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Does oil price shocks mitigate sectoral CO_2 emissions in Malaysia? Evidence from ARDL estimations

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Abstract

This study provides new evidence regarding the effects of oil price shocks on sectoral environmental indicators. We used annual time series data for the period 1983–2014 and employed the autoregressive distributed lag (ARDL) modelling approach to estimate the long-run impact of oil price shocks on sectoral CO_2 emissions. We found a negative relationship between oil price shocks and CO_2 emissions in all sectors; namely, manufacturing and construction, agriculture, transportation, and the oil and gas sectors. This suggests that higher oil price can mitigate sectoral CO_2 emissions while lower oil price can increase sectoral CO_2 emissions. Generally, income exerts a positive impact on sectoral CO_2 emissions, implying that an increase in the level of income invokes sectoral CO_2 emissions. However, the level of capital and labour were found to mitigate sectoral CO_2 emissions in Malaysia. Thus, we recommend contractionary fiscal measures on oil-related products during lower oil prices.

Introduction

The price of crude oil has long been influencing energy markets worldwide. Fluctuations in oil price have both direct and indirect impacts on the rest of the economy. For oil exporting economy, the fall in oil price reduces government revenue and Gross Domestic Product (GDP). Reduction in government revenue impacts indirectly on the domestic component of aggregate demand such as consumption expenditure, investment expenditure and public expenditure. Furthermore, oil price decline can lead to a transfer of wealth from oil-exporting countries to the oil importing country. In 2016 the Organization of Petroleum Exporting Countries (OPEC) reported a decline in crude oil price below $30 per barrel which marked eleven years of history when crude oil was last sold below this price. Since then, the oil price has gradually increased (Bank Negara, 2018) and stood at about $70 in the fourth quarter of 2018.

However, studies in energy literature have concentrated on the impact of oil price shocks on macro economy and less concern on its impact on carbon dioxide (CO_2) emissions. Oil price fluctuation can have a considerable indirect impact on mitigating or increasing CO_2 emissions. Thus, environmental sustainability in the pursuit of economic growth and development cannot be taken for granted. The level of real oil price can affect CO_2 emissions in two ways. Besides their indirect effect through GDP, an increase in oil price can imply a reduction in energy consumption. Reduction in energy consumption due to higher oil price may be compensated by using other production inputs (Balaguer & Cantavella, 2016; Rodríguez, Pena-Boquete, & Pardo-Fernández, 2016) and substitution of energy consumption by other cleaner and more efficient energy resources. Thus, higher oil prices can mitigate CO_2 emissions and improve environmental quality (Maji, Habibullah, Saari, & Abdul-Rahim, 2017).

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Moreover, the consumption of energy such as petroleum, gas and diesel from the oil and gas sector for economic activities may also contribute to CO_2 emissions. Petroleum and other liquids and natural energy sources consumed in Malaysia accounted for forty percent (40%) and thirty six percent (36%) of total energy consumed in 2012 respectively (Energy Information Administration [EIA], 2015). The Malaysia CO_2 emissions per capita as a share of total emissions stood at zero point eight percent (0.8%) in year 2010. This is greater than some of the oil-exporting countries like Iraq and Venezuela that emit zero point four percent (0.4%) and zero point seven percent (0.7%) respectively. As at 2012, Malaysia's total CO_2 emissions from the consumption of energy in million metric tons was 199; CO_2 emissions from the consumption of petroleum in the same year was 84 million metric tons; CO_2 emissions from the consumption of natural gas was 62 million metric tons; while per capita CO_2 emissions from energy consumption was 6.8 metric tons (EIA, 2015). As such, measuring energy consumption through changes in oil price for sectoral CO_2 emissions contributes to scientific knowledge.

Despite the recent concern on the link between oil price fluctuation and environmental sustainability, there exists a literature gap of relating oil price shocks to sectoral CO_2 emissions. Emissions resulting from oil price fluctuation can vary across sectors of the economy. For instance, CO_2 emissions arising from oil price fluctuation in the manufacturing and construction sector may differ significantly from that of the agricultural sector, the transportation sector and the oil and gas sector. This, to the best of our knowledge, has not been captured by existing literature. As such, the main contribution of this paper is the investigation of oil price shocks on sectoral CO_2 emissions. The paper also provides a new insight and the basis for further understanding of the extent to which contractionary fiscal measures on oil products may be considered as a useful environmental policy.

