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AN EMPIRICAL ANALYSIS OF CO_2 EMISSION AND SOCIOECONOMIC FACTORS NEXUS: IS THE LONG RUN CO-INTEGRATING RELATIONSHIP EXIST IN MALAYSIA?

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Abstract. One of the most crucial environmental and economic issue was the rising trend of carbon dioxide emission that leads to climate change. Malaysia is one of the highest contributors of carbon dioxide emission relative to its neighbouring countries in Southeast Asia. The inability to curb the upward trend will harm the environment and cause a threat to public health. Using a time series data from 1980 until 2017, this study investigates the long run equilibrium relationship between socioeconomic factors namely economic growth, energy consumption, renewable energy consumption and population with carbon dioxide emission in Malaysia. The findings showed that there is a long run cointegrating relationship between the socioeconomic factors and carbon dioxide emission in Malaysia. Whereas, the Granger causality indicates that there exists a bidirectional causality running from energy consumption to CO_2 emission and a unidirectional causality running from CO_2 emission towards population, but there is no causality link between economic growth and renewable energy consumption with CO_2 emission. Since any activities of these variables could influence the level of CO_2 emission, apparently the key recommendation for Malaysia is to adopt the use of renewable energy.

Keywords: Economic Growth, Energy Consumption, Renewable Energy Consumption, Population, Carbon Dioxide Emission

Introduction

Climate change has been a major concern in every country including Malaysia as it is believed to be the biggest threat on environmental security in a country (Vijayavenkataraman et al., 2012). This can be observed through the changes in the ecosystems, supplies of freshwater and human health. While climate change cannot be completely avoided, the most severe impacts of climate change can be evaded through significantly reducing the amount of heat-trapping gases released to the atmosphere. Malaysia is one of the highest carbon dioxide (CO_2) emission per capita in comparison of its neighbouring countries in Southeast Asia. This might indicate that Malaysia is relying heavily on non-renewable resources to generate the economic activities as a way to achieve the target high–income economy. If this is so it would also mean that there will be an expected prolong increase of energy demand for consumption purpose. When this is still occurring, the carbon dioxide emission is expected to increase further (Tan & Tan, 2018). Moreover, the existing oil and gas reserves are expected to extinct if no alternative reserves are identified beside it being a threat to the public health.

There is a burgeoning literature about economic growth, energy consumption, renewable energy consumption, population with carbon dioxide emission. The literature of carbon dioxide was conceptualized under I=PAT Model. I=PAT Model is basically a formula to explain the impact of activities by human towards the environment where the equation starts with I and I represents the impact of human activities, P is the population, A is basically an Affluence and T is Technology. The equation was created in 1970 where Ehrlich and Holdren planned a simple equation and involving a conversation with commoner in identifying three factors that created environmental impact (Chertow, 2000). The equation can help to understand some of the factors that affects the impact of human activities to the environment (Chertow, 2001).

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A lot of previous researches investigate whether the economic growth, energy consumption, renewable energy consumption, population and the carbon dioxide emissions are related with each other. Generally, the results are usually varied and contradicted. Study by Ozturk & Al-Mulali (2015) found that there is no causality between economic growth (GDP) and CO_2 in Turkey. This research explores the causal nexus between the use of natural gas resources and economic growth where the study included the trade openness, total labour force and gross fixed capital formation at countries in the Gulf Cooperation by using panel data. On the other hand, a study using time series data by Pao & Tsai (2011), found a one-way causality relationship and a long run positive relationship between GDP and carbon dioxide emissions in Brazil. This study indicates that the causal relationship is functioning in two directions where both variables are causing and affecting each other. Another study by Kasman & Duman (2015) saw a unidirectional panel causality running from energy consumption to carbon dioxide emissions. This result is also supported by Wang, Li, Fang, & Zhou (2016), that there is a one-way causal relationship between energy consumption and carbon dioxide emission in China from 1990 to 2012.

Farhani & Shahbaz (2014) carried out a research between renewable and non-renewable electricity consumption, output and carbon emissions for ten MENA countries using data from 1980 to 2009. They found in the short-run there is a two-way causality running from renewable and non-renewable electricity consumption and output to CO_2 emissions but in the long-run, the result shows that there is a bidirectional causality link between electricity consumption (renewable and non-renewable) with CO_2 emissions. A recent study by Rahman (2017) examines the nexus between carbon dioxide emissions, energy use, economic growth, exports and population density for eleven Asian countries from 1960 to 2014. Employing the panel cointegration tests and panel Granger causality to identify whether the variables are related to each other. The results indicate that energy use, exports and population density had negatively influenced environmental quality in the long run. Apart from that, there is a one-way Granger panel causality in the short run starting from energy consumption, gross domestic product and exports to carbon dioxide emissions, from energy consumption and exports to GDP, from exports to energy consumption, from population density to exports, and a two-way causality link between GDP and population density. Alam et al. (2016) utilized the ARDL bounds test technique to investigate the impacts of income, energy consumption and population growth on carbon dioxide emissions from 1970 to 2012 for emerging countries namely China, Indonesia, Brazil and India. Their findings show that carbon dioxide emissions in the four countries have risen significantly and aligned with increases in income and energy consumption. While the relationship between carbon dioxide emission and population has been found to be important for India and Brazil, but insignificant for China and Indonesia.

