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THE STATIONARITY OF ELECTRICITY CONSUMPTION IN SELECTED EUROPEAN COUNTRIES

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Abstract

This study explores the stationary process of electricity consumption per capita for 16 European countries over 1960-2009 period using the individual unit root test (KPSS) with structural breaks developed by Carrion-i-Silvestre et al. (2005).This test allows for cross-sectional dependence and multiple structural breaks in both intercept-no trend and intercept-trend models. The results of individual KPSS tests with intercept-no trend show the null hypothesis of stationarity cannot be rejected except Belgium, France, Germany, Greece, Luxembourg, and Sweden. On the other hand, KPSS tests with intercept-trend indicate that the stationarity of electricity consumption per capita cannot be rejected except Luxembourg. Empirical results illustrate that the electricity consumption per capita is stationary process for almost all countries. These results reveal that any shock to electricity consumption per capita has a temporary effect for 15 countries, meaning that electricity consumption will return to its time trend. The stationary characteristic of electricity consumption is vital for forecasting electricity demand in response to exogenous shocks. As a result, the stationarity of electricity consumption per capita is important for forecasting and demand modeling of energy consumption.

Keywords: Electricity Consumption, Unit Root, European Countries

Introduction

Electricity consumption has gained increasing importance in recent years. Researchers and policymakers have been still discussing the stationary properties of electricity consumption to distinguishing the transitory versus permanent nature of shocks. In the literature, the temporary or permanent

shocks to energy consumption are vital with regard to the impact of policy implications of different viewpoints. Recently, researchers focus on the assessment of the stationarity of electricity consumption per capita by using different unit root tests (Apergis and Payne, 2010).

Generally, testing the stationarity of electricity consumption has led to the increasing importance the economic and energy policies. If energy consumption follows a stationary process (i.e. does not include unit root), any shock to energy consumption will have transitory effect. Thereby, energy consumption will return to its time trend and such shocks will not have negative effect on macroeconomic policies. Consequently, the stationary process for electricity consumption means that the past conduct of energy consumption can be used to forecast the electricity consumption and energy demand. After any transitory shock to energy consumption, electricity consumption per capita will return its trend path and such policies have a temporal impact on energy consumption. On the other hand, if energy consumption process is non-stationary (i.e. involves unit root), any shock to energy consumption will have permanent effect. These shocks have an deep impact on energy consumption and electricity consumption per capita will not return its equilibrium level. Any shocks to electricity consumption, also known as the permanent effects, may be transfer into other sectors in economy including macroeconomic variables such as gross domestic product, manufacturing sector growth rate, capacity utilization rate. Therefore, the permanent response of electricity consumption to any shocks is vital modeling and forecasting demand for electricity. In the context of permanent shocks, the past behavior of electricity consumption do not serve a role of future electricity consumption forecasting (Apergis et al., 2010a; Apergis et al., 2010b; Apergis and Payne, 2010; Mishra et al. 2009; Chen and Lee, 2007; Smyth, 2013; Lean and Smyth, 2013).

This study is the first attempt to examine the stationary of electricity consumption per capita for 16 European countries using a panel unit root test with structural breaks developed by Carrion-i Silvestre et al. (2005) covering the 1960-2009 period. Most of the earlier studies in this topic investigated the stationarity of electricity consumption yield mixed results such as Chen and Lee (2007), Hsu et al. (2008), Narayan et al. (2008) and Apergis et al. (2010a, 2010b). The previous studies on the electricity consumption per capita can be seen in Table 1.

The structure of paper is as the following: section 2 overviews the data and methodology, section 3 presents empirical results and finally we conclude in the section 4.

