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Evidence of Electricity Consumption Lead Climate Change in Malaysia

(Bukti Penggunaan Elektrik Memimpin Perubahan Iklim di Malaysia)

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ABSTRACT

The consumption of electricity in Malaysia increase in demand as one of the driving forces of economic development. The main source of electric power generation in Malaysia depends on fossil fuels which lead to air pollution currently and a shortage of natural resources (fossil) in the future if this method continues. Moreover, this will cause a serious problem such as sustainability of energy choice and will harm the environment. This study investigates the relationship between climate variables and electric power consumption in Malaysia. The important climate variables included such as average temperature, average rainfall, forest area, carbon dioxide emission and arable land over a period of 1991 to 2015. Augmented Dickey-Fuller unit root test shows that average rainfall, average temperature, and electrical power consumption stationary at their level. However, forest area, carbon dioxide emission, and arable land stationary after first differences. The result of this study indicates that electric power consumption has a long-run relationship between average temperature and average rainfall. This indicates that electric power consumption has an impact on climate change in Malaysia. These studies also find evidence that unidirectional causality between electric power consumption and climate factors. Overall, the wise consumption of electricity and adopting renewable energy to generate electricity will reduce carbon emission in Malaysia.

Keywords: Energy consumption; electricity consumption; climate change; carbon emission; global warming

ABSTRAK

Penggunaan elektrik di Malaysia meningkatkan permintaan sebagai salah satu daya penggerak pembangunan ekonomi. Sumber utama penjanaan tenaga elektrik di Malaysia bergantung pada bahan bakar fosil yang menyebabkan pencemaran udara dan kekurangan sumber daya alam (fosil) pada masa akan datang jika kaedah ini terus berlanjut. Selain itu, ini akan menyebabkan masalah serius seperti pemeliharaan pilihan tenaga dan akan merosakkan alam sekitar. Kajian ini menyiasat hubungan antara pembolehubah iklim dan penggunaan tenaga elektrik di Malaysia. Pembolehubah iklim yang penting termasuk suhu purata, hujan purata, kawasan hutan, pelepasan karbon dioksida dan tanah pertanian sepanjang tempoh 1991 hingga 2015. Ujian akar unit Dickey-Fuller yang dipertingkatkan menunjukkan bahawa purata hujan, suhu purata dan penggunaan kuasa elektrik bergerak di tahap mereka. Walau bagaimanapun, kawasan hutan, pelepasan karbon dioksida dan tanah subur tidak bergerak selepas perbezaan pertama. Hasil kajian ini menunjukkan bahawa penggunaan kuasa elektrik mempunyai hubungan jangka panjang antara suhu purata dan penurunan hujan purata. Ini menunjukkan bahawa penggunaan tenaga elektrik mempunyai kesan terhadap perubahan iklim di Malaysia. Kajian-kajian ini juga mendapati bukti bahawa kausaliti antara satu sama lain antara penggunaan tenaga elektrik dan faktor iklim. Secara keseluruhan, penggunaan bijak elektrik dan menyesuaikan tenaga boleh diperbaharui untuk menjana elektrik akan mengurangkan pelepasan karbon di Malaysia.

Kata kunci: Penggunaan tenaga; penggunaan elektrik; perubahan iklim; pengeluaran karbon; pemanasan global

INTRODUCTION

Malaysia, a small emerging nation situated near the Equatorial region in South East Asia, is characterised by a hot and humid climate. On average, the country records a rainfall of 250 centimetres in a year, while the average temperature is 27^{o}C (DOS 2013). Since the past decade, climate change and global warming have emerged as critical issues across the world. According to the Intergovernmental Panel on Climate Change (IPCC), the global temperature tend rise between 2.5 up to 10 degrees Fahrenheit over the next century. Most of the climate scientists believe that the present global warming issue is man-made, primarily triggered by the emission of carbon dioxide into the environment. A direct relationship is said to exist between climate change and consumption of energy (Fodha & Zaghdoud 2010; Tajudeen et al. 2014).

In 2009, Malaysia's demand for energy stood at 16,132 MW, as against 9690 MW ten years ago (The Ninth Malaysia Plan). There was been about 66.5 percent increase in the demand, driven by the high rate of economic progress. Indeed, there is growing concern in the Malaysian government on the sustainable energy consumption with introduction of The Malaysian Code of Practice on Energy Efficiency and Use of Renewable Energy for Non Residential Building, MS 1525:2007 (Kamaluddin et al. 2016). The populace of the country was 25.4 million in 2009. Around 75 percent of the populace is predicted to live in urban regions by 2020, and the overall populace would be almost twice as much since 1980 (MOH 2005). Rate of population is under 3 percent annually. While the rate of electricity consumption up to 19.5% in the early of 80an. In the past 28 years, key energy utilisation has risen 6.8 percent on average, while utilisation of electricity has increased 9.2 percent every year (The Ninth Malaysia Plan).

