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A MULTIVARIATE STUDY OF ENERGY CONSUMPTION, URBANISATION, TRADE OPENNESS AND ECONOMIC GROWTH IN MALAYSIA

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ABSTRACT

This paper investigates both the short and long term dynamic relationships between energy consumption, trade openness, urbanization and economic growth in Malaysia through econometric model during the period of 1971 – 2013. The novel methodology in econometric techniques such as unit root without structural breaks, co-integration, and vector error correction model (VECM) are being used to analyse the data. Co-integration has been carried out to find long run relationship between the variables. For short run dynamics relationship among the variables, VECM model has been used. The estimated income elasticities indicate that per capita GDP in real term puts a larger influence on energy consumption. The results showed that all variables are stationary at first difference. Also from the empirical results it is evident that there is long run relationships exist among energy consumption and economic growth for the Malaysian economy.

Keywords: economic growth, Malaysia, VECM, econometric model.

INTRODUCTION

Energy plays an important role in the growth process of a country by facilitating progress in scientific and technological innovations along with the emergence of improved information and communication technologies (ICT) that have increased the trade and production of the economy. The availability of energy is an important and driving force for enhancing standard of living of the general public across the countries. Energy infrastructure emerged as a contributing factor alongside the population growth, industrialization, and urbanization for the economy. The importance of energy is evident from the advancement and growth in the ICT in the developed economies [1]. A high correlation between energy consumption and wealth creation exist among the wealthy countries than the poor one and that, as a whole for the global economy the correlation between electricity consumption and wealth creation is stronger as compared to the total energy consumption and economic growth [2]. An increase in energy consumption is a driving force for enhancing an economic growth, and the supply of electricity (a form of energy), its consumption is critical for sustainable economic growth [3].Well-documented debates on energy consumption and economic growth relationship exist in earlier literature at aggregated and disaggregated levels in context of individual country level as well as panel of countries, but their consensuses are inconclusive, and controversial results obtained from various studies. Some of the seminal empirical studies on causal relationship between energy consumption and economic growth support that economic growth induces electricity consumption [4 - 7]. But study results of [8-11] showed unidirectional causality running from electricity to income, which means that electricity consumption is vitally important for sustainable economic growth

Malaysia is one of the leading economically developing the second largest country exporting liquefied natural gas (LNG) in the world and oil and natural gas producer in Southeast Asia as well. The energy industry in Malaysia has significant role in the growth of economy, as it makes up about 20% of the total GDP. In Malaysia, energy consumption, coal share is about17%, biomass and waste 4% and hydropower 3% of the total consumption. Industrial sector power demand is 45%, commercial 3%, residential sector 21% and transportation and agriculture sector demand is less than 1% (Malaysia, Energy Commission, 2012). Natural gas is the rich source to meet the electricity demand of Malaysia. There is a contribution of the coal in the country demand but to a smaller extent (U.S. Energy Information, 2013). Economic development and population growth of Malaysia led the country to a significantly higher electricity generation which doubled in the last decade (MEIH, 2012). Energy consumption, economic growth, CO2 emission and population growth exhibited long run co-integration relationship in Malaysia economy [12]. Energy consumption, GDP per capita and price share are related in the long run to each other in the Malaysian economy [13].

Many of the studies just investigated the relationship between energy consumption and economic growth by ignoring other important relevant variables [14-17]. Omitting relevant variables from the model create problem of variable bias and provide inconsistent estimates of parameters [18 - 19]. It is also known that non-causality in a system of bivariate can be due to variables omission [20 - 21]. To cope with the bias problem of omitted variable bias and obtain consistent estimates of the parameters, some studies included other variables such as capital and labor [22 - 25].

In case of Malaysia, previous studies either have investigated causal links between energy consumption and growth nexus; energy consumption-CO2 emission or including some other variables such as labor, trade but ignored some of the important determinants of energy growth production function. In this study we extend the current literature by incorporating urbanization as a new variable into the energy-growth nexus.

Data and methodology

Data

The study based on annual data which has been provided by Department of Statistics Malaysia. Data on some variables has been online source like Statistical, Economic and Social Research and Training Centre for Islamic Countries (SESRIC), the World Bank data source for the time period 1971-2013.

An empirical model specification

Growing population, electrification facilities to rural areas, rapid urbanization, industrial growth, household demands for energy and increase in per capita income are the key factors of the energy demand. In this research, the relationship between energy consumption, population growth, urbanization, trade and economic growth were modelled to study causal association between the variables of interest for Malaysia economy over the period of 1971-2013.

A general dynamic model to capture the relationship among the energy consumption, population growth, urbanization, trade and economic growth (GDP) can be specified as follows:

EC = f (Y, PG, U, O) (1)

Where,
Y= Gross domestic product (GDP)
EC= Energy Consumption,
PG=Population Growth,
U= Urbanization, and
T= Trade Openness.

