Journal of Energy Technologies and Policy
ISSN 2224-3232 (Paper) ISSN 2225-0573 (Online)
Vol.5, No.4, 2015 

# The Relationship Between Electricity Consumption, Real GDP And Employment In G-7 Countries: Seasonal Panel Unit Roots And Cointegration Model

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**Abstract**

The energy sector unarguably play a crucial role economic growth and employment in developed countries. The changes in energy use, particulary electricity consumption, are often correlated with changes in macro economic variable such as economic development, labor market, investment. This paper aims to reveal the relationship between electricity consumption and macroeconomic variables by using new techiques for seasonal unit root test for panel data. At first, we have applied the HEGY-IPS test which is the presence of seasonal panel unit root test. Secondly, we have investigated the relationship between electricity consumption, income and employment in G-7 countries using seasonal cointegration analysis which is called EGHL-type test over the period of 1995:q1 to 2013:q3.

The results of this study show that all variables have unit root at zero frequency and electricity consumption and employment series have seasonal unit roots at semi-annual and annual frequencies for each countries. Besides that, there exists seasonal panel unit roots in electricity consumption and employment series excepted income series. These results indicate that the series are possibly cointegrated. For G-7 countries, there isn't any cointegration relationship detected among the electricity consumption, real GDP and employment series at the zero, semi annual and annual frequencies excepted for Italy.

**Key words:** Electricity Consumption, Economic Growth, Employment, Seasonal Panel Unit Roots, Seasonal Cointegration, G-7 Countries

## 1. Introduction

Energy is a crucial part of life and plays a major role in economic growth. It is necessary to factories, households, commercial establishments, etc. Electricity is a flexible form of energy and important resource for modern life and and essential infrastructural input for economic development (Masuduzzaman, 2013; He *et al.*, 2014).

The electricity sector unarguably played a fundamental role in the developed countries economic progress and employment generation (Rosenberg, 1998). The globalizing world, rapidly increaseddemand for electricity and dependence of countries on electricity show that electricity will be one of top problem in the next century. The links between electricity consumption and economic growth is of great interest to economists and policymakers because of its significant policy implications.

Many researches have studied not only correlation and linkages between electricity usage and economic development but also the way of causality between these variables. Ferguson *et al.* (2000) examined directional causality between economic development and electricity or energy consumption over 100 developing countries. They found that electricity consumption is more relevant to measurement of economic growth than enery consumption.

The relationships between electricity consumption, real GDP and other macro economic variables; such as inflation rate, investment, price, labour force etc., has been investigated a great number of studies in the last three decades. The previous studies results can be summed up generally three categories: (1) bidirectional causality, (2) unidirectional causality and (3) no causality between electricity consumption, economic development and other macro economic variables (Aktas&Yılmaz, 2008).

The early empirical results in this literature way of the causality between economic development and electricity usage remains ambiguous and can be summarised in Appendix. For example, Jumbe (2004), Yoo (2005), Yoo (2006) and Yoo & Kwak (2010) found that electricity usage and economic development have a bidirectional causality for different countries. Besides that, Narayan and Smyth (2005), Chandran *et al.* (2010), Bakırtaş *et al.* (2000); Ghosh (2002); Hondroyiannis (2004); Yoo *et al.* (2006); Squalli (2007); Narayan & Singh (2007); Mozumder & Marathe (2007) and Criarreta *et al.* (2010) found one way causality from electricity consumption to economic growth or vice-versa. However, Chen *et al.* (2007), Tang (2008), Cheng et al. (1998), Narayan and Prasad (2008),Payne (2009) found that there is no causality between electricity consumption and economic growth.

Previous researches have attemped to find the causality between electricity consumption and economic growth. Besides that in this study, we have aim to investigate not only the relationship between electricity consumption and real GDP growth but also the connection between electricity usage and employment by considering cross sectional independency in the panel data. According to literature on panel unit roots, there are fewer studies on seasonal unit root in panels. However, this paper is employed the technique the seasonal unit roots for panel data which is called HEGY-IPS test developed by Otero *et al.* (2004). We have investigated whether or not have seasonal unit root for electricity consumption, real GDP and employment series for G7 countries. Then we use nonstationary series to test for seasonal cointegration analysis using EGHL – type test developed by Engle *et al.* (1993). This paper is organized as follows. Second section has been mentioned about data and econometric methodology. The next section we report the emprical results and finally we conclude with a discussion of the findings.

