The Effect of Urbanization, Affluence and Trade Openness on Energy Consumption: A Time Series Analysis in Malaysia

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Abstract
This paper investigates the impact of urbanization on energy consumption by applying the Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) in case of Malaysia. The study covers the time period of 1970Q1-2011Q4. The unit root test and the ARDL bounds testing approach have been applied to examine integrating properties and long run relationship in the presence of structural breaks. Our results validated the existence of cointegration and exposed that urbanization is a major contributor in energy consumption. Affluence raises energy demand. Capital stock boosts energy consumption. Trade openness leads affluence and hence increases energy consumption. The causality analysis finds that urbanization Granger causes energy consumption. The feedback effect is found between energy consumption and affluence and, energy consumption and capital. The bidirectional causality exists between trade openness and energy consumption.
Keywords: Urbanization, Energy, Malaysia

I. Introduction

Urbanization is a dynamic moderation phenomenon on social and economic capability from rural area which based on agriculture economy towards urban areas with industries and services sectors. Indeed, urbanization with high urban densities also able to structure out the economic patterns of resource use and global environmental quality (Parikh and Shukla [1]). Basically, most of the developing countries are undergoing economic transition through urbanization in recent decades have high potential for energy demand and will be part of incremental degradation. The rapid urbanization is observed in Africa and Asia regions, where urban population has increased coupling of percentages between year 2000 and expected growth by 2030. Urbanization process also has increased the world urban population statistics from 1.52 billion in 1970 to almost 4.6 billion people in 2030 (Poumanyvong and Kaneka [2]; UNDP [3]). However, with half of the world population lives in urban areas, urban cities will mostly consume more than 50% of overall energy and produce over 60% carbon dioxide (CO_2) emissions which contributes to global warming (IEA [4]). Whereby, CO_2 emissions are rapidly increasing from developing countries especially from China, India and ASEAN region since 2005; and its accounted for almost 50% of the world's CO_2 emissions (World Bank [5]). Urban areas may also be expected to be energy intensive with high tendency of economic activities such as manufacturing industrial, transportation and other economic development activities.

Urban growth is one of the important agenda for economic development in Malaysia. In the past 10 years, Malaysia archived an average of 4-5% economic growth; and rapid urbanization has caused high pressure on energy demand from various sources of resources. According to Malaysia's census report, urbanization increases from 25% I 1960 to 65% in 2005 and 3 quarters of the population in Malaysia will live in urban areas by 2020 (Tenth Malaysia Plan [6]). In the early 1980s, Malaysia has 4 major urban cities located in developing states consists more than 50% proportion or population and they're employed around KlangValley, Ipoh, Johor Bahru and Penang. Less developed states such as Terengganu, Kedah, Kelantan, Sabah and Sarawak have a low proportion of people living in urban areas. This has driven rural to urban migration as well as the transformation from agriculture to industrial based activities. Most of the rural people move to urban areas to seeking jobs, and conductive living environment. Table-1 shows the urban, rural and total population in Malaysia where by 2030 almost 80% of the overall population will live in urban cities Population Distribution by Local Authority Areas and Mukim [7]. Rapid urbanization occurred in 1990s and this mainly caused by rural-urban migration activities along with high intensity of industrial development in the West-coast of Peninsular Malaysia.

[Insert Table 1 here]

In terms of rural township and regional land development in Malaysia, several rural urban areas proposed such as DARA, KEJORA, KETENGAH and KESEDAR. These rural areas are basically supported with rubber and oil palm agricultures without high demand for energy resources. Majority of the population living in urban settlements relatively enjoy high standards of livings with quality infrastructure, electricity, telecommunication and clean water supply facilities. Although resource rich states such as Terengganu, Sabah, Sarawak and Pahang attract resource based industries, but most of the export based industries located in the western part of Peninsular Malaysia. Besides that, urbanization in this area also supported with accessibility, infrastructure, transportation and high skilled manpower.

During the Ninth Malaysia Plan period, the government has promoted 5 regional developments and accelerates growth in designated geographic areas. Meanwhile, under the Tenth Malaysia Plan period, the economic development of the regional development areas will be accelerated by focusing around a limited number of high-density clusters in the corridors that have sector and geographic advantages. The corridors developed in Malaysia are Iskandar Malaysia (Southern Peninsular Malaysia), Northern Corridor Economic Region (NCER), East Coast Economic Region (ECER), Sarawak Corridor Renewable Energy (SCORE) and Sabah Development Corridor (SDC). All these urban areas surely increased demand for energy and this will lead to CO_2 emission with several economic activities. This is the main interest of authors to investigate the impact of urbanization on energy consumption in the case of Malaysia.

II. Literature review

Urbanization is defined as a process regrouping large permanent residents in moderately small areas and as results forming crowded metropolises. Further, urbanization is immigration from the agricultural area of non-agricultural area. Physical accumulation of people in urban areas generates a critical increase of costs, social disparities and negative impact on the environment. Further urbanization has a wide effect on energy consumption due to massive housing rate and growth of investment and industrialization among other factors. The urbanization-energy consumption nexus has been largely analyzed in both theoretical and empirical literature. For instance, using a sample of 59 countries, Jones [8] examined the effect of urbanization on energy consumption. For robustness check, he applied aggregate and cross-sectional regression analysis. The empirical analysis revealed that urbanization, industrialization, land use and population growth incraese energy demand. Further, in a different study, Jones[9] observed that urbanization increases energy consumption as urban citizens rely heavily on electric appliance comparing to rural citizens. Moreover, urban citizens have more possibility to use private transportation and as a result, energy demand increases. Urban density is also a source of energy demand growth. Dhal and Erdogan [10], when investigating the relationship between urban population and oil consumption, found that urbanization leads industrialization which raises oil demand. On the other hand, Solarin and Shahbaz [11] also has analyzed the relationship between economic growth, urbanization and electricity consumption for Angola several econometric estimation techniques. They concluded, urbanization and electricity are the bidirectional Granger cause of Angola; and the variables exist long run relationship.