Fundamentally, the increasing trend of carbon dioxide emission is already a problem, the failure of controlling the problem is the critical issue. The increase of population, the consumption of energy by the nations, bad choices of technologies and the social arrangements to supply the consumption have led to environmental problems (Ehrlich, 2014). Hence, this paper aims to investigate the nexus between four socioeconomic variables which are economic growth, energy consumption, renewable energy consumption, and population with carbon dioxide emission specifically in Malaysia from 1980 to 2017. It is critical: i) to examine the long run cointegration relationship between economic growth, energy consumption, renewable energy consumption, population and CO_2 emissions in Malaysia; and ii) to identify the causality link between these variables and CO_2 Emissions in Malaysia.

Method

The study will apply the Johansen Cointegration and Granger Causality tests to investigate the linkage between socioeconomic factors with carbon dioxide emission. The analysis will begin with the unit root test to determine the stationary status of the data based on the Augmented

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Dickey Fuller (ADF) and Phillips-Perron (PP) statistical tests. The initial economic function is shown as:

$$CO_2 = f\,(GDP, EC, REC, POP)$$

Where CO_2 = carbon dioxide

GDP = Gross Domestic Product/economic growth

EC = energy consumption

REC = renewable energy usage

POP = population

The econometric equation to analyze is:

$$\ln CO_{2t} = \beta_0 + \beta_1 \ln GDP_t + \beta_2 \ln EC_t + \beta_3 \ln REC_t + \beta_4 \ln POP_t + \varepsilon_t$$

Where β_0 is constant; $\beta_1, \beta_2, \beta_4 > 0$ *and* $\beta_3, < 0$

ln = natural log

t = 1980-2017

ε = disturbance term

The equation to test the existence of unit root is shown by:

$$\Delta Y_t = \beta_0 + \beta_1 T + \beta_2 Y_{t-1} + \;\; + \varepsilon_t$$

Where Δ refers to the change in Y and Y is the natural logarithm of the five variables (CO_2, GDP, EC, REC & POP), β_0 is constant whereas T is the trend. Parameters β and Ψ are estimated, and ε denotes the disturbance term. Once the variables integrated order is determined, the appropriate model could be identified.

Based on the results shown in Table 2, the variables were stationary at I(1), suggesting that they will achieve equilibrium in the long run. In theory, the existence of a cointegrating relationship would mean these variables have a common trend. Thus, Johansen and Juselius test is the suitable technique and the equation is stated as:

$$\Delta y_t = \mu + \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t$$

Where $\Pi = \sum_{i=1}^{p} A_i - I$ and $\Gamma_i = -\sum_{j=i+1}^{p} A_j$

y_t refers to the set of variables i.e. CO_2, GDP, EC, REC and POP that are stationary at I(1). The number of cointegrated variables, r, is fixed by both maximum eigenvalue and the trace tests. However, the cointegration test could only determine the long run relationship among these variables, but the direction of their causal relationship would not be identified.

Thus, the Granger causality test is employed to determine the direction of the relationship among the variables to indicate whether unidirectional, bidirectional or no causal direction. One example of Granger causality regression is shown as:

$$LCO_{2t} = \square_0 + \sum_{i=1}^{m} \beta_{1i} LGDP_{t-i} + \sum_{i=1}^{m} \beta_{2i} LEC_{t-i} + \sum_{i=1}^{m} \beta_{3i} LREC_{t-i} + \sum_{i=1}^{m} \beta_{4i} LCO_{2t-i} + \sum_{i=1}^{m} \beta_{5i} LPOP_{t-i} + \square_{1t}$$

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Discussion and Result

The discussion begins with a preliminary testing to describe the characteristics of the data using a descriptive analysis as shown in Table 1. Generally, since the result rejected the null hypothesis of the *p*-value of Jarque Bera, it implies that the data for all variables are non-normal except the data for renewable energy. Hence, it is best that the variables should be analyzed in the form of natural log.