## 2. Research Methodology And Model

### *2.1. Data and Model Specification*

The aim of this study is to test presence of seasonal unit root test for panel data and to examine causality between electricity consumption, employment and income in the long run. In this paper, *GDP* is expressed in terms of million dollar, electricity consumption is expressed in terms of *Gwh* and employment is expressed in terms of million of person. All variables are transformed into natural logarithms and the time series graphs of these variables by countries are showed in Appendix.

As a conceptual model, this study is predicated on the standard economic assumption and earlier studies such as Narayan and Smyth (2005). The linkages between electricity consumption, real GDP and employment has been analyzed based on the following panel regression model,

$$GDP_{it} = \alpha_i + \beta_{1i} EC_{it} + \beta_{2i} EMP_{it} + \varepsilon_{it} \qquad (1)$$

where $GDP_{it}$, $EC_{it}$ and $EMP_{it}$ represent real *GDP*, electricity consumption and employment, respectively. And i= 1, .., *N* denotes G-7 countries and t = 1,…,*T* represents the period of 1995:q1–2013:q3. We have gathered the data from Eurostat, EIA, Canada and Japan statistics yearbooks.

### *2.2. Methodology*

#### 2.2.1.Panel Seasonal Unit Root Tests

Various economic time series incorporate significant seasonal components. Seasonal patterns may be depicted by seasonal dynamic effects or deterministic seasonal intercepts. Nevertheless, the seasonal patterns comprise non-statistionary components. The existence of stochastic trends the series can be estimated by the seasonal unit roots, and also the unit root can be exist at the zero, semi-annual and annual frequencies. The properties of some standard testing procedures for seasonal unit root test proposed by Dickey *et al.* (1984) and Hylleberg *et al.* (HEGY) (1990).

HEGY is one of the most popular seasonal unit root tests. As an approximation test, in it allows for changes in the seasonal model, and the choice between a seasonally integrated process. (Hylleberg et al., 1993). HEGY type test for testing seasonal unit root data with any frequency in a series $Y_t$, by estimating Eq.(2):

$$Y_{4t} = \sum_{i=1}^{4} \mu_i D_{it} + \gamma t + \pi_1 Y_{1,t-1} + \pi_2 Y_{2,t-1} + \pi_3 Y_{3,t-2} + \pi_4 Y_{3,t-1} + \varepsilon_t \qquad (2)$$

where $Y_{1t} = (1 + L + L^2 + L^3)Y_t$ ; $Y_{2t} = (-1 + L - L^2 + L^3)Y_t$ ; $Y_{3t} = (-1 + L^2)Y_t$ and $Y_{4t} = \Delta_4 Y_t = Y_t - Y_{t-4}$, L denoting the usual lag operator and $\varepsilon_t$ is assumed to be a white noise process.

The seasonal unit root test for panel data, which is called HEGY-IPS test, is developed by Otero et al. (2004). It is analyzed a seasonal unit root test for heterogeneous panel and generalised the HEGY test. The test statistics are based on standardised t-bar and F-bar statistics. And these statistics are averages of the HEGY (1990) tests statistics among the groups (Otero *et al.,* 2004). The assumption of HEGY-IPS test is that the existence of cross sectional independence between variability within units for panel data. (Dreger *et al.*, 2005).

HEGY-IPS test, which is seasonal unit root test for heterogenous panel, is set a sample of i=1,…, N cross sections (industries, countries) observed over t=1,…, T time periods, as follows (Otero *et al.,* 2004):

$$y_{4it} = \mu_{it} + \pi_{1i}y_{1i,t-1} + \pi_{2i}y_{2i,t-1} + \pi_{3i}y_{3i,t-2} + \pi_{4i}y_{3i,t-1} + \sum_{j=1}^{p_i}\varphi_{ij}y_{4i,t-j} + \varepsilon_{it} \quad (3)$$

where $\mu_{it} = \alpha_i + \beta_i t + \sum_{s=1}^{3}\gamma_{is}D_{st}$; $D_{st}$ is a seasonal dummy variable and takes the value of 1 in quarter *s* (and zero otherwise); $\varepsilon_{it} \sim N(0, \sigma_{\varepsilon_i}^2)$. And also, $y_{1it} = y_{it} + y_{it-1} + y_{it-2} + y_{it-3}$ ; $y_{2it} = -y_{it} + y_{it-1} - y_{it-2} + y_{it-3}$ ; $y_{3it} = -y_{it} + y_{it-2}$ and $y_{4it} = \Delta_4 y_{it} = y_{it} - y_{it-4}$.