Table 1 Some Previous Empirical Results about Energy Consumption

Author(s)	Country - Period	Frequency	Method(s)	Result(s)
Masih and Masih (1996)	India, Pakistan, Malaysia, Singapore, Indonesia and the Philippines - 1955-1990	Annual	Conventional Unit Root Tests (ADF and PP)	Non-Stationary
Cheng and Lai (1997)	Taiwan - 1955-1993	Annual	Phillips-Perron Tests	Non-Stationary
Chan and Lee (1997)	China - 1953-1994	Annual	ADF Test	Non-Stationary
Asafu-Adjaye (2000)	India- Indonesia, Philippines and Thailand 1971-1995	Annual	ADF and PP Tests	Non-Stationary
Soytas and Sari (2003)	10 Emerging Markets G7 Countries (except China) - 1950-1994	Annual	DF, ADF and PP Tests	Non-Stationary
Altinay and Karagol (2004)	Turkey - 1950-2000	Annual	Zivot-Andrews Test	Stationary
Chen and Lee (2007)	Seven Regions (104 Countries) 1971-2002	Annual	Panel Unit Root with Structural Breaks (Carrion-i Silvestre)	Stationary
Narayan and Smyth (2007)	182 Countries - 1979-2000	Annual	Univariate and Panel Unit Root Tests	Stationary
Hsu et al. (2008)	Five Regions - 1971-2003 (84 Countries)	Annual	Panel Unit Root (SURADF)	Non-Stationary
Narayan et al. (2008)	60 Countries - 1971-2003	Annual	Panel Unit Root without Structural Breaks with Structural Breaks	Mixed Results and Stationary
Mishra et al. (2009)	13 Pacific Island Countries 1980-2005	Annual	Panel Unit Root with Structural Breaks (Carrion-i Silvestre)	Stationary of 60% of the sample
Lean and Smyth (2009)	US (Five Sectors) 1973:1-2008:7	Monthly	Univariate and Multivariate Lagrange Multiplier (LM)Tests	Mixed Results
Narayan et al. (2010)	Six States in Australia	Annual	Lee-Strazicich Univariate Unit	Stationary

	1973-2007		Root with Two-Break	
Apergis et al. (2010a)	US (50 States) - 1980-2007	Annual	Panel Unit Root with Structural Breaks	Stationary
Apergis et al. (2010b)	US (50 States) - 1982-2007	Annual	Panel Unit Root with Structural Breaks	Stationary
Apergis and Payne (2010)	US (50 States) - 1960-2007	Annual	Panel Unit Root with Structural Breaks	Stationary
Hasanov and Telatar (2011)	178 Countries - 1980-2006	Annual	Conventional Unit Root Tests and New Developed Tests with Structural Breaks	Stationary (mostly)

Data and Methodology

The stationarity of electricity consumption per capita is examined for a sample of sixteen EU countries, namely Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Poland, Portugal, Spain, Sweden, and UK. In this study, annual data of per capita electricity consumption taken from the International Monetary Fund's World Economic Outlook database is employed. This research is conducted using annual series covering the period from 1960 to 2009. These countries are selected according to the data availability.

This study used the KPSS unit root test with structural breaks which proposed by Carrion-i Silvestre et al. (2005) and Carrion-i Silvestre (2005) with intercept-no trend and intercept-trend to assess whether electricity consumption has an unit root. This unit root test allows for the presence of multiple structural breaks affecting the individual effects and the time trend. Generally, KPSS test proposed by Carrion-i Silvestre et al. (2005) and Carrion-i Silvestre (2005) is formulated as follows:

$y_{i,t} = \alpha_{i,t} + \beta_i t + u_{i,t}$ with $i = 1,...,N$ (individuals), $t = 1,...,T$ (time periods)

$$\alpha_{i,t} = \sum_{k=1}^{m_i} \theta_{i,k} D(T_{b,k}^{i})_t + \sum_{k=1}^{m_i} \gamma_{i,k} DU_{i,k,t} + \alpha_{i,t-1} + \varepsilon_{i,t} \qquad (1)$$

where $D(T_{b,k}^{i})_t$ and $DU_{i,k,t}$ are defined as dummy variables in the model. In addition, this model can be written $D(T_{b,k}^{i})_t = 1$ for $t = T_{b,k}^{i} + 1$ and 0 elsewhere, $DU_{i,k,t} = 1$ for $t > T_{b,k}^{i}$ and 0 elsewhere, $T_{b,k}^{i}$ indicates the *k*th break dates (i.e. $k = 1,...,5$) for *i*th individual. This test considers multiple

structural breaks, which can be both in the level and the slope of the time series.