Literature Review

Three main reasons motivated the writing of this paper, namely: fluctuation of oil price, which is exogenously determined by external factors beyond the control of a country like Malaysia; the increasing need to reduce greenhouse gases arising from CO_2 emissions and the gap in literature regarding the relationship between oil price movement and sectoral CO_2 emissions.

The empirical consideration of this paper deviates from recent literature on the link between oil price, energy consumption, income and environmental quality (Aydın & Acar, 2011; Ali Ahmed & Wadud, 2011; Balaguer & Cantavella, 2016; Rodríguez et al., 2016). For a study in Turkey, Aydın and Acar (2011) evaluated the relationship between oil price and environmental quality and revealed that only limited studies incorporate the environmental component of oil price shocks in their analysis. Rodríguez et al. (2016) revisited the environmental quality and economic growth nexus through the oil price lens. After providing strong evidence on the importance of oil price to CO_2 emissions they found the absence of the environmental Kuznets curve.

Additionally, Balaguer and Cantavella (2016) explored the environment and economic growth nexus with oil price as an indicator of variations in energy consumption, which allowed them to capture the impact of the most pollutant energy on CO_2 emissions. They found the presence of an environmental Kuznets curve and that oil price is a valuable measure of energy consumption. The concern highlighted in these studies relate to the impact of energy consumption on increasing millions of metric tonnes of CO_2 emissions that lead to environmental pollution, climate change and global warming, especially when it was discovered that CO_2 emitted today has the tendency of being retained in the environment for several years (Intergovernmental Panel on Climate Change [IPCC], 2015).

Literature regarding energy consumption and CO_2 emissions from the industry and carbon footprint and embodied carbon of products have also emerged from China (Xie, 2014; Su, Ang, & Low, 2013; Liu, Liu, Fan, & Zou, 2015; Su & Ang, 2015; Yuan & Zhao, 2016). For instance, Su et al. (2013) revealed that there is an underestimation of CO_2 emissions embodied in normal trade and overestimation of CO_2 emissions embodied in processing trade. Xie (2014) on the other hand, found that the components of final demand that include domestic demand and exports contribute about one-third to the changes in total energy use in China. Again, Yuan and Zhao (2016) showed that external components are more responsible for the increasing CO_2 emissions from China's energy-intensive industries. While Liu et al. (2015) provided evidence that the transferred CO_2 embodied and net transfers in demand and supply chains driven by export and consumption are on the increase.

The consideration in this paper also differs from recent literature for Malaysia (Ali Bekhet &Yasmin, 2014; Begum, Sohag, Abdullah, & Jaafar, 2015; Mustapa & Bekhet, 2016). Begum et al. (2015) investigated CO_2 emissions, energy demand, economic and population growth and found that both per capita energy demand and income have a positive impact on CO_2 emissions, but population growth does not possess the statistical power to impact CO_2 emissions in Malaysia. Mustapa and Bekhet (2016) pointed out that removal of fuel price subsidies has the capacity to reduce about 652 tonnes of fuel consumption and decrease CO_2 emissions by six point six percent (6.6%) and allow Malaysia to achieve its objective of becoming a high-income nation by 2020. Ali Bekhet and Yasmin (2014) found that fall in exports resulting from global financial crises led to a decrease in economic growth and sixteen percent (16%) reduction in energy consumption.

Similarly, the methodologies used by the consulted literature are mostly time series analysis (Balaguer & Cantavella, 2016; Rodríguez et al., 2016; Mustapa & Bekhet, 2016), computable general equilibrium analysis (Aydın & Acar, 2011) and input-output analysis (Ali Bekhet, & Yasmin, 2014; Su & Ang, 2015; Liu et al., 2015). However, to the best of our knowledge and from the literature reviewed, none of the studies considers the sectoral aspect of CO_2 emissions arising from oil price shocks for a net oil-exporting country like Malaysia. This paper contributes to knowledge in filling this gap.