HEGY test is designed to test the existence of seasonal integration in quarterly data of each country in the sample. This test for the presence of a unit root at zero frequency by testing **H₀:** $\pi_1 = 0$ against **H₁:** $\pi_1 < 0$, and for the presence of seasonal unit root at semi annual frequency by testing **H₀:** $\pi_2 = 0$ against **H₁:** $\pi_2 < 0$ and for the presence of seasonal unit root at annual frequency by testing **H₀:** $\pi_3 = \pi_4 = 0$ against **H₁:** $\pi_3 < 0, \pi_4 \neq 0$. The null hypothesis of unit root is rejected when t-test for $\pi_1$ and a seasonal unit root is rejected when both the t-test for $\pi_2$ and the joint F-test for $\pi_3$ and $\pi_4$ are rejected. Alternatively, Ghysels *et al.* (1994) suggested using a test of **H₀:** $\pi_2 = \pi_3 = \pi_4 = 0$ against **H₁:** $\pi_2 < 0, \pi_3 < 0, \pi_4 \neq 0$. A failure to not reject the null hypothesis means that there is not the presence of seasonal unit roots (Otero et al.,2007).

In a panel context, the null hypothesis is similar to the time series to test the presence of a unit root but we add a cross sectional dimension to each hypothesis. For example, becomes $H_0$: $\pi_{1i} = 0\ \forall_i$ against $H_1$: $\pi_{1i} < 0$ for i = 1,2,3,..N (Jintranun *et al.,* 2011). This allows some, but not all, of the individual series to have a unit root, but assumes that a non-zero fraction of the processes are stationary (Otero *et al.,* 2005).

The HEGY-IPS statistics from estimating equation (3) for the $i^{th}$ group given by the t-ratios on $\pi_{ji}$ as $\tilde{t}_{jiT}$, *j*=1,2 and F-tests of the joint significance of $\pi_{3i}, \pi_{4i}$ and $\pi_{2i}, \pi_{3i}$ and $\pi_{4i}$ as $\tilde{F}_{jiT}$, *j*=2,3. For a fixed *T* define the average statistics:

$$HEGY - IPS_{t_j} = \tilde{t}_j bar_{NT} = (N)^{-1}\sum_{i=1}^{N}\tilde{t}_{jiT} \quad j=1,2 \quad (4)$$

$$HEGY - IPS_{F_j} = \tilde{F}_j bar_{NT} = (N)^{-1}\sum_{i=1}^{N}\tilde{F}_{jiT} \quad j=2,3. \quad (5)$$

The critical value based on a Monte Carlo simulation is presented in Otero *et al.* (2004).

### 2.2.2. Seasonal Cointegration Test

If the time series variables contain unit roots at semi annual and annual frequencies, the standard cointegration procedure of Engle and Granger (1987) is inappropriate. The presence of seasonal unit roots suggest that the need to test for seasonal cointegration. Lee (1992) developed tests for cointegration and seasonal cointegration for nonstationary time series which have unit roots at the zero frequency as well as at seasonal frequencies. Besides that, Engle *et al.* (1993) developed seasonal cointegration techniques which based on the maximum likelihood method was proposed by Lee (1992).

The method of Engle *et al.* (1993), which called EGHL-type test, is based on HEGY procedure which is described for time series consisting of quarterly observed variables. Each series must be integrated of same order for seasonal cointegration analysis. And also, the cointegration analysis is applied separately for each frequency at the integrated series.

According to EGHL- type cointegration and seasonal cointegration tests were estimated using the following regression equations:

$w_{1t} = p_{1t} - \alpha_{12}y_{1t}$ , $w_{2t} = p_{2t} - \alpha_{22}y_{2t}$ and $w_{3t} = p_{3t} - \alpha_{32}y_{3t} - \alpha_{41}p_{3,t-1} - \alpha_{42}y_{3,t-1}$ where $p_{it}$ and $y_{it}$ (*i=1,2,3*) show the transformed series at different frequencies.

Cointegration of $p_{1t}$ and $y_{1t}$ mean that long run equilibrium at the zero frequency. If the null hypothesis of no cointegration is rejected, seasonal cointegration of $p_{2t}$ and $y_{2t}$ occurs at semi annual frequency. The test implies to determine unit roots at zero and semi annual frequencies, respectively. The EGHL-type test tests for cointegration at zero and semiannual frequencies are performed by testing residuals from cointegrating regressions and also this test is residual test.

The cointegration of $p_{3t}$ and $y_{3t}$ are estimated by regressing $p_{3t}$ on $y_{3t}$ and $y_{3t,t-1}$. The residuals will be used to test for seasonal cointegration at annual frequency. The ordinary least squares estimates of above equations are supposed to "super-consistency". Besides that, error correction model used the error terms from cointegrating analysis equation. All critical values obtained from Engle and Yoo (1987).

