

Are Fluctations In Energy Consumption Transitory Or Permanent? Evidence From A Fourier Adf Unit Root Test

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Abstract

This study analysis the stationarity of energy demand for 30 countries with annual data between 1960-2013 using the per capita energy consumption data acquired from kilogram petrol equivalent value. The per capita energy demand stationarity analysis is examined with the Fourier Augmented Dickey Fuller unit root test. The basic feature of the used econometric method is to include the unknown structural breaking features of the per capita energy demand to the analysis. The analysis results show that the energy demand are not stationary in Australia, Austria, Belgium, Brazil, Canada, China, Denmark, Finland, France, Germany, Greece, Iceland, India, Israel, Italy, Japan, South Korea, Mexico, Holland, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Turkey, England and USA, so that the energy demand management policies have lasting and long term effects in these countries. It has been determined that the per capita energy demand series of the Czech Republic and South Africa are stationary and the energy demand policies in these countries won't create long lasting effects but the energy demand predictions can be made by benefiting from the previous data of the energy demand.

Keywords: Energy Consumption, Order of Integration, Fourier Unit Root Test

Introduction

Testing the integrative features of the energy demand variables is showing up as a new part in the energy economy literature. The analysis of the energy demand stationarity and to understand it right is very important. This has many reasons. First, if the energy demand follows a stationary process, the energy demand policies used in order to manage energy demand will have temporary effects and after a certain while energy demand will return to its trend value. So if the energy demand has a non-stationary feature, any shock on the energy demand will have permanent effects. This

will lead to successful policies. The second reason explaining the importance of these analysis is, if the energy demand doesn't include unit root (if it is stationary) the previous data of the energy demand can be used for energy demand modeling.

The third fact lies in the relation of energy demand with other macroeconomic variables. Today the stationarity structure of the energy used in every field of economic life as raw material, intermediate input, final goods, can pass onto the other macroeconomic variables due to these close relations (Hsu et al., 2008, p.2318). As a result of this transfer mechanism the stationary situations of the key macroeconomic variables will also affect the alternative economic theories examining the efficiency of the guiding attempts to economy of governments via macroeconomic stability policies.

For example if a reel output is unit rooted, so as to say not being stationary, as a result of a negative shock on the output, it means that the value won't return to its normal trend value on its own. So Keynesian stabilization policy will be needed. If the reel output is stationary, Keynesian policies will cause temporary effects and will be ineffective.

Most of the literature examining the energy demand has made analysis without taking into account the structural breakdowns. But when the structural breakdowns are included into the analysis, the results of the stationarity analysis can change. So the unit root tests in which structural breakdowns are included increase the explanation power of the analysis.

In this study analysis will be realized for the 1960-2013 period by using Fourier Augmented Dickey Fuller (FADF) unit root test for 30 countries consisting of Australia, Austria, Belgium, Brazil, Canada, China, Denmark, Finland, France, Germany, Greece, Iceland, India, Israel, Italy, Japan, South Korea, Mexico, Holland, New Zealand, Norway, Poland, Portugal, Czech Republic, South Africa, Spain, Sweden, Turkey, England and USA.

The remaining part of the study is as follows. Part 2, selected literature review. Part 3, explanation of econometric methodology. Part 4, data and empirical findings. And at the conclusion part result and political suggestions will be presented.

Selected Literature Review

Literature examining the stability of energy demand starts with Narayan and Smyth (2007) study. After this study, many studies have been realized about the stability of energy demand. Some of the studies have been given in Table 1. An agreement couldn't be reached about the stability of energy demand in these studies. Data ranges of the studies, countries and the development levels of them, different econometric methods are the basic reason of this difference.

Table 1: Survey of selected literature for stationarity properties

Author(s)	Time Period	Unit Root Test	Conclusion
Narayan and Smyth	1979-2000	ADF	%31 of countries stationary
Chen and Lee	1971-2002	Carrion-i Sivestre	Stationarity
Hsu et al.	1971-2003	Panel unit root test	Mixed evidence
Apergis and Payne	1960-2007	Lee and Strazicich	Mixed evidence
Apergis et al.	1982-2007	Carrion-i Sivestre, Westerlund panel unit rrot test	Stationarity
Aslan	1960-2008	Lee and Strazicich	Non-stationarity
Barros et al.	1973:1-2008:10	Fractional integration with structural breaks	Non-stationarity
Kula et al.	1960-2005	Lee and Strazicich	Mixed evidence
Narayan and Popp	1980-2006	Pesaran panel unit root test	Non-stationarity
Shahbaz et al.	1971-2010	LM unit root test	Mixed evidence
Kum	1971-2007	LM unit root test with structural break	Stationarity
Yilanci and Tunali	1960-2011	Fourier LM unit root test	Mixed evidence
Ozturk and Aslan	1970-2006	LM unit root test with structural break	Mixed evidence
Mishra et al.	1980-2005	Carrion-i Sivestre	Mixed evidence

