputs in both linear and nonlinear frameworks. Specifically, this study adopts the linear ARDL and nonlinear ARDL testing procedures to investigate whether there is a linear or nonlinear evidence of oil price-output nexus for case of Malaysia. To preview our findings, it is found that linear oil price-output nexus is absent for both aggregate and disaggregate outputs. Nonetheless, nonlinear oil price-out nexus is revealed for the manufacturing and industrial outputs. Specifically, the current study finds that rising output is significantly associated to oil price increase, while to falling output is significantly related to oil price decrease. Hence, through the estimation of nonlinear ARDL model, this study contributes to the literature by providing empirical evidence on the asymmetrical impact of oil price shocks on the specific sectoral outputs in Malaysia.

2. A Brief Review

The impact of oil price shocks on macroeconomic variables has been widely investigated. For instance, Chen and Chen (2007) discovered that oil prices have been the overriding source of currency movements among G-7 countries. Rafiq, Salim and Bloch (2008) investigated the effects of oil price volatility on investment and unemployment for the case of Thailand. The authors reported that oil volatility has an important influence on unemployment and investment in Thailand. Du et al. (2010) documented significant effect of oil prices on growth and inflation in China. Cunado and Gracia (2014) established a negative impact of oil prices on stock prices for 12 European countries. Papaterou (2001) found a negative impact of oil prices on Greece stock prices. Conversely, several studies found positive relationship between oil price and stock prices. For example, Narayan and Narayan (2010) found a positive impact of oil prices on Vietnamese's stock prices.

Empirical evidence of nonlinear impact of oil price on macroeconomy were also revealed in few past studies. Cunado and Gracia (2005) found nonlinear relationship between oil price and output and inflation. In another study, Mehrara (2008) investigated the relationship between output growth and oil price in nonlinear panel data settings. Interestingly, the author found that output growth had been negatively influenced by oil price decrease. Nonetheless, oil price increase had limited impact on output growth. More recently, Allegret, Couharde and Coulibaly (2014) reported that oil price variations nonlinearly influenced the current account for the case of 27 oil exporting countries.