The seasonal cointegration analysis, which is located in study of Hylleberg *et al.* (1990) and is offered by developed Engle *et al.* (1993), based on error correction term model which is appropriately constituted from HEGY test. The seasonal error correction term is stated as following (Hylleberg *et al.* (1990), Engle *et al.* (1993)):

$$A*(B)\Delta_4 X_t = \gamma_1\alpha_1 Y_{1,t-1} + \gamma_2\alpha_2 Y_{2,t-1} - (\gamma_3\alpha_3 - \gamma_4\alpha_4)Y_{3,t-2} + (\gamma_4\alpha_3 - \gamma_3\alpha_4)Y_{3,t-1} + \varepsilon_t \quad (6)$$

where $A*(B)$ is an autoregressive matris, $\alpha_i$ are cointegration vectors at different frequencies in $n*r_i$ matricies ( i= 1,2,3) and $\gamma_i$ are the error correction parameters (Mithani&Khoon, 1999). $Y_{1,t}$, $Y_{2,t}$ and $Y_{3,t}$ $n*1$ dimensional vector process, which are in the form of $Y_{1t} = (1 + L + L^2 + L^3)X_t$; $Y_{2t} = (-1 + L - L^2 + L^3)X_t$ ; $Y_{3t} = (-1 + L^2)X_t$, obtain from conversion of observation of $X_t$.

## 3. Emprical Results

### *3.1. Panel Seasonal Unit Root Tests Results*

In this part we apply to approach of the HEGY test and the HEGY-IPS test for non-stationarity of three variables for G7 countries. Nevertheless, one of the foundations of the this study is to integrate specific unit roots for each season.

The HEGY test is similar to other unit root tests, except that we aim to determine whether there are non-stationarity or stationarity movements within a given season. For this, as can be seen in Tables 1 to 3, the HEGY test is utilised to identify the univariate context by countries and the HEGY-IPS test seasonal unit root test for panel data as reported in Table 4.

**Table 1.** Seasonal unit root test by country for ln(*GDP*)

| Null Hypothesis | $\Pi_1$=0 | $\Pi_2$=0 | $\Pi_3$=$\Pi_4$=0 | $\Pi_2$=$\Pi_3$=$\Pi_4$=0 |
|---|---|---|---|---|
| USA | -2.806 | -4.604** | 26.093** | 90.494** |
| UK | -2.931 | -6.030** | 30.821** | 149.617** |
| CANADA | -2.683 | -2.462** | 1.071 | 2.922 |
| JAPAN | -2.257 | -5.857** | 27.121** | 102.583** |
| FRANCE | -1.929 | -0.060 | 1.356 | 0.904 |
| GERMANY | -1.394 | -2.382** | 1.491 | 2.880 |
| ITALY | -1.502 | -0.783 | 0.745 | 0.702 |
| **HEGY-IPS** | **-2.624** | **-3.256**** | **12.554**** | **51.735**** |

Note: ** and * denote the significance at the %5 and %10 levels, respectively.

Table 1 indicates seasonal unit root test for ln(*GDP*). The results present that all time series have unit roots at the zero frequency. There is seasonal unit root at semi annual frequency for France and Italy. It should be noted that we found evidence of seasonal unit roots at annual frequency for Canada, France, Germany and Italy among the sampled countries.

**Table 2.** Seasonal unit root test by country for ln(*EMP*)

| Null Hypothesis | $\Pi_1$=0 | $\Pi_2$=0 | $\Pi_3$=$\Pi_4$=0 | $\Pi_2$=$\Pi_3$=$\Pi_4$=0 |
|---|---|---|---|---|
| USA | -2.252 | -0.525 | 1.882 | 1.335 |
| UK | -2.316 | -3.487** | 4.529** | 7.359** |
| CANADA | -2.515 | -0.594 | 1.039 | 0.819 |
| JAPAN | -3.860** | -1.006 | 1.722 | 1.508 |
| FRANCE | -1.511 | -25.797** | 0.022 | 270.910** |
| GERMANY | -1.347 | -1.431 | 1.686 | 1.644 |
| ITALY | -0.305 | -1.003 | 1.851 | 1.592 |
| **HEGY-IPS** | **-2.015** | **-4.835**** | **1.819** | **40.738**** |

Note: ** and * denote the significance at the %5 and %10 levels, respectively.