Literature on energy has widely debated on issues such as the kind of causal relationship between average rainfall and temperature, carbon dioxide discharge, forest area, and cultivable land (Fodha & Zaghdoud 2010). There is not much evidence associating particular behaviour changes to measured energy utilisation (Shah 2017). For instance, Ong and co-researchers appraised the energy situation and sustainable usage of energy in Malaysia (Ong 2011). Ali and Shekarchian offered a synopsis of the present and prospective energy sources for generating electricity (Ali 2012). Chua and Oh assessed the country's national energy development by presenting strategic policies, programs, agencies, and international relations (Shekarchin et al. 2011). Considering the dearth of methodical links between climate change variables such as rainfall, temperature, carbon dioxide discharge, forest area and cultivable land, and consumption of energy in Malaysia, more studies are needed to offer a more all-inclusive and profounder comprehension of the country's energy requirement and utilisation (Ahmad et al. 2016; Shah 2017).

Yet, as population and income increase causes increase in demand for electricity consumption in Malaysia (Tan et al. 2013). Nevertheless, the study conducted by Puay (2015) shows that has relationship between Malaysia gross domestic product (GDP) and climate change. Indeed, the short-run economic growth of Malaysia is dependent on the ability to generate more energy to support the nation's development (Olatunji 2014). Add with Mahlia (2002) reported that electricity generation company has produced large emission in Malaysia. Objective of this study is to investigate the relationship between climate variables and electric power consumption.

First, the climate change affects consumption of energy. The contributory impact of discharges owing to the burning of fossil fuels on climate change is firmly established. However, warmer weather and hotter summers are bound to impact utilisation of energy and patterns of production (Pielke et al. 2002).

Current literature covering the effect of weather on the utilisation of energy has majorly focused on particular fuels – by and large, residential electricity – at the domestic level. Although this study is in line with this literature, it distinguishes itself with regards to how variability in the climate should be gauged. It also ascertains which functional form is more apt for encapsulating the relationship between temperatures, demand for energy, and forest, land and carbon (CO_2) variable factors.

It is widely reckoned that the climate will affect energy consumption by changing consumers respond in the both short run weather shocks (the intensive margin) and in the long run adjustment (Auffhammer & Mansur 2014). During the warmer days, it is expecting higher cooling demand, which would lead to increased electricity consumption while the cold winter days would result in decreased heating demand, and drive down natural gas, oil and electricity demand (Auffhammer & Mansur 2014; Azhar et al. 2014). Similarly, Mansur et al. (2008) found that warmer summers result in more electricity and oil consumption compared to warmer winters with less natural gas consumption for households. Besides households, the weather and temperature also influences energy utilization of Commercial buildings (Chowdhurya & Khan 2017; Giang et al. 2017). Private commercials seem to increase electricity consumption and decrease oil consumption as temperatures increase (Mansur et al. 2008). There are several evidences found to be influencing the climate that eventually lead to the intensive growth of electricity consumption in Malaysia.

Tangang et al. (2006), who studied interannual variability of surface temperature in Malaysia found that significant warming trends in surface temperatures between 2.7–4.0c/100 years in most regions in Malaysia during the last 42 years between 1961 and 2002. Manton et al. (2001) conducted a study on daily temperature and rainfall in the Southeast Asia and the South Pacific using 38-year period data. The results found a significant increase in the yearly number of hot days and warm nights, with significant decreases in the annual number of cool days and cold nights across the observed countries especially in the Southeast Asia region. According to Karl et al. (1999), the number of rain days with at least 2 mm of rain has decreased significantly throughout Southeast Asia.

