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Energy Consumption, Co_2 Emissions and Economic Growth: A Causality Analysis for Malaysian Industrial Sector

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ABSTRACT

Malaysia is currently a developing country which is from agriculture based to manufacturing and service-based economy by implementing Industrialisation Plan in 1985. Thus, the country is consuming more energy due to the rapid industralisation hoping to fully transform into a fully industralised country in future. It is decisive for the government to develop policies to minimize energy consumption and reducing CO2 emissions to protect the environment without impairing the economy. The study looks into the causal relationship between real income (Y), energy consumption (EC) and carbon dioxide (CO2) emission in Malaysian industrial sector during the period of 1980-2014, by applying the time-series econometric techniques. Major findings of this paper consists of long-run relationship exists between Y, EC and CO2 emissions; unidirectional causality relationship from EC and CO2 emissions to Y in both short and long-run; and results of the variance decompositions suggest that the impact of Y and EC towards CO2emissions becomes noticeable only over the longer period of time.

Keywords: Industrial Sector, Energy Consumption, Carbon Dioxide Emission
JEL Classifications: L16, Q43, O13

1. INTRODUCTION

In 1985, Industrialisation Plan had been implemented by Malaysian government which incurred a structural shift from an agriculture-based to manufacturing and service-based economy. Due to the manufacturing and service-based economy in Malaysia, Malaysia has high rates of energy consumption (EC) (Lean and Smyth, 2014a). As supported by Islam et al. (2009), Bari et al. (2012) and Lean and Smyth (2014a), the demand for energy in Malaysia had increased rapidly in the past three decades. This status is consistent with the data in Malaysia energy information Hub, which stated that energy demand in industrial sector had been rising for more than 300% from 1985 to 2015. Hence, it is clearly evident that there is a rapid growth in energy demand in Malaysia.

In Malaysia, there is high economic growth, especially the industrial sector contribution was around 38% of the total gross domestic product (GDP) in 2016 (World Bank, 2017). This has been on the back of increasing energy consumption where Malaysia is heavily depending on fossil fuels. Unfortunately, Malaysia's proven oil and natural gas reserves are projected to be depleted in the next 19 and 33 years, respectively, if no alternative measures are found to sustain the reserves (Bekhet and Yusof, 2009). Similarly, Oh et al. (2010) also documented that Malaysia will become a net oil importer country by the year 2030. This situation compels Malaysia to find an alternative energy source to replace the fossil fuels.

Furthermore, the increasing pollution level in Malaysia has awakened researchers' interest in further investigation. Lean and Smyth (2014b) stated that Malaysia has one of the highest rates of greenhouse gas (GHG) emissions in the world. In fact, Malaysia will continue to rely on fossil fuels to meet the growth in its energy demand and intrinsically, its emerging economy is expected to increase the CO_2 emissions. This is because dependence on fossil fuel consumption has caused serious concerns about its effects on the environment. The burning of fossil fuels for energy use increases GHG emissions as well. In addition, Shamsuddin (2012) stated that Malaysia's GHG emissions are expected to increase

74% from 2005 to 2020. In other words, Malaysia is currently facing the challenge of increasing pollution level in the exchange of achieving economic growth.

Therefore, a number of studies (Chen et al., 2007; Tang, 2008; Chandran et al., 2010, Nanthakumar and Subramaniam, 2010; Aziz, 2011; Ismail and Yunus, 2012; Apergis and Tang, 2013; Zakaria and Shamsuddin, 2016; Nuryartono and Rifai, 2017) have analysed the casual relationship either between EC and GDP or between electricity consumption and GDP in Malaysia. Additionally, some authors have extended their analysis to the multivariate setting to include CO_2 emissions (Ang, 2008; Saboori and Sulaiman, 2013; Chandran and Tang, 2013). To the best of researcher's knowledge, the only handful of studies (Ewing et al., 2007; Ray and Reddy, 2007; Hamit-Haggar, 2012, Shahbaz et al., 2014; Al Mamun et al., 2014) focussed on the industrial sector. Bekhet et al. (2016), focused on Malaysia's manufacturing sector and EC in their study. Hence, the gap in the literature has been highlighted in this research study by not only considering manufacturing sector but also including GDP and CO_2 emissions in the model using Malaysia's industrial sector as the case study.

This study aims to investigate the causal interplay between real GDP (Y), EC and CO_2 emissions in Malaysian industrial sector from 1980 to 2014 by using time series data analysis. Furthermore, in this research paper, the line of research was tentatively extended in a multivariate setting to gauge the causal relationship between these variables. To accomplish the objective, rigorous systematic statistical tests of integration, cointegration, causality and dynamic analysis are presented in the current work. In this manner, the robustness of empirical findings in relation to the link between the variables in play could be ascertained.

This research paper is organised as follows: Section 1 provides the detailed introduction and background of this research study, Section 2 describes the empirical approach and data adopted in the paper, Section 3 reports the empirical results and Section 4 concludes the paper.