Methodology

Empirical Model

The theoretical framework of this paper is the linearized version of the Environmental Kuznets Curve (EKC) theory used in recent literature (Jaunky, 2011; Ahmed, Shahbaz, Qasim, & Long, 2015; Salahuddin, Gow & Ozturk, 2015). However, the difference between the present paper and the literature is that this paper examines the impact of energy consumption through the oil price on sectoral CO_2 emissions. Moreover, the Autoregressive Distributed Lag (ARDL) approach to cointegration developed by Pesaran, Shin, and Smith (2001) serves as the empirical model. The justification for using this empirical model includes the following: The model is applicable regardless of whether the variables are $I(0)$ or $I(1)$ or a combination of both. The model provides good property and consistent result for small sample size; and the model can estimate both long-run and short-run results simultaneously. Thus, the extended sectoral CO_2 emissions model that expresses CO_2 emission as a function of energy price (proxy by oil price) and other controlled determinants is specified in Equation 1.

$$lncoj_{2t} = \gamma_0 + \gamma_1 lny_t + \gamma_2 lncap_t + \gamma_3 lnlab_t + \gamma_4 lnop_t + \mu_{jt} \quad (1)$$

where $lncoj_{2t}$ measures sectoral CO_2 emissions (an indicator for environmental quality). The symbol $j = m_t, a_t, t_t, og_t$ *and* p_t represents CO_2 emissions from manufacturing and construction, agriculture, transportation, oil and gas and total CO_2 emissions respectively. lny_t is the level of income, $lncap_t$ represents capital, $lnlab_t$ denotes labour and $lnop_t$ is oil price. The parameter γ_0 is the intercept, μ_0 is the error term that is expected to be normally distributed. We have expressed all the variable in the logged form in order to harmonize the unit in which each variable data is expressed and thus, normalize them.

Hence, following Pesaran et al. (2001) and the work of the previous authors such as Coban and Topcu (2013), Shahbaz, Arouri, and Teulon (2014), Omri, Daly, Rault, and Chaibi (2015), Rodríguez et al. (2016) and Balaguer and Cantavella (2016), the ARDL Unrestricted Error-Correction model (ARDL-UECM) can be specified in the following Equation 2:

$$\Delta lncoj_{2t} = \rho_0 + \sum_{i=1}^{n} \rho_{1i} \Delta lncoj_{2t-i} + \sum_{i=0}^{n} \rho_{2i} \Delta lny_{t-i} + \sum_{i=0}^{n} \rho_{3i} \Delta lncap_{t-i} + \sum_{i=0}^{n} \rho_{4i} \Delta lnlab_{t-i} + \sum_{i=0}^{n} \rho_{5i} \Delta lnop_{t-i} + \tau_1 lncoj_{2t-1} + \tau_2 lny_{t-1} + \tau_3 lncap_{t-1} + \tau_4 lnlab_{t-1} + \tau_5 lnop_{t-1} + \vartheta_t \quad (2)$$

To test for cointegration by using the bound testing approach, a null hypothesis of no cointegration given by: H_0: $\tau_1 = \tau_2 = \tau_3 = \tau_4 = \tau_5 = 0$ can be tested against its alternative hypothesis that suggests the presence of cointegration as: H_a: $\tau_1 \neq \tau_2 \neq \tau_3 \neq \tau_4 \neq \tau_5 \neq 0$, after which the F-statistic estimated via the OLS are compared with the bounds critical values presented in Narayan (2005). Cointegration exists if the values of F-statistic are greater than the upper bounds value of Narayan critical values and vice versa. The result is inconclusive when the value of F-statistic falls between the lower and the upper bounds values. Nevertheless, cointegration can also be inferred from the parameter τ_1 when it is negative, significant and not less than –1.

Given the long-run model as per Equation 1, we can specify the short-run or the ARDL Restricted Error-Correction (ARDL-RECM) model in Equation 3 below.

$$\Delta lncoj_{2t} = \alpha + \sum_{i=1}^{n} \alpha_{1i} \Delta lncoj_{2t-i} + \sum_{i=0}^{n} \alpha_{2i} \Delta lny_{t-i} + \sum_{i=0}^{n} \alpha_{3i} \Delta lncap_{t-i} + \sum_{i=0}^{n} \alpha_{4i} \Delta lnlab_{t-i} + \sum_{i=0}^{n} \alpha_{5i} \Delta lnop_{t-i} + \delta ect_{t-1} + \omega_t \quad (3)$$

where the error-correction term, ect_{t-1}, is the residual of the long-run model of Equation (1) lagged one period and can be expressed in Equation 4 as follows:

$$ect_{t-1} = \mu_{t-1} = lncoj_{2t-1} - (\gamma_0 + \gamma_1 lny_{t-1} + \gamma_2 lncap_{t-1} + \gamma_3 lnlab_{t-1} + \gamma_4 lnop_{t-1}) \quad (4)$$

Parameter δ is the coefficient of the error-correction term, ect_{t-1} which indicates the speed of adjustment. It suggests cointegration when it is negative, significant and not less than -2.