 

The univariate seasonal unit root test for ln(*EMP*) is represented Table 2. All time series considered, except for Japan, have unit roots at zero frequency. The results shows that each countries except for UK and France have seasonal unit root at semi annual frequency and also except for UK have seasonal unit roots at annual frequency.

**Table 3.** Seasonal unit root test by country for ln(*EC*)

| Null Hypothesis | $\Pi_1$=0 | $\Pi_2$=0 | $\Pi_3$=$\Pi_4$=0 | $\Pi_2$=$\Pi_3$=$\Pi_4$=0 |
|---|---|---|---|---|
| USA | 0.800 | 0.157 | 0.211 | 0.151 |
| UK | -2.241 | -5.689* | 0.716 | 11.780* |
| CANADA | -2.446 | -0.605 | 0.325 | 0.336 |
| JAPAN | -0.110 | 0.101 | 1.880 | 1.258 |
| FRANCE | 0.076 | -2.114 | 0.326 | 1.864 |
| GERMANY | -2.366 | -1.509 | 1.063 | 1.507 |
| ITALY | -0.477 | -0.264 | 2.682 | 1.809 |
| **HEGY-IPS** | **-0.966** | **-1.418** | **1.029** | **2.672** |

Note: ** and * denote the significance at the %5 and %10 levels, respectively.

Table 3 shows the results for unit root and seasonal unit root test in ln(*EC*), which shows that in the case of $t_1$, $t_2$, $F_{34}$ and $F_{234}$ the null hypothesis cannot be rejected in every data series. Hence, there are seasonal unit roots in ln(*EC*) in every country in the sample.

For the panel data method, as mentioned, we employed HEGY-IPS test, which is developed as a cross sectional independence of the HEGY test from Otero *et al.* (2005). For refusal of the seasonal unit root hypothesis it is sufficient that either $t_2$ and $F_{34}$ are both rejected or $F_{234}$ is rejected . As can be seen from Table 4, which is the seasonal panel unit root test as called HEGY-IPS test for three variables, the results explains that $t_2$ and $F_{34}$ are both rejected or $F_{234}$ is significiantly rejected for ln(GDP) series, while $F_{34}$ is not significantly rejected for ln(EMP) and also $t_2$ and $F_{34}$ are not both rejected or $F_{234}$ is not significiantly rejected for ln(EC). Therefore, it can be strongly concluded that there are seasonal unit roots in ln(EMP), ln(EC).

**Table 4.** Seasonal panel unit root test HEGY-IPS test by variables

| Null Hypothesis | $\Pi_1$=0 | $\Pi_2$=0 | $\Pi_3$=$\Pi_4$=0 | $\Pi_2$=$\Pi_3$=$\Pi_4$=0 |
|---|---|---|---|---|
| ln(*GDP*) | -2.624 | -3.256** | 12.554** | 51.735** |
| ln(*EMP*) | -2.015 | -4.835** | 1.819 | 40.738** |
| ln(*EC*) | -0.966 | -1.418 | 1.029 | 2.672 |

Note: ** and * denote the significance at the %5 and %10 levels, respectively.

### *3.2. Seasonal Cointegration Test Results*

As necessitated by EGHL - type test, each series must be integrated of the same order, in a sense, have unit roots at common frequencies.

According to seasonal unit root results, it is necessary to determine which series are integrated of same order at which frequencies. It found that real GDP, electricity consumption and employment series have as a common unit root at the zero frequencies for all countries. The estimated models are prefered when constant and deterministic components are added. The results of seasonal cointegration analysis of series at 0, $1/2$, $1/4$(and $3/4$) frequencies are given in Table 5.

 