In the case of Malaysia, it was found that there was significant decrease in rain days in the most of the observed region except in Kuching. Although there were no significant trends in extreme rainfall, the frequency of cool days and cold nights has been significantly declining in Malaysia. This was mainly due to the El Nino-Southern Oscillation (ENSO) and highly influencing the interannual differences in the rainfall (Nicholls et al. 2005; Tangang 2001; Tangang & Juneng 2004, 2005; Juneng & Tangang 2005). Despite of warming trends between first two quarter and the last quarter of a year, all regions in Malaysia experience uniform warming especially between October and march and continuing until the month of June during the El-Nino event. There are several other empirical findings also approving the apparent uniform warming throughout Malaysia (Newell & Wu 1992; Yulaeva & Wallace 1994; Wu & Newell 1998; Soden 2000; Chiang & Sobel 2002).

Although climate change has been the central discussion in the energy consumption, we should not disqualify other factors that would have influencing electricity consumption. Unlike the findings on economic analysis of the impact of climate change in Trinidad and Tobago, the temperature variance is not a significant determinant of domestic consumption of energy, electricity in the short run (Economic Commission for Latin America and the Caribbean – 2011). Economic growth or the GDP growth found to the single major determinant of electricity consumption in the short-run while the combination of temperature, GDP, and patterns of electricity use, jointly determine electricity consumption in the long run.

However, Bigano et al. (2006), who studied the energy consumption of the industrial, residential, and service sectors of about 26 OECD countries, were able to differentiate among five different fuel types. They observed significant effects on temperature only for the energy demand of the residential sector. Temperature changes did not have a significant influence on the energy use of the service and industrial sectors. Bessec and Fouquau (2008) conducted a study that focused on the total electricity use in the EU-15. They did not distinguish among the specific sectors. The only study that had a global scope – since it involves a heterogeneous group of countries from around the world – was conducted by De Cian et al. (2007). Their analysis was restricted to the residential sector but it involved five non-OECD and 31 OECD countries, thus covering a greater variety of climate zones and development levels than previous studies. They were able to examine heating and cooling demands and how they respond to temperature changes based on season, region, and fuel type.

Second, the consumption of energy and the forest has relationship. 'The International Year of Forests' was observed in 2011. This event brought back focus on the concerns faced by forests across the globe. Forests, which are spread across 33 percent of the planet's land mass (around 3.9 billion hectares), offer several environmental advantages, including their significant role in the hydrologic cycle and avoidance of unfavourable changes in climate, and preservation of soil as well as biodiversity (Sheram 1993).

It is projected that the actual forest cover was around six billion hectares (Bryant et al. 1997). Forests are among the key terrestrial bionetworks (Pan et al. 2013), crucial for all living organisms and activities. Of the total forest area, over 1.5 billion hectares (around 12 percent) is utilised for cultivating crops (FAO 2017). The changes to land cover have resulted in deforestation, one of the major concerns that have surfaced in recent times. Deforestation has considerably affected the surface of the planet, particularly through degradation of soil (FAO, 2017). As noted by Pan et al. (2013), forests significantly impact the climate cycle and other biodiversity activities in comparison to other biomes on the earth.

As per Millennium Ecosystem Assessment (2005), the overall forest land across the world has been projected to have decreased by half. Elimination of tropical forests can trigger several unfavourable impacts like soil dilapidation, reduction in soil organic carbon that is harmful to biodiversity and change in climate (Mahapatra & Kant 2003; Mohamed et al. 2015)

Forests encompass around 30 percent of the land mass of the world. Huge plots of forests are being destroyed because of deforestation (FAO 2017). If this continues at the present rate, no rainforests will be left after 100 years. Over 1.5 billion tons of carbon dioxide is said to be discharged annually because of cutting and burning of woodlands. On account of thousands of square miles of woodlands being destroyed every year (around 46–58,000), several of the world's largest carbon sinks are shrinking considerably (Millennium Ecosystem Assessment 2005). In other words, less of the atmospheric carbon dioxide is getting transformed back to oxygen through photosynthesis, which is already affecting our climate severely. Carbon dioxide is the key impact of deforestation. High quantity of greenhouse gases in the air indicates that an increasing amount of heat is being trapped, increasing the average temperature of the planet (global warming) and triggering several cumulative impacts. Empirical study of Hassan and Salleh (2016) had found that northern, central, and southern region of peninsular Malaysia had become less cold between 1994 and 2013. The rising temperature due to global warming and rapid development was also significant in the urban areas in Malaysia since 1970s Ahmad et al. (2016), Hashim (2010). Rapid deforestation and poor building constructions planning may directly influence soil temperature as buildings were indirect heat source for surrounding soil (Zhou et al. 2016).