The parameterized form of the equation (1) in production form approach can be written as:

$$EC_t = A^{\beta_0} Y_t^{\beta_1} PG_t^{\beta_2} U_t^{\beta_3} O_t^{\beta_4} T \qquad (2)$$

Taking the natural log and adding error term into equation (2), further we have equation in the following form:

$$\ln EC_t = \ln \beta_0 + dT + \ln \beta_1 y_t + \ln \beta_2 U_t + \ln \beta_3 PG_t + \ln \beta_4 O_t + \delta EC_{t-1} \varepsilon_t \qquad (3)$$

Where β_0 is intercept, β_1 income elasticity, β_2 the urbanization effect of, β_3 the effect of population growth, β_4 shows the influence of trade openness, δ is, is an adjustment parameter; and T is the time trend.[2]

This paper used VAR and VECM models to investigate the relationship between energy consumption and economic growth for the Malaysian economy over the period 1971-2013.When there is an evidence of co-integration between variables, then error correction model (ECM) is used to estimate short run relation. When a set of variables have a co-integration, it suggests that there exists a causal association between the variables at least in either direction. Evidence of co-integration between groups of variables is significant in the sense that it confirms the existence of error correction mechanism. The error correction mechanism tells us that changes in the endogenous variable are demonstrated as a function of the level of disequilibrium in the co-integration relationship and changes in other exogenous variables VECM for the equation. (3) Can be written as:

$$\Delta EC_t = a_1 + \sum_{i=1}^{p} \alpha_1 \Delta y_{t-i} + \sum_{i=1}^{p} \alpha_2 \Delta U_{t-i} + \sum_{i=1}^{p} \alpha_3 \Delta PG_{t-i} + \sum_{i=1}^{p} \alpha_4 \Delta O_{t-i} + \alpha_5 \varepsilon_{t-1} + u_{1t}. \qquad (4)$$

$$\Delta y_t = a_2 + \sum_{i=1}^{p} \alpha_1 \Delta y_{t-i} + \sum_{i=1}^{p} \alpha_2 \Delta U_{t-i} + \sum_{i=1}^{p} \alpha_3 \Delta PG_{t-i} + \sum_{i=1}^{p} \alpha_4 \Delta O_{t-i} + \alpha_5 \varepsilon_{t-2} + u_{2t} \qquad (5)$$

$$\Delta U_t = a_3 + \sum_{i=1}^{p} \alpha_1 \Delta y_{t-i} + \sum_{i=1}^{p} \alpha_2 \Delta U_{t-i} + \sum_{i=1}^{p} \alpha_3 \Delta PG_{t-i} + \sum_{i=1}^{p} \alpha_4 \Delta O_{t-i} + \alpha_5 \varepsilon_{t-3} + u_{3t}. \qquad (6)$$

$$\Delta PG_t = a_4 + \sum_{i=1}^{p} \alpha_1 \Delta y_{t-i} + \sum_{i=1}^{p} \alpha_2 \Delta U_{t-i} + \sum_{i=1}^{p} \alpha_3 \Delta PG_{t-i} + \sum_{i=1}^{p} \alpha_4 \Delta O_{t-i} + \alpha_5 \varepsilon_{t-4} + u_{4t}. \qquad (7)$$

$$\Delta O_t = a_5 + \sum_{i=1}^{p} \alpha_1 \Delta y_{t-i} + \sum_{i=1}^{p} \alpha_2 \Delta U_{t-i} + \sum_{i=1}^{p} \alpha_3 \Delta PG_{t-i} + \sum_{i=1}^{p} \alpha_4 \Delta O_{t-i} + \alpha_5 \varepsilon_{t-5} + u_{5t}. \quad (8)$$

Where Δ is the difference operator, p" is lag length, $EC_t, y_t, U_t, PG_t, O_t$ are energy consumption, output, urban population, and trade openness, all are in the natural log form, ε_{t-i} is an error correction term of the residuals from equation (3) and *u* is the random term for errors.

The ECM represents both long run equilibrium (through the co-integration term) and short term dynamics (changes through other exogenous variables).

Estimation methodology

Unit root analysis

In order to determine the stationarity of the time series data, the standard approach is checking of the existence of unit root in the series. To this end the commonly used test is the Augmented Dickey Fuller (ADF, 1981). The general form of the ADF test equation is given as under:

$$\Delta y_{t-1} = \beta_1 + \beta_2 t + \alpha y_{t-1} + \sum_{t=1}^{k} \delta_i \Delta y_{t-i} + \varepsilon_t \quad (9)$$

Where, *Y* is the time series variable to be tested, t is the time trend incorporated in to the model, k is the number of lags the variable y to be included into the model to make the time series white noise. Δ, is the difference operator, β_1 and β_2 are the intercept and coefficient of the trend term, and ε_t is a white noise error term. Maximum lags are selected through the Akaike Information Criteria (AIC) and Bayesian Schwarz Information Criteria (BSIC) for making the error term white noise.

A series is said to be stationary if the value of the α turns out to be non-zero otherwise non-stationary at the level. The successive differences of the series are taken in order to check the order of integration of the series. A series is I(1), I(2) or I(d) if it becomes stationary at first, second or at dth difference respectively.

