Volume and Issues Obtainable at Center for Sustainability Research and Consultancy

Review of Economics and Development Studies
ISSN: 2519-9692 (E): 2519-9706
Volume 3: Issue 1 June 2017
Journal homepage: www.publishing.globalcsrc.org/reads

Electricity Generation and Real Output in Asia: A Panel Co-Integration Approach

[1]Furrukh Bashir, [2]Tusawar Iftikhar Ahmad, [3]Ismat Nasim, [4]Kishwar Parveen

[1]Assistant Professor, Department of Economics, The Islamia University of Bahawalpur, Bahawalnagar Campus, Pakistan. farrukh.bashir@iub.edu.pk
[2]Assistant Professor, Department of Economics, The Islamia University of Bahawalpur, Pakistan.
[3]Lecturer, Department of Economics, The Government Sadiq College Women University, Bahawalpur, Pakistan. ismat.nasim@gscwu.edu.pk
[4]MPhil Scholar, School of Economics, Bahauddin Zakariya University, Multan, Pakistan.

ARTICLE DETAILS

History
Revised format: May 2017
Available Online: June 2017

Keywords
Electricity Production,
Kao Panel Co-integration test,
Labor, FM-OLS,
Central Asia,
East Asia,
South Asia, South East Asia.

JEL Classification:
C23, C58, E22, E24, F43, L94, N15, N75, O13, P48, Q48, Q41

ABSTRACT

Purpose: The present study concentrates on the relationship of electricity with real output in Asia. The paper analyzes this connection individually among all regions of Asia. Some countries are selected from Central Asia, East Asia, South Asia and South East Asia. Time period of 1990 – 2015 has been chosen for the analysis. We have considered Solow growth model and have taken labor and capital as necessary variables for growth. After confirmation of integration of order as 1 for all variables, Kao Co-integration test infers presence of long run relationship in all models. FM-OLS suggests that labor and capital are positively significant factors for the development of real output in all the regions of Asia. Electricity Production is positively influencing real output in Central Asia, South Asia and South East Asia; For East Asia, it has been stated as negative. On the basis of results, study suggests that government should develop more skilled labor, cheap investment opportunities, efficient and cheap electricity production.

© 2017 The authors, under a Creative Commons Attribution-NonCommercial 4.0

Corresponding author's email address: farrukh.bashir@iub.edu.pk
Recommended citation: Bashir, F., Ahmad, T.I., Nasim, I. & Parveen, K., (2017). Electricity Generation and Real Output in Asia: A Panel Co-Integration Approach. *Review of Economics and Development Studies, 3*(1) 13-28
DOI: https://doi.org/10.26710/reads.v3i1.163

1. Introduction

Energy including electricity plays pivotal role in generation of real output, employment generation, price stability etc. Economic activity is also a source of increased consumption of energy remarkably in commercial energy like electricity (Jumbe, 2004). Industrial outputs are dependent upon available efficient energy resources and electricity production. Energy also promotes the productivity of labor, capital and real output as well. Cheaper supply of electric power may encourage the establishment of small industries and hence lead to higher economic growth.

The relationship between real output and electricity production in Central Asia, East Asia, South Asia and South East Asia are presented in table 1. It is evident from the table that the average growth rate of central Asia is very low as compared to other regions during the time period of study (1990 – 2015). While South Asian region is enjoying the highest growth rate and South East Asian region is at second number and East Asia is at 3rd. In the Asian block, East Asia is having the highest real GDP i.e. 1400 billion dollar during the study period. Central Asia is again at the last number in this respect. The mean of real GDP is

very low in Central Asia that is 10 billion dollars. Same situation of Asian regions is in case of electricity production East Asia is producing 652 billion KWh on the average while central Asia is producing 32.2 billion KWh on the average in a year. An Asian region having higher electricity production is having higher real GDP but growth rate is not higher in specific region (Central Asia). Growth rate is higher for the regions (South Asia and South East Asia) where electricity production is just near to real GDP. The large difference between electricity production and real GDP may not lead to higher growth rate as in East Asia.

Table-1: Some Indicators of Asian Regions

Indicators	Central Asia	East Asia	South Asia	South East Asia
Growth rate (Percentage)	2.56	4.84	5.19	5.00
Real GDP (Billion Dollars)	10	1400	140	92.9
Electricity Production (Billion KWh)	32.2	652	138	55.6
Total Labor force (Millions)	4.74	165	108	31.47
Gross Capital Formation (Billion Dollars)	4.59	452	52.1	32.7
Electricity Consumption (Billion KWh)	28.5	618	107	50.9

Note: The above values are Mean of variables from 1990 – 2015.

Table 1 also discusses the situation of total labor force, gross capital formation and electricity consumption. Central Asia is having lower growth rate also due to lower labor force and capital formation. East Asia has a huge amount of total labor force as well as gross capital formation on the average between the time periods of 1990 – 2015. Electricity consumption is also not much different from electricity production in East Asia. South Asia comprises with moderate situation in terms of electricity consumption, electricity production, total labor force, gross fixed capital formation and real GDP but still having higher GDP growth rate. On the other side, South East Asia contains total labor force of 31.47 million, gross capital formation of 32.7 billion dollars and electricity consumption of 50.9 billion KWh on the average during 1990 - 2015.

Table 2 explains about excess electricity production in central Asia, East Asia, South Asia and South East Asia during the study period. We can recognize that electricity excess production is having an upward trend in all the regions of Asia from 1990 to 2015. The highest excess production is correlated with higher real GDP and Electricity Production in East Asian region but with moderate growth rate. These values may explain that higher growth rate is not necessary to be achieved by higher production of electricity. As Excess electricity production and average electricity production is the highest for East Asia but growth rate is not highest. This evidence may conclude negative relationship among growth rate and electricity production for East Asian Region. With the lower excess production of electricity in Central Asia and lower real output, it is having lower growth rate and it shows direct association of real GDP with electricity output. Discussing South Asia and South East Asia, positive association can be also predicted among electricity production and growth rate.

Table 2: Excess Electricity Production (in Billion KWh)

Regions	1990 – 1995	1996 – 2000	2001 – 2005	2006 - 2015
Central Asia	2.6	3.50	4.42	4.61
East Asia	19.78	26.51	36.98	51.88
South Asia	15.56	27.56	38.97	42.69
South East Asia	2.78	4.43	5.66	5.76

Note: The values are averages in the specific years.