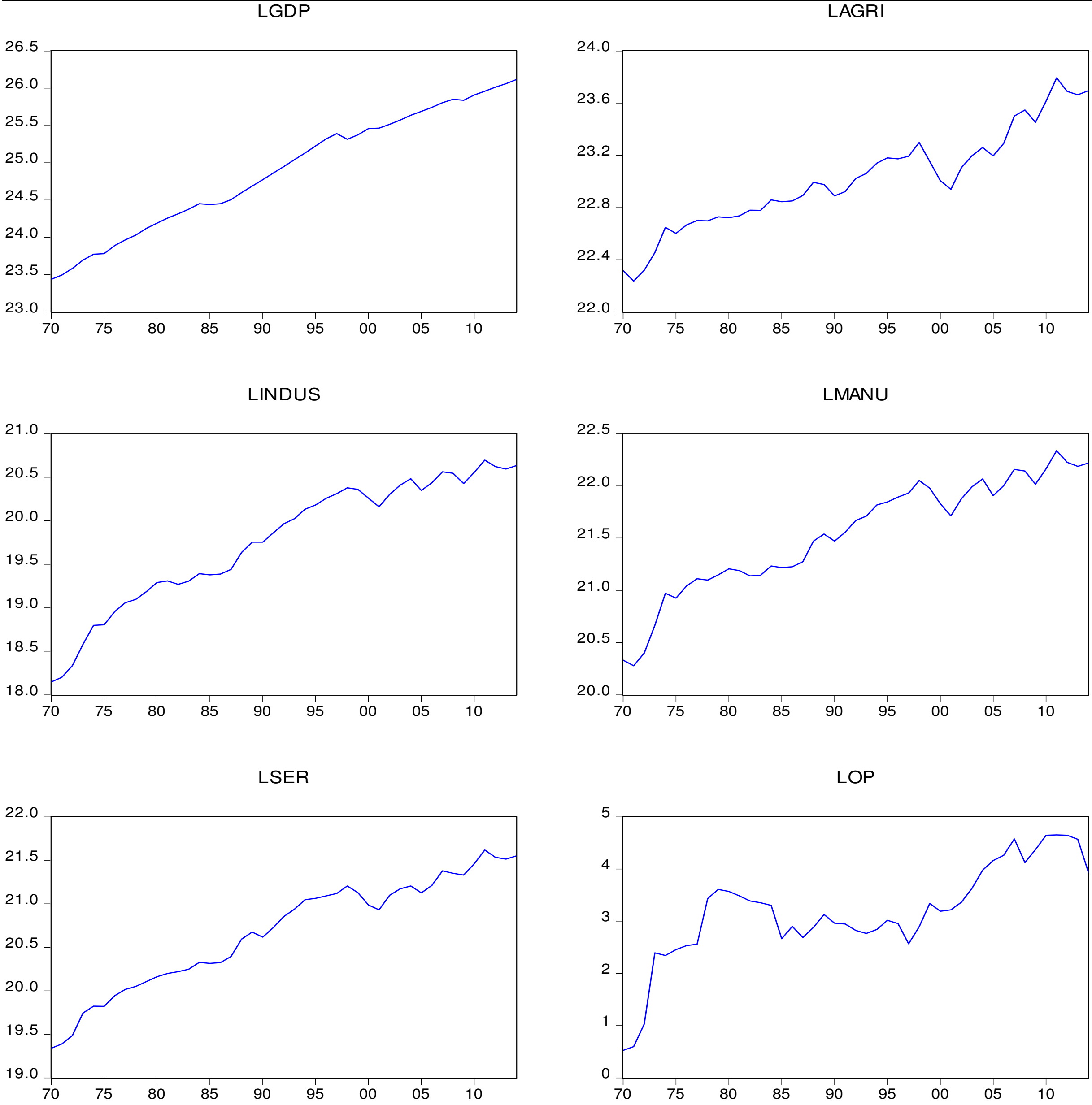
Among the few studies on the impacts of oil price and macroeconomy of Malaysia, Abdul Jalil, Mat Ghani and Duasa (2009) documented a positive long-run association between GDP and oil prices. It is also reported that change in domestic oil price Granger-caused change in GDP. Notably, the authors found asymmetrical effect of oil price changes on Malaysian GDP. Specifically, using Wald test of restriction on the impact of oil price increase and oil price decrease dummies, Malaysia GDP appeared to be significantly affected during periods of oil price decrease only. More recently, Shaari, Tan and Abdul Rahim (2013) documented the long-term effects of oil prices on the agriculture, construction, manufacturing, and transportation sectors using the commonly adopted Johansen cointegration test. Besides, the authors demonstrated using Granger causality test that in Malaysia, oil price shocks can affect agriculture sector, whereas the construction sector was found to be dependent on oil prices. In a separate attempt, Mohamed Yusoff and Abdul Latif (2013) adopted linear ARDL approach to measure the effects of world oil price change on economic growth and energy demand in Malaysia. Recently, Ibrahim (2015) adopted the nonlinear ARDL approach to reveal the patterns of asymmetries in food price behaviour in Malaysia. Among the major findings, Ibrahim (2013) reported a significant long-run relation between oil price increase and food price. However, the long run relation between oil price reduction and the food price was not detected.

It is noteworthy that, nonlinear estimation of the effects of oil price on outputs is relatively limited compared to linear estimation. This study contributes to the literature by estimating the nonlinear impact of oil price shocks on Malaysian real GDP and sectoral outputs.

3. Data

To investigate the relationship between oil price and output, this study employs annual time series over the period of 1970 to 2014. The variables involved are the oil price, Malaysian real GDP, and the sectoral outputs of agriculture, manufacturing, industrial and services sectors. According to the World Bank definition, Agriculture corresponds to ISIC divisions 1-5, which includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production. Manufacturing refers to industries belonging to ISIC divisions 15-37. Services correspond to ISIC divisions 50-99 and they include value added in wholesale and retail trade (including hotels and restaurants), transport, and government, financial, professional, and personal services such as education, health care, and real estate services. Industry corresponds to ISIC divisions 10-45, which includes manufacturing (ISIC divisions 15-37). It comprises of the value added in mining, manufacturing (also reported as a separate subgroup), construction, electricity, water, and gas. All sectoral outputs are the value-added outputs for the corresponding sectors expressed in constant 2005 U.S. dollars. These outputs data are obtained from the *World Development Indicators* (WDI), published by the World Bank. The oil price used in this study is the average of spot price of Brent, Dubai and West Texas intermediate crude oil. It is gathered from the *World Bank Commodity Price Data* (The Pink Sheet). All data are analyzed in the natural logarithmic form. The graphs of the natural logarithmic transformed variables are presented in Figure 1 and their descriptive statistics are summarized in Table 1.