Burney [12] stated that socioeconomic factors also increase energy consumption. His empirical analysis revealed that urbanization promotes energy demand. However, this outcome diverges across countries by fixing income per capita and industrialization. Parikh and Shukla [1] explored the different effects of urbanization, economic structure, population density and economic growth in energy consumption across both developed and developing economies. They found that urbanization, economic structure and economic growth augment energy consumption yet, and population density lowers energy consumption. Similarly, Imai [13] demonstrated that population and urbanization raise energy demand. However, his causality analysis designated urbanized as a cause of population density and energy consumption upsurge. Cole and Nuemayer [14] stated that urbanization is positively associated with energy demand because of growth in demand for housing and transportation. Additionally, they established a U-shaped relationship between urbanization and energy consumption. Liddle [15] considered the influence of population and urban density on road use and transport energy consumption and found that population and urban density decrease transport energy consumption. This implies that in populous and urban areas people demand more for public transport as compared to person transport. These outcomes were confirmed by Chen et al. [16] for China.

Similarly, Kalnay and Cal [17] put forward that urbanization generates pressure on agriculture sector to overproduce. This has negative effects such as massive land use and raise of energy demand in agriculture sector. Bryant [18] found out that urbanization is related to industrialization, technological involvement, globalization and migration. All these variables contribute to increasing energy demand. Hemmati [19] studied the impact of income and urbanization on energy demand for Iran usingannual data. He statedthat urbanization leads industrialization and commercialization that result of rising raw material demand and consumer goods which by the way affect energy demand. Halicioglu [20] used the vector error correction method Granger causality technique to determine the causal relationship between economic growth, energy prices, urbanization and energy consumption in Turkey. He pointed out that urbanization Granger causes energy consumption in the long run but not vice versa. By examining the impact of demographic factors on energy consumption in European Union countries, York [21] found that energy demand is source of fast urbanization and industrialization in these economies. Likewise, Mishra et al. [22] explored the relationship between urbanization and energy consumption by including output growth in energy demand function in case of Pacific Island nations. They observed that urbanization causes structural changes across the economy and has important implications for energy consumption.

Using a different approach, Tang [23] inspected energy demand function for Malaysia by integrating foreign direct investment and population. The results showed that foreign direct investment and population have positive effect on energy consumption. Further, population Granger causes energy consumption[1]. Lui [24] defined the relationship between population growth, urbanization and energy consumption using the ARDL bounds testing approach and factor decomposition model over the period of 1978-2008. The causality analysis exposed that population and economic growth does not have any impact on energy consumption. Zhao-Hui [25] explored the relationship between different stages of urbanization and energy consumption. The empirical analysis confirmed the cointegration between the variables. Further, energy demand seems Granger causes both industrial development and urbanization. In a similar way, Poumanyvong and Kaneko [2] studied the relationship between urbanization and energy consumption including other different factors such as economic growth, industrial development and population growth in energy demand function. They concluded that urbanization, output growth, population and industrialization increase energy consumption while technical efficiency reduces energy demand. In addition they pointed out that in developing economies, urbanization decreases energy consumption thanks to modern and efficient energy fuels. It seems that the effect of urbanization on energy is superior in high-income countries compared to middle-income economies.

Hossain [26] investigated the relationship between energy consumption, economic growth and urbanization. The sample included data of newly industrialized countries over the period of 1971-2007. He confirmed the cointegration between the variables. However, the causality analysis showed a causal relationshiponly in the short run. Equally, Ekpo [27] examined the

[1]Tang [23] used electricity consumption as an indicator of energy consumption

dynamic relationship between energy demand and its determinant factors in Nigeria. He found that per capita income growth, industrial development and urbanization are the most important factors raising the energy consumption. Using a huge data set of 100 developed and developing economies, Madlener and Sunk [28] explored the effect of urbanization on urban structure and energy demand on urbanization. They discovered that urbanization affects energy demand through changes in urban structure. Further, they pointed out that urbanisation is source of economic development and that growth of income levels changes the consumer needs that in turn affect energy demand. Taking Iran as country case, Abouie-Mehrizi et al. [29] used energy demand function to explore the impact of population growth, urbanization and affluence on energy consumption. The empirical results exposed that population growth, urbanization and affluence on energy consumption have long run relationship and these variables increase energy demand. Shahbaz and Lean [30] studied the relationship between urbanization and energy consumption in Tunisia. They found that financial development, industrialization and urbanisation contribute energy consumption. In addition, urbanization and financial development lead industrialization, which Granger causes energy demand. Likewise, Islam et al. [31] also observed the bidirectional causal relationships between population and energy consumption. In the case of Ghana, Adom et al. [32] investigated the impact of energy prices, income, industrial growth and urbanization on energy consumption. They confirmed that energy demand and its determinants are cointegrated. Additionally, industrial growth affects negatively energy consumption (electricity consumption) while income and urbanization increase energy demand.

In case of China, Ma and Du [33] explored the relationship between urbanization, industrialization, energy prices and energy consumption. Their empirical results revealed that industrialization leads urbanization and urbanization is positively linked with energy consumption. Moreover; impact of tertiary industrial value added has negative effect on energy use because of advanced technology used. The Chinese energy policies as well as environmental regulations have played a key role to reach this situation. In another framework, Mickieka and Fletcher [34] considered the impact of urbanization on coal consumption using two different approaches namely the vector autoregressive framework and Toda and Yamamoto [35] Granger causality approach. Their results showed that economic growth Granger causes coal consumption and the unidirectional causality is found from urbanization to electricity consumption as well as coal consumption. Using national, provincial and regional data Zhang and Lin [36] examined the impact of urbanization on energy consumption by applying the STIRPAT model. The results confirmed that urbanization increases energy demand, however it varies from region to region. Regional results showed that urbanization decreases energy demand in West, Central and Eastern regions due to use of energy efficient technology.