By considering the view Solow growth theories, the study is aimed to investigate the influence of Electricity on real output separately for all regions of Asia Continent like Central Asia, East Asia, South Asia and South East Asia during 1990 to 2015. Apart from introduction in Section 1, the study is composed of following sections. Section 2 presents summary of some past studies, Section 3 is dealing with panel data and estimation issues. In section 4, Panel results are discussed based upon Panel Co-integration technique and FM-OLS method. Last Section 5 finally concludes the whole research work and also gives some policy implications based upon estimated results.

2. Literature Review

Electricity, Energy and Growth relationships are investigated previously by several economists. These economists are belonging to either from Pakistan or from other Nations. This section summarizes few of those studies comprehensively.

Asafu-Adjaye (2000) has examined the energy income relationship for four energy-dependent Asian developing countries: India, Indonesia, the Philippines and Thailand. The series for India and Indonesia cover the period of 1973-1995, while those for Thailand and the Philippines cover the period of 1971-1995. The data has been obtained from World Development Indicators (WDI) 1998, published by the World Bank. The study utilizes Johansen Maximum Likelihood method and Temporal Granger Causality tests and concludes the positive association among energy consumption, prices and economic growth.

Soytas et al. (2001) investigate the causal relationship between energy consumption and GDP in Turkey. The results indicate a unidirectional causality running from energy consumption to GDP. This suggests that energy conservation may harm economic growth in the long run. Stern and Cleveland (2004) have reviewed the links between energy and growth. Time series analysis shows that energy and GDP is Co-integrated and energy use Granger causes GDP when additional variables such as energy prices or other production inputs are included. As a result, prospects for further large reductions in energy intensity seem limited.

Abdulnasser and Manuchehr (2005) examine the energy – income relationship for Sweden during the time period 1965 – 2000. The estimation results reveal that energy consumption does not cause economic activity but rather it is caused by economic activity. Mehrara (2007) examines the causality issue between energy consumption and economic growth for three typical oil-exporting countries: Iran, Kuwait and Saudi Arabia. The results are based on Causality analysis consistently show a unidirectional long-run causality from economic growth to energy consumption for Iran and Kuwait and unidirectional strong causality from energy consumption to economic growth for Saudi Arabia.

Aktas and Yilmaz (2008) investigate empirically the existence and direction of causal relationship between electricity consumption and economic growth in Turkey. By taking time series data for 1970 – 2004, Co-integration results suggest positive association between GDP and electricity consumption. Chebbi (2009) has understood long and short-run linkages between economic growth, energy consumption and carbon emission using Tunisian data based on time series data of 1971 – 2004. The results reveal a positive linkage between output and energy use. Other result indicates that carbon emission and energy consumption are positively related in the long-run. Pradhan (2010) explores the nexus between energy consumption (oil and electricity) and economic growth in the five SAARC countries over the period 1970-2006. Based on Co-integration and Error Correction Model, the paper finds a unidirectional short run and long run causality from oil consumption to economic growth in Bangladesh and Nepal. A unidirectional short run and long run causality from electricity consumption to economic growth in Pakistan and Sri Lanka is evident. A unidirectional short run and long run causality from economic growth to oil consumption in India and Sri Lanka is examined. It is analyzed that a unidirectional causality moves from economic growth to electricity consumption in India and Nepal. The bidirectional causality between electricity consumption and economic growth is also found in Bangladesh and between oil consumption and economic growth in Pakistan.

Noor and Siddiqi (2010) examine causal link between energy use and economic growth for five South Asian countries over period 1971-2006. Panel Co-integration, ECM and FMOLS are applied for short and long run estimates. In short run unidirectional causality from per capita GDP to per capita energy consumption is found, but not vice versa. In long run one percent increase in per capita energy consumption tend to decrease 0.13 percent per capita GDP i.e. Energy use discourages economic growth.

Payne and Taylor (2010) examine the relationship between nuclear energy consumption growth and real gross domestic product (GDP) growth within a neoclassical production function framework for the US using annual data from 1957 to 2006. The Toda-Yamamoto (1995) test for long-run Granger-causality reveals the absence of Granger-causality between nuclear energy consumption growth and real GDP growth which supports the neutrality hypothesis within the energy consumption economic growth literature.

Binh (2011) investigates the energy consumption-growth nexus in Vietnam using time series data for the period 1976 – 2010. It is seen that per capital GDP is inversely affected by per capita energy consumption.

Magazzino (2011) has assessed the empirical evidence of the nexus between aggregate income and energy consumption for Italy during the period 1970-2009, using a time-series approach. The short-run dynamics of the variables show that the flow of causality runs from energy use to GDP, and there is a long-run bi-directional causal relationship (or feedback effect) between the two series. Consequently, we conclude that energy is a limiting factor to GDP growth in Italy.

Adom (2011) seeks to investigate the direction of causality between electricity consumption and economic growth using the Toda and Yomamoto Granger Causality Test from 1971 to 2008. The author reveals that there exists a unidirectional causality running from economic growth to electricity consumption. Thus, data on Ghana supports the Growth-led-Energy Hypothesis.

Hossain and Saeki (2011) empirically examine the dynamic causal relationships between electricity consumption and economic growth for the panel of south Asian countries using time series data from 1971 to 2007. The Granger causality test results support the existence of unidirectional causality from economic growth to electricity consumption in India, Nepal and Pakistan; and from electricity consumption to economic growth in Bangladesh. No causal relationship is found in Iran and Sri-Lanka.

Qazi et al. (2012) concentrate on the relationship between industrial output and disaggregate energy consumption in Pakistan. Utilizing time series data from 1972 to 2010 and Johansen maximum likelihood econometric technique, the study finalizes employment, oil consumption, electricity consumption, consumer price index and gas consumption as positively influencing industrial and real output in Pakistan.

Amiri and Zibae (2012) have introduced a new way for investigating linear and nonlinear Granger causality between energy use and economic growth in France over the period 1960 to 2005 using geo-statistical models. Existence of long run unidirectional causality from energy consumption to economic growth is seen in the analysis.

Shahbaz and Ozturk (2012) reconsider the relationship between electricity consumption and economic growth by incorporating financial development, capital and labor as important factors of production using augmented production function in Turkey for the period of 1971-2009. The study reveals positive association of GDP per capita with electricity consumption per capita, real capital stock per capita, real domestic credit to private sector per capita and labor force participation using ARDL bound testing approach.