Third, the empirical studies related to carbon CO_2 emission and climate change has been one of the major interest among the researchers as a result of global concern. Often, the two most common strand of literatures on economic growth and environment attempt to address the causal relationship between economic growth-CO_2 and economic growth-energy consumption. Literatures relating CO_2 and energy consumption and economic growth seem to be relatively new among the scientific community (Lean & Smyth 2010).

A number of studies had found unidirectional Granger causality between energy consumption to pollution emissions in the long run (Soytas et al. 2007; Soytas & Sari 2009). The rapid economic development and the increase of energy consuming information and communication technology (ICT) equipment and gadgets particularly in the region of ASEAN region has been the major contributor to the increase in the CO_2 (Leen & Smyth 2010). According to the ASEAN Centre for Energy, energy consumption in ASEAN is expected to increase from 200 million tons of oil equivalent (MTOE) in 2000 to approximately 580 MTOE in 2020 (Lean & Smyth 2010). Ironically, Thavasi and Ramakrishna (2007), Ang (2007) and Apergis and Payne (2009) suggest a causal link running from CO_2 emissions to electricity consumption.

Leen and Smyth (2010) found that 1% increase in electricity consumption per capita will results in the largest increase in per capita carbon dioxide emissions of 0.72% in Malaysia, compared to the 0.51% average among the other ASEAN-5 countries. Apart from that, evidence found by Wahid et al. (2013) also indicates there were unidirectional causality link from CO_2 emission to energy consumption and economic growth in Malaysia. Thus, continues increase in energy consumption as a result of changing industrial input will intensify CO_2 emission in Malaysia (Chik & Rahim 2014)

Nevertheless, according to the prevailing literatures, carbon emission policies does not imply that CO_2 does not result in GDP growth in the long run but the potential adversity of GDP growth on CO_2 (Bella et al. 2014). It was found that there is no independent linear relationship between GDP, CO_2 and energy consumption in a group of OECD countries (Bella et al. 2014).

METHODOLOGY

This study used annual time series data covering the time period from 1991 to 2015 for Malaysia. The data divides in to three categories of variables such as energy consumption variable which is measured by electric power consumption; atmospheric variables included average rain, average temperature and carbon dioxide emission topographic variables such as forest area and arable land. The data set of the variables taken from World Development Indicator which publish in World Bank website.

The effect of energy consumption in climate change already investigated various studies (Dale 1997; McMichael et al. 2007; Harry & Morad 2013; Holmes & Reinhart 2013; Akmat et al. 2014). However, two new variables consider for this study such as average temperature and average rainfall. A simple theoretical model has been extracted from previous studies to show energy consumption and climate variables are shown in Figure 1.

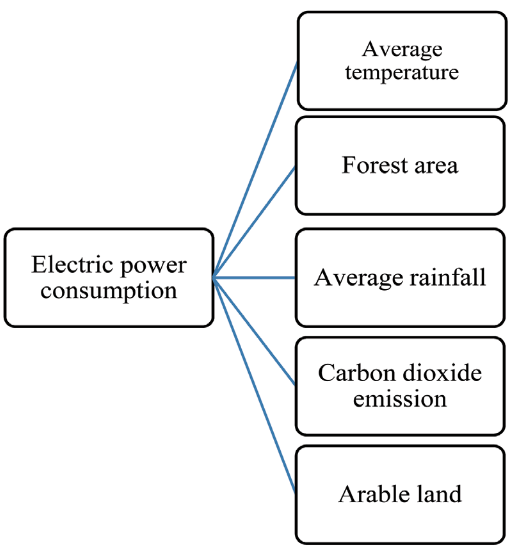

FIGURE 1. Research framework for energy and climate change variable

This study adapted and developed model based on Akmat et al. (2014) in the context of five broad regions of the world. The same model with added with average rainfall and temperature to use to investigate the relationship between energy and climate variable as follows in Equation (1):

$$\ln(EPC)_t = \beta_0 + \beta_1 \ln(RAIN)_t + \beta_2 \ln(TEMPATURE)_t + \beta_3 \ln(FOREST)_t + \beta_4 \ln(CO2)_t + \beta_5 \ln(ARABLELAND)_t + \varepsilon_t \quad (1)$$

Where β_0 represents intercept, $\beta_1 - \beta_5$ are the slope of the respective variables, ln (EPC) is the natural logarithm of electric power consumption, ln (RAIN) is the natural logarithm of average rainfall, ln (TEMPATURE) is the natural logarithm of average temperature, ln (FOREST) is the natural logarithm of forest area, ln (CO_2) is logarithm of carbon dioxide emission and ln (ARABLELAND) is logarithm of arable land and ε is error term. The dependent and independent variables used in this study listed in Table 1.