In panel framework, Al-mulali et al. [37] investigated the relationship between urbanization, energy consumption and carbon dioxide emissions. They applied FMOLS (fully modified ordinary least squares) approach[2]. However, the results rejected the cointegration hypothesis between the variables. Additionally, urbanization boosts energy demand in most of sample countries. Poumanyvong et al. [38] examined the impact of urbanization on national transport and road energy use. They found that urbanization increases demand for transportation and therefore energy in high-income countries comparatively in low-income countries. Unexpectedly, the effect of urbanization on national transport is positive and therefore on energy

[2]American Samoa, Australia, Brunei, Cambodia, China, Fiji, Hong Kong, Indonesia, Japan, Kiribati, Korea, Dem. Rep, Korea, Dem., Lao PDR, Macao, Malaysia, Mongolia, Myanmar, New Zealand, Papua New Guinea, Philippines, Samoa, Singapore, Solomon Islands, Thailand, Tonga, Vanuatu, Vietnam.

consumption in middle-income countries as compared but less compared to low-income countries. Sadorsky [39] explored the effect of urbanization and industrialization on energy intensity using the mean group estimator (MGE) for a sample of 75 developing countries. The results revealed that income has a negative effect on energy intensity i.e. -0.45%-0.35%. It means that an increase in income leads to adopting advanced and energy efficient technology for enhancing domestic production which reduces energy consumption. Additionally, industrialization upsurges energy intensity i.e. 0.07%-0.12% and the impact of urbanization on energy intensity varies across regions. In a comparative framework, Pachauri and Jiang [40] observed that rural households consume more energy due to the heavy dependence on inefficient energy fuels and these energy fuels represent 85% of rural energy demand in China and India. In the same way, O'Neill et al. [41] applied iPETS (integrated-Population-Economy-Technology-Science) model to evaluate the effect of urbanization on energy use in India and China. They concluded that urbanization has direct effect on energy use in both countries.

Furthermore, Zhou et al. [42] searched the relationship between urbanization and energy consumption.They stated that urbanization is a major factor affecting energy consumption. This is due to a rise of transportation and production of building materials caused by an increase of residential households demand. More, they suggested that production of goods designed for export and domestic energy consumption play a key role in defining energy demand in China. Xia and Hu [43] demonstrate that urbanization path in China increases the migration of labor from rural areas to urban are as because of industrialization. This transformation of the population has significant impact on energy consumption. Zaman et al. [44] examined energy demand function over the period of 1975-2010. The empirical analysis showed that population leads urbanization which in resulting, increases energy consumption. The causality analysis displayed that urbanization Granger causes energy demand. Since to date, there is no empirical study related to urbanization and energy use conducted in Malaysia. As discussed in the earlier section of this study, most of the previous studies focusing Malaysia's economic performance and energy related indicators. Therefore, this study will be a pioneer study looking at the effects of urbanization on energy demand for transition economic country such as Malaysia.

The existing literature provides panle as well as single country case studies. The results of above studies may be baised as researchers ignored the role of struturla breaks arising in time series data. These structural breaks occur due the implementation of economic, demographic and energy policies in developed and developing economies of the globe. The presence of structural breaks may be cause of unit root problem. This leads to the ambiguity of results. This paper fills the gap in existing literature by not only applying structural unit root tes but also cointegration approach accommodating the structural breaks.

III. Model building and data collection

We follow the Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) model developed by Dietz and Rosa [45] and York et al [46]. This model is rapidly investigated in existing literature to examine impact of socioeconomic changes on environmental degradation. Often, population is treated as independent variables to examine its impact on environmental quality. This model corrects the weakness of environmental Kuznets curves (EKC) where income per capita is used as independent variables and CO_2 emissions per capita as dependent variables but keeping the impact of population on environment unitary elastic. The point is that either population elasticity of energy remains same in developed and developing economies. If the population elasticity of energy consumption varies sample countries then the assumptions of EKC are not corrected (Poumanyvong and Kaneko [2]. The general form of STIRPAT model is given below:

$$E_t = \alpha P_t^b A_t^c T_t^t \mu_t \tag{1}$$

Where E is energy consumption, P is population, A is affluence (economic growth), T is technology and μ is error term. We extend this model by incorporating trade openness. Trade openness transfers advanced technology from the developed world towards emerging and developing economies. Trade openness promotes economic activity and hence economic growth. So, trade openness may affect energy consumption via income effect, technique effect and composite effect. The augmented version of STIRPAT model is given below:

$$E_t = \alpha P_t^b A_t^c T_t^d O_t^e \mu_t \tag{2}$$

Where O is for trade openness (exports + imports). Following Lean and Smyth [47]; Shahbaz and Lean [30] we divide both sides by population and get each series in per capita terms; but leave the impact of population constant. Taking logs, the linearized STIRPAT model is as follows:

$$\ln E_t = \beta_1 + \beta_U \ln U + \beta_Y \ln Y + \beta_K \ln K + \beta_{TR} \ln TR + \mu_t \tag{3}$$

Where, $\ln U_t$, $\ln Y_t$, $\ln K_t$ and $\ln TR_t$ represent energy consumption per capita, urbanization per capita, real GDP per capita proxy for affluence (economic growth), real capital use per capita and real trade openness per capita, respectively, each series is in natural logarithm; and μ_t is a random error term.