Data Sources, Variable Measurement and Expected Signs

The datasets for this paper were collected from the World Bank's World Development Indicators (World Bank, 2015), Food and Agriculture Organization (FAO, 2015) and Energy Information Administration (EIA) of United State for the period of 1983–2014. The variables include oil price, income, capital, labour and sectoral CO_2 emissions. The main focus and contribution of this study is the sectoral analysis of CO_2 emissions. However, the study faced constraint with access to sectoral CO_2 emissions data, as such, the scope of the study did not extend beyond the year 2014. The source of the data, variable measurement and expected signs are presented in Table 1. We expected that the sign of coefficients of income, labour and capital with respect to CO_2 emissions to be negative. This is because Malaysia is an emerging economy and the government is concerned with the adverse effect of CO_2 emissions and also creating awareness on how to reduce it.

Table 1 Data sources, variable measurement and expected signs

Variables	Data sources	Measurements	Expected signs
Oil price	EIA	West Texas Intermediate (WTI) crude oil in barrels	-
Income	WDI	GDP per capita (constant 2005 US$)	Negative
Sectoral and total CO_2 emissions	WDI/ FAO	CO_2 emissions from manufacturing, agriculture, transportation, oil and gas sectors and per capita CO_2 emissions	Negative
Capital	WDI	Gross fixed capital formation (% of GDP)	Negative
Labour	WDI	Labour force participation rate, total (% of total population ages 15+)	Negative

Results and Discussion

The standard augmented Dickey-Fuller (ADF) (Dickey & Fuller, 1981) and Phillips-Perron (PP) (Phillips & Perron, 1988) unit root tests were used to determine the order of integration of the time series. The results of the unit root tests are reported in Table 2. The unit root test results clearly show that all variables are *I*(1) except for labour ($lnlab_t$) which is *I*(0), implying that ($lnlab_t$) is stationary at level while the rest of the variables are stationary after first-differencing.

Table 3 presents the results of the cointegration tests as well as the long-run models for CO_2 emissions in Malaysia by sectors, namely; the manufacturing and construction (*com*), agriculture (*coa*), transportation (*cot*), oil and gas sector (*coog*), and lastly the total CO_2 emissions at the national level (*cop*), respectively; and each is indicated by Models 1 to 5. In this table, we report the long-run models, the bounds test for cointegration, the error-correction test for cointegration and the ARDL model for each sector.

Table 2 Results of ADF and PP unit root tests

Variables	ADF				PP			
	Level	m	First difference	m	Level	m	First difference	m
$lncom_t$	-2.479(.336)	0	-5.122(.001)***	0	-2.541(.308)	3	-6.109(.000)***	8
$lncoa_t$	-1.664(.743)	0	-5.278(.000)***	0	-1.722(.717)	1	-5.312(.000)***	4
$lncot_t$	-2.463(.343)	0	-6.938(.000)***	0	-2.463(.343)	0	-6.874(.000)***	1
$lncoog_t$	-2.517(.319)	0	-6.329(.000)***	0	-2.464(.342)	2	-6.627(.000)***	5
$lncop_t$	-1.339(.859)	0	-5.622(.000)***	0	-1.541(.793)	2	-5.625(.000)***	2
lny_t	-1.659(.745)	0	-4.5145(.006)***	0	-1.848(.657)	2	-4.535(.005)***	1
$lncap_t$	-1.576(.779)	0	-3.948(.022)**	0	-1.826(.667)	1	-3.809(.030)**	5
$lnlab_t$	-4.334(.009)***	0	-3.699(.041)**	5	-4.398(.008)***	2	-10.039(.000)***	1
$lnop_t$	-2.517(.318)	0	-6.329(.000)***	0	-2.464(.342)	2	-6.627(.000)***	5

Notes: Figures in parentheses are *p*-values. *** $p < .01$, ** $p < .05$. Unit root test is conducted with constant and trend while *m* is the lag length for ADF and bandwidth for PP and lag length chosen using the Schwarz criterion.