Econometric Methodology

In this study FADF unit root test will be used. The econometric method which will be used is a method which can include the unknown features of the structural breakdowns into the analysis. In the 54 year period which is included in the analysis, many events affecting the energy markets have occurred. Some of them are petrol crisis like in 1970s, excessive decrease in petrol prices in 1985, and invasion of Kuwait by Iraq in 1990. Using unit root test taking into account such structural breakdowns will increase the reliability of the results. So the basic benefit of this study to the literature is to create healthier and more reliable results by using a new econometric method taking into account unknown structural breakdowns of the energy demand series.

In the Christopoulos (2010) study, the application starts with the prediction of the model stated in equation 1 stated below;

$$y_t = \delta_0 + \delta_1 \sin\left(\frac{2\pi kt}{T}\right) + \delta_2 \cos\left(\frac{2\pi kt}{T}\right) + v_t \quad (1)$$

In the equation π means pi; k means frequency number; t means trend value of the serial and T means the observation number.

At the second stage the model is determined from which minimum residual sum of squares (SSR) will be acquired by giving values between 1-5 to the k value in equation 2.

$$\hat{v}_t = y_t - \hat{\delta}_0 + \hat{\delta}_1 \sin\left(\frac{2\pi k^* t}{T}\right) + \hat{\delta}_2 \cos\left(\frac{2\pi k^* t}{T}\right) \quad (2)$$

At the third stage the significance of the coefficient of the trigonometric terms of the model from which we acquired the minimum SSR

is tried. If the coefficients of the trigonometric terms are significant, residual series are acquired and ADF unit root test is applied to them and the acquired FADF test statistic values are compared with the critical values.