Jakovac (2013) indicated bi-directional short run causality and uni-directional long run causality running from total energy consumption to economic growth using annual data covering the period 1952 – 2010 for Croatian Economy. Kusuma and Muqorrobin (2013) indicated that granger causality was not running in both directions between output growth and energy consumption and confirmed the presence of neutral hypothesis theory. It implied that economic growth of Malaysia was not highly dependent upon energy consumption.

Nelson et al. (2013) indicated one way granger causality from electricity and petroleum consumption to manufacturing in the short run and long run and bi-directional causality between manufacturing and electricity consumption using time series data of Kenya from 1970 to 2010. Saatci and Dumrul (2013) took a structural breaks modeling approach to investigate the role of energy consumption in economic growth for Turkish economy from 1960 to 2008. The study concluded positive association of energy consumption concerning economic growth.

Muse (2014) employed the cointegration, ordinary least square analysis, error correction model and Pairwise granger causality tests to examine causal relationships between economic growth and energy consumption in Nigeria. Using time series data from 1980 to 2012, the study indicated energy consumption as enhancing factor for energy growth. Jebran (2014) revealed uni-directional causality flowing from electricity consumption to economic growth using time series data from 1971 to 2010 for Pakistan by applying granger causality test.

Chaudhry et al. (2015) discerned total labor force, capital formation, industrial output, government expenditure and energy consumption as rising factors for real Gross Domestic Product in South Asia while Real Gross Domestic Product was decreased by GDP Deflator in the long run.

Rehman and Bashir (2015) highlighted the involvement of energy consumption concerning Agricultural output. The study used Panel Autoregressive and Distributed lag model over panel data of middle income developing countries from 1990 to 2014. The long run results found energy consumption as significant and positive feature for agricultural output. GDP Deflator, broad Money and government expenditure were also improving agricultural output while capital formation and labor force were negative in the long run.

Ali et al. (2016) preferred biomass as a source of energy because it was more suitable for environmental protection as compared to fossil fuel as energy consumption. On the other side, biomass energy consumption was also revealed to be significant cause of higher growth in Sub – Saharan African countries. The findings of the study were based on pooled mean group (PMG), Dynamic OLS (DOLS), mean group (MG) and fully modified OLS (FMOLS) techniques.

Yap and Bekhet (2016) advocated that energy security had been highly required for rapid growth in Malaysia and energy security issues may be resolve by effective pricing policies. The authors analyzed that income, FDI, population and electricity prices were involved in affecting residential electricity consumption in the long run.

The above studies present the research conducted before this paper. Some studies have practiced time series data as well as Panel data in their analysis. And most of them have utilized granger causality approach for analyzing the causality. Few of them have made use of ARDL technique to examine the connection between electricity consumption and growth. Some panel studies are old enough and no one has analyzed the association with reference to Asia. The present study is different from previous studies and adds some additional points that are;

i). Existence of Solow growth model

ii). Latest data range (1990 - 2015)

iii). Estimation technique (Panel Co-integration)
iv). Segregated analysis of all regions of Asia continent (Central Asia, East Asia, South Asia and South East Asia)
v). No. of countries (22)
vi). Analysis of estimates (fully modified ordinary least square method)
vii). One additional variable that is electricity production.

3. Panel Data, Models and Estimation Issues

The collection of data, specification of models and estimation of results need serious attention to be taken. This section deals with the issues related to estimation of results, model specification and data collection.

3.1 Model Specification

The objective of the study is to examine the influence of electricity on real output for all regions of Asia i.e. Central Asia, East Asia, South Asia and South East Asia. The research follows Solow Growth model that's why labor force and capital formation are included as proxy of labor and capital respectively. Considering linear form of equations, the study determines the following models independently for all regions.

3.1.1 Central Asia

$$RGDP_{CA} = \alpha_0 + \alpha_1 TLF_{CA} + \alpha_2 GCF_{CA} + \alpha_3 ELPROD_{CA} + \varepsilon_{CA}$$

3.1.2 East Asia

$$RGDP_{EA} = \beta_0 + \beta_1 TLF_{EA} + \beta_2 GCF_{EA} + \beta_3 ELPROD_{EA} + \varepsilon_{EA}$$

3.1.2 South Asia

$$RGDP_{SA} = \gamma_0 + \gamma_1 TLF_{SA} + \gamma_2 GCF_{SA} + \gamma_3 ELPROD_{SA} + \varepsilon_{SA}$$

3.1.4 South East Asia

$$RGDP_{SEA} = \delta_0 + \delta_1 TLF_{SEA} + \delta_2 GCF_{SEA} + \delta_3 ELPROD_{SEA} + \varepsilon_{SEA}$$

Where subscripts CA, EA, SA, and SEA respectively denote Central Asia, East Asia, South Asia and South East Asia; $\alpha's,\ \beta's,\ \gamma's\ and\ \delta's$ show values of coefficients for Central Asia, East Asia, South Asia and South East Asia; and $\varepsilon's$ indicate error terms of regression models.

3.2 Definition of variables

In the above specified models, following variables are used as explained below.

3.2.1 Real Gross Domestic Product (RGDP)

The dependent variable, Real Gross domestic product is defined as total goods and services produced within the economy evaluated at constant market prices. We have taken the prices of year 2000 to calculate Real GDP. RGDP is taken in U.S. dollars for Central Asia, East Asia, South Asia and South East Asia.

3.2.2 Total Labor Force (TLF)

TLF denotes total labor force in these Asian regions i.e. Central Asia, East Asia, South Asia, South East Asia. In total labor force, all males and female are considered who fall in age group of 15 – 65. It is taken as a proxy of labor. Labor force is expected to be positively related to real output in these regions.

3.2.3 Gross Capital Formation (GCF)

GCF explains gross capital formation for all the regions of Asia. GCF is taken as a proxy of capital. The unit of gross capital formation is current U.S dollars. Capital is hypothesized as positively influencing real

gross domestic product of Asia Continent.

3.2.4 Electricity Production (ELPROD)

For energy production, we are including electricity production in KWh because electricity is considered as the major source of energy for producing goods and services in an economy. We suppose that more Electricity production may lead to higher real output in Asia. But excess production above the limits may decline real output as well due to unnecessary utilization.