Table 1. Descriptive Statistics

Variables	CO_2 (mtoe)	GDP (constant LCU)	EC (mtoe)	REC (mtoe)	POP (million)
Mean	129263	586296674857	21.42	1.61	22692105263
Median	117700	536475125902	20.29	1.32	22622000000
Std. Dev.	77974	337698125668	14.26	1.13	5632313934.7
Jarque Bera	3.486	2.7776	3.84	99.8	2.5869
Probability	0.175	0.2494	0.15	0.00	0.2743
Observation	38	38	38	38	38

The analysis proceeds by running the stationarity test for all variables using the ADF and PP statistics that include constant and intercept. Table 2 reveals that the variables become stationary at the first order-differencing I(1) significant at 1% level of significance. Consequently, it confirms that the null hypothesis is rejected implying the variables can cointegrate.

Table 2. Unit Root Test

Variables	Unit root based on level I(0)		Unit root based on first difference I(1)	
	ADF	PP	ADF	PP
LCO_2	0.9934	0.9964	0.0411**	0.0017***
LGDP	0.7978	0.8402	0.0131***	0.0015***
LEC	0.8357	0.9915	0.0000***	0.0000***
LREC	0.3616	0.6584	0.0105***	0.0025***
LPOP	1.0000	1.0000	0.4719	0.0014***
† $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$				

Next, before testing the presence of a long run cointegrating relationship, a series of nested likelihood ratio tests is utilized to decide the optimum lag length for the estimations. The lag length was given as two (2) and eventually the analysis in Table 3 illustrates only the result from the trace statistics. It is advised to focus more on trace statistics as it considers all the small eigenvalues compared to the Max-Eigen statistics (Lütkepohl et al., 2002). Hence, the analysis found that the number of cointegrating variables is two (2).

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Table 3. Co-integration Test based on Trace Statistics

Hypothesized Number of Cointegrating equations	Eigenvalue	Trace Statistics	Critical Value at 0.05	*p*-value
None*	0.658544	86.9536	69.81889	0.0012
At Most 1*	0.493455	48.27038	47.85613	0.0457

Trace test indicates 2 cointegrating equation at the 0.05 level

* denotes rejection of the null hypothesis at the 0.05 level

** MacKinnon-Haug-Michelis (1999) p-values

The result specifies the five series GDP, EC, REC, POP and CO_2 emission have two (2) cointegrating equations indicating that there is a long run relationship among the variables. The evidence of cointegrating could suggest that the causality might exist at least in one direction but the direction of the causal relationship is not indicated. Thus, to identify the direction the analysis needs to conduct the Granger Causality test.

Table 4 portrays that there is no causality between GDP and CO_2 emission meaning GDP does not granger cause CO_2 and CO_2 does not granger cause GDP. This finding is supported by Ozturk & Al-Mulali (2015) for Turkey and Gorus & Aydin (2019) MENA countries. On the other hand, there is a bidirectional causality running from energy consumption (EC) to CO_2 emission and vice versa. This specifies that EC grangers cause CO_2 and CO_2 grangers cause EC. The result is similar to the study by Saboori & Sulaiman (2013) on five ASEAN countries for the period 1971 to 2009.

Table 4. Granger Causality Test

	F – statistics
LGDP does not granger cause LCO_2	0.0869
LCO_2 does not granger cause LGDP	0.0622
LEC does not granger cause LCO_2	3.8313**
LCO_2 does not granger cause LEC	3.3785**
LREC does not granger cause LCO_2	1.1965
LCO_2 does not granger cause LREC	1.9431
LPOP does not granger cause LCO_2	0.8765
LCO_2 does not granger cause LPOP	2.9200***
† $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$	

For renewable energy, the result proves that there is no causality linking renewable energy (RE) to CO_2. Thus, REC does not granger cause CO_2 and CO_2 does not granger cause REC. Similar result is obtained by Apergis et al., (2010) using a panel error correction model. There is a unidirectional causality running from CO_2 emission towards population (POP) which is CO_2 granger cause POP not vice versa. This finding is supported by Asumadu-Sarkodie & Owusu (2016) research on Ghana in the year 1971 to 2013.

Conclusion

This paper reveals the Johansen cointegration test has proved that a long run cointegration relationship exists between economic growth, energy consumption, renewable energy

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consumption, population and CO_2 emission in Malaysia. From the Granger causality test, it indicates that there is a bidirectional causality running from energy consumption to carbon dioxide emission. However, a unidirectional causality can be found running from carbon dioxide emission towards population but no causality link between economic growth and renewable energy consumption with carbon dioxide emission.

Henceforth, there are two key recommendations from this research. First, since this study found that a long run cointegration relationship among these variables and carbon dioxide emission exist in Malaysia, it is apparent that any of these activities would result in worsening the sustainability of the environment and a threat to public health. The best way to ensure economic growth could be sustained and simultaneously carbon emission could be controlled is that Malaysia could adopt the usage of renewable energy to gradually replace the fossil fuel. Moreover, these fossil fuels energy such as petroleum and coal are expected to deplete in the future thus alternatives energy must be identified to maintain the sustainability of energy supply. Eusoff (2019) found renewable energy in Malaysia has only contributed 2% in year 2019 and expected to increase to 18% in year 2030.