TABLE 1. List of variables

Variables	Measurement	Expected sign	Data source
Dependent variable: energy consumption	Kilo watt hour (kWh) per capita	Positive	World bank
Independent variables:			
Average temperature	Celsius (°C)	Positive	World bank
Average rainfall	Millimetre (mm)	Negative	World bank
Forest area	% of land area	Positive	World bank
Carbon dioxide emission	Total emission	Positive	World bank
Arable land	% of land area	Positive	World bank

The yearly time series secondary data for electric power consumption, Average temperature, Average rainfall, Forest area, Carbon dioxide emission and Arable land are collected from data page of World Bank. The data estimation period covers from 1991 to 2015, which as total 24 observations. This study used E-view for analysed the data. The first research methods for this study are the preliminary analyses such as correlation, and unit root test, secondly, the Vector Error Correction Method (VECM), co-integration rank test and granger causality test and finally the diagnostic checking involves the application of four tests such as multicollinearity test, heteroscedasticity test, serial autocorrelation test, and normality test.

The preliminary analysis such as correlation analysis, it is to measure the strength of a linear or nonlinear relationship between two variables (William, 2006). Hence, Augmented Dickey Fuller (ADF) test are used to determine whether a time series variable has a unit root. The ADF equation denoted as:

$$\Delta Y = \alpha_0 + \delta Y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta Y_{t-i+1} + \varepsilon_t \quad (2)$$

Where, Δ = difference operator; t = linear time trend; n = number of lags; ε_t = pure white noise error term; and Y_{t-1} = $(\Delta Y_{t-1} - Y_{t-2})$, $(\Delta Y_{t-2} - Y_{t-3})$, etc. The error term, ε_t is assumed to be correlated. Moreover, granger causality test is carried out to determine the causality and direction of causality between variables (Gujarati & Porter 2009). This test verifies whether the incorporation of past values of an *X* variable contribute to better predictions for the *Y* variable. Thus, it is a test of temporal preceding and not of causality in the sense of a relation of cause and effect. This test requires the estimation of the following:

$$\Delta X_t = a_x + \sum_{i=1}^{k} \beta_{x,i} \Delta X_{t-i} + \sum_{i=1}^{k} \gamma_{x,i} \Delta Y_{t-i} + \varepsilon_{x,t} \quad (3)$$

$$\Delta Y_t = a_y + \sum_{i=1}^{k} \beta_{y,i} \Delta Y_{t-i} + \sum_{i=1}^{k} \gamma_{y,i} \Delta X_{t-i} + \varepsilon_{y,t} \quad (4)$$

Where, ΔX_t and ΔY indicate the first difference of the variables a, β, γ to be tested are the coefficients of the regressions to be estimated; ε_t is the random error term. Vector Error Correction Method (VECM) is from the unrestricted vector autoregressive (VAR) model that used to estimate non-stationary time series that were identified to be cointegrated. VECM model can be expressed as:

$$\Delta Y_t = \sum_{i=1}^{k} \phi Y_{t-1} + \varepsilon_t \quad (5)$$

Where, Y_t is the vector of endogenous variables; k is the order of lag, Y_{t-1} is lagged variable; ϕ is the coefficient to be estimated; and ε_t is a stochastic error term, which also known as impulse or innovation. the trace test seeks to test the null hypothesis that the number of distinct cointegrating vectors is less than or equal to r (H_0 = cointegrating vectors $\leq r$) against the alternative hypothesis that the number of these vectors is greater than r (H_1= cointegrating vectors > r) which can be expressed by:

$$\gamma_{trace}(r) = -T \sum_{i=r+1}^{k} \ln(1-\lambda_i) \quad (6)$$

The maximum eigenvalue test aims to test the null hypothesis that the number of vectors is r (H_0: cointegration vectors = r) against the alternative hypothesis of the existence of r +1 cointegrating vectors (H_1: cointegrating vectors = r +1) which can be represented as follows:

$$\gamma_{trace}(r, r+1) = -T \ln(1-\lambda_{r+1}) \quad (7)$$

After detecting the cointegration relationship between the variables X_{t-i} and Y_{t-i} we passed on to the next step, which consists in the inclusion of the model of error correction, which has the advantage of retaining information about the level of the series, so that the long-term relationships between the variables of the studied model remain present. The following mode of error correction:

$$\Delta Y_t = \beta_0 + \beta_1 \Delta Y_{t-i} + \beta_j \Delta Y_{t-i} + \varphi ECT_{y,t-i} + \mu_{y,t} \quad (8)$$

$$\Delta X_t = \alpha_0 + \alpha_1 \Delta Y_{t-i} + \alpha_j \Delta X_{t-i} + \varphi ECT_{x,t-i} + \mu_{x,t} \quad (9)$$