The data on all variables has been taken from world development indicators (World Bank [5]). The variables are used such energy consumption (kt of oil equivalent), urbanization population, real GDP, real capital use proxied by real gross fixed capial formation and real trade openness. The population series is used to convert all series into per capita. The data period of our study is 1971Q1-2011Q4. We use the *Interpolation Method* to convert the annual data of all the series into quarterly frequency[3].

IV. Empirical strategy

Search for cointegration among the time series must be preceded by testing the stationary properties of each of the variables. Of the most commonly used tests are the ADF (Dicky and Fuller [48]); PP (Philip and Perron[49]); DF-GLS (Elliot et al. [50]) and Ng-Perron (Ng and Perron [53]). Results from these unit root tests would be biased in many of the situations. For example, Dejong et al. [54] pointed out that these tests results are unreliable due to small sample size and poor power properties. Unit root tests such as ADF, PP and DF-GLS may over-reject the true null hypothesis or accept the null when it is false. Ng-Perron [53] unit root test does not

[3] We used the interpolation method in EVIEWS 7 for converting the annual data of real GDP into quarterly data. This method was followed by Romero [51] and McDermott and McMenamin [52]. Furthermore, The Denton univariate is not free from seasonality problem. It is reported by Herrmann and Joebges (2008) that quadratic match-sum method adjusts seasonal variations in the data while transforming data from low frequency into high frequency. Cheng et al. (2012) noted that quadratic match-sum method lessens the point to point variations in the data to handle the seasonality problem. Therefore, we prefer quadratic match-sum method due to its convenient operating procedure to transform annual into quarterly data.

suffer from this problem. The Ng-Perron [53] is also inappropriate in the presence of structural breaks in the series. The Clemente et al. [55] test is better suited when problems are due to structural break. This test has more power, compared to the Perron and Volgelsang [56], Zivot-Andrews [57], ADF, PP and Ng-Perron unit root tests. Perron and Volgelsang [56] and Zivot-Andrews [57] unit root tests are appropriate if the series has one potential structural break. Clemente et al. [55] extended the Perron and Volgelsang [56] method to allow for two structural breaks in the mean. The null hypothesis H_0 against alternate H_a is stated as follows:

$$H_0 : x_t = x_{t-1} + a_1 DTB_{1t} + a_2 DTB_{2t} + \mu_t \quad (4)$$

$$H_a : x_t = u + b_1 DU_{1t} + b_2 DTB_{2t} + \mu_t \quad (5)$$

In equation-5 and equation-6, DTB_{1t} is the pulse variable which equals 1 if $t = TB_i + 1$ and zero otherwise. Moreover, $DU_{it} = 1$ if $TB_i < t (i = 1,2)$ and zero otherwise. Modification of the mean is represented by TB_1 and TB_2 time periods. To further simplify, we assume that $TB_i = \delta_i T (i = 1,2)$ where $1 > \delta_i > 0$ while $\delta_1 < \delta_2$ (see Clemente et al. [55]). If two structural breaks are contained by innovative outlier, then the unit root hypothesis can be investigated by applying equation-5, as provided in the following model:

$$x_t = u + \rho x_{t-1} + d_1 DTB_{1t} + a_2 DTB_{2t} + d_3 DU_{1t} + d_4 DU_{2t} + \sum_{i=1}^{k} c_j \Delta x_{t-1} + \mu_t \quad (6)$$

This equation helps us to estimate minimum value of t-ratio through simulations and the value of the simulated t - ratio can be utilized to identify all break points if the value of autoregressive parameter is constrained to 1. For the derivation of the asymptotic distribution of the estimate, we assume that $\delta_2 > \delta_1 > 0, 1 > \delta_2 - 1 > \delta_0$ where, δ_1 and δ_2 obtain the values in interval i.e. $[(t+2)/T, (T-1)/T]$ by applying the largest window size. The assumption i.e. $\delta_1 < \delta_2 + 1$ is used to show that cases where break points exist in repeated periods are purged (see Clemente et al.[55]). Two steps approach is used to test the unit root hypothesis, if shifts can explain the additive outliers. In 1[st] step, we remove deterministic trend, following equation-8 for estimation as follows:

$$x_t = u + d_5 DU_{1t} + d_6 DU_{2t} + \hat{x} \quad (7)$$

The second step involves searching for the minimum t-ratio to test the hypothesis that $\rho = 1$, using the following equation:

$$\hat{x}_t = \sum_{i=1}^{k} \phi_{1i} DTB_{1t-1} + \sum_{i=1}^{k} \phi_{2i} DTB_{2t-1} + \rho \hat{x}_{t-1} + \sum_{i=1}^{k} c_i \Delta \hat{x}_{t-1} + \mu_t \quad (8)$$

To make sure that the $\min t_{\rho\ t}^{IO}(\delta_1, \delta_2)$ congregate i.e. converges in distribution dummy variable include the estimated equationin estimated equation for estimation:

$$\min t_{\rho\ t}^{IO}(\delta_1, \delta_2) \rightarrow \inf_{\gamma} = \wedge \frac{H}{[\delta_1(\delta_2 - \delta_1)]^{1/2} K^{1/2}} \quad (9)$$