Figure 1: Graphs of Variables (1970 to 2014)



Notes: LGDP, LAGRI, LINDUS, LMANU, LSER and LOP represent the natural logarithm of the real gross domestic product, agriculture outputs, industrial outputs, manufacturing outputs, service sector's outputs and oil price respectively.

It can be observed from Figure 1 that the oil price is more volatile than the outputs. Furthermore, the oil price is shown to exhibit nonlinear behavior. Table 1 shows that oil price has the highest standard deviation, confirming the more volatile nature of oil price, compared to outputs. Moreover, oil price is not normally distributed according to the Jarque-Bera statistics. This is because the null hypothesis of normal distribution can be rejected at 5% significance level for this variable. All the outputs are normally distributed, however.

Table 1: Descriptive Statistics (1970 to 2014)

	LGDP	LAGRI	LINDUS	LMANU	LSER	LOP
Mean	24.8901	23.0174	19.7686	21.5420	20.6763	3.1838
Median	24.9481	22.9929	19.9655	21.6681	20.8536	3.1925
Maximum	26.1180	23.7935	20.6980	22.3377	21.6186	4.6541
Minimum	23.4373	22.2354	18.1478	20.2777	19.3412	0.5247
Std. Dev.	0.8074	0.3824	0.7264	0.5413	0.6379	0.9476
Jarque-Bera	3.1206	0.5114	3.6385	2.9545	2.9066	6.9330*
Probability	0.2101	0.7744	0.1621	0.2283	0.2338	0.0312
Observations	45	45	45	45	45	45

Notes: LGDP, LAGRI, LINDUS, LMANU, LSER and LOP represent the natural logarithm of the real gross domestic product, agriculture outputs, industrial outputs, manufacturing outputs, service sector's outputs and oil price respectively. Asterisk (*) denotes rejection of the null hypothesis of normal distribution at 5% significance level.

4. Methodology

We apply the linear and nonlinear ARDL approach to investigate the oil price-output nexus. ARDL model is suitable for short-span data as is the case of this study, as well as variables of mixed integration of order zero, *I*(0) and/or one, *I*(1) (Pesaran, Shin and Smith, 2001). To provide justification on the absence of integration of order two, *I(*2*)* among variables, we employ the Augmented Dickey Fuller (ADF) and Philips-Perron (PP) unit root tests to identify the integration order of the respective variables in this study.

Linear ARDL Model

We can specify the oil price-output connection in a linear ARDL bound testing framework proposed by and Pesaran and Shin (1999) and Pesaran et al. (2001) as follows:

$$\Delta LY_t = \alpha_0 + \alpha_1 LY_{t-1} + \alpha_2 LOP_{t-1} + \sum_{i=1}^{q} \delta_{1i} \Delta LY_{t-i} + \sum_{i=0}^{r} \delta_{2i} \Delta LOP_{t-i} + \varepsilon_t, \qquad (1)$$

where delta (Δ) represents the first difference operator and epsilon (ε) refers to the white noise disturbance. *LY* denotes the natural logarithm of outputs and *LOP* refers to the natural logarithm of oil price. The parameters of alphas (α's) show the long-run relationships, while deltas (δ's) show the short-run relationships. The ARDL bound test approach to cointegration is conducted to examine whether output and oil price are cointegrated.

If linear cointegration exists, the linear long-run equation can be specified as below:

$$LY_t = \beta_0 + \beta_1 LOP_t + \epsilon_t , \qquad (2)$$

where betas (β's) are cointegration vectors or vector of long-run parameters, where $\beta_1 = -\alpha_2/\alpha_1$.

Nonlinear ARDL Model

Following Shin et al. (2014), we can specify the nonlinear ARDL approach as follows:

$$\Delta LY_t = \alpha_0 + \alpha_1 LY_{t-1} + \alpha_2 LOP_{t-1}^{+} + \alpha_3 LOP_{t-1}^{-} + \sum_{i=1}^{q} \theta_{1i} \Delta LY_{t-i} + \sum_{i=0}^{r} (\theta_i^{+} \Delta LOP_{t-i}^{+} + \theta_i^{-} \Delta LOP_{t-i}^{-}) + \mu_t, \quad (3)$$

where q and r are lag orders and alphas are long-run coefficients. $\sum_{i=0}^{r} \theta_i^{+}$ and $\sum_{i=0}^{r} \theta_i^{-}$ are the asymmetric distributed lag parameters that show the short-run influences of oil price on outputs. LOP_{t-1}^{+} and LOP_{t-1}^{-} are partial sums of positive and negative changes in oil prices, where these can be computed as follows:

$$LOP_t^{+} = \sum_{i=1}^{t} \Delta LOP_i^{+} = \sum_{i=1}^{t} \max(\Delta LOP_i, 0), \quad (4)$$

and

$$LOP_t^{-} = \sum_{i=1}^{t} \Delta LOP_i^{-} = \sum_{i=1}^{t} \min(\Delta LOP_i, 0). \quad (5)$$