Where β_1, β_1, β_j, α_0, α_1, α_j, are the coefficients of the model ΔY_{t-i} and ΔX_{t-i} indicate the first difference of variables to be tested, lagged in i periods; φ is the coefficient of long-term adjustment; $\mu_{y,t}$ and $\mu_{x,t}$ are the random error terms, and ECT_{t-i} are the deviations from long-term balance between ;ΔY_{t-i} and Y_{t-i}, lagged in i periods.

RESULTS AND DISCUSSION

Residual analysis conducted on electric consumption model shows that residuals are normally distributed, no heteroscedasticity, no serial correlation and no multicollinearity issues. The correlation among variables presented in Table 2. The correlation between electricity consumption and carbon emission was large positive relationship with r = 0.97. However, rain and temperature has low positive relationship respectively r = 0.35 and r = 0.12. Moreover, arable land and electricity consumption has moderate and negative relationship.

Table 3 shows the results of unit root test. The result shows that electric power consumption, average rain and average temperature variables stationary at their level. However, forest, carbon emission and arable land variables are non-stationary at level but become stationary after first difference.

TABLE 2. Correlation matrix among variables

	Energy consumption	Average rainfall	Average temperature	Forest area	Carbon dioxide emission	Arable land
Energy consumption	1.000	0.352	0.120	-0.088	0.965	-0.692
Average rainfall	0.352	1.000	0.111	-0.101	0.362	-0.396
Average temperature	0.120	0.111	1.000	-0.048	0.053	-0.160
Forest area	-0.088	-0.101	-0.048	1.000	-0.098	0.609
Carbon dioxide emission	0.965	0.362	0.053	-0.098	1.000	-0.651
Arable land	-0.692	-0.396	-0.160	0.609	-0.651	1.000

The VECM and the long run equation between variables are below:

$$LEPC_{t-1} = -23.607 + 0.145LRAIN_{t-1} + 0.567LTEM_{t-1} + 0.601LFOR_{t-1} + 0.882LCO2_{t-1} - 0.646LARAB_{t-1} \quad (10)$$

S.E	(0.401)	(0.281)	(0.241)	(0.019)	(0.211)
T-stat	[-3.617***]	[-20.195***]	[-2.495**]	[-47.275***]	[3.058***]

TABLE 3. Unit root test result

	Augmented Dickey Fuller (ADF)	
	Level	
	Constant Without Trend	Constant With Trend
LEPC	-3.035***	-3.577**
LRAIN	-4.172***	-3.832***
LTEM	-7.521***	-7.494***
LFOR	-2.223	-2.114
LCO2	-1.902	-3.104
LARAB	-2.143	-0.882
	First Difference	
	Constant Without Trend	Constant With Trend
LEPC	-3.376***	-4.237***
LRAIN	-1.751	-1.770
LTEM	-5.490***	-5.326***
LFOR	-1.702	-3.583**
LCO2	-5.045***	-5.242***
LARAB	-6.140***	-6.842***

Notes: ***, **, * indicates that H0 is rejected at 0.01 and 0.05 significant level.
Lag lengths for the ADF unit root test are based on the Akaike's information criterion

Long run equation shows that average rain and temperature, carbon dioxide emission and arable land significant at 1%, however, forest area at 5%. This study outcome similar with previous studies outcome. Where, climate change has impact on electricity power consumption (Parkpoom et al. 2004, 2008; Akimat et al. 2014). When the average temperature increase electricity power consumption also increases to reduce the temperature in different regions (Partpoom et al. 2008) and increases monthly electric demand (Partpoom et al. 2008). This shows that electric power consumption and average temperature and rain have positive relationship in long run.

Electric power consumption and forest are having positive and significant relationship. This study supports the outcome of one of research conducted in Portugal on forest biomass for use as alternative energy consumption (Viana et al. 2010). The research found the more forest area will generate more electricity generated to fulfil required demand.