Table 3 Results of cointegration bounds tests and long-run models for sectoral CO_2 emissions

Estimators	lny_t	$lncap_t$	$lnlab_t$	$lnop_t$	Constant
Model 1: Dependent variable = $lncom_t$					
ARDL(1,0,0,0,3)	-0.505***	0.057	4.159	-0.003*	-9.973
	(-3.186)	(0.415)	(1.501)	(-2.0264)	-0.901
	Bound F-test = 5.149**				
	ect_{t-1} = -0.413**				
	ARDL(1,0,0,0,3) model:		R^2 = 0.947	LM $\chi^2(1)$ = [0.220]	
Model 2: Dependent variable = $lncoa_t$					
ARDL (2,0,2,2,1)	0.979***	0.161	-7.447***	-0.185**	32.291***
	(7.540)	(1.086)	(-3.129)	(-2.493)	(3.179)
	Bound F-test =5.297**				
	ect_{t-1}= -0.564***				
	ARDL(2,0,2,2,1) model:		R^2 = 0.978	LM $\chi^2(1)$ = [0.500]	
Model 3: Dependent variable = $lncot_t$					
ARDL (1,0,1,1,0)	-0.059	-0.332***	1.495*	-0.129***	-0.966
	(-1.119)	(-5.573)	(1.895)	(-4.227)	(-0.294)
	Bound F-test =5.801***				
	ect_{t-1}= -0.804***				
	ARDL(1,0,1,1,0) model:		R^2 = 0.882	LM $\chi^2(1)$ = [0.742]	
Model 4: Dependent variable = $lncoog_t$					
ARDL (1,0,0,1,0)	-0.762***	0.288***	1.582	-0.265	2.719
	(-8.389)	(2.979)	(1.116)	(-0.232)	(0.462)
	Bound F-test =3.189				
	ect_{t-1} = -0.706***				
	ARDL(1,0,0,1,0) model:		R^2=0.964	LM $\chi^2(1)$ = [0.837]	
Model 5: Dependent variable = $lncop_t$					
ARDL (1,2,0,3,2)	1.625***	-0.061	-6.976**	-0.294**	18.155
	(10.804)	(-0.359)	(-2.545)	(-2.909)	(1.617)
	Bound F-test =5.208***				
	ect_{t-1} = -0.651***				
	ARDL(1,2,0,3,2) model:		R^2 = 0.987	LM $\chi^2(1)$ = [0.135]	

Notes: Figures in round (.) and square [.] brackets are *t*-statistics and *p*-values respectively. * $p < .1$, ** $p < .05$, *** $p < .01$. respectively. Critical values at 5% level for bounds tests are $I(0) = 3.354$ and $I(1) = 4.774$ with $k = 4$ are taken from Narayan (2005). Breusch-Godfrey LM $\chi^2(1)$ is a test for no serial correlation.

The lag order selection for model 3, 4 and 5 is based on Akaike Information Criterion (AIC) while that of model 1 and 2 is based on Schwarz Bayesian Criterion (SIC). The justification for their choice of selection is that the AIC does relatively better when the sample size is small while SBC enhances performance when the sample size is either small or large.

The result of the ARDL Bounds tests are reported at the lower part of each model (see the F-test). The values of the F-statistics suggest that model 1, 2, 3 and 5 are cointegrated at five percent (5%) level of significance while model 4 is cointegrated at ten percent (10%) level. This is because the F-statistics are greater than the upper bound critical value (see the footnote of Table 3). This implies that a stable long-run relationship exists among the variables and the null hypothesis of no cointegration stated earlier can be rejected in favour of the alternative hypothesis.

Model 1 presents the long-run results of the impact of oil price on CO_2 emissions from the manufacturing and construction sector. The result shows that the coefficient of oil price is significant and inversely related to CO_2 emissions of this sector. This suggests that higher oil prices can mitigate CO_2 emissions while lower oil price can increase CO_2 emissions from this sector. Thus, a fall in oil price such as the ones witnessed from the middle of the year 2014 to the first quarter of 2016 can increase CO_2 emissions from the manufacturing and construction sectors. Income has also revealed evidence of mitigating CO_2 emissions from this sector while capital and labour reveal a neutral impact.