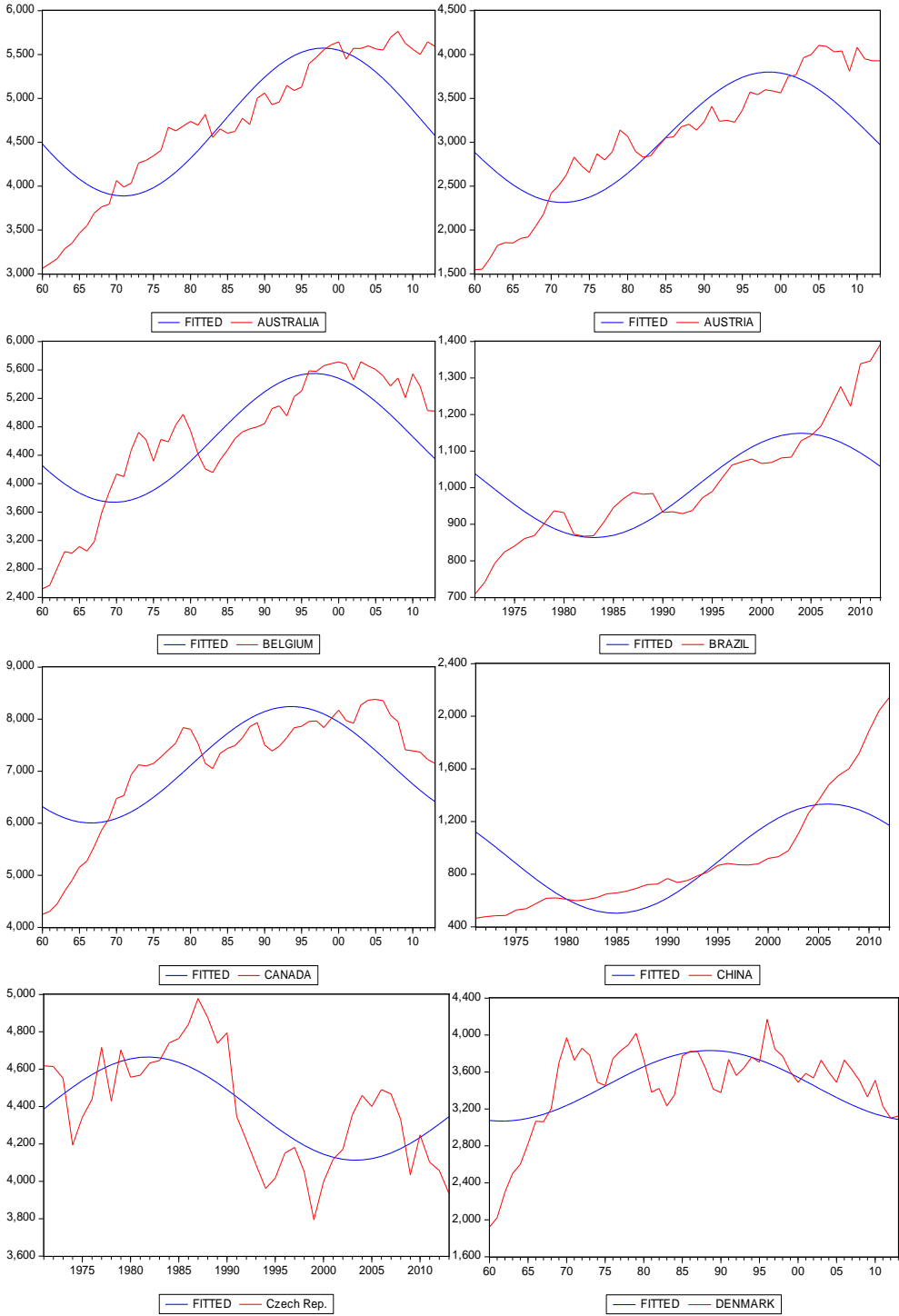
Data and Empirical Results

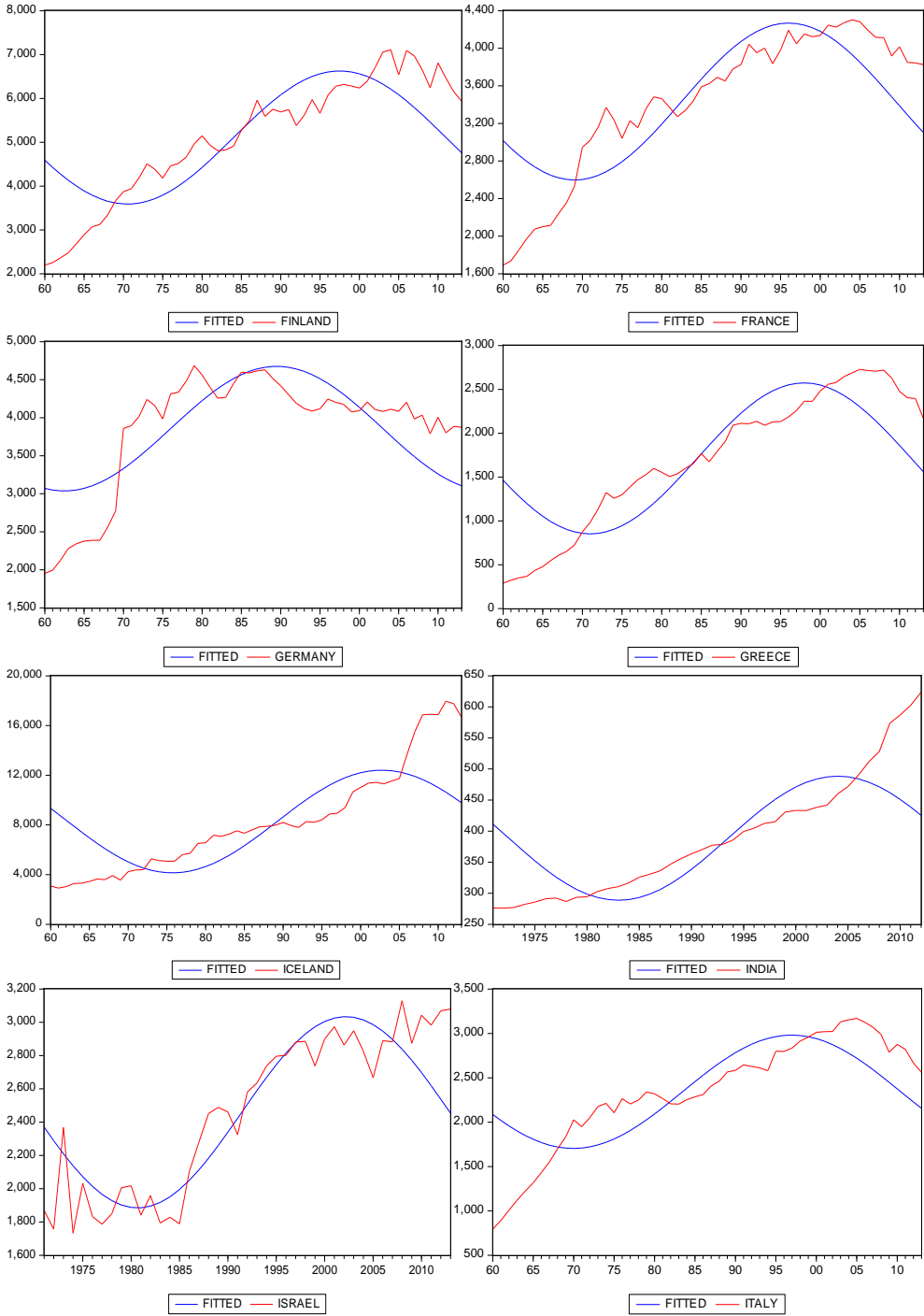
In the study per capita energy consumption data acquired as kilogram petrol equivalent annually between 1960-2013 for 30 countries from the World Bank database. Table 2 reports the FADF unit root test results. In column 2 the data ranges of the countries included in the analysis are stated. Different data range periods have been used due to lack of data. Column 3 states the frequency number selected according to the minimum SSR value; column 4 states the F statistic value calculated for the significance of the trigonometric terms; column 5 states the FADF test statistic value.