3.3 Data Sources

To investigate the dimensions of electricity for real gross domestic product in Asia Continent, the research incorporates all regions of Asia like Central Asia, East Asia, South Asia and South East Asia. Moreover, the study is based upon segregated analysis of all the regions of the Continent. The research chooses some selected countries from each region according to availability of data. From central Asia, the paper considers Kazakhstan, Kyrgyz, Tajikistan, Turkmenistan, and Uzbekistan. In East Asia, we have taken China, Hong Kong, Japan, Korea and Mongolia. Among South Asia region, the study includes Bangladesh, India, Nepal, Pakistan, and Sri Lanka. Some countries are selected from South East Asia region those are Brunei, Indonesia, Malaysia, Philippines, Singapore, Thailand and Vietnam. The analysis selects time period from 1990 to 2015 for all countries regarding selected variables. Data is collected from website of World Bank, World Development Indicators, International Financial Statistics and Global Development Finance.

3.4 Estimation Issues

The current study analyses the influence of electricity on real output in Asia Continent. It is based upon segregated evaluation of all the regions of Asia (Central Asia, East Asia, South Asia and South East Asia) by forming panel of all regions individually. Whenever, we try to inspect panel of countries, we need to pay attention on several issues of panel data those are described step by step as follows;

1. To explore stationary of the panel variables.
2. To decide about an appropriate estimation approach (Fixed & Random Effects or Panel Co-integration or Generalized Method of Moments).
3. Apply Panel Co-integration test (Pedroni or Kao or Fisher) to investigate long run relationship (If Panel Co-integration is decided to apply on the basis of unit root test).
4. To evaluate coefficients for general specified model using Fully Modified Ordinary Least Square method (FM-OLS).
5. Then use the results for economic interpretation and policy making.

Based upon the above steps, econometric methodology is described in detail.

3.4.1 Im, Pesaran and Shin W-Stat (Unit Root Test)

The Im, Pesaran and Shin test (1997) provides separate estimation for each 'i' section, allowing different specifications of the parameter values, the residual variance and the lag lengths. Their model is given by;

$$\Delta Y_{i,t} = a_i + \rho_i Y_{i,t-1} + \sum_{k=1}^{n} \phi_k \Delta Y_{i,t-k} + \delta_i t + \theta_t + \mu_{it} \qquad \text{(a)}$$

The null hypothesis of this test is that all series are non-stationary processes under the alternative that a fraction of the series in the panel are assumed to be stationary.

3.4.2 Kao (Engle – Granger based) Co-integration Test

The Kao test (1999) follows the same basic approach as the Pedroni tests, but specifies cross section specific intercepts and homogenous coefficients on the first stage regressors. Under the null of no Co-integration, Kao shows that following the statistics;

$$ADF = \frac{t_{\bar{\rho}} + \sqrt{6N}\hat{\sigma}_v/(2\hat{\sigma}_{0v})}{\sqrt{\frac{\hat{\sigma}_{0v}^2}{2\hat{\sigma}_0^2} + \frac{3\hat{\sigma}_v^2}{10\hat{\sigma}_{0v}^2}}} \qquad \text{(b)}$$

3.4.3 Fully Modified Ordinary Least Square Method (FM-OLS)

After establishing Panel Co integration, the analysis requires estimates for macroeconomic variables to get the intensity of long run relationships. Kao and Chen (1995) notice that ordinary least square method gives asymptotically normal but asymptotically biased results in Panel Co-integrated models. Chen, McCoskey and Kao (1999) have investigated that generally, the bias – corrected ordinary least square coefficients do not improve over the OLS estimators. They suggest Fully Modified least square (FM-OLS) estimators or dynamic least square (DOLS) may be more appropriate for Panel Co-integrated regressors. Phillips and Moon (1999) and Pedroni (1996) also have proposed fully modified least square (FM-OLS) method for Co-integrated panel results. FM – OLS is a generalization of Phillips and Hansen (1990). Kao and Chang (2000) propose another approach that is based on a panel dynamic least squares (DOLS). On the basis of above discussion, the research has made use of Fully Modified least squares (FM-OLS) technique.

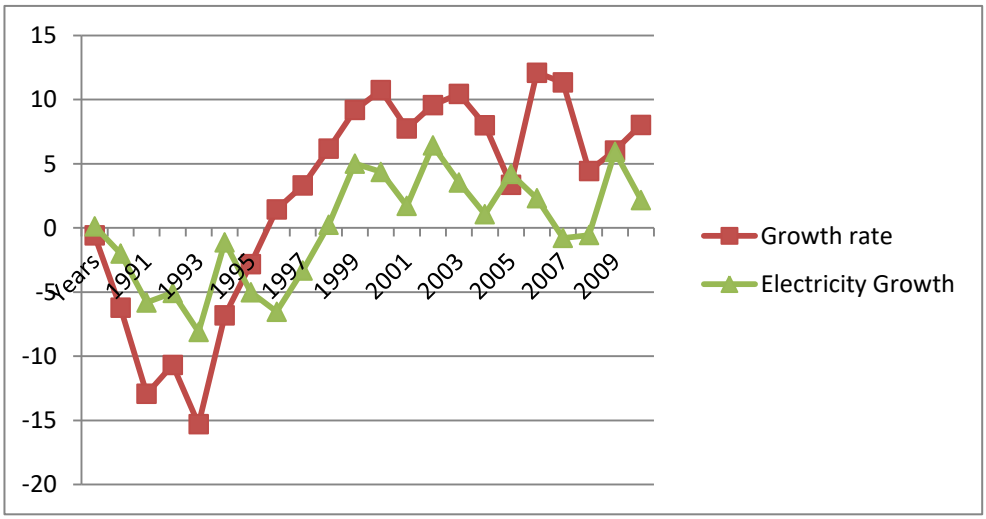
4. Panel Results and Discussions

This section describes Panel results on the basis of Graphical analysis and Econometric Analysis explained below.

