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Exploring the bi-directional long run relationship between energy consumption and life quality

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ABSTRACT

This study aims at investigating the bi-directional long run relationship for the period of 1990–2009 between energy consumption and life quality in 198 countries categorized by income level. To achieve this goal, the canonical cointegrating regression (CCR) was utilized. The results revealed that energy consumption improves the life quality of 70% of the countries despite their different incomes. The study's results, unlike all other previous studies, also revealed that the life quality indicators also increase energy consumption, a phenomenon that appears to be true in 65% of the countries. Despite the fact that energy consumption plays an important role in achieving a better life quality, the world still depends on fossil fuels which represent 81% of total energy consumption. Therefore, it is suggested that these countries should rationalize their fossil fuel energy consumption by increasing the role of renewable energy and increasing their energy saving to improve life quality without causing any damage to the environment.

Contents

1. Introduction

Energy consumption is essential to achieve a better life quality. Hence, energy consumption, especially fossil fuels consumption, has been increasing significantly since the 19th century. Energy is perceived to represent the backbone of global industrialization. For the last five decades, the world has been witnessing a remarkable economic growth and development assisted by the increase in energy consumption. Many studies indicated that energy consumption is the major source of economic growth in different developed and developing countries [1–12]. Moreover, energy consumption plays an important role in achieving economic development [13–18] and financial development [19–27].

Since energy plays a role in achieving a sustainable development, it might have an impact on life quality. During the last two decades, the world witnessed a large improvement in life quality indicators, namely gross domestic income per capita, population with access to water, life expectancy at birth, as well as mortality ratio. During the period of 1990–2009, the world gross domestic income per capita, population with access to water, and life expectancy at birth increased more than 46%, 85%, and 93%, respectively. On the other hand, the mortality ratio decreased more than 55%. In spite of the large improvement of life quality, only a few studies have investigated the role of energy consumption on life quality. Therefore, this study attempts to determine the impact of energy consumption on life quality indicators in 198 developed and developing countries.

Examples of researchers who explored the impact of energy on life quality include Pasten and Santamarina [28] who found that energy consumption could improve life quality. Their results,

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however, revealed that the increase in life quality in the developing countries increases the cost of energy. The two researchers suggested that the increase in energy saving without affecting the quality of life is essential. Martins [29] concluded that electricity consumption plays an important role in increasing the life quality of poor communities. Mazur [30] found that the increase in electricity consumption per capita is not associated with the improvement of life quality in the industrialized nations. Finally, Banister [31] showed that energy consumption has an indirect effect on life quality improvement due to its role in increasing the world transportation.

2. Data, methodology and results

The primary aim of this study is to examine the impact of energy consumption on the life quality in 198 countries. The countries were categorized by income levels into low, lower middle, upper middle, and high income. The reason behind categorizing the countries by income is due to the fact that higher income countries have higher life quality indicators such as, income per capita, population with access to water, life expectancy at birth, and lower mortality rate. These four life quality indicators, namely income per capita, population with access to water, life expectancy at birth, and mortality rate were used in this study.

This study is different from all the studies that focused on the impact of energy consumption on life quality because it explores the bi-directional long run relationship between energy consumption and life quality indicators. Moreover, this study also intends to investigate the long run relationship because the result of the long run relationship is very important to policy implications.

Although the results arrived at by the previous studies indicated clearly that energy consumption can improve life quality, the effect of life quality on energy consumption was not explored. The improvement of life quality might increase energy consumption. This is because the increase in income can increase, as a consequence, the standard of living which, in turn, increases energy consumption. Moreover, the increase in the number of population with access to water will inevitably require more energy to fulfill their need of water. Furthermore, the increase of births and the decrease of mortality rate will certainly increase the level of population which, in turn, increases energy consumption.

This study utilized the four indicators of life quality employed by Pasten and Santamarina [28]. These indicators are gross income per capita measured in 2000 of constant US dollars (INP), the percentage of the population with access to water (IWS), life expectancy at birth (LEX), and infant mortality rate (MR). In addition, total primary energy consumption per capita (ENP) was also used. The study used time series data taking the period of 1990–2009. The data for the INP, IWS, LEX, and MR were retrieved from the World Development Indicators (WDI) [33] and the data for ENP were taken from the Energy Information Administration (EIA) [34]. Table 1 reviews a detailed definition for each of the four variables.

Since time series is used in this study, it is important to test the stationarity of the variables. The basic idea behind the unit root test is that the variable is perceived to be stationary if the mean and the auto covariance of the series do not depend on time. The ADF test is widely used by different economists to test the stationarity of variables because it can control the serial correlation problem associated with the variables. The test creates a parametric correction for higher order of correlation. The ADF test uses the following regression:

$$\Delta y_t = \alpha y_{t-1} + \theta_t' \delta + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + \ldots + \beta_p \Delta y_{p-t} + \upsilon_t \qquad (1)$$

Eq. (1) above was utilized to test the following null and alternative hypothesis:

H_0: $\alpha = 0$

H_1: $\alpha < 0$

The T-statistics determine whether the null hypothesis is rejected or not.

The unit root test results for the low, lower middle, upper middle, and high income countries are presented in Tables A1, A2, A3, and A4 (see Appendix 1). The results show that all the variables are stationary, thus, rejecting the null hypothesis whereby the variables have a unit root.

Since some of the variables are stationary at the first difference and the others are stationary at levels, the canonical cointegrating regression (CCR) was used because applying the old cointegration tests will lead to bias and misleading results.

This single cointegration equation was proposed by Park [32]. This equation employs a stationary transformation of the (y_i, X_t') data to obtain the least square estimates to eliminate the long run dependency between the cointegration equation and stochastic regressors' innovations. The CCR eliminates the endogeneity caused by the long run correlation of the cointegrating equation errors as well as the stochastic regressors innovations, and it simultaneously corrects the asymptotic bias resulting from the contemporaneous correlation between the regression and stochastic regressor errors. The CCR is unbiased and its estimates follow a blend normal distribution which is free of non-scalar nuisance parameters. It permits asymptotic Chi-square testing and can function with variables which are stationary in different levels. The first step of this test is to obtain innovations $\hat{\mu}_t = (\hat{\mu}_{1t}, \hat{\mu}_{2t'})'$ and corresponding constant estimates of the long-run covariance matrix $\hat{\Omega}$ and $\hat{\Lambda}$. The CCR also requires a constant estimator of the modern covariance matrix $\hat{\Sigma}$. The columns corresponding is extracted to the one-sided long run covariance matrix of $\hat{\mu}_t$ and $\hat{\mu}_{2t}$.

$$\hat{\Lambda}_2 = \begin{bmatrix} \hat{\lambda}_{12} \\ \hat{\lambda}_{22} \end{bmatrix} \qquad (2)$$

Table 1
Definition of the variables.

Variable	Definition
INP	GNI per capita (formerly GNP per capita) is the gross national income, converted to U.S. dollars divided by the midyear population.
IWS	Access to an improved water source refers to the percentage of the population with reasonable access to an adequate amount of water from an improved source, such as household connections, public standpipes, boreholes, protected wells or springs, and rainwater collection. Unimproved sources include vendors, tanker trucks, and unprotected wells and springs. Reasonable access is defined as the availability of at least 20 liters for a person a day from a source within one kilometer from his/her dwelling.
LEX	Life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life.
MR	Infant mortality rate is the number of infants dying before reaching one year of age, per 1,000 live births in a given year.
ENP	Total primary energy consumption per capita (Million Btu per Person).