**Table 5.** Result For Seasonal Cointegration

| ***Cointegration Analysis Between ln(EC) and ln(GDP)*** | | | | | | |
|---|---|---|---|---|---|---|
| | ***p (lags)*** | $\Pi_1$ | ***p (lags)*** | $\Pi_2$ | ***p (lags)*** | $\Pi_3 \cap \Pi_4$ |
| USA | 1,4 | 2.876 | 1,2,4 | -1.871 | 1,4 | 3.598 |
| UK | 1,4 | 3.551 | 1,2,4 | -2.918 | 1,4 | 2.114 |
| CANADA | 1,4 | 6.149 | 1,4 | 1.778 | 1,4 | 21.154** |
| JAPAN | 1,2,4 | 5.881 | 1,2,4 | 2.116 | 1,4 | 8.659 |
| FRANCE | 1,4 | 27.981** | 1,2,4 | 14.652** | 1,4 | 26.112** |
| GERMANY | 1,4 | 6.746 | 1,2,4 | 2.558 | 1,4 | 7.875 |
| ITALY | 1,4 | 26.102** | 1,2,4 | 11.954** | 1,4 | 29.884** |
| ***Cointegration Analysis Between ln(EC) and ln(EMP)*** | | | | | | |
| USA | 1,4 | 1.918 | 1,2,4 | -0.468 | 1,4 | -1.887 |
| UK | 1,4 | -2.224 | 1,2,4 | -1.321 | 1,4 | -1.111 |
| CANADA | 1,2,4 | -1.110 | 1,4 | -2.613 | 1,4 | 2.365 |
| JAPAN | 1,4 | 3.557 | 1,4 | -2.136 | 1,4 | 3.487 |
| FRANCE | 1,2,4 | 4.221 | 1,2,4 | -2.602 | 1,4 | 2.789 |
| GERMANY | 1,2,4 | -1.786 | 1,4 | -0.488 | 1,4 | 1.784 |
| ITALY | 1,4 | 19.568** | 1,4 | 7.387 | 1,4 | 17.984** |

Note: -Critical value was obtained from study of Engle and Yoo (1987).
- ** denotes the significance at the %5 level.
- The basic hypothesis is ($H_0$: $\pi_1 = 0$) "There is no cointegration relation at zero frequency."
- The basic hypothesis is ($H_0$: $\pi_2 = 0$) "There is no seasonal cointegration relation at semi annual frequency."
- The basic hypothesis is ($H_0$: $\pi_3 = \pi_4 = 0$) "There is no seasonal cointegration relation at annual frequency."

Table 5 shows that the null hypothesis of no cointegration at the long run, in a sense, at zero frequency can not be rejected in both electricity consumption, employment and GDP relationships except for Italy. The null hypothesis of the presence of seasonal cointegration between electricity consumption and real GDP is rejected at the 5% significance level at semi annual and annual frequencies for France and Italy, however is not rejected between electricity and employment relationships. Finally, the null hypothesis of seasonal cointegration between electricity usage and real GDP at annual frequency is rejected for Canada, France and Italy and also the null hypothesis of seasonal cointegration between electricity usage and employment at annual frequency is only rejected for Italy.

## 4. Conclusion

In this study investigated whether or not the series of electricity consumption, employment and real GDP have seasonal unit roots and seasonal cointegration relationship for G-7 countries over the period of 1995:q1-2013:q3.

The main goal of this paper was examined that a new method for panel data analysis that concerns seasonality on macro variables including GDP, electricity consumption and employment. The HEGY-IPS test, which is used to the seasonal unit root test for panel data without cross section dependence, is developed by Otero et al. (2004). It is analyzed a seasonal unit root test for heterogeneous panel and generalised the HEGY test. This test was employed for the detection of seasonal panel unit roots in each variable. The EGHL-type test was used in order to test seasonal cointegration. The EGHL-type test is based on HEGY procedure which is described for time series consisting of quarterly observed variables developed by Engle *et al.* (1993).

The test for unit roots confirm that each variables have unit roots at the zero frequency for all countries. Employment and real GDP series have seasonal unit roots some selected countries at the semi annual and annual frequencies. For electricity consumption series have seasonal unit roots at the same frequencies for all countries. The result of the seasonal panel unit root test shows that electricity consumption and employment series have seasonal panel unit root except income.

Seasonal cointegration was established at zero, semi annual and annual frequencies. The cointegration test results show that electricity consumption is cointegrated with real GDP at the zero and seasonal frequencies for Italy and France. Besides that, the cointegration tests confirm the existence of a long run relation and seasonal cointegration between electricity consumption and employment only in Italy at zero and annual frequencies.

Consequently, the findings show that electricity consumption and employment series have seasonal panel unit roots. However, there is no cointegration between electricity usage and macro variables as given GDP, employment. In this study is found that there is the linkages between electricity consumption, real GDP and employment only for Italy at different frequencies.

In future work, we would like to investigate the relationship between electricity usage and other macroeconomic variables such as investment, inflation rate. This approach is more important for policy makers and economists Morever, another possible extension would be to consider cross sectional dependence seasonal panel unit root tests.