If nonlinear cointegration exists, the nonlinear long-run equation can be specified as below:

$$LY_t = \beta_0 + \beta_1 LOP_t^{+} + \beta_2 LOP_t^{-} + \omega_t, \quad (6)$$

where alphas are cointegrating vectors or vectors of long-run parameters, where $\beta_1 = -\alpha_2/\alpha_1$ and $\beta_2 = -\alpha_3/\alpha_1$ may show the directions and magnitudes of the oil price increase and oil price decrease on the Malaysian real GDP or sectoral outputs.

5. Empirical Results and Interpretation

Unit Root Tests Results

Table 2 reports the results of the Augmented Dickey-Fuller (ADF) and Philips-Perron (PP) unit root analysis. The unit root tests results suggest that we have a mixture of *I*(0) and *I*(1) variables as the series are found to be stationary at the levels or first-differenced forms, and there is no *I*(2) series.

Results of Cointegration Tests

This study chooses a maximum lag length of 2 periods (m=2) to obtain the optimum lag orders for each variable. Table 3 shows cointegration test results estimated based on Equation (1). The results show that there is no linear long-run relationship between oil price and outputs for the case of Malaysia. On the other hand, nonlinear cointegration test results show that long-run relationship exists between oil price and outputs of manufacturing and industrial sectors. As the evidence of long-run relationship only exists for the manufacturing and industrial outputs, this limits us to present the nonlinear ARDL estimates for manufacturing and industrial outputs only.

ARDL Estimated Coefficients

Table 4 presents results of the nonlinear ARDL estimation of the oil price impact on the manufacturing and industrial outputs, based on Equation (3). The estimated coefficients are presented in Table 4, together with the diagnostic tests results. From Table 4, it is observed that the estimated models are satisfactory for interpretation as the residuals are normally distributed and the models are free from heteroscedasticity and serial correlation problems. In order to check for the suitability of the nonlinear model, we conducted Wald test for long-run (W_{LR}) and short run (W_{SR}) asymmetrical behaviour.

Table 2: Unit Root Tests Results

	ADF		PP	
	***t*-Statistics**	**Probability**	***t*-Statistics**	**Probability**
Level: Intercept without Trend				
LGDP	-1.8476	0.3533	-1.7894	0.3808
LAGRI	-0.7790	0.8147	-0.6071	0.8586
LMANU	-2.7861	0.0688	-4.0183*	0.0031
LINDUS	-3.6006*	0.0099	-5.4087*	0.0000
LSERV	-2.5475	0.1120	-3.9892*	0.0034
LOP	-2.9876*	0.0439	-2.9789*	0.0448
Level: Intercept with Trend				
LGDP	-1.4295	0.8381	-1.5000	0.8146
LAGRI	-2.3685	0.3899	-2.7284	0.2308
LMANU	-3.5857*	0.0433	-2.4382	0.3559
LINDUS	-2.4205	0.3642	-1.9531	0.6100
LSERV	-2.4428	0.3535	-2.2428	0.4551
LOP	-2.7423	0.2257	-2.7552	0.2209
First-Difference: Intercept without Trend				
ΔLGDP	-5.5399*	0.0000	-5.5142*	0.0000
ΔLAGRI	-6.6163*	0.0000	-6.5595*	0.0000
ΔLMANU	-	-	-	-
ΔLINDUS	-	-	-	-
ΔLSERV	-6.5941*	0.0000	-	-
ΔLOP	-	-	-	-
First-Difference: Intercept with Trend				
ΔLGDP	-5.8605*	0.0001	-5.8668*	0.0001
ΔLAGRI	-6.5364*	0.0000	-6.3598*	0.0000
ΔLMANU	-	-	-6.3538*	0.0000
ΔLINDUS	-6.7485*	0.0000	-6.1034*	0.0000
ΔLSERV	-7.1610*	0.0000	-8.1104*	0.0000
ΔLOP	-5.8513*	0.0001	-5.8559*	0.0001

Notes: LGDP, LAGRI, LINDUS, LMANU, LSER and LOP represent the natural logarithm of the real gross domestic product, agriculture outputs, industrial outputs, manufacturing outputs, service sector's outputs and oil price respectively. Delta (Δ) denotes the first differenced series. The unit root test exercise stops when a series is found stationary in its level form, Otherwise, we proceed to test if the series is stationary in its first-differenced form. Asterisk (*) denotes rejection of the null hypothesis of stationary series at 5% significance level.