4.1 Graphical Analysis

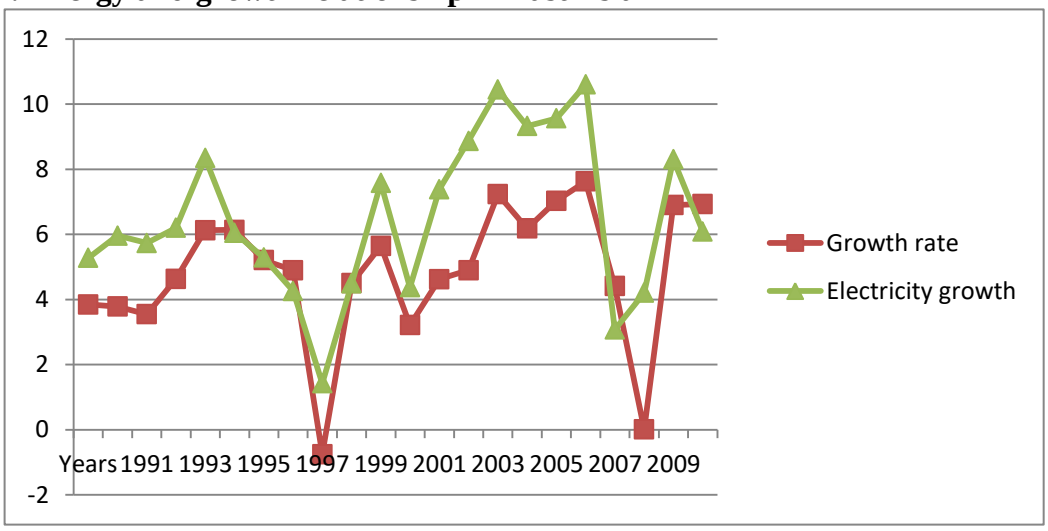
Figure 1 exhibits picture of central Asia about real growth rate of GDP and electricity production growth. There is decline in electricity production growth and growth rate up to 1993, after this year both have started increasing up to 2000. After 2000, a mixed behavior is seen among growth rate and energy growth but in all cases both are moving in same direction. So for Central Asia, we can conclude positive relationship between real GDP and Electricity production. Interestingly, in initial years of analysis from 1990 – 1998 and from 2007 – 2008, growth rate and electricity growth has remained negative as well.

Figure-1: Growth and Electricity relationship in Central Asia



Association among electricity growth and real growth rate of GDP is displayed in figure 2 for East Asia. For 1997, electricity production growth is negative, leading to lowest growth rate in East Asia; in 2008, it is near to 0 in East Asia. Electricity production growth is remained higher during 2001 – 2007. Despite lower excess production of electricity in East Asia on the average as compared to real GDP as it is remained higher i.e. 1400 billion dollars (Table 2). On the other side, most of the times, growth rate and electricity production growth rate were moving side by side or may be in same direction. This evidence gives us confused direction of relationship among electricity production and economic real output. The relationship may be positive or negative among electricity production and real GDP.

Figure 2: Energy and growth relationship in East Asia



Relationship of economic growth with electricity growth is presented in figure 3 in South Asia for 1990 to 2011. The association among these variables is seem to be confused because the relationship may be explored as positive during 1990 to 1994. But these variables are oppositely related to each other during 1995 to 2000. Again positive connection between growth rate and electricity production growth is analyzed from 2002 to 2008. In 2009-2011, the correlation among them is again negative. We may not conclude that whether the link is positive or negative among them.

Figure 3: Economic growth and Electricity growth in South Asia

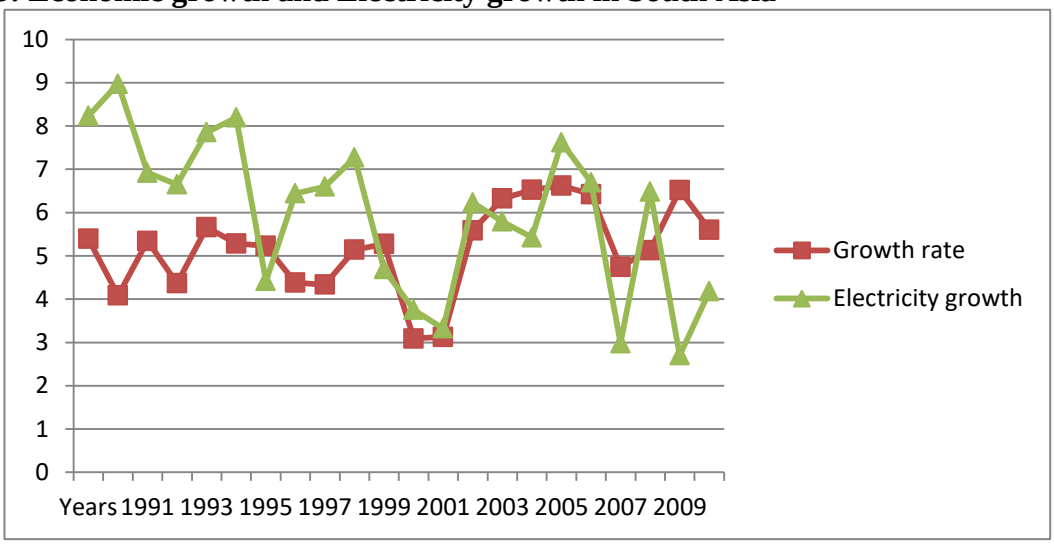
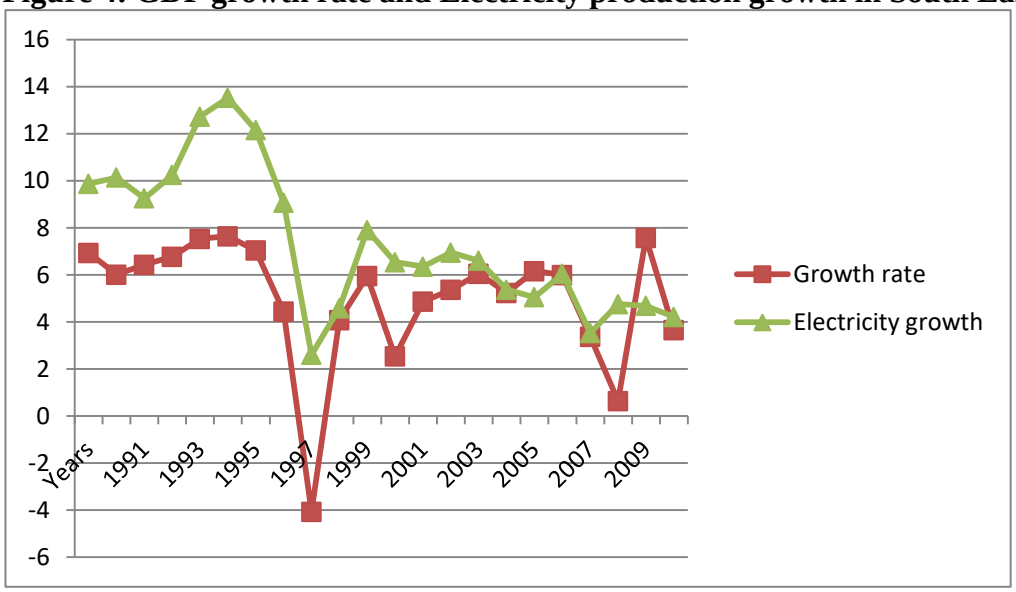


Figure 4: GDP growth rate and Electricity production growth in South East Asia



To interpret the correlation among real GDP growth rate and electricity production growth in South East Asia, we have drawn figure 4. This figure clearly presents that electricity growth is negative or low from 1996 to 1998; in the same years growth rate of GDP is also remained very low. But surprisingly, other than these years, growth rate and electricity growth are moving in same direction. We can conclude direct correlation among growth rate of GDP and electricity production growth.