In this carbon dioxide emission and electricity power consumption has positive relationship in long run. Similar findings reported in China where, electricity power consumption has positive and long run relationship with carbon emission (Zhang & Cheng 2009). However, Bella et al. (2014) found that negative relationship in long run due to usage of carbon saving technology. Moreover, in this study found that electric power consumption has negative and significant relationship in long run.

This outcome different from researcher form Morocco found that renewable energy consumption and arable land has positive relationship (Ben & Ben 2017). This due to waste from arable land used as renewable energy. However, this study investigates the relationship between electric power consumption and arable land.

The VECM model generated six equations as stated below:

$$LEPC = 0.031 + 0.116\,LRAIN_{t-1} - 0.488LTEM_{t-1} - 0.306LFOR_{t-1} - 0.000LCO2_{t-1} - 0.055LARAB_{t-1} + 0.345\,LEPC_{t-1} + 0.018\varepsilon_t \quad (11)$$

S.E	(0.130)	(0.518)	(1.723)	(0.155)	(0.684)	(0.228)
T-stat	[0.859]	[-0.941]	[-0.177]	[-0.003]	[-0.079]	[1.514*]

$R^2 = 0.350$
Adjusted $R^2 = 0.046$

$$LRAIN = -0.05 + 0.205\,LEPC_{t-1} + 1.832\,LTEM_{t-1} - 0.205\,LFOR_{t-1} - 0.009LCO2_{t-1} + 0.003\,LARAB_{t-1} + 0.131\,LRAIN_{t-1} + 0.047\varepsilon_t \quad (12)$$

S.E	(0.613)	(1.394)	(4.633)	(0.417)	(1.840)	(0.349)
T-stat	[0.335]	[1.314*]	[-0.044]	[-0.022]	[0.545]	[0.375]

$R^2 = 0.158$
Adjusted $R^2 = -0.235$

$$LTEM = -0.005 - 0.057LEPC_{t-1} + 0.015LRAIN_{t-1} + 0.659LFOR_{t-1} + 0.166LCO2_{t-1} - 0.062\,LARAB_{t-1} + 0.308\,LTEM_{t-1} + 0.008\,\varepsilon_t \quad (13)$$

S.E	(0.116)	(0.065)	(0.874)	(0.078)	(0.347)	(0.263)
T-stat	[-0.489]	[0.231]	[0.753]	[2.115**]	[-0.177]	[1.172]

$R^2 = 0.793$
Adjusted $R^2 = 0.696$

$$LFOR = 0.002\text{-}0.007\,LEPC_{t-1} - 0.001\,LRAIN_{t-1} - 0.042\,LTEM_{t-1} - 0.014\,LCO2_{t-1} + 0.101\,LARAB_{t-1} + 0.755\,LFOR_{t-1} + 0.001\varepsilon_t \quad (14)$$

S.E	(0.019)	(0.011)	(0.043)	(0.013)	(0.057)	(0.143)
T-stat	[-0.379]	[-0.06]	[-0.96]	[-1.054]	[1.768**]	[5.268***]

$R^2 = 0.717$
Adjusted $R^2 = 0.585$

$$LCO2 = 0.022 + 0.845LEPC_{t-1} - 0.027\,LRAIN_{t-1} - 1.325\,LTEM_{t-1} - 2.155\,LFOR_{t-1} - 0.161\,LFOR_{t-1} - 0.347\,LCO2_{t-1} + 0.027\,\varepsilon_t \quad (15)$$

S.E	(0.364)	(0.207)	(0.828)	(2.751)	(1.092)	(0.248)
T-stat	[2.317**]	[-0.129]	[-1.601*]	[-0.783]	[-0.148]	[-1.404*]

$R^2 = 0.345$
Adjusted $R^2 = 0.040$

$$LARAB = 0.000 - 0.002\ LEPC_{t-1} - 0.082\ LRAIN_{t-1} - 0.414\ LTEM_{t-1} + 0.418\ LFOR_{t-1} - 0.049\ LCO2_{t-1} - 0.454\ LARAB_{t-1} + 0.005\ \varepsilon_t \quad (16)$$

S.E	(0.069)	(0.040)	(0.157)	(0.525)	(0.047)	(0.208)
T-stat	[-0.023]	[-2.073**]	[-2.620***]	[0.795]	[-1.043]	[-2.178**]

$R^2 = 0.430$

Adjusted $R^2 = 0.165$

Note: t-statistics in [ ], *** statistically significant at the 0.01 level, ** at the 0.05 level and * at the 0.10 level