Table 3: ARDL Approach to Cointegration Test Results

Dependent Variable	*F*-Statistic	95% Lower Bound	95% Upper Bound	Outcome
Linear ARDL Model				
LGDP	1.0837	4.94	5.73	No cointegration
LAGRI	1.0912	4.94	5.73	No cointegration
LMANU	2.1673	4.94	5.73	No cointegration
LINDUS	4.5298	4.94	5.73	No cointegration
LSERV	1.0974	4.94	5.73	No cointegration
Nonlinear ARDL Model				
LGDP	1.9374	3.79	4.85	No cointegration
LAGRI	2.6772	3.79	4.85	No cointegration
LMANU	6.3175*	3.79	4.85	Cointegration
LINDUS	6.4373*	3.79	4.85	Cointegration
LSERV	3.1786	3.79	4.85	No cointegration

Notes: LGDP, LAGRI, LINDUS, LMANU, LSER and LOP represent the natural logarithm of real gross domestic product, agriculture outputs, industrial outputs, manufacturing outputs, service sector's outputs and oil price respectively. Asterisk (*) denotes rejection of the null hypothesis of no cointegration at 5% significance level.

In Table 4, W_{LR} denotes Wald test of restriction for the long-run asymmetry where the null hypothesis is defined as $\alpha_2 = \alpha_3$. W_{SR} denotes Wald test of restriction for the short-run asymmetry where the null hypothesis is defined as $\sum_{i=0}^{r} \theta_i^+ = \sum_{i=0}^{r} \theta_i^-$. The results confirm that linear model would be probably mis-specified as the null hypothesis of the W_{LR} test can be rejected at 5% significance level for both manufacturing and industrial outputs models. Moreover, the null hypothesis of the W_{SR} test can be rejected at 5% significance level for both models also.

Table 4: Nonlinear ARDL Estimation Results: Effects of Oil Price on Malaysia's Manufacturing and Industrial Outputs

	Dependent Variable			
	$\Delta LMANU_t$		**$\Delta LINDUS_t$**	
Regressors	**Coefficient**	**Probability**	**Coefficient**	**Probability**
CONSTANT	9.9167*	0.0022	4.9561*	0.0035
$\Delta LMANU_{t-1}$	0.2157	0.2601	-	-
$\Delta LMANU_{t-2}$	-0.2709	0.1013	-	-
$\Delta LINDUS_{t-1}$	-	-	0.1136	0.5922
$\Delta LINDUS_{t-2}$	-	-	-0.3537*	0.0188
ΔLOP^+	-0.0049	0.9299	-0.0124	0.8023
ΔLOP^+_{t-1}	0.0323	0.4223	0.0077	0.8451
ΔLOP^+_{t-2}	-0.1066	0.1496	-0.0853	0.1958
ΔLOP^-	0.0717	0.0886	0.0770*	0.0423
ΔLOP^-_{t-1}	0.1628	0.1635	0.1832*	0.0269
ΔLOP^-_{t-2}	0.1383	0.1469	0.1079	0.2536
LOP^+_{t-1}	0.0010	0.9809	-0.0190	0.5686
LOP^-_{t-1}	-0.1951*	0.0002	-0.1566*	0.0016
$LMANU_{t-1}$	-0.4678*	0.0030	-	-
$LINDUS_{t-1}$	-	-	-0.2512*	0.0060
Diagnostic Tests				
JB	0.2628	0.8769	1.1544	0.5615
LM(1)	1.0675	0.3103	0.2434	0.6255
LM(2)	0.5356	0.5914	0.1311	0.8777
ARCH(1)	0.4163	0.5227	1.0801	0.3052
ARCH(2)	0.1673	0.8466	0.7844	0.4640
W_{LR}	14.6841*	0.0001	9.3607*	0.0022
W_{SR}	5.8730*	0.0154	7.7491*	0.0054