Again, model 2 presents the long-run results of the impact of oil price shocks on CO_2 emissions from the agricultural sector. The result shows that oil price fluctuation has an indirect relationship with CO_2 emissions from the agricultural sector. Given that the Malaysian economy is among the largest producers of palm oil in the world, increase in the production of palm oil definitely required the use of more energy. Higher input price, such as energy price can increase production costs and reduce both farmers and government revenue. In order to meet up with revenue generated from palm oil, farmers and the government may resort to the use of alternative (cleaner) energy. Doing this will indirectly reduce the use of primary energy, as a result, reduce CO_2 emissions. This result is intuitive and supports the findings of Balaguer and Cantavella (2016). On the other hand, income has a positive impact on CO_2 emissions of this sector; labour has a negative impact while the elasticity capital is neutral.

Moreover, model 3 in Table 3 presents the long-run result of the impact of oil price shocks on CO_2 emissions from the transportation sector. The result shows that oil price and CO_2 emissions from the transportation sector move in the opposite direction, suggesting that higher oil price can mitigate CO_2 emissions from the transportation sector. Thus, a higher energy price can serve as a policy instrument for controlling the proliferation of vehicle in Malaysia. This result is consistent with the work of Rodríguez et al. (2016). Similarly, the impact of income is neutral; capital has a negative impact while labour has a positive impact on CO_2 emissions from the transportation sector.

In addition, model 4 presents the long-run result of the impact of oil price shocks on CO_2 emissions from the oil and gas sector. The result reveals a negative and significant relationship between oil price and CO_2 emissions from the oil and gas sector. This suggests that higher energy price can mitigate CO_2 emissions from the oil and gas sector and lower energy price such as the one witnessed in 2016, can increase CO_2 from this sector in Malaysia. The Malaysian government mostly exports its expensive Tapis crude oil and purchases a lesser grade for local consumption. The higher the price of the substituted crude oil grade for local consumption, the lower the quantity that will be purchased and hence, the lower the CO_2 emissions from the oil and gas-related sectors and vice versa. This is verified by the work of Rodríguez et al. (2016). Likewise, income mitigates CO_2 emissions of this sector; capital increases CO_2 emissions while labour is neutral. The unexpected sign of capital and CO_2 emissions from the oil and gas sector could be attributed to fluctuations in crude oil prices.

Lastly, the long-run Model 5 for total CO_2 emissions suggests that increased oil price and labour usage reduces CO_2 emissions in Malaysia while income or wealth of the nation increases CO_2 emissions. This may not be unconnected with the fact that the nation has not yet reached a turning point of income beyond which an increase in income would mitigate CO_2 emissions.

The results of short-run dynamic coefficients along with the result of the error-correction terms (ect_{t-1}) for the sectoral and total CO_2 emissions are presented in Table 4. All the coefficients of the error correction terms are less than one in absolute terms, negative and significant, suggesting that there is long-run convergence in the models. As shown in Table 4, -0.413, -0.564, -0.804, -0.706 and -0.651 are the coefficient of the error-correction term for model 1-5 that inform the speed of adjustment of each model toward long-run equilibrium in event of any short term deviation.

Table 5 presents the diagnostic tests for serial correlation, functional form, normality test and heteroscedasticity test. With the exception of the functional test of model 2, the models have passed all the diagnostic tests. This can be verified by the probability values of the test statistic in parenthesis. The diagnostic tests were further supported by a stability test of Cumulative Sum of Recursive Residuals (CUSUM) and Cumulative Sum of squares of Recursive Residuals (CUSUMsq) forwarded. The results of the stability tests presented in Figure 1 show that the models are relatively stable and reliable as evidenced by the critical bounds at five percent (5%) level of significance.