4.2 Econometric Analysis

This section confers the panel results considering unit root test (Im, Pesaran and Shin W-Stat), Co-integration test (Kao Panel Co-integration test) and Fully Modified Ordinary least square methods. Table 3 displays the levels of stationary regarding dependent and explanatory variables included in the models with reference to all regions of Asia (Central Asia, East Asia, South Asia and South East Asia). The study incorporates only final conclusions concerning to all variables. We may successfully reject Null Hypothesis (variable is non-stationary) of unit root test on the basis of Probability value (should be less than 0.05) and may deduce that all the concerned variables (RGDP, GCF, ELPROD and TLF) are integrated of order 1. Fulfilling basic condition of Co-integration, we can apply Kao Panel Co-integration test on specified models.

Table 3: Im, Pesaran and Shin W-Stat

Variables	Test in	By Including	Statistics	Prob.	Lag	Result
Central Asia						
RGDP	1st Difference	Trend and Intercept	-2.23	0.01	Auto	I(1)
GCF	1st Difference	Intercept	-2.25	0.01	Auto	I(1)
ELPROD	1st Difference	Intercept	-4.89	0.00	Auto	I(1)
TLF	1st Difference	Trend and Intercept	-4.52	0.00	Auto	I(1)
East Asia						
RGDP	1st Difference	Intercept	-3.80	0.00	Auto	I(1)
GCF	1st Difference	Trend and Intercept	-2.77	0.00	1	I(1)
ELPROD	1st Difference	Intercept	-4.53	0.00	Auto	I(1)
TLF	1st Difference	Intercept	-5.48	0.00	Auto	I(1)
South Asia						
RGDP	1st Difference	Trend and Intercept	-2.44	0.00	Auto	I(1)
GCF	1st Difference	Trend and Intercept	-2.52	0.00	Auto	I(1)
ELPROD	1st Difference	Intercept	-3.73	0.00	Auto	I(1)
TLF	1st Difference	Intercept	-6.16	0.00	Auto	I(1)
South East Asia						
RGDP	1st Difference	Intercept	-5.65	0.00	Auto	I(1)
GCF	1st Difference	Intercept	-7.61	0.00	Auto	I(1)
ELPROD	1st Difference	Intercept	-6.86	0.00	Auto	I(1)
TLF	1st Difference	Intercept	-5.12	0.00	Auto	I(1)

In table 4, results of Kao Residual Panel Co-integration test are provided. Null hypothesis (No Co-integration) may be rejected for Panel Co-integration test on the basis of Probability values and presence of Panel Co-integration is inferred. By selecting Bandwidth as Newey West Automatic at 1st lag, Panel Co-integration is found for Central Asia, East Asia and South Asia. Panel Co-integration also exists in South East Asian model by selecting Bandwidth as Newey West Fixed at 1st lag. After tracing out Panel Co-integration, we can apply fully modified ordinary least square test for values of coefficients.

Table 4: Kao Residual Panel Co-integration Test

Region	t – Statistic	Prob.	Lag	Bandwidth Selection	Cointegration
Central Asia	-3.61	0.00	1	Newey West Automatic	Yes
East Asia	-3.32	0.00	1	Newey West Automatic	Yes
South Asia	-6.27	0.00	1	Newey West Automatic	Yes
South East Asia	1.68	0.04	1	Newey West Fixed	Yes

Note: Null Hypothesis: No Co-integration among variables

Table 5 portrays the panel estimates provided by the fully modified ordinary least square method. First column shows the information about variables while second column displays the values of coefficients and probability values for Asia Continent. In 2nd column, estimates of all Asian regions are reported in relation to their individual columns. The significance of variables may be examined by probability value that should be less than 0.05.

Considering Gross Capital formation that is representative of Capital in Solow Growth model, the study analyzes it most important variable for real output. The sign for the concerned variable is significantly positive for all regions of Asia continent (Central Asia, East Asia, South Asia and South East Asia). In East Asia, gross capital formation has much stronger and more elastic influence on real output as compared to other regions of Asia. One dollar increase in Gross capital formation is a cause of increasing 5.07 dollars in real output of East Asia on the average in the long run. The progress of China, Japan, Korea and Hong Kong are evident due to optimally utilized capital in East Asia region. In Central Asia, South Asia and South East Asia; capital has less elastic influence means capital is less efficiently utilized here in these regions. The values of coefficient suggest that 1 dollar rise in gross capital formation leads to real output by 0.61, 0.57 and 0.76 dollars on the average in the long run. Positive relationship of capital is in line with the economic theory. More capital formation and investment offers the economy and

industrial sector to expand more to produce goods and services within the geographical location of country or to enhance GDP in real sense that is one of the macroeconomic goals. Out results are consistent with the study of Shahbaz and Ozturk (2012).

Coming towards the total labor force (proxy of labor), it is therefore concluded that labor force is a source of higher real output. In the short run as well as in the long run, labor plays its significant role in producing more goods and services. Normally, under developed countries are more dependent upon labor force participation due to less availability of new technology. Skilled labor is also a blessing for any economy. In comparison with South Asia and South East Asia, the labor force of Central Asia seems to be extremely productive and skilled. Although Kazakhstan, Turkmenistan, Uzbekistan, and Tajikistan are less populated areas, the mean value of total labor force is 4.74 million for Central Asia; but labor force proves to be extremely productive in this region. It is also clear from the value of coefficient that is 1.21. For South Asia and South East Asia, values of labor force are correspondingly 0.19 and 0.12. Labor force of East Asia also looks extensively improved but it is associated with insignificant coefficient value. Real output will increase by 1.21, 0.19 and 0.12 thousand dollars on the average due to an additional unit of labor force in Central Asia, South Asia and South East Asia respectively in the long run. The analysis is in line with the Shahbaz and Ozturk (2012) and Qazi et al. (2012).