4.1. The ARDL bounds testing approach

Since traditional approaches to cointegration have certain demerits, we have used the structural break autoregressive distributed lag model or the ARDL bounds testing approach to cointegration in the presence of structural break stemming in the series. The ARDL bounds testing approach to cointegration has certain merits like it is flexible regarding integrating order of the variables whether variables are found to be stationary at I (1) or I (0) or I (1) / I (0). In addition, Monte Carlo investigation confirms that this approach is better suited for small sample size (Pesaran and Shin [58]). Moreover, a dynamic unrestricted error correction model (UECM) can be derived from the ARDL bounds testing through a simple linear transformation. The UECM integrates the short run dynamics with the long run equilibrium without losing any information for the long run. The empirical formulation of the ARDL bounds testing approach to cointegration is given below:

$$\begin{aligned}\Delta \ln E_t &= \alpha_1 + \alpha_T T + \alpha_E \ln E + \alpha_Y \ln Y_{t-1} + \alpha_K \ln K_{t-1} + \alpha_{TR} \ln TR_{t-1} + \alpha_U \ln U_{t-1} \\ &+ \sum_{i=1}^{p} \alpha_i \Delta \ln E_{t-i} + \sum_{j=0}^{q} \alpha_j \Delta \ln Y_{t-j} + \sum_{l=0}^{s} \alpha_l \Delta \ln K_{t-l} + \sum_{m=0}^{t} \alpha_m \Delta \ln TR_{t-m} \\ &+ \sum_{n=0}^{t} \alpha_n \Delta \ln U_{t-n} + \mu_t\end{aligned} \tag{10}$$

Where, $\ln E_t$, $\ln Y_t, \ln K_t$, $\ln TR_t$ and $\ln U_t$ natural log of energy consumption per capita, natural log of real GDP per, natural log of capitalization, natural log of trade openness per capita and natural log of urbanization per capita. Δ is for difference operator and μ_t denotes residual term. F-statistics are computed to compare with upper and lower critical bounds generated by Pesaran et al. [59] to test for existence of cointegration. The null hypothesis to examine the existence of the long run relationship between the variables is $H_0 : \alpha_E = \alpha_Y = \alpha_K = \alpha_{TR} = \alpha_U = 0$ against alternate hypothesis $(H_a : \alpha_E \neq \alpha_Y \neq \alpha_K \neq \alpha_{TR} \neq \alpha_U \neq 0)$ of cointegration for equation-6. Using Pesaran et al. [59] critical bounds, if computed F-statistic is more than upper critical bound (UCB) there is cointegration between the variables. If computed F-statistic does not exceed lower critical bound (LCB) the variables are not cointegrated for a long run relationship. If computed F-statistic falls between lower and upper critical bounds then decisions regarding cointegration between the variables is uncertain. However, since our sample size is large (160 observations) and critical bounds generated by Pesaran et al. [59] may be suitable. Therefore, we use lower and upper critical bounds developed by Pesaran et al. [59] rather than Narayan [60].

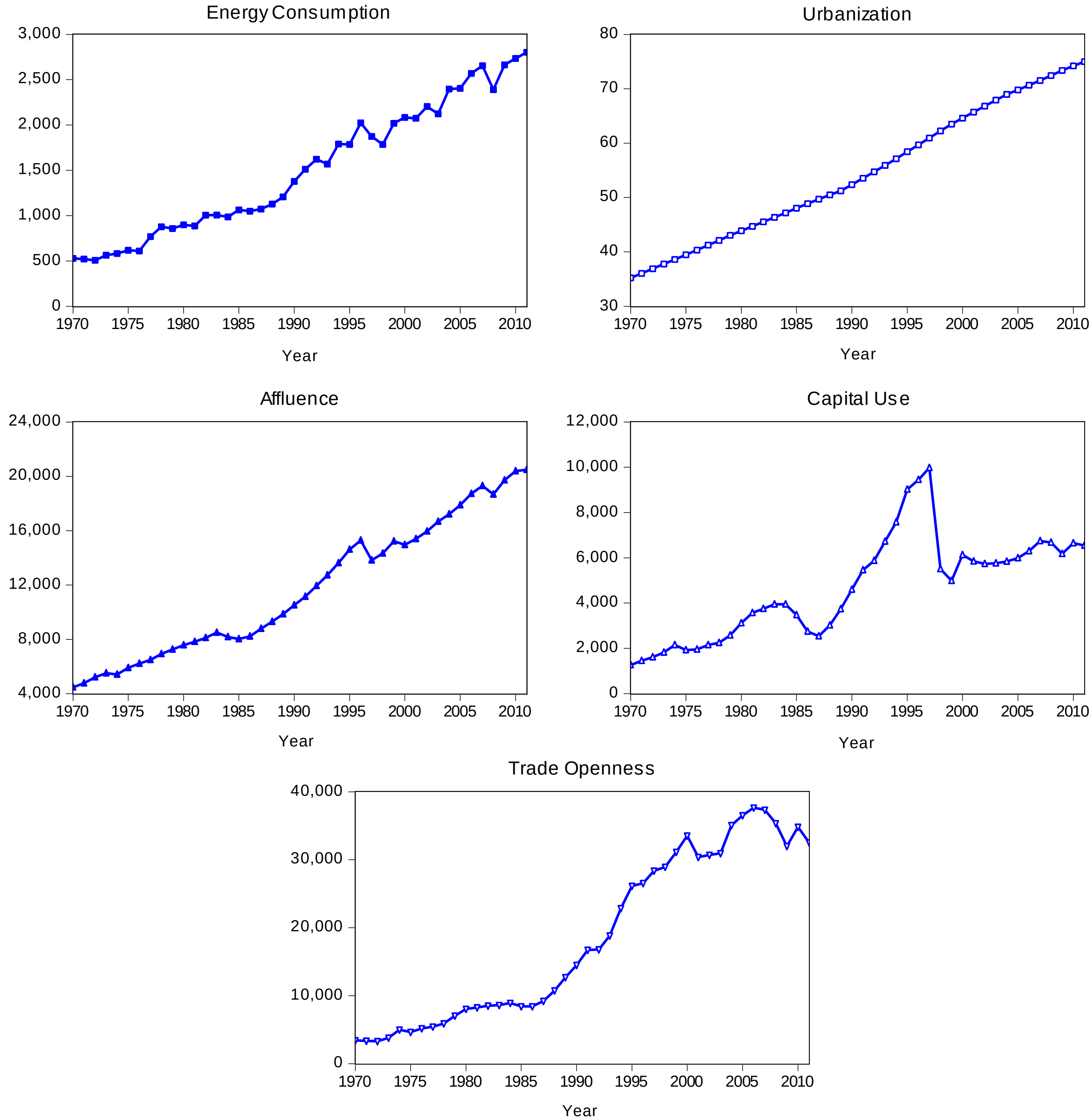
IV.I The VECM Granger CausalityAapproach