Table 4 ARDL Short-run results for sectoral and total CO_2 emissions

Estimator	lny_t	$lncap_t$	$lnlab_t$	$lnop_t$	Constant	Ect_{t-1}
Model 1: Dependent variable = $lncom_t$						
ARDL (1,0,0,0,3)	-0.209**	0.023	1.719**	0.003**	-4.122	-0.413**
	(-2.594)	(0.396)	(2.389)	(2.358)	(-1.188)	(-2.779)
Model 2: Dependent variable = $lncoa_t$						
ARDL(2,0,2,2,1)	0.553***	-0.053	-1.392*	0.022	18.224***	-0.564***
	(2.896)	(-0.528)	(-1.943)	(0.319)	(3.428)	(-3.756)
Model 3: Dependent variable $lncot_t$						
ARDL(1,0,1,1,0)	-0.048	-0.027	0.436	-0.104***	-0.776	-0.804***
	(-1.036)	(-0.465)	(1.044)	(-4.069)	(-0.298)	(-5.594)
Model 4: Dependent variable = $lncoog_t$						
ARDL(1,0,0,1,0)	-0.538***	0.204**	0.090	-0.1874	1.919	-0.706***
	(-3.489)	(2.731)	(0.123)	(-0.225)	(0.453)	(-3.476)
Model 5: Dependent variable = $lncop_t$						
ARDL(1,2,0,3,2)	1.684**	-0.039	-1.216	-0.072	11.821*	-0.651***
	(2.846)	(-0.366)	(-1.625)	(-0.704)	(2.005)	(-3.459)

Note: Figures in parenthesis (.) are t-statistics, * $p < .1$, ** $p < .05$, *** $p < .01$.

Table 5 Diagnostic test for sectoral and total CO_2 emissions

Test statistics	Serial Correlation	Functional Form	Normality	Heteroscedasticity
Model 1: Dependent Variable: $lncom_t$				
LM Version	1.507[0.220]	3.015[0.083]	1.360[0.507]	0.108[0.742]
F Version	1.041[0.320]	2.204[0.154]	N/A	0.101[0.753]
Model 2: Dependent Variable: $lncoa_t$				
LM Version	0.816[0.366]	9.949[0.002]	0.622[0.733]	1.353[0.245]
F Version	0.475[0.500]	8.436[0.010]	N/A	1.323[0.260]
Model 3: Dependent Variable: $lncot_t$				
LM Version	0.158[0.691]	0.685[0.408]	0.165[0.921]	0.578[0.447]
F Version	0.111[0.742]	0.491[0.491]	N/A	0.550[0.464]
Model 4: Dependent Variable: $lncoog_t$				
LM Version	0.059[0.808]	0.031[0.861]	2.241[0.326]	1.277[0.258]
F Version	0.043[0.837]	0.022[0.882]	N/A	1.245[0.274]
Model 5: Dependent Variable: $lncop_t$				
LM Version	4.260[0.039]	2.141[0.143]	1.343[0.511]	1.090[0.764]
F Version	2.512[0.135]	1.159[0.300]	N/A	0.084[0.774]

Note: Figures in parenthesis [.] are probability values

Conclusion and Recommendations

The present study investigates the impact of oil price shocks on sectoral CO_2 emissions in Malaysia. The linear Environmental Kuznets Curves (EKC) was used as the theoretical framework while the ARDL bounds testing approach was utilised as the empirical model. In this study, we use annual time series data ranging from 1983–2014. Examining the effect of oil price changes on sectoral CO_2 emissions is a contribution to knowledge. Our results on the long-run impact of energy price revealed a negative relationship between oil price and all the sectoral CO_2 emission. This suggests that a higher oil price can mitigate CO_2 emissions and improve environmental quality, while lower oil price can increase CO_2 emissions in Malaysia. Since energy is an important ingredient in the production process, a higher energy price implies a higher cost of production. In order to minimise this cost, producers may resort to efficient utilisation of energy by using alternative energy sources such as renewable energy. Efficiency in energy utilisation and the use of cleaner energy source reducethe demand for fossil energy and thus, reduce the amount of CO_2 emissions into the environment.

Therefore, apart from generating revenue for the government of oil-exporting countries, higher oil price can assist in controlling environmental pollution arising from fossil fuel energy consumption. Thus, paying attention to the dynamics of oil price can assist the government to ascertain the extent to which taxes on oil products can be considered as a useful environmental policy. To further mitigate CO_2 emissions, the study recommends contractionary fiscal measures such as environmental value-added taxes during a lower oil price. This will ensure efficiency in the utilisation of energy from fossil fuel sources and also draw the attention of producer to alternative cleaner sources of energy for production purposes.