Second, Malaysia need to invest on the technology used in renewable energy in order to achieve economic growth sustainability. When Malaysia able to adopt the renewable energy early, it will help the industry to become more competitive which eventually help to increase the nation's income. Additionally, this new industry can create more job opportunities which will boost further Malaysia's economy. It is undeniable that the cost to set up the renewable energy is costly at early stages, but the investment will provide a better return in the long run and more critical, it does not emit carbon dioxide or harm the environment.

References

Alam, M. M., Murad, M. W., Noman, A. H. M., & Ozturk, I. (2016). Relationships among carbon emissions, economic growth, energy consumption and population growth: Testing Environmental Kuznets Curve hypothesis for Brazil, China, India and Indonesia. *Ecological Indicators*. https://doi.org/10.1016/j.ecolind.2016.06.043

Apergis, N., Payne, J. E., Menyah, K., & Wolde-Rufael, Y. (2010). On the causal dynamics between emissions, nuclear energy, renewable energy, and economic growth. *Ecological Economics*. https://doi.org/10.1016/j.ecolecon.2010.06.014

Asumadu-Sarkodie, S., & Owusu, P. A. (2016). Carbon dioxide emissions, GDP, energy use, and population growth: a multivariate and causality analysis for Ghana, 1971–2013. *Environmental Science and Pollution Research*. https://doi.org/10.1007/s11356-016-6511-x

Chertow, M. R. (2000). The IPAT Equation and Its Variants. *Journal of Industrial Ecology*. https://doi.org/10.1162/10881980052541927

Chertow, M. R. (2001). The IPAT equation and its variants: Changing views of technology and environmental impact. In *Journal of Industrial Ecology* (Vol. 4, Issue 4, pp. 13–29). https://doi.org/10.1162/10881980052541927

Ehrlich, P. R. (2014). Human impact: The ethics of I=PAT. *Ethics in Science and Environmental Politics*. https://doi.org/10.3354/esep00151

Eusoff, N. S. (2019). Malaysia sets new goal of 20% clean energy generation by 2030. *The Edge Markets*.

Farhani, S., Chaibi, A., & Rault, C. (2014). CO_2 emissions, output, energy consumption, and trade in Tunisia. *Economic Modelling*. https://doi.org/10.1016/j.econmod.2014.01.025

Kasman, A., & Duman, Y. S. (2015). CO_2 emissions, economic growth, energy consumption, trade and urbanization in new EU member and candidate countries: A panel data analysis. *Economic Modelling*. https://doi.org/10.1016/j.econmod.2014.10.022

Lütkepohl, H., Saikkonen, P., & Trenkler, C. (2002). Maximum eigenvalue versus trace tests for the cointegrating rank of a VAR process. *The Econometrics Journal*, *4*(2), 287–310. https://doi.org/10.1111/1368-423X.00068

Ozturk, I., & Uddin, G. S. (2012). Causality among carbon emissions, energy consumption and growth in India. In *Ekonomska Istrazivanja*. https://doi.org/10.1080/1331677X.2012.11517532

Pao, H. T., & Tsai, C. M. (2011). Multivariate Granger causality between CO_2 emissions, energy consumption, FDI (foreign direct investment) and GDP (gross domestic product): Evidence from a panel of BRIC (Brazil, Russian Federation, India, and China) countries. *Energy*. https://doi.org/10.1016/j.energy.2010.09.041

Rahman, M. M. (2017). Do population density, economic growth, energy use and exports adversely affect environmental quality in Asian populous countries? In *Renewable and Sustainable Energy Reviews*. https://doi.org/10.1016/j.rser.2017.04.041

Saboori, B., & Sulaiman, J. (2013). CO_2 emissions, energy consumption and economic growth in association of Southeast Asian Nations (ASEAN) countries: A cointegration approach. *Energy*. https://doi.org/10.1016/j.energy.2013.04.038

Tan, C. C., & Tan, S. (2018). Energy consumption, Co2emissions and economic growth: A causality analysis for Malaysian industrial sector. *International Journal of Energy Economics and Policy*.

Vijayavenkataraman, S., Iniyan, S., & Goic, R. (2012). A review of climate change, mitigation and adaptation. In *Renewable and Sustainable Energy Reviews*. https://doi.org/10.1016/j.rser.2011.09.009

Wang, S., Li, Q., Fang, C., & Zhou, C. (2016). The relationship between economic growth, energy consumption, and CO_2 emissions: Empirical evidence from China. *Science of the Total Environment*. https://doi.org/10.1016/j.scitotenv.2015.10.027