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A new approach to energy consumption per capita stationarity: Evidence from OECD countries

Burcu Ozcan [a,*], Ilhan Ozturk [b]

[a] Faculty of Economics and Administrative Sciences, Firat University, 23200, Elazig, Turkey
[b] Faculty of Economics and Administrative Sciences, Cag University, 33800 Mersin, Turkey

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ABSTRACT

Applying a new panel stationary test procedure to data from 32 OECD countries from 1971 to 2013, this study examines the time series properties of per capita energy consumption. The results indicate that energy consumption per capita follows a mean reverting process for 16 OECD countries whereas, for the remaining 16 OECD countries, a mean reverting process is not the case. Besides, energy consumption per capita exhibits some sharp and smooth structural shifts (breaks) in its mean and/or trend levels, and the endogenously identified break dates correspond to specific macroeconomic events such as oil crises, Gulf War, Asian and Global financial crises. These results also have important policy implications. For the 16 OECD countries that have stationary energy consumption per capita series, government policies intended to stabilize energy demand will have no long-lasting effects, and therefore, governments should not adopt unnecessary policy targets for energy demand level. However, for the remaining 16 OECD countries, such policies will have long-lasting effects.

Contents

1. Introduction

An increasing demand for energy as a result of a high level of urbanization and industrialization has led to a new research area in energy economics that involves testing for the unit root properties of energy consumption [66]. Given the close link of energy consumption with the economy and the environment, it is crucial for researchers and policymakers to analyze the time series properties of per capita energy consumption [57].

Understanding the time series features of energy consumption has implications for the design of energy policies that target to achieve specified levels of energy consumption over time [12]. The effects of shocks, permanent versus temporary, depend on the time path that the energy variable follows. If energy consumption is nonstationary, shocks to the global oil market will have permanent or long-term effects on energy demand [52]. This is consistent with the hysteresis in energy demand[1] (see [13,52]). In this

* Corresponding author.
E-mail addresses: bozcan@firat.edu.tr (B. Ozcan), ilhanozturk@cag.edu.tr (I. Ozturk).

[1] Hysteresis, or path dependence, arises when the energy consumption variable has a unit root. That is, any shock is entirely incorporated into the series level (Golpe et al. [29]).

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case, given that disruptions in energy consumption will have a permanent effect on economic activity, the government policies will be more effective [66]. However, if energy consumption follows a stationary process, shocks to energy consumption will result in a temporary deviation from the long-run growth path [33], and thus, energy consumption will return to its original trend path after being hit by a shock in energy markets. Therefore, governments should not adopt unnecessary targets when energy consumption temporarily deviates from the trend path because energy conservation and demand management policies designed to reduce energy consumption have no long-lasting effects [31,57]. Furthermore, as stated by Apergis and Payne [2], if oil consumption follows a stationary process, then energy consumption and management policies such as fuel economy standards, tariffs on imported fuels and vehicles, and carbon tax on transportation fuels will have only temporary impacts because oil consumption will return to its mean.

The time series properties of energy consumption shed some lights on the forecasting of future movements in energy demand. Such forecasting is a basic tool for energy planning and policy formulation [49]. If energy consumption returns to its trend path over time (trend stationary), there is a mean reverting process, and it might be possible to use past energy consumption behavior in the generation of forecasts [19]. In other words, in case that shocks do not persist indefinitely, energy series will return to its trend path and it will be possible to forecast future values based on its past behaviors [1]. However, if energy consumption does not return to its trend path following a shock (stochastic trend), its past behavior is of little or no use for forecasting [4,28], and in that case, it would be necessary to look at other variables explaining energy consumption to generate forecasts of energy demand into the future [49].

Because of the close relationship between energy consumption and real economy, the structural breaks in energy markets may generate fluctuations on macroeconomic variables. In a case of permanent shocks to energy consumption, through the transmission mechanism to other sectors in the economy, some macroeconomic variables such as output, employment, and exchange rate can be expected to inherit that nonstationarity [49,52]. As [32] note, “variables related to the level of any variables with a stochastic trend will inherit that nonstationarity, and transmit it to other variables in turn”. In this regard, some macroeconomic theories would become invalid. For example, as indicated by Hasanov and Telatar [31], fluctuations in real output are assumed to be transitory, and thus, real output is stationary in the real business cycle theory. However, if oil consumption contains a unit root, through the transmission mechanism to real output via oil price shocks, business cycle theories lose their empirical supports [53]. Similarly, real exchange rates are accepted as stationary in the law of one price in the international trade theory while the price level is assumed to be stationary in the conventional sticky price models of Dornbusch [23] and Taylor [68]. However, the presence of unit root in energy consumption may cast some doubt on the validity of these theories via transmission mechanisms.