Table 5: Panel Estimates of Fully Modified Ordinary Least Square

Variables	Asia			
	Central Asia	**East Asia**	**South Asia**	**South East Asia**
	Coefficient (Probability)	**Coefficient (Probability)**	**Coefficient (Probability)**	**Coefficient (Probability)**
Gross Capital Formation	0.61 (0.00)	5.07 (0.00)	0.57 (0.00)	0.76 (0.00)
Total Labor Force	1.21 (0.00)	0.76 (0.58)	0.19 (0.00)	0.12 (0.07)
Electricity Production	0.13 (0.00)	-2.01 (0.01)	0.55 (0.00)	0.76 (0.00)
Constant	-2.59 (0.00)	3.23 (0.09)	1.25 (0.00)	2.17 (0.00)
Adj. R – Square	0.96	0.66	0.99	0.81

With regards to electricity production in Asia Continent, it is not incorrect to express that it is the major source of energy. Agriculture sector, Services sector, Manufacturing sector, Government sector as well as all sectors are dependent upon this important source of energy. The study notices significant relationships for Central Asia, East Asia, South Asia and South East Asia. The relationship of electricity production is positive with real output. The negative relationship is observed in case of only East Asia (China, Hong Kong, Japan, Korea, and Mongolia). It shows that real GDP is significantly expanded by efficient use of capital and labor force but electricity production is not essential for real output in East Asia. May be in this region, there is no shortage of electricity, real GDP is at maximum level as compared to all other regions having much sustained growth rate, labor force and capital are available in excess in contrast with other regions so electricity keeps no value among all these. Discussing electricity production for Central Asia, South Asia and South East Asia, outcome that is matched with the economic theory as energy production is playing vital role in real output expansion significantly. More electricity production enables the industrial sector to produce more at least cost and ultimately it will lead to higher real output. On the average, respectively in Central Asia, South Asia and South East Asia, one KWh more production of electricity raises real output by 0.13, 0.55 and 0.76 dollars in the long run.

5. Concluding Remarks and Policy Implications

The intension of the current paper is to investigate the influence of Electricity on real output of Asia Continent containing data from 1990 – 2015. Following Solow growth model, separate effect is traced out for each region of Asia. Graphical analysis suggests the positive association of real growth rate and

electricity production growth rate in all the regions. In some years, we get the negative relationship of real growth rate with electricity production growth rate in South Asia region, South East Asia region and Central Asia. This is happened either due to lag effect of electricity production growth rate on real growth rate or due to any inefficiency in electricity production.

For Econometric analysis; Im, Pesaran and Shin W – test (Unit root test) is pertained to analyze stationarity of panel variables. It implies that dependent and explanatory variables are integrated of order 1 that allows proceeding further for Co-integration analysis. Kao Panel Co-integration test is utilized to examine long run relationship among variables, and it infers the presence of Co-integration. Fully Modified Ordinary least square test is employed for values of long run coefficients. It advocates that in all regions of Asia Continent, real GDP is highly dependent upon total labor force in the long run. On the other side, regarding gross capital formation, the study indicates the same results. Gross capital formation is playing vital role in enhancing real output in all regions of Asia.

The findings of this paper investigate mixed results in terms of electricity generation. Electricity production is accomplished to significantly increase real output in various regions of Asia like Central Asia, South Asia and South East Asia. In East Asia, outcome is conflicting probably as a result of no dependence on electricity production of this region. There is no concept of electricity shortage there and their dependence is on skilled labor force and efficient capital investment.
On the basis of above findings, following policies may be recommended.

- **i.** As labor force plays essential role in real output enhancement, still attention should be given for provision of skill development plans to the young labor specifically in underdeveloped countries of Asia.
- **ii.** Gross capital formation has always active part in amplifying real output for any economy. In Asia Continent, it is also behaving like that but there should be cheap delivery of such finances in all the regions equally.
- **iii.** On the basis of electricity production, it may be suggested that there should be keen emphasis on cheap electricity production through cheap resources in all the regions so that it may be supplied at lower rates.

References

Abdulnasser, H. J. and Manuchehr, I. (2005). Energy Consumption and Economic Growth in Sweden: A Leveraged Bootstrap Approach, (1965-2000). *International Journal of Applied Econometrics and Quantitative Studies*, 2(4), 87 – 98.

Adom, P. K. (2011). Electricity Consumption-Economic Growth Nexus: The Ghanaian Case. *International Journal of Energy Economics and Policy*, 1(1), 19 – 31.

Aktaş, C. and Yilmaz, V. (2008). Causal Relationship between Electricity Consumption and Economic Growth in Turkey. *Zkü Sosyal Bilimler Dergisi*, 4(8), 45 – 54.

Asafu-Adjaye, J. (2000). The relationship between energy consumption, energy prices and economic growth: time series evidence from Asian developing countries. *Energy Economics*, 22, 615 - 625

Asteriou, D. (2005). Applied Econometrics: A modern approach using EViews and Microfit, Palgrave Macmilan.

Binh, P. T. (2011). Energy Consumption and Economic Growth in Vietnam: Threshold Cointegration and Causality Analysis. *International Journal of Energy Economics and Policy*, 1(1), 1 – 17.

Chebbi, H. E. (2009). Long and Short-Run Linkages between Economic Growth, Energy Consumption and CO_2 Emissions in Tunisia. *Economic Research Forum, Working Paper*, 485, 1 – 20.

Chen, B., McCoskey, S. and Kao, C. (1999). Estimation and Inference of a Cointegrated regression in panel data: A Monte Carlo Study. *American Journal of Mathematical and Management Sciences*, 19, 75 – 114.

Choi, I. (2001). Unit root tests for panel data. *Journal of International Money and Finance*, 20, 249 – 272.

Christian, G. (2011). Explaining the (non-) causality between energy and economic growth in the US: A multivariate sectoral analysis. *Papers on economics and evolution, 1104*, 1 – 29.

Gujarati, D. N. and Porter, D. C. (2009). Basic Econometrics, 5th Edition.

Halkos, G. E. and Tzeremes, N. G. (2011). The effect of Energy Consumption on Countries' Economic Efficiency: a conditional robust non parametric approach. *MPRA Paper No. 28692*, 1 – 28.

Hirschman, A. O. (1958). The Strategy of Economic Development. New Haven: Yale University Press.

Hirshman A. O. (1958). The Strategy of Economic Development, Westview Press.

Hossain, M. S. and Saeki, C. (2011). Does Electricity Consumption Panel Granger Cause Economic Growth in South Asia? Evidence from Bangladesh, India, Iran, Nepal, Pakistan and Sri-Lanka. *European Journal of Social Sciences*, 25(3), 316 – 328.