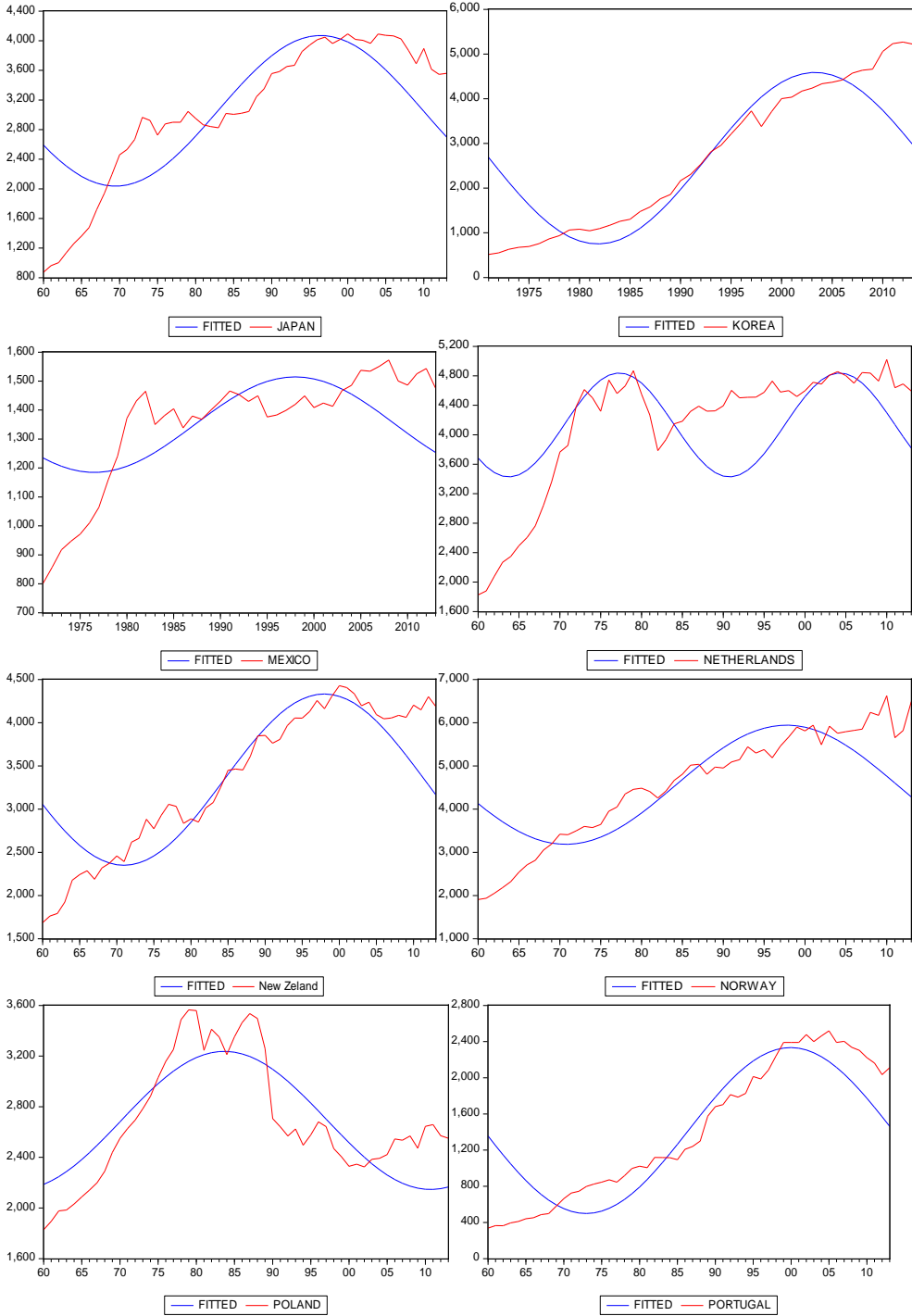
Table 2: FADF Unit Root Test Results

Country	Data Range	Frequency Value	F(k)	FADF
Australia	1960-2013	1	33.8759	-1.2488 (3)
Austria	1960-2013	1	26.7614	-0.4343 (13)
Belgium	1960-2013	1	27.6134	-3.3341 (7)
Brazil	1971-2012	1	13.3511	-0.6705 (2)
Canada	1960-2013	1	27.5293	-2.9006 (7)
China	1971-2012	1	15.8145	-0.9396 (1)
Czech Republic	1971-2013	1	15.4832	-4.6116 (11)
Denmark	1960-2013	1	12.9260	-2.6984 (9)
Finland	1960-2013	1	38.3209	-1.6387 (11)
France	1960-2013	1	41.2276	-2.4186 (6)
Germany	1960-2013	1	33.2074	-2.1593 (6)
Greece	1960-2013	1	46.6948	-2.4625 (3)
Iceland	1960-2013	1	22.7158	-1.4465 (14)
India	1971-2012	1	22.5861	-1.5116 (6)
Israel	1971-2013	1	60.1083	-1.1651 (7)
Italy	1960-2013	1	30.2837	-0.7629 (14)
Japan	1960-2013	1	36.6815	-0.9396 (16)
Korea	1971-2013	1	51.8623	-0.7602 (3)
Mexico	1971-2013	1	10.4238	-2.2518 (7)
Netherlands	1960-2013	2	12.9677	-2.5703 (0)
New Zeland	1960-2013	1	64.0336	0.4354 (14)
Norway	1960-2013	1	34.6079	-0.3162 (16)
Poland	1960-2013	1	50.6779	-2.5646 (9)
Portugal	1960-2013	1	85.9828	-1.4340 (3)
South Africa	1971-2012	2	20.3085	-3.0525 (0)
Spain	1960-2013	1	52.0165	-2.9372 (5)
Sweden	1960-2013	1	42.3096	-2.6092 (3)
Turkey	1960-2013	1	31.7650	-1.1827 (10)
United Kingdom	1690-2013	2	24.3897	-1.2118 (14)
USA	1960-2013	2	19.5652	-2.1315 (15)

Note: Numbers in the parentheses show the optimal lag length.