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**Appendix**

Figure 1. Time series graph of series of LGDP by countries

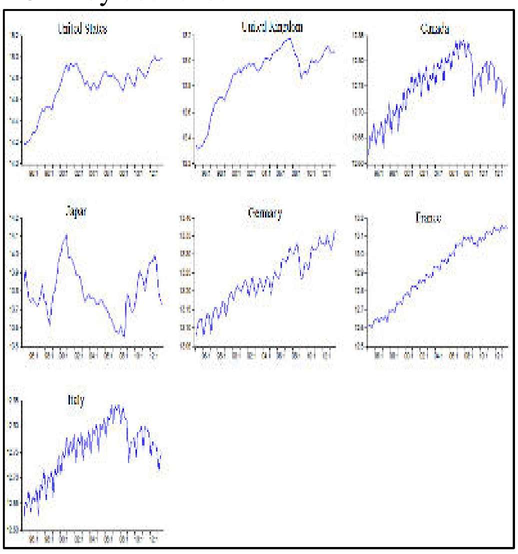

Figure 2. Time series graph of series of LEMP by countries

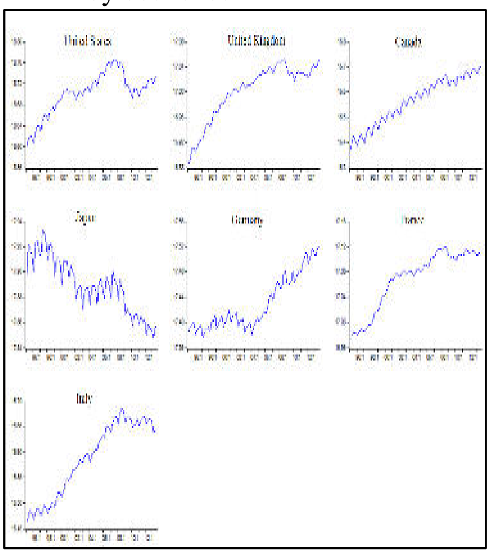

 

Figure 3. Time series graph of series of LEC by countries

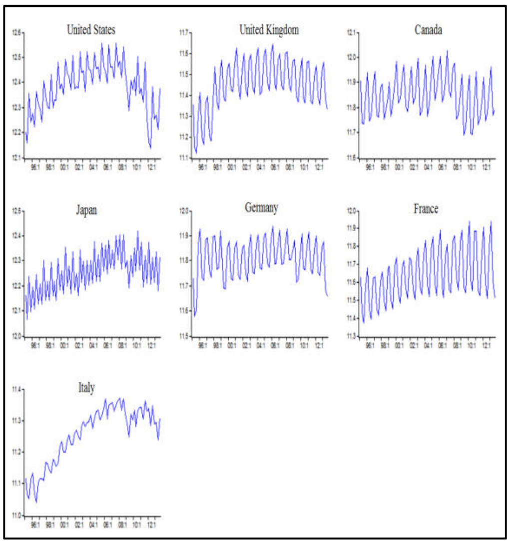


Table 1. Brief Summary Of The Previous Studies

| Authors | Method | Countries | Period | Result |
|---|---|---|---|---|
| Masih & Masih (1996) | Granger causality and Vector Error Correction Model | Six Asian Countries: India, Pakistan, Malaysia, Singapore, Indonesia nad Philippines | 1955-1990 | For India:<br>Enery consumption→income<br>For Indonesia:<br>Income→energy consumption<br>For Pakistan:<br>Enery consumption ↔income<br>For Phillippines:<br>No cointegration |
| Glasure & Lee, (1998) | Cointegration and Error correction models | South Korea and Singapore | 1961-1990 | For South Korea:<br>No cointegration<br>For Singapore:<br>Enery consumption→income |
| Cheng & Lai (1997) | Hsiao's Granger causality | Taiwan | 1955-1993 | GNP → Energy consumption<br>Energy consumption → employment |
| Cheng *et al.* (1998) | Hsiaso's version of Granger causality | U.S. | | No cointegration |
| Bakırtaş *et al.* (2000) | Cointegration and Error correction models | Turkey | 1962-1996 | Electricity consumption→GDP |
| Chang *et al.* (2001) | Vector Error Correction Model | Taiwan | 1982:01-1997:11 | Employment↔output<br>Employment↔energy consumption<br>Energy consumption →output |