2. DATA, MODEL AND METHODOLOGY

Annual data covering the period 1980–2014 were used in this study. EC and carbon dioxide (CO_2) emissions in Malaysian industrial sector data were obtained from Asia-Pacific Economic Cooperation (APEC) energy database and for real industry value-added as a share of GDP was obtained from World Bank's World Development Indicators. For our analysis, these variables have been converted to logarithmic form.

For this empirical study, the formula showing the relationship between real GDP, EC and CO_2 emissions in Malaysian industrial sector is given below:

$$Y=f(EC,CO_2) \quad (1)$$

Where, Y is industrial sector's real GDP, EC is EC by industrial sector and CO_2 is carbon dioxide (CO_2) emissions by industrial sector.

This empirical study has two specific objectives. The first objective is to examine the relationship between GDP, EC and CO_2 emissions in the long-run. The second objective is to examine the existence and different directions of causation in the short- and long-run between the variables. The empirical analysis of this study employed unit root tests to test whether the variables contain a unit root. The second step is to test whether there is a long-run cointegrating relationship between the variables, using Johansen and Juselius cointegration test proposed by Johansen and Juselius (1990).

In the presence of cointegration, there always exists a corresponding error-correction representation. In other words, if a vector autoregressive (VAR) system is cointegrated, the Granger causality test (Granger, 1988) must be conducted in the environment of vector error-correction model (VECM). In this study, the three-dimensional VECM systems were determined as follows:

$$\Delta Y_t = \alpha_1 + \sum_{i=1}^{p} \beta_i \Delta Y_{t-i} + \sum_{i=1}^{p} \varnothing_i \Delta EC_{t-i} + \sum_{i=1}^{p} \eta_i \Delta CO_{2t-i} + \lambda_1 ECT_{t-1} + e_{1t} \quad (2)$$

$$\Delta EC_t = \alpha_2 + \sum_{i=1}^{p} \delta_i \Delta EC_{t-i} + \sum_{i=1}^{p} \Upsilon_i \Delta Y_{t-i} + \sum_{i=1}^{p} \omega_i \Delta CO_{t-i} + \lambda_2 ECT_{t-1} + e_{2t} \quad (3)$$

$$\Delta CO_{2t} = \alpha_3 + \sum_{i=1}^{p} \zeta_i \Delta CO_{t-i} + \sum_{i=1}^{p} \vartheta_i \Delta Y_{t-i} + \sum_{i=1}^{p} \theta_i \Delta EC_{t-i} + \lambda_3 ECT_{t-1} + e_{3t} \quad (4)$$

Where Δ denotes the first difference operator, Y_t is real industry value-added as a share of GDP, EC_t is EC in the industrial sector, CO_{2t} is CO_2 emission and ECT is the error-correction term. e_{it} is the disturbance term, p denotes the lag order and λ_i are the coefficients of ECT. From the equations above, there is Granger causality runs from ΔEC to ΔY if the null hypothesis $\varnothing_i = 0\forall_i$ is rejected through a Wald test. Likewise, if the null hypothesis $\eta_i = 0\forall_i$ is rejected implies that there is Granger causality runs from ΔCO_2 to ΔY. On the other hand, causality from ΔY to ΔEC is supported if the null hypothesis $Y_i = 0\forall_i$ is rejected, then ΔCO_2 does not Granger-cause to ΔEC if the null hypothesis $\omega_i = 0\forall_i$ cannot be rejected via a Wald test. The same testing procedure can be applied to examine the causalities from ΔY or ΔEC to ΔCO_2 in Malaysia.

3. EMPIRICAL RESULTS

Before testing for cointegration, it is necessary to ascertain the order of integration for each variable. An ADF test (Dickey and Fuller, 1979) and KPSS test (Kwiatkowski et al., 1992) on the series of Y_t, EC_t and CO_{2t} were conducted. The results which are made available upon request suggest the existence of unit root or non-stationarity in level or *I (1)* for these variables. The findings that the two variables have the same order of integration allowed the researchers to proceed with the Johansen and Juselius (1990) cointegration analysis.

Table 1: Johansen-Juselius cointegration test results

Null	Alternative	λmax		Trace	
		Unadjusted	95% C.V	Unadjusted	95% C.V
		k=1 r=1			
r=0	r=1	30.1174**	21.1316	39.4332**	29.7971
r≤1	r=2	6.2892	14.2646	9.3158	15.4947
r≤2	r=3	3.0266	3.8415	3.0266	3.8415

k is the lag length and r is the cointegrating vector and r is number of cointegrating vectors that are significant under both tests. Asterisks (**) denote significance at 5% level

Table 2: Granger causality test based on VECM

Dependent variables	χ^2-statistic (P-value)			ECT	
	ΔY	ΔEC	ΔCO_2	Coefficient	T-statistic
ΔY	-	4.5441 (0.0330)**	4.9152 (0.0266)**	−0.7736**	−4.3938
ΔEC	2.9302 (0.0869)	-	0.0821 (0.7745)	0.3397	1.2371
ΔCO2	2.2759 (0.1314)	0.0110 (0.9165)	-	−0.5823	−0.6537