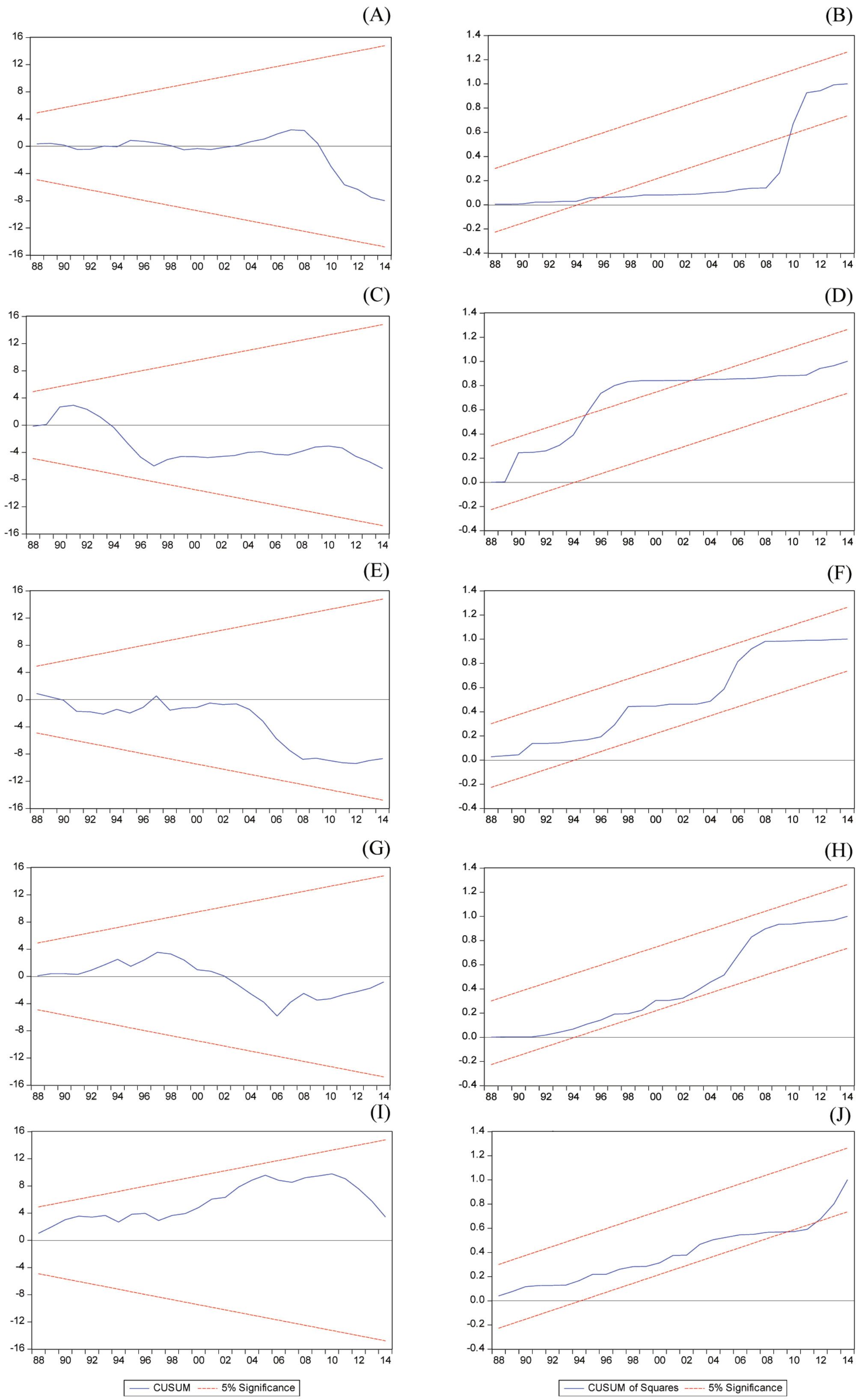

Figure 1 CO_2 emissions from the manufacturing and construction sector (A and B), the agricultural sector (C and D), the transportation sector (E and F), the oil and gas sector (G and H), and Total CO_2 emissions (I and J)

Generally, the findings of this study showed evidence that labour force can mitigate CO_2 emissions. Hence, we recommend that the government should pay attention to the use of foreign workers in Malaysia. To this effect, government should design a suitable labour force participation ratio of domestic to foreign workers that would further mitigate CO_2 emissions. Efficient criteria should be designed in the selection and employment of such labour force. The level of capital was evidenced to mitigate sectoral CO_2 emission. Since the control of capital can be less exogenous compared to oil price, the study recommends that policymakers can control this variable by giving incentives to productive sectors that incorporate efficiency in the use of capital to encourage them and to further reduce environmental problems.

Conflict of Interest

There is no conflict of interest.

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