We should apply the vector error correction model (VECM) to investigate the causal relationship between the variables once cointegration relationship exists between the series. It is argued by Granger [61] that the VECM is an appropriate approach to examine causality between the variables when series are integrated at I(1). The empirical equation of the VECM Granger causality approach is modeled as follows:

$$(1-L)\begin{bmatrix}\ln E_t \\ \ln U_t \\ \ln Y_t \\ \ln K_t \\ \ln TR_t\end{bmatrix} = \begin{bmatrix}a_1 \\ a_2 \\ a_3 \\ a_4 \\ \alpha_5\end{bmatrix} + \sum_{i=1}^{p}(1-L)\begin{bmatrix} b_{11i} & b_{12i} & b_{13i} & b_{14i} & b_{15i} \\ b_{21i} & b_{22i} & b_{23i} & b_{24i} & b_{25i} \\ b_{31i} & b_{32i} & b_{33i} & b_{43i} & b_{53i} \\ b_{41i} & b_{42i} & b_{43i} & b_{44i} & b_{45i} \\ b_{51i} & b_{52i} & b_{53i} & b_{54i} & b_{55i}\end{bmatrix} \times \begin{bmatrix}\ln E_{t-1} \\ \ln U_{t-1} \\ \ln Y_{t-1} \\ \ln K_{t-1} \\ \ln TR_{t-1}\end{bmatrix} + \begin{bmatrix}\alpha \\ \beta \\ \delta \\ \theta \\ \vartheta\end{bmatrix} ECT_{t-1} + \begin{bmatrix}\varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t}\end{bmatrix} \quad (11)$$

Where $(1-L)$ indicates difference operator and lagged residual term is indicated by ECT_{t-1} which is obtained from long run relationship while $\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}, \varepsilon_{4t}$, and ε_{5t} are error terms. These terms are supposed to be homoscedastic i.e. constant variance. The statistical significance of the coefficient of lagged error term i.e. ECT_{t-1} shows the long run causal relationship causal relationship between the variables. The short run causality is shown by statistical significance of F-statistic using Wald-test by incorporating differences and lagged differences of independent variables in the model. Moreover, the joint significance of the lagged error term with differences and lagged differences of independent variables provides joint long-and-short runs causality. For example, $b_{12,i} \neq 0 \forall_i$ implies that economic growth Granger-causes energy consumption and economic growth is Granger cause of energy consumption shown by $b_{21,i} \neq 0 \forall_i$.

Figure-1: The Trend of the Variables



V. Results interpretations

The descriptive statistics reveal that all the series have normal distributions ad error terms having zero mean with finite variance (Table-2). This supports us for further analysis. The correlation analysis indicates that urbanization, economic growth, capital use and trade openness are positively correlated with energy demand. The positive correlation is found from economic growth, capital use and trade openness to urbanization. Capital use and trade openness are negatively correlated with economic growth. The positive correlation exists between trade openness and capital use.

[Insert Table 2 here]

The primary step is to test the unit root properties of the variables to proceed for the ARDL bounds testing approach to cointegration. The ARDL bounds testing approach is free from pre-unit root testing but we ensure that none of the variables is integrated at I (2). The bounds testing approach assumes that variables should be stationary at I (0) or I (1) or I (0) /I (1). So to overcome this issue, we have applied traditional unit root tests such as ADF test by Dickey and Fuller, (1981); PP test by Philips and Perron[48] and DF-GLS test by Elliott et al. [49]. The results of these tests show that all the variables have a unit root at level with intercept and trend. At 1st difference, the variables are found stationary. This implies that the series are I (1). We cannot rely on these traditional unit root tests as they do not seem to accommodate structural break arising in the series. The exact information about the structural break would help policy to consider these structural breaks while designing a comprehensive urbanization and energy policies in the country. We have applied Clemente et al. [55] unit root test with one and two unknown structural breaks. The results are detailed in Table-3 show that variables are non-stationary at level in the presence of single structural breaks but integrated at I(1). This indicates that the null hypothesis of unit root is rejected with structural break points for the series. The estimated break points are in the middle of the 1970s and the late 1980s. The estimated break points coincide with 1970s urbanization plan formulated from the New Economic Policy (NEP) and in 1980s, under the Malaysian Industrial Master Plan (IMP) have caused on industrial activities in Western Part of Peninsular Malaysia. Both of these dynamic plans have caused directly to the movement of people from rural to urban megacities at those particular break points. This, indeed, makes a Malaysia's economic transition from agriculture towards industrializing economy starting from the breakpoints onward. The same inference is true, once we applied same unit root test in the presence of two structural breaks occurring in the variables. We find that all the variables are integrated at I(1) in the presence of structural break in the series.

[Insert Table 3 here]

The unique order of the variables leads us to apply the ARDL bounds testing to examine cointegration between the variables. The ARDL bounds approach requires appropriate lag length for model specification. The results are reported in Table-4 by various lag length criteria. We followed Akaike information criteria to select an appropriate lag length. Lütkepohl [62] argued that AIC has superior power properties for small sample data compared than other lag length criteria. Akaike information criterion provides efficient and consistent results as compared to final prediction error (FPE), Schwarz information criterion (SBC) and Hannan-Quinn information criterion (HQ). Based on empirical evidence provided by AIC, we find that the optimum lag is 6 in such quarter frequency data over the period of 1970-2011 in case of Malaysia.