Furthermore, the time series features of energy consumption are important in modelling the relationship between energy consumption and other variables such as economic growth [31,67]. On one hand, if all variables in a system are stationary, the right modelling technique is a vector autoregressive (VAR) model in levels. On the other hand, if all variables are nonstationary, there are two modelling options. First, if there is no a co-integrating relationship between the variables, the best modelling way is a VAR model in differences. Second, if the variables are co-integrated, then a vector error correction (VEC) model must be used.[2] Additionally, in respect of modelling issue, the relationship between real output and energy consumption indicates the important policy implications. In case of a unidirectional causal relationship from energy consumption to real output, energy consumption could be one of the stimuluses for economic growth, and thus, direct measures at reducing energy consumption should be avoided as energy conservation policies may impede economic growth [38].

In this study, the time series behaviors of energy consumption per capita series in 32 OECD countries are analyzed over the period of 1971–2013. OECD region deserves a special research interest regarding energy demand since it includes the countries that have the highest levels of total final energy consumption worldwide. For instance, the United States was the biggest energy consumer in the world with its 18% of world total primary energy consumption until China recently outpaced it [24]. The level of energy consumption per capita in OECD countries has increased based on their fast development levels because OECD region includes the most developed and wealthiest countries of the world. On average, final energy use per capita in non-OECD countries is still only 23% of the level in the OECD [35]. Regarding the regional shares of total final energy consumption, OECD ranked first with about 39.1% total final energy consumption of the world in 2013 (see [36]). We implement the Carrion-i-Silvestre et al. [18] univariate and panel stationary tests extended with a Fourier function, proposed by Bahmani-Oskooee et al. [9] in this study. We allow for both sharp and smooth breaks along with cross-sectional dependence and nonlinearities issues. In general, the early studies in the literature considered only sharp breaks by including dummy variable, whereas we also allow for smooth breaks involving a Fourier function in our model. To our knowledge, this is the first study using Bahmani-Oskooee et al.'s (2014) test for analyzing the time series features of energy consumption. As a result, we aim to contribute to the literature by employing this new test which will fill the shortcomings of the previously used tests.

2. Literature review

Empirical studies examine the time series properties of energy consumption or production variables.[3] They report wide ranging results based on their samples, methods, and periods. In general, they can be classified into four research strands.[4] The first research strand includes univariate unit root tests with or without break(s). Among them, the studies applying unit root tests without break(s), such as ADF [22] and PP [61], as the first stage of their analyses that aim to define the long-run relationship among energy consumption, economic growth, and other variables generally obtain results against stationarity.[5] However, the studies utilizing univariate unit root tests with break(s) often provide evidence of stationary results. For instance, applying the LM unit root tests with one and/or two breaks developed by Lee and Strazicich

[2] The vector autoregressive (VAR) model is a general framework used to describe the dynamic interrelationship among stationary variables. The structure is that each variable is a linear function of past lags of itself and past lags of the other variables. However, if the time series are not stationary then the VAR framework needs to be modified to allow consistent estimation of the relationships among the series. The vector error correction (VEC) model is just a special case of the VAR for variables that are stationary in their differences, and it can also take into account any cointegrating or long-run relationship among the variables. (See [37]).

[3] See Smyth [67] for an extensive literature review.

[4] Also, some studies apply different methods, such as Congregado et al. [21] for U. S. coal consumption per capita and Golpe et al. [29] for U. S. natural gas consumption. They utilized unobserved component models in a linear and/or nonlinear frameworks. When nonlinearity is taken into account, they provided evidence in favor of nonstationarity. There are also some applied studies examining the similar issue in other disciplines such as mining engineering (see [71,72]; and [73]). For instance, Zhang et al. [72] modelled the gold prices using a mean reverting process in the framework of real option value method.

[5] For a detailed review of this research strand, the interested reader can refer to Chen and Lee [19].