In the model, the number of break points is estimated by using the LWZ (Liu, Wu and Zidek (1997)) information criteria that allows maximum five structural breaks. Additionally the long run variance is estimated using the Bartlett kernel with automatic spectral window bandwidth selection as in Sul et al. (2005).

We use the univariate stationarity test as described in Kwiatkowski *et al.* (1992) to test the null hypothesis of a stationary panel proposed by Hadri (2000). LM test statistics is defined by the following.

$$LM(\lambda) = N^{-1} \sum_{i=1}^{N} \left(\hat{\omega}_i^{-2} T^{-2} \sum_{t=1}^{T} \hat{S}_{i,t}^2 \right) \quad (2)$$

The model tests the null hypothesis of stationarity against the alternative of a unit root.

$$H_0 : \sigma_{\varepsilon,i}^2 = 0 \quad (3)$$

$$H_A : \sigma_{\varepsilon,i}^2 > 0$$

Empirical Results

In this section, we examined the behavior of electricity consumption by KPSS unit root method which proposed by Carrion-i Silvestre et al. (2005) and Carrion-i Silvestre (2005) with intercept-no trend and intercept-with-trend. Carrion-i Silvestre et al. (2005) method evaluates the stationarity using both a panel data stationary (PANKPSS) and individual data stationary tests with multiple structural breaks. Nevertheless, we apply only individual KPSS test with multiple structural breaks in order to see the different effect of electricity consumption on each country.

The detailed test results about the behavior of electricity consumption give some information on the future movement of electricity consumption. Test results illustrated in Table 2 and Table 3 demonstrate the KPSS tests with intercept-no trend and intercept-trend, respectively. If the KPSS test statistics are smaller than the critical values, the series has a stationary process or does not unit root or *vice versa.*

Table 2 shows the results of the KPSS tests with intercept-no trend. The individual KPSS test results with intercept and no trend show the stationary of electricity consumption per capita for the rest of tests cannot be rejected except Belgium (1%), France (1%), Germany (10%), Greece (1%), Luxembourg (5%) and Sweden (1%). In other words, empirical results show that the electricity consumption per capita is stationary process in 10 countries except Belgium, France, Germany, Greece, Luxembourg, and Sweden.

We can say that any shocks to electricity consumption per capita have temporary effects for 10 EU countries in Table 1. While some countries,

namely Germany, Luxembourg, and Poland, have two structural breaks, some countries, i.e. Denmark, Portugal, Spain, UK and Sweden, have three structural breaks. Finally, four structural breaks have in the other countries (Austria, Belgium, Finland, France, Greece, Ireland, Italy and Netherlands).

Table 2 Individual KPSS test results with intercept and no trend for 16 European countries (1960-2009)

			Dates of structural breaks				Critical values		
Countries	**KPSS Test**	**m**	$T_{b,1}$	$T_{b,2}$	$T_{b,3}$	$T_{b,4}$	**0.90**	**0.95**	**0.99**
Austria	0.149	4	1968	1975	1986	1998	0.153	0.169	0.207
Belgium	0.485***	4	1967	1975	1984	1993	0.149	0.165	0.249
Denmark	0.108	3	1966	1975	1984		0.165	0.208	0.321
Finland	0.086	4	1968	1977	1984	1995	0.196	0.215	0.259
France	0.418***	4	1968	1975	1984	1995	0.147	0.175	0.330
Germany	0.168*	2	1969	1977			0.152	0.190	0.287
Greece	0.523***	4	1966	1973	1984	1997	0.146	0.160	0.217
Ireland	0.043	4	1967	1977	1988	1997	0.145	0.167	0.262
Italy	0.042	4	1967	1977	1987	1997	0.189	0.206	0.250
Luxembourg	0.271**	2	1968	1987			0.138	0.177	0.281
Netherlands	0.125	4	1967	1975	1987	1996	0.181	0.241	0.381
Poland	0.122	2	1967	1975			0.155	0.192	0.287
Portugal	0.073	3	1967	1982	1995		0.121	0.159	0.264
Spain	0.070	3	1967	1979	1996		0.129	0.171	0.280
Sweden	0.524***	3	1968	1975	1983		0.178	0.224	0.334
UK	0.100	3	1967	1985	1995		0.130	0.169	0.275

Notes: m presents the number of break points. $T_{b,1}, T_{b,2}, T_{b,3}, T_{b,4}$ are the dates of structural breaks. The finite sample critical values are estimated via Monte Carlo simulations using the bootstrap distribution based on 10.000 replications. ***, ** and * indicate significance at 1, 5 and 10% levels, respectively.