[Insert Table 4 here]

[Insert Table 5 here]

The results of bounds testing are detailed in Table-5. Our empirical evidence reveals that calculated F-statistic exceeds the upper critical bound at the 5% level of significance. This concludes that we may reject the null hypothesis of no cointegration. The results reported in Table-5 show that there is evidence of cointegration once we treated energy consumption, economic growth, capital and trade openness as regressand variables. This shows that there are four cointegrating vectors validating the existence of the long run relationship between the variables in case of Malaysia.

The next turn is to find the impact of independent actors on the dependent variable. The results show that urbanization has a positive impact on energy consumption. This shows that a 1% urbanisation raises energy demand by 0.7176% by keeping other things constant. Due to the vision 2020 to become a developed nation, the countryside is growing rapidly with the urban facilities. At the same time, infrastructural advancement causes the expansion of urban areas. The growing income facilities in rural areas are also leading to more use of technology. Eventually, the urbanisation effect causes an increase in energy consumption in Malaysian society. The impact of income on energy consumption is positive and it is statistically significant at the 1% level of significance. A 1% increase in income is linked with 0.6386% energy consumption. Due to the vision 2020 to become a developed nation, the Malaysian economy is growing very fast. Like other developed countries, the consumption patterns of people are moving more towards the technological usage. Moreover, better financial growth and credit facilities are leading to more use of energy. Further, due to the high subsidy and lower price of fuel, people tend to use more vehicles and household machineries. Therefore, energy reduction policies will have less impact on economic growth here.

The impact of capitalization has positive impact on energy demand and it is statistically significant at the 1% level of significance. It implies that keeping other things constant, a 1% increase in capitalization is linked with energy use by 0.0806%. The positive and statistically significant relationship is found between trade openness and energy consumption. We find that a 0.0519% increase in energy consumption is related to 1% increase in trade openness, all else is same. Generally, in a low-income country an increase in trade openness will increase their energy usage, but in a high-income country energy usage falls in response to trade liberalization. As Malaysia is a growing economy, energy consumption shows an inelastic nature in response to trade openness. Therefore, emphasizing on more openness in trade will lead to very low level of increase in energy usage. Thus, trade expansion policies like export promotion policies designed to increase exports will not increase energy consumption here. Another implication of the findings is that environmental policies that reduce energy consumption will not affect growth in exports.

[Insert Table 6 here]

The short run results are also reported in the lower segment of Table-6. Urbanization is also positively linked with energy consumption but it is statistically significant at 10% level. Economic growth adds in energy demand. These findings are statistically significant at 1% level of significance. The capitalization has positive and statistically significant impact on energy demand. Trade openness declines energy consumption. Trade openness and energy demand is negatively linked and this relationship is statistically significant at 10% level. The long run relations between urbanization and energy consumption established through the lagged error correction term which is negative and significant. The negative sign of the error correction term confirms the expected convergence process in long-run dynamics of urbanization and energy consumption model in Malaysia. In fact, 14 percent of the last year's disequilibria are corrected in the current year based on these results, suggesting a speed of adjustment in the relationship process following a shock. In order to achieve the stable long run equilibrium energy demand in Malaysia, it would take around 7 years. The results of the diagnostic tests suggest that the underlying desirable assumptions are fulfilled. The short run findings of the empirical results are consistent in order to implement the carbon emissions or environmental policy in Malaysia.

The stability of the ARDL bounds testing estimates is investigated by applying the CUSUM and CUSUMsq tests. The results are shown in Figure-1 and 2. The plots of the CUSUM statistics are well within the critical bounds.

[Insert Fig.1 here]

[Insert Fig.2 here]

[Insert Table 7 here]

The plot of the CUSUMsq of squares statistics are not well within the critical bounds that shows the presence of structural break in the model. This relates the Malaysian economy for the period 1983-1984 due to industrialization in terms of consumer goods and restrictive trade policy.

We have applied Chow forecast test to confirm the presence of structural break. The computed F-statistic is reported in Table-7 suggests that there is no significant structural break in the economy during the sample period. The Chow forecast test is more reliable and preferable than graphs (Leow [63]). This confirms that the ARDL estimates are reliable and efficient.

The existence of long run (cointegration) relationship between the variables such energy consumption, urbanization, economic growth, capitalization and trade openness intends us to apply the VECM Granger causality approach. The appropriate information about the direction of causality between the variables provides a clearer picture for policymakers to formulate urban, energy, economic and trade policy to sustain long run economic growth. The VECM Granger causality approach provides information about the causality between the variables both for long-and-short runs. The results of Granger causality test are reported in Table-8. The long run causality is indicated by the significance of coefficient of the one period lagged error-correction term ECT_{t-1} in equation (7) using t-test. The short run causality can be detected by the joint significance of LR test of the lagged explanatory variables in the equation. Our empirical results suggest that the ECT_{t-1} is having negative sign and statistically significance in all the VECM equations except in urbanization VECM equation.

The results of long run causality reveal that feedback effect is found between energy consumption and economic growth. This shows that economic growth interdependent. This shows that reductions in energy supply would retard economic growth. The energy exploration policies should be encouraged to sustain economic growth in long run. The relation between trade openness and economic growth is bidirectional. This implies that energy exploration polices should be on priority and adoption of energy conservation policies is not only reduce trade but also it would adversely affect economic growth. Capitalization is Granger cause of energy consumption and same is true from opposite side.