"Δ" is the first different operator. Asterisks (**) indicate statistical significance at 5% level. VECM: Vector error-correction model

The cointegration results are presented in Table 1. The null hypothesis of no cointegrating vector (*r = 0*) was soundly rejected at the 5% significance level in Malaysia. However, both null hypotheses of <1 cointegrating vector (*r ≤ 1*) and the null of <2 cointegrating vectors (*r ≤ 2*) cannot be rejected at the 5% significance level. This implies that the Y, EC and CO_2 are cointegrated and there is one cointegrating vector over the long-run.

Results for VECM are portrayed in Table 2. Several short- and long-run causalities evidence were discovered by the present study. The result shows that short-run causality was detected from EC to Y and CO_2 to Y. Moreover, the ECT is statistically significant where it is accepted by Y in Malaysia. Subsequently, the speed of adjustment stood at 77% per year due to the short-run adjustments. So, this implies that Malaysia will need above 1.3 years to adjust back to an equilibrium whenever disequilibrium happens. So, Y functions as the initial receptor of any exogenous shocks that distort the equilibrium system in Malaysian industrial sector. Furthermore, the ECT results show that there is an existence of a long-run causality running from EC and CO_2 to Y. In summary, the findings revealed that there is unidirectional causality relationship from EC and CO2 to Y in both long- and short-run. This causal relationship is consistent with some of the previous studies by Ang (2008), Lean and Smyth (2010), Pao and Tsai (2010) and Alkhathlan et al. (2012).

In earlier part, the granger causality was employed to verify the direction of causality between the variables of interest. Here, it was attempted to gauge the relative strength of the variables and the transmission mechanism responses with respect to a shock. To do so, the forecast error variance decomposition (VDC) analysis was conducted. The innovation of the VDCs are represented in percentage form and strength of the three variables are in the values up to 100%. For the purpose of the analysis, the VDCs were executed using time horizons of 1–48 years. Table 3 reports the relative strength of the causal relationship among Y, EC and CO_2 beyond the sample period with respect to exogenous shock. The major findings are discussed as follows.

Table 3: Variance decomposition test results

Percentage of variations in	Horizon	Due to innovation in		
		ΔY	ΔEC	ΔCO_2
years relative variance in: ΔY	1	100.00	0.00	0.00
	4	60.93	30.05	9.01
	8	56.96	34.30	8.74
	12	55.58	35.69	8.73
	24	54.30	36.97	8.74
	48	53.71	37.55	8.74
Years Relative Variance in: ΔEC	1	24.19	75.81	0.00
	4	43.66	54.94	1.39
	8	42.98	56.35	0.67
	12	42.83	56.70	0.46
	24	42.71	57.01	0.28
	48	42.65	57.16	0.19
Years relative variance in: ΔCO_2	1	0.02	19.11	80.87
	4	4.11	37.34	58.55
	8	5.32	44.81	49.88
	12	5.75	47.49	46.76
	24	6.18	50.20	43.62
	48	6.40	51.55	42.05

The column in bold represents their own shock

EC is the most exogenous variable and CO_2 seems to be the most endogenous variable in the system. In the case of CO_2, the VCDs show that almost 58% of the forecast error variance can be explained by Y (6%) and EC (52%) at the end of the 48 years horizon. This provides for strong direct causality originating from Y and EC to CO_2 on the entire forecast horizon. Although this is not in line with causality interplay, it provides the view beyond the sample period, an important indication from policy impetus in Malaysia.

4. CONCLUDING REMARKS

This paper investigated the causal relationship between real income, EC and CO_2 emissions in Malaysian industrial sector during the period 1980–2014. Applying cointegration and Granger causality based on VECM, it was found that there is unidirectional causality running from EC and CO_2 to Y in both long- and short-run. The evidence seems to suggest that a reduction in EC can be harmful to Malaysia's economic growth in the industrial sector. In addition, the causality relationship from CO_2 emissions to Y indicated that the decline in environmental quality may exert negative externalities to the economy. The negative externalities will adversely affect the tourism sector and also affect human health and thereby reducing nation productivity and growth in the long-run.

A complete picture emerged when VDCs were executed where Y and EC explained the innovation in CO_2 in the 48 years forecast horizon. The evidence seems to suggest that CO_2 emissions in Malaysia will depend on Y and EC in the future. Certainly, Malaysia will consume more energy due to rapid industrialisation which is required to become a fully industrialised country in future. Generally, the energy that is generated by fossil fuels (natural gas, coal and oil) causes environmental pollution and as for Malaysia, this situation is like several other developing countries. Therefore, Malaysian government should develop policies that aim at minimising EC and reducing CO_2 emissions to protect the environment for future generations without impairing the economy.

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