Notes: LGDP, LAGRI, LINDUS, LMANU and LSER represent the natural logarithm of real gross domestic product, agriculture outputs, industrial outputs, manufacturing outputs and service sector's outputs. LOP^+ and LOP^- are partial sums of positive and negative changes in oil prices. Delta (Δ) denotes the first differenced series. Equation (3) is estimated. JB denotes the Jarque-Bera normality test. LM(1) and LM(2) are the Lagrange Multiplier test for serial correlation of orders 1 and 2 respectively. Meanwhile, ARCH(1) and ARCH(2) test for heteroscedasticity of orders 1 and 2 respectively. W_{LR} denotes Wald χ^2 test of restriction for the long-run asymmetry where the null hypothesis is defined as $\alpha_2 = \alpha_3$. W_{SR} denotes Wald χ^2 test of restriction for the short-run asymmetry where the null hypothesis is defined as $\sum_{i=0}^{r} \theta_i^+ = \sum_{i=0}^{r} \theta_i^-$. Asterisk (*) denotes significant at 5% significance level.

Long-Run Parameter Estimates

The long-run parameter estimates depicted in Table 5 show significant impacts of oil price increase and oil price decrease on the manufacturing and industrial outputs. Specifically, a 1% increase in the oil price can be associated to an increase of 0.180% on the manufacturing output and 0.201% on the industrial output. As the industrial output includes the manufacturing output, we can deduce that the impact on the other non-manufacturing outputs of mining, construction, electricity, water and gas is 0.201% – 0.180% = 0.021%. On the other hand, a 1% decrease in the oil price can be associated to a reduction of 0.197% on the manufacturing output and 0.341% on the industrial output. As the industrial output includes the manufacturing output, we can deduce that the impact on other non-manufacturing outputs 0.144%. The finding of asymmetrical impact of oil price shocks is consistent with Abdul Jalil *et al*. (2009), which reported that oil price decrease gives significant impact to Malaysia economy compared to oil price increase. In addition, the current findings further show that rising output is associated to oil price increase, while falling output is significantly related to oil price decrease. In this conjunction, Mehrara (2008) reported evidence of oil price decrease and falling outputs for oil-exporting countries. This study provides complementary supportive evidence since Malaysia was not included in Mehrara's (2008) sample although it is also an oil-exporting country.

Table 5: Long Run Parameter Estimates: Effects of Oil Price on Malaysian's Manufacturing and Industrial Outputs

	Independent Variable			
	LMANU		**LINDUS**	
Regressor	**Coefficient**	**Probability**	**Coefficient**	**Probability**
Constant	20.5609*	0.0000	18.5179*	0.0000
LOP^{+}	0.1803*	0.0063	0.2010*	0.0121
LOP^{-}	-0.1986*	0.0356	-0.3408*	0.0045

Notes: LINDU and LMANU represent the natural logarithm of the real industrial outputs and manufacturing outputs respectively. LOP^{+} and LOP^{-} are partial sums of positive and negative changes in oil prices. Asterisk (*) denotes significant at 5% significance level.

6. Conclusion

This study investigates oil price-output relationship at the aggregate and disaggregates levels using linear and nonlinear ARDL approaches. We estimated the linear ARDL approach to cointegration to investigate the linear long-run relationships for five bivariate models which include oil price-real GDP (aggregate level), oil price-agriculture sector's outputs, oil price-manufacturing outputs, oil-price-industrial outputs and lastly on oil price-services outputs. The ARDL cointegration analysis shows no long-run relationship in the linear framework. Therefore, this study proceeds with investigation using the nonlinear framework and found the existence of long-run relationships for the case of manufacturing and industrial outputs with the oil price. Next, this study reveals that oil price increase will enhance outputs significantly, whereas oil price decrease has significant dampening impact on Malaysia manufacturing and industrial outputs. As Malaysia is an oil-dependent country, falling oil price may result in under-capacity in these two sectors owing to the reduction in crude oil exports revenues, which in turn limits capital access and imports of intermediaries. On the other hand, the agriculture and services sectors are insignificantly affected by oil price shocks as they are less energy-intensive compared to the manufacturing and industrial sectors. As such, policy-makers need to consider the nonlinear effect of oil price shocks to formulate policy which is able to maintain favorable environment that enhances economic growth. Among others, as oil price negative shocks retard outputs, government may need to increase (rather than decrease, due to reduction in revenues) the budget for manufacturing and industrial sectors to offset the negative shocks.

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