[Insert Table 8 here]

The feedback effect exists between capitalization and trade openness and, same inference is drawn between economic growth and capitalization. Energy consumption is Granger caused by urbanization. Urbanization also Granger causes economic growth, capitalization and trade openness in long run. In short run, energy consumption Granger causes economic growth and same is true from opposite side. The relationship between capitalization and energy consumption is bidirectional. Urbanization Granger causes trade openness and same is not true from opposite side. The feedback effect is found between economic growth and capitalization. The bidirectional causal relationship exists between trade openness and economic growth. Capitalization Granger causes trade openness and same is true from opposite side.

VI. Conclusion, Policy Implications and Future Directions

This paper investigated the how much energy demand is affected by urbanization by incorporating capital, economic growth and trade openness in energy demand function in case of Malaysia. We applied the ARDL bounds approach to examine the long run relationship between the variables while dummy variable is included to capture the structural break arising in the series. Our results exposed that in the presence of structural breaks, cointegration exists between the variables. The findings unveiled that urbanization has positive effect on energy demand. Economic growth adds in energy demand. Capitalization is positively linked with energy consumption. A positive relationship from trade openness to energy consumption is found. The causality analysis exposed the unidirectional causality running from urbanization to energy consumption. The feedback effect is found between economic growth and energy consumption. The relationship between capital and energy consumption is bidirectional and same is true for economic growth and capital. Trade openness Granger causes energy consumption.

Through the empirical results of this paper, we obtained evidence confirming the modernization theory for developing nation, predicting that environmental impacts may follow the basic Kuznets theory relative to urbanisation and energy use in Malaysia. This is not a surprising result, because Malaysia is moving forward with high speed of urbanisation process with huge numbers of industrial areas and well-planned housing settlement in the urban metropolitan cities since 1990s. There is some possibility the government able to reduce energy use in urban cities, where transportation can be economize by emphasis urban transportation network. Furthermore, Tenth Malaysia Plan [6] has highlighted this agenda and in long term, this program will able to reduce demand for energy in the transportation sectors. Energy consumption in industrial production activities may be high in urban areas in Malaysia, especially in the newly open economic corridors. These economic corridors also bulk with urban population and various supporting economic activity concentrate with the corridors niche areas and decoupling demand for energy resources. Consequently, in the long-term this able to capture the urban environmental theory faced by developed countries. Since 1970s, Malaysia has formulated New Economic Policy (NEP), National Development Policy (NDP), Vision 2020 and Regional Corridors is formulated to ensure urbanisation process in Malaysia moves smoothly in the long-term period with sustainable environment protection. Under the Tenth Malaysia Plan [6], the government has intensified efforts to reduce energy use and CO_2 emission by climate adaption and mitigation measures. Unfortunately, as far we concern there is no comprehensive policies related on urbanisation and energy use in Malaysia. We found that, there is only environment regulation which protecting natural resources which indirectly able to reduce energy consumption and CO_2 emissons in Malaysia. Although Malaysia already emphasis 2 major national environment policies, such as National Green Technology Policy 2009; and National Climate Change 2009, we would like to suggest special needs of urbanisation and energy related policy to protect urban settlement from pollutant environment cause by energy consumption. On the other hand, transport and industrial sectors is the largest consumer of energy in urban areas in Malaysia, generally accounting 50-60%. To overcome this matter, efforts have been introduce by utilizing non-renewable energy resources. Therefore, Small Renewal Energy Power Program (SREP) and Malaysia Building Integrated Photovoltaic Technology Application Project (MBIPV) has been introduces in Iskandar Malaysia Development Corridor which is one of the rapid urbanize area located southern part of Peninsular Malaysia. These types of innovative projects able to hamper out the energy consumption in urban areas and reduce CO_2 emissions in long cycle of urbanization process in Malaysia. Hence, the low carbon cities policy package introduce in this urban corridor by energy efficiency improvement, lowering CO_2 intensity and transport demand control also able to make to urbanize area be more sustained in term of environment in future decades.

In the meantime, some researchers also pointed that energy conservation is a right choice to overcome the conflict between energy supply and energy demand for urban areas (Jones [9]; Li et al. [64] and Yuan et al. [65]). In the case of Malaysia, economic growth directly has increased energy demand and new economic agenda for Malaysia is to be a high income country by 2020 with high volume of economic growth. Therefore, an idea to reduce energy consumption in urban areas is not a good decision for policymakers because this will give negative impact on future economic performance, unemployment and social issues. For us, technological innovation introduced in the recent urban corridors is the answer, to solve the puzzle which always surrounding developing countries such as Malaysia in the past 2 decades.

Toward this end, most of study related to urbanization focusing energy consumption, as a future direction, future researchers should use micro data's according to states or economic regions in Malaysia to compare empirically the effects of urbanization and energy use as well as the economic performance. This type of study may capture the effect of economic transformation plan introduced by the government with urbanization and the demand side of energy use by states and regions. Other than that, it is generally evident that the moment of people from rural areas to urban areas has created problems on productivity and unemployment level, mainly agriculture and industrial sectors. This problem may seriously effects on sustainable regional development of Malaysia in future. Therefore, theses aspects should take into consideration in future direction of urbanization issues. Another issue is 'over-urbanisation' problem, which might be faced in future by Malaysia. In order to face this issue, future studies should also put attention on urban population growth structure in urban and megacities in Malaysia while estimating the effects of urbanization and energy use. Finally, and most importantly, the direction of future research is the nonlinear modeling procedures. Future researcher may use nonlinear approach to identify the robustness of the present linear cointegration and causality more efficiently. Mainly, this happens because the outcomes in this study do not provide ultimate solution and more concentrating on the direction of cointegration and causality effect in long run and short run. To conclude, future analysis should include more related variables with the urbanization and energy use with extended sample period to capture the effects of urbanization policies introduced by the Malaysian government.

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