Table 3 shows the results of the KPSS tests with intercept-trend. The individual KPSS test results present the stationary of electricity consumption per capita cannot be rejected except Luxembourg (5%). In other word, the electricity consumption per capita for 16 European countries except Luxembourg is a stationary process. This result shows that any shocks to

electricity consumption per capita have transitory effects for 15 countries, meaning that electricity consumption will return to its time trend. There is an one structural break in some countries such as Spain, Italy, Netherlands, Poland, Portugal, and Ireland and countries where have two structural breaks are Austria, Belgium, Greece, Luxembourg, and Sweden. The rest of other countries that have three structural breaks are Denmark, Finland, Germany, France, and UK.

Table 3 Individual KPSS test results with intercept and trend for 16 European countries (1960-2009)

Countries	KPSS Test	m	Dates of structural breaks				Critical values		
			$T_{b,1}$	$T_{b,2}$	$T_{b,3}$	$T_{b,4}$	0.90	0.95	0.99
Austria	0.076	2	1972	1992			0.091	0.122	0.172
Belgium	0.066	2	1972	2000			0.122	0.163	0.232
Denmark	0.066	3	1973	1980	1991		0.148	0.190	0.274
Finland	0.047	3	1974	1987	2002		0.143	0.181	0.258
France	0.032	3	1979	1992	2002		0.144	0.185	0.277
Germany	0.028	3	1969	1979	1990		0.152	0.193	0.274
Greece	0.048	2	1971	1978			0.152	0.202	0.300
Ireland	0.072	1	1967				0.141	0.215	0.405
Italy	0.089	1	1967				0.136	0.193	0.339
Luxembourg	0.192**	2	1967	1974			0.122	0.165	0.270
Netherlands	0.058	1	1967				0.131	0.174	0.267
Poland	0.097	1	1967				0.136	0.178	0.270
Portugal	0.103	1	1968				0.130	0.184	0.300
Spain	0.038	1	1967				0.142	0.222	0.433
Sweden	0.031	2	1968	1984			0.140	0.188	0.302
UK	0.025	3	1970	1980	2001		0.141	0.180	0.259

Notes: m presents the number of break points. $T_{b,1}, T_{b,2}, T_{b,3}, T_{b,4}$ are the dates of structural breaks. The finite sample critical values are estimated via Monte Carlo simulations using the bootstrap distribution based on 10.000 replications. ***, ** and * indicate significance at 1, 5 and 10% levels, respectively.

Conclusion

In this study, we examined the stationarity of electricity per capita for 16 European countries over the 1960-2009 period. This paper employs the method developed by Carrion-i Silvestre et al. (2005) panel unit root in order to test the stationary properties of electricity consumption. Based on structural breaks, the analysis of energy policies are essential to determine the future movements of energy. Especially, the sustainable energy policies connected with the forecast of energy demand and the long-term policies related to energy. In this context, determining the permanent or transitory response of electricity consumption to any shocks is important for forecasting and demand modeling of energy consumption.

Test results demonstrated in Table 2 show the KPSS tests with intercept-no trend. The individual KPSS test results with intercept and no trend show the stationary of electricity consumption per capita for the rest of tests cannot be rejected except Belgium, France, Germany, Greece, Luxembourg and Sweden. In other words, empirical results illustrate that the electricity consumption per capita contains stationary process for 10 countries except Belgium, France, Germany, Greece, Luxembourg, and Sweden. Test results illustrated in Table 3 show the KPSS tests with intercept-trend. The results show that the stationary of electricity consumption per capita cannot be rejected except Luxembourg. Any shocks to electricity consumption per capita have transitory effects for 15 countries, meaning that electricity consumption will return to its time trend.

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