Vector autoregressive (VAR) and vector error correction model (VECM)

Vector Auto- Regressive (VAR) model based on the system of regression equations was popularized by Sim (1980) as the starting point for the analysis of co-integration regression. The VAR model of order "p" for the k variables in the matrix notation is given as:

$$X_t = A_1 X_{t-1} + A_2 X_{t-2} + A_3 X_{t-3} + A_4 X_{t-4} + ... + A_p X_{t-p} + U_t ,$$

Where, $(X_t) = (x_{1t}, x_{2t}, x_{3t}, x_{4t}............x_{kt})'$

$A_1 + A_2 + A_3 + A_4 .... + A_p$ is akxk matrix and U_t is vector k dimensional error terms.

When there is a bi-directional causality, then the transfer function is not applicable anymore, so, we use the VAR model to model the causal relationship between variables. In two way causality all variables are considered as endogenous.

Co-integration analysis

Co-integration is a technique used to examine the short run and long run association between two or more than two time series variables which are integrated of the same order. If a linear combination of two of more than twoI(1) series is I(0), then process is said to have co-integration. Co-integration analysis is performed to find the existence long equilibrium, common stochastic trend and to separate short run and long run relationship between variables. In this paper the co-integration was used to examine long run and short run relation between energy consumption and economic growth for Malaysian economy over the period of 1971-2013.

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RESULT AND DISCUSSIONS

Table-1. Regression results of the model, using values 1971-2013 (T = 43)
Dependent variable: LnEC.

Variable	Coeff	Std. Error	t-ratio	p-value
const	**-3.69681**	**0.452655**	**-8.1669**	**0.00001**
LnGDP	0.216886	0.0923178	2.3493	0.02411
PopGr	0.053500	0.0150629	3.5518	0.00104
TrOpn	0.121581	0.0180175	6.7480	0.00001
LnUPop	0.788662	0.204273	3.8608	0.00043
R-sq	0.995009	Adj R-sq	0.994484	-----

Table-1 results indicate that all the explanatory variables are statistically significant at given significant values. The per capita income in real term has positive relation with the energy consumption in the long run. The estimated income elasticity for energy consumption is 2.35, which reveals that as the income increases by one percentage point, per capita energy consumption increase by 2.35 percent point. The positive relationship between per capita income and energy consumption means that energy is a normal good and the people in Malaysia demand more for energy as the income level increases. Other variables of the model also have significant and positive influence on energy consumption. The effect of consumption open to trade is highly significant on energy. The possible reason could be that the more the economy open to trade, the greater would be the investments in various sectors of the country, which results in increase consumption and demand for energy use.

Unit root test results

Table-2, results show that all variables are non-stationary at level, but stationary after taking first difference, which means that the order of integration of all variables is I(1). We checked for unit root in the residual series to find that linear combination of the series is less than one or not. The residual series was turned out as I(0), which is an evidence of co-integration

Table-2. The ADF unit root test results at level and difference series.

Series	Spec.	Level (atLag)	First diff.	Second diff.	Intégration ordre
LEC	C and T	-1.944 (1)	-6.903*	Nil	I(1)
LGDP	C and T	-2.661(0)	-6.403*	Nil	I(1)
LUPOP	C and T	-0.591(0)	-5.369*	Nil	I(1)
LTOPN	C and T	-2.391 (1)	-5.218*	Nil	I(1)

Note: "*" indicates significance at 5% level.

Table-3. Lag length selection criteria.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	**146.1802**	**NA**	**9.61e-09**	**-7.109**	**-6.9401**	**-7.047947**
1	349.3700	355.5820*	8.32e-13*	16.46850*	-15.62406*	-16.16318*
2	360.9347	17.92536	1.07e-12	-16.24674	-14.72674	-15.69715
3	369.4213	11.45686	1.66e-12	-15.87106	-13.67552	-15.07722

Various lag length criteria suggested the maximum lag length of one for all the variables, as shown from the Table-2.

Co-integration analysis

Table=4a. Co-intégration Test (Trace)
Séries: LECCP, LNDGP, LU, TROPN

No. CE(s)	Eigen value	Trace stat.	Critical value	P-value
None	0.754	101.610	69.818	0.000
At most 1	0.448	44.091	47.856	0.108
At most 2	0.213	19.742	29.797	0.440

Table-4b. Co-intergation test (Maximum eigen value))
Series: LECCP, LNDGP, LU, TROPN.

No. CE(s)	Eigen value	Max. Eigenvalue Stat.	Critical value	P-value
None	0.754	57.518	33.876	0.000
At most 1	0.448	24.349	27.584	0.123
At most 2	0.213	9.807	21.131	0.763

Table 3a and 3b, showed there is one co-integrating equation at 5% significance level, which implies that there is a long run dynamic relationship among the variables. The long run co-integration could be

CONCLUSIONS

The objective of this paper was to find a dynamic short and long terms relationship between energy consumption, trade openness, urbanization and economic growth in Malaysia through econometric model during the period of 1971 - 2013. First, a unit root test was conducted through ADF test, which showed all the series were first difference I(1)stationary. The I (1) time series indicated the existence of co-integration among the variables. The empirical results confirmed long run and short run dynamic relationship between energy consumption and economic growth in Malaysia over the period 1971-2013.

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