Im, K. S., Pesaran, M. H. and Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics*, 115, 53 – 74.

Imran, K. and Siddiqui, M. M. (2010). Energy Consumption and Economic Growth: A Case Study of Three SAARC Countries. *European Journal of Social Sciences*, 16(2), 206 – 213.

Jhingan, M. L. (2009). The Economics of Development and Planning. 38th Revised and Enlarged Edition.

Jumbe, C. B.L. (2004). Co-integration and Causality between Electricity Consumption and GDP: Empirical Evidence From Malawi. *Energy Economics*, 26, 61 – 68.

Kao, C. and Chen, B. (1995). On the estimation and inference for Co-integration in panel data when the cross section and time series dimensions are comparable. *Manuscrpit*, Center for Policy Research, Syracuse University,

Kao, C. and Chiang, M. H. (2000). On the estimation and inference of a co integrated regression in panel data. *Advances in Econometrics*, 15. 179 – 222.

Kao, C. D. (1999). Spurious Regression and Residual – Based Tests for Cointegration in Panel Data. *Journal of Econometrics*, 90, 1 – 44.

Khan, M. A. and Ahmed, U. (----).Energy Demand in Pakistan: A Disaggregate Analysis.

Magazzino, C. (2011). Energy consumption and aggregate income in Italy: cointegration and causality analysis. *MPRA Paper No. 28494*, 1 – 19.

Mehrara, M. (2007). Energy-GDP relationship for oil-exporting countries: Iran, Kuwait and Saudi Arabia. *Organization of the Petroleum Exporting Countries*, 1 – 16.

Noor, S. and Siddiqi, M. W. (2010). Energy Consumption and Economic Growth in South Asian Countries: A Co-integrated Panel Analysis. *International Journal of Human and Social Sciences*, 2(14), 921 – 926.

Payne, J. E. and Taylor, J. P. (2010). Nuclear Energy Consumption and Economic Growth in the U.S.: An Empirical Note. *Energy Sources*, 5, 301 – 307.

Pedroni, P. (1996). Fully Modified OLS for Heterogeneous Cointegrated panels and the case of purchasing power parity. *Working paper, department of economics, Indiana University.*

Phillips, P. C. B. and Hansen, B. E. (1990). Statistical Inference in Instrumental variables regression with I(1) processes. *Review of Economic Studies,* 57, 99 – 125.

Phillips, P. C. B. and Moon, H. (1999). Linear Regression Limit theory for Non stationary panel data. *Econometrica*, 67, 1057 – 1111.

Pradhan, R. P. (2010). Energy Consumption- Growth Nexus in SAARC Countries: Using Cointegration and Error Correction Model**.** *Modern Applied Science*, 4(4), 74 – 90.

Qazi, A. Q., Ahmed, K. and Mudassar, M. (2012). Disaggregate Energy Consumption and Industrial Output in Pakistan: An Empirical Analysis. *Economics discussion papers*, 1 – 15.

Salim, R. A., Rafiq, S. and Hassan, A. F. M. K. (2008). Causality and Dynamics of Energy Consumption and Output: Evidence from Non-OECD Asian Countries. *Journal of Economic Development*, 33(2), 1 – 26.

Shahbaz, M. and Ozturk, I. (2012). Electricity consumption and economic growth causality revisited: evidence from Turkey. *MPRA Paper No. 37637*, 1 – 25.

Solow, R. M. (1956). A contribution to the theory of economic growth. *Quarterly Journal of Economics*, 70, 65-94.

Soytas, U., Sari, R. and Ozdemir, O. (2001). Energy Consumption and GDP Relation in Turkey: A Cointegration and Vector Error Correction Analysis. Economies and Business in Transition:

Facilitating Competitiveness and Change in the Global Environment Proceedings, 838 – 844.

Stern, D. I. and Cleveland, C. J. (2004). Energy and Economic Growth. *Rensselaer working paper in economics*, 1 – 41.

World Data Bank, World Development Indicators and Global Development Finance, Source: http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=2

Yang, G., Wang, H., Zhou, J. and Liu, X. (2012). Analyzing and Predicting the Economic Growth, Energy Consumption and CO2 Emissions in Shanghai. *Energy and Environment Research*, 2(2), 83 – 91.

Yap, L. L. I. and Bekhet, H. A. (2016). Modelling the causal linkages among residential electricity consumption, gross domestic product, price of electricity, price of electric appliances, population and foreign direct investment in Malaysia. *International Journal of Energy Technology and Policy*, 12 (1), 41 – 59.

Ali, H. S., Law, S. H., Yusop, Z. and Chin, L. (2016). Dynamic implication of biomass energy consumption on economic growth in Sub-Saharan Africa: evidence from panel data analysis. *GeoJournal*, 81, 1 – 10.

Rehman, H. and Bashir, F. (2015). Energy Consumption and Agriculture Sector in Middle Income Developing Countries: A Panel Data Analysis. *Pakistan Journal of Social Sciences*, 35 (1), 479 – 496.

Chaudhry, I. S., Farooq F. and Nasim, I. (2015). Long run Panel Data Analysis of Energy Consumption and Real GDP of South Asian Economies. *Pakistan Journal of Social Sciences*, 35 (2), 715 – 727.

Jebran, K. (2014). Causal relationship between electricity consumption and GDP in Pakistan. *Journal of Asian Developing Studies*, 3(1), 90 – 100.

Muse, B. O. (2014). Energy Consumption and Economic Growth in Nigeria: Correlation or Causality? *Journal of Empirical Economics*, 3(3), 108 – 120.

Saatci, M. and Dumrul, Y. (2013). The relationship between energy consumption and economic growth: Evidence from a structural break analysis for Turkey. *International Journal of Energy Economics and Policy*, 3(1), 20 – 29.

Nelson, O., Mukras, M. S. and Siringi, E. M. (2013). Causality between disaggregated energy consumption and Manufacturing Growth in Kenya: An empirical approach. *Journal of Economics and Sustainable Development*, 4(16), 29 – 36.

Kusuma, D. B. W. and Muqorrobin, M. (2013). The relationship between energy consumption and economic growth. *Trikonomika*, 12(2), 103 – 112.

Jakovac, P. (2013). Empirical analysis on economic growth and energy consumption relationship in Croatia. *Ekonomska Istrazivanja Economic Research*, 26(4), 21 – 42.