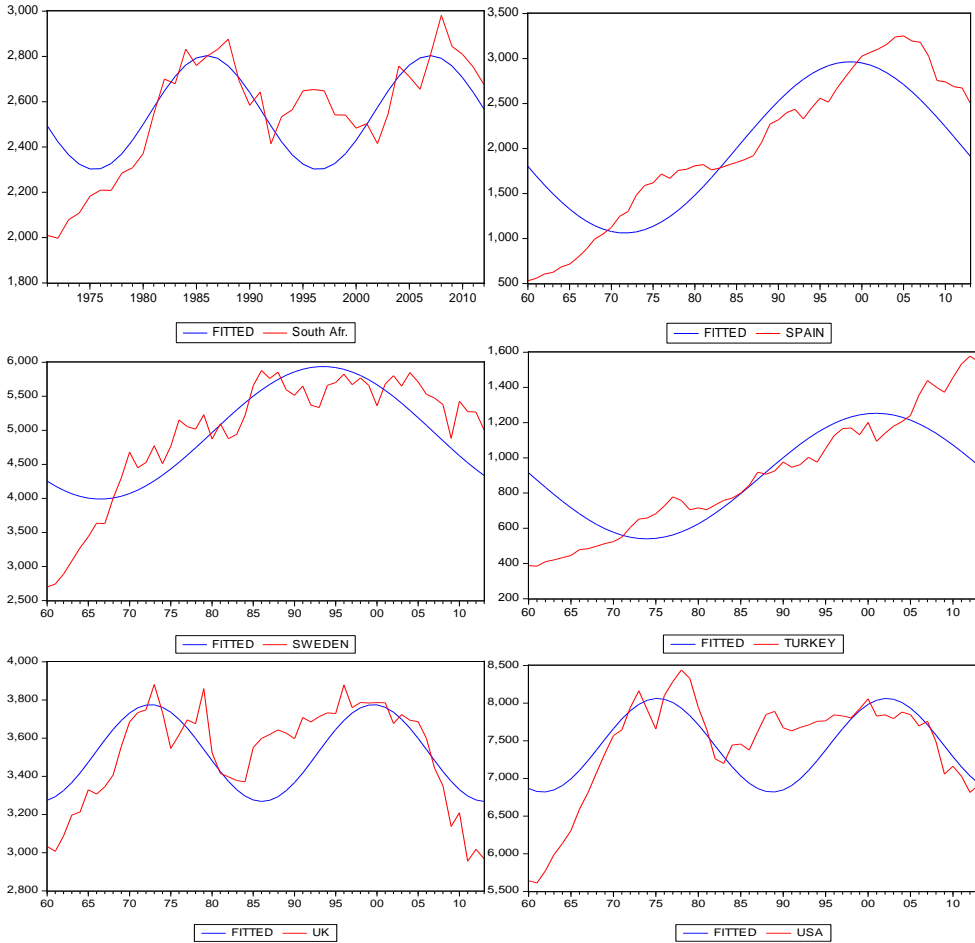


Figure 1: Per capita energy consumption and Fourier Function

In figure 1 per capita energy consumption and Fourier functions are shown. In all countries movements have been realized so as to catch the Fourier function breakdowns.

Results in column 3 shows that the frequency value from which the minimum SSR has been acquired, except Holland, South Africa, England and USA, is 1; and that the minimum SSR value in these countries has been acquired with the model in which the SSR value frequency number is 2. The $F(k)$ value in column 4 shows us the F statistic value of which we test the significance of trigonometric terms. According to this, since the trigonometric terms in 30 countries have been found statistically significant at the 10% level, FADF value could be calculated for all countries in the analysis.

According to the FADF value in column 5 the per capita energy consumption series of countries, except Czech Republic and South Africa,

have unit root. The energy consumption management policies in Czech Republic and South Africa, will have temporary effects. At the same time when making energy demand predictions in these countries, previous data from the energy demand can be used. There are various aspects explaining the stability of energy demand in the energy literature. According to Hsu et Al (2008) these are;

- Abundance of energy sources,
- Low energy consumption,
- New environmental laws stepping in,
- Middle income level

It has been determined that the energy demand series are unit rooted so as to say not stable for the countries except these countries. So the energy demand policies of Australia, Austria, Belgium, Brazil, Canada, China, Denmark, Finland, France, Germany, Greece, Iceland, India, Israel, Italy, Japan, South Korea, Mexico, Holland, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Turkey, England and USA can be used because they have permanent effects.

Conclusion

The analysis of stationarity of energy demand is gaining importance in energy literature. This has several reasons. The first reason is related to energy demand management policies. Most of the developed and developing countries are foreign dependent in energy and so they give great importance to energy demand policies. The energy demand shouldn't be stationary in order to create the demanded results so the energy demand policies shall provide lasting effects.

In this study the stability of the per capita energy consumption has been analyzed with Fourier ADF unit root test for 30 countries between 1960-2013 with annual data. So the basic benefit of this study to the literature is to create healthier and more reliable results by using a new econometric method taking into account unknown structural breakdowns of the energy demand series.

According to the analysis results, per capita energy consumption data of countries, except Czech Republic and South Africa, have unit root. So the energy demand management policies in these countries can create lasting effects. Since the per capita energy consumption data of Czech Republic and South Africa are stationary, policy applicators shall take into account that the energy demand estimations can be made based upon previous data but that energy demand management policies won't leave long lasting permanent effects.

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