Based on the VECM model of EPC Equation (11), 35% of the variation in the explanatory variables is explained by electric power consumption equation. The result pointed out that the explanatory variables namely the lagged period of the electric power consumption ($LEPC_{t-1}$) variable only was the most influential and decisive factors with statistically significant at 10%. Next, based on average rain Equation (12), only lagged period of average temperature significant at 10% with R^2 of 15.8%. Furthermore, average temperature Equation (13), on influence by lagged value of carbon dioxide emission significant at 5% with R^2 value of 79.3%. Next for forest area Equation (14), lagged period of arable land and forest significant at 5% and 1% respectively with R^2 value of 71.7%. Moreover, for carbon dioxide emission Equation (15), lagged period of electric power consumption, temperature and carbon emission significant at 5% and 1%. However, for arable land Equation (16), lagged period of average rain temperature and arable land decisive factors.

TABLE 4. Johansen-Juselius cointegration tests

Hypothesized No. of CE(s)	Trace	Max-Eigen	Critical Values (5%)	
	Statistic	Statistic	Trace	Max-Eigen
r = 0	204.0631***	85.95090***	95.75366	40.07757
r ≤ 1	118.1122***	42.63193***	69.81889	33.87687
r ≤ 2	75.48026***	37.51774***	47.85613	27.58434
r ≤ 3	37.96252***	20.97206	29.79707	21.13162
r ≤ 4	16.99046**	15.69858**	15.49471	14.26460
r ≤ 5	1.291882	1.291882	3.841466	3.841466

Note: *** denotes significant at 1% significance levels; ** denotes significant at 5% significance levels.

Using Johansen and Juselius (1990), multivariate cointegration test, the study finds that statistically significant relationship exists between electricity power consumption and climate variables. Table 4 presents the Johansen-Juselius co-integration test. The result shows that both Trace test and Max-Eigen test are statistically significant to reject the null hypothesis of $r = 0, 1, 2$ & 3 at 1% and $r = 4$ at 5% significant level. Therefore, the co-integration test indicates that four long-run co-integration relationships exist between electric power consumption and its determinant.

Figure 2 shows that unidirectional causality between electricity power consumption and carbon dioxide emission (Bella et al. 2014). However, both average rain and temperature are found to "Granger cause" arable land. However, arable land has unidirectional causality to forest area. These study outcomes indicate that electricity power consumption should reduce to reduce carbon emission. Moreover, the arable land (land used for grow crops) also influence Malaysia average temperature and rainfall.

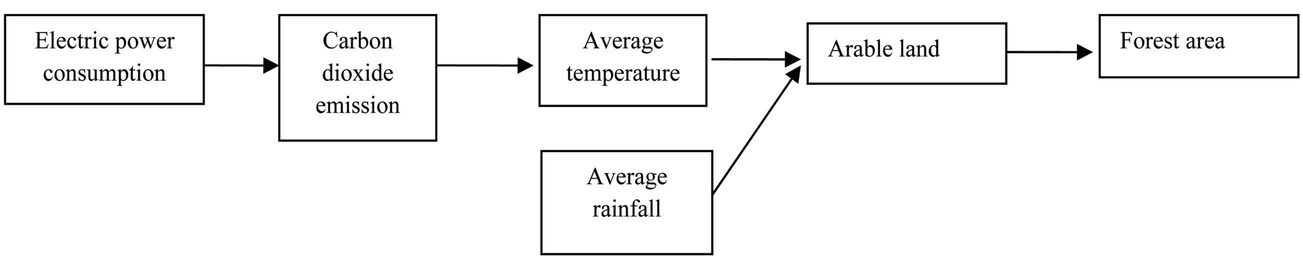

FIGURE 2. Granger causality results based on VECM

CONCLUSION

This study presents the analysis of the causal relationship between electricity power consumption and impact on climate change in Malaysia. The result shows that the average rain and temperature, carbon dioxide emission and arable land have long run relationship between electricity power consumption. The granger causality relationship shows that unidirectional causality between electricity power consumption and carbon dioxide emission, arable land causes change in average rainfall and average temperature, average temperature causes change in carbon dioxide emission, and forest area causes changes in arable land. Wise electricity Consumption will reduce the carbon emission in Malaysia. Moreover, carbon emission will influence average temperature and rain fall. Yet, long run result indicate that electricity power consumption will increase average temperature and average rain fall in Malaysia. Conversely, increase in electricity power consumption will reduce arable land area and increase in forest area. Overall, electricity power consumption has impact on climate change in Malaysia.

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