| | | | | |
|---|---|---|---|---|
| Ghosh (2002) | Granger's causality | India | 1950–1997 | Economic growth → electricity consumption |
| Soytas & Sarı (2003) | Vector Error Correction Model | Top 10 emerging countries and G-7 countries | | For Argentina: Income↔energy consumption<br>For Italy and Korea: Income→energy consumption<br>For Turkey, France, Germany and Japan: Electricity consumption → GDP |
| Fatai *et al.*(2004) | Error correction models | New Zealand, Australia, India, Indonesia, The Philippines and Thailand | 1960–1999 | For India and Indonesia: Enery consumption→income<br>For Thailand and Philippines: Enery consumption ↔income |
| Shiu & Lam (2004) | Error correction models | China | 1971–2000 | Electricity consumption→real GDP |
| Jumbe (2004) | Granger causality and Error correction models | Malawi | 1970–1999 | Granger causality results: Electricity consumption ↔income<br>Income→electricity consumption<br>ECM Results: GDP→electricity consumption |
| Hondroyiannis (2004) | Vector Error Correction Model | Greece | 1986:1-1999:12 | Electricity consumption →income |
| Narayan and Smyth (2005) | ARDL cointegration and Granger causality tests | Australia | 1966-1999 | Income→Employment<br>Income→electricity consumption |
| Yoo, 2005 | Cointegration and Error correction models | Korea | 1970–2002. | Electricity consumption ↔ economic growth |
| Yoo (2006) | Granger's causality | South East Asian Nations members: Indonesia, Malaysia, Singapore, and Thailand | 1971–2002 | For Malaysia and Singapore: Electricity consumption ↔ economic growth<br>For Indonesia and Thailand: Economic growth → electricity consumption |
| Yoo *et al.* (2006) | Hsiaso's version of | Indonesia | 1971–2002 | Economic growth → electricity consumption |

 

| | | | | |
|---|---|---|---|---|
| | Granger causality | | | |
| Squalli (2007) | ARDL bounds testing procedure | OPEC members | 1980-2003 | Electricity consumption → economic growth |
| Narayan & Singh (2007) | ARDL bounds testing procedure | Fiji Islands | 1970-2006 | Electricity consumption → Employment, Income→Employment |
| Chen *et al.* (2007) | Error correction models | 10 Asian Countries: China, Hong Kong, Indonesia, India, Korea, Malaysia, the Philippines, Singapore, Taiwan and Thailand | 1971–2001 | For Hong Kong and Korea: Income→electricity consumption<br>For Indonesia: Electricity consumption → income<br>For India, Singapore, Taiwan and Thailand: No cointegration |
| Mozumder and Marathe (2007) | Granger causality and Vector Error Correction Model | Bangladesh | 1971–1999 | Income→electricity consumption |
| Tang (2008) | ARDL model | Malaysia | 1972:1-2003:4 | No cointegration |
| Narayan and Prasad (2008) | Bootstrapped causality testing approach | OECD countries | | For Australia, Iceland, Italy, the Slovak Republic, the Czech Republic, Korea, Portugal, and the UK: Electricity consumption → economic growth<br>For Finland, Hungary: Income→electricity consumption<br>For the other 22 countries: No cointegration |
| Payne (2009) | Toda-Yamamoto causality tests | U.S. | 1949-2006 | No cointegration |
| Chandran *et al.* (2010) | ARDL bounds testing procedure | Malaysia | 1971–2003 | Electricity consumption → economic growth |
| Criarreta *et al.*, 2010 | Toda-Yamamoto causality tests, Granger causality tests | Spain | 1971-2005 | Real GDP→electricity consumption |
| Yoo and Kwak (2010) | Granger's causality | South American countries: Argentina, | 1975–2006 | For Argentina, Brazil, Chile, Columbia, and Ecuador: Electricity consumption → real GDP |

| | | | | |
|---|---|---|---|---|
| | | Brazil, Chile, Columbia, Ecuador, Peru, and Venezuela | | For Venezuela:<br>Electricity consumption ↔ economic growth<br>For Peru:<br>No causality |
| Ozturk *et al.* (2010) | ARDL bounds testing procedure and Cointegration, Vector Error Correction Model | Albania, Bulgaria, Hungary and Romania | 1980-2006 | For Hungary:<br>Enery consumption per capita ↔ real GDP per capita<br>For Albania, Bulgaria and Romania (Bounds test result):<br>No cointegration<br>For Hungary:<br>(Granger causality results):<br>Enery consumption per capita ↔ real GDP per capita |
| Lee&Chien (2010) | Toda Yamamoto (1995) Granger causality | G-7 countries | 1960-2001 | For Canada, Italy and UK:<br>Energy consumption → income<br>For France and Japan:<br>Economic growth → energy consumption<br>For Germany and U.S.:<br>No causality |
| Polat *et al.* (2011) | ARDL bounds testing procedure, Granger causality, Vector Error Correction Model | Turkey | 1950-2006 | Employment → electricity consumption<br>Employment → income in the long run<br>Employment → electricity consumption in the short run |