UDC:519.86:620.92(54)

MULTIVARIATE GRANGER CAUSALITY BETWEEN ECONOMIC GROWTH, ELECTRICITY CONSUMPTION, EXPORTS AND REMITTANCE FOR THE PANEL OF THREE SAARC COUNTRIES

Md. Sharif Hossain, PhD
Associate Professor of Econometrics; Department of Economic Engineering, Faculty of Economics, Kyushu University, Japan

Abstract

This paper empirically examines the dynamic causal relationship between economic growth, electricity consumption, export values and remittance for the panel of three SAARC countries using the time series data for the period 1976- 2009. Using four different panel unit root tests it is found that all the panel variables are integrated of order 1. From the Johansen Fisher panel cointegration and Kao tests it is found that all the panel variables are cointegrated. The panel Granger F test results support that there is only bidirectional short-run causal relationship between economic growth and export values but there is no evidence of long-run causal relationship. It is found that the long-run elasticity of economic growth with respect to electricity consumption and remittance are higher than short run elasticity. This means that over time higher electricity consumption and higher remittance from manpower supply in the panel of SAARC countries give rise to more economic growth.

Keywords: Panel unit root tests, Panel cointegration tests, Panel Granger causality tests, Short-run and long-run elasticities

1. Introduction

Economic growth of the SAARC countries especially Bangladesh, India, Pakistan and Sri-Lanka, is closely related to its energy consumption, export values, and remittance receipts from manpower supply. However this does not necessarily imply a causal relationship between them. The direction, strength and stability of the relationship between economic growth, energy consumption, export values and remittance play a significant role in designing different policies that are associated with economic growth and energy consumption. The direction and policy implications for the causal relationship between economic growth, electricity consumption, export values and workers' remittance can be classified as follows. If unidirectional causal relationship from electricity consumption, and export values to economic growth is found, indicates that any restriction on the use of energy which negatively affects the export values leads to a reduction of economic growth. Thus about this negative effect on economic growth that caused by a policy of restriction of energy use in order to slow down the rate of climate change grows by reducing GHG's, many SAARC countries specially India as a rising country will be worried. On the other hand if unidirectional causal relationship from economic growth to electricity consumption or from economic growth to export values is found, any restriction on the use of electricity has very little or no adverse impacts on economic growth. A bi-directional causal relationship implies that both the variables are jointly determined and will affect at the same time. If no causal relationship between these variables is found, the hypothesis of neutrality holds indicates that any restriction on energy use will not work as a barrier for economic development of the panel.

It is well known to us political crises are going on in Libya, Egypt, Tunisia and some Middle East countries namely Syria, Iraq, Iran etc. Due to the political crises the workers' remittance receipt will be declined in different SAARC countries. If unidirectional causality is found from remittance to economic growth in the panel of SAARC countries, indicates that the political crises negatively affect the economic growth of SAARC countries. If unidirectional causality is found from economic growth to remittance, economic growth will not be negatively affected due to the political crisis. If bi-directional causal relationship between economic growth and remittance is found implies that both the variables are jointly determined and will affect at the same time due to the political crises. Now-a-days, energy efficiency measures will play a vital role as energy savings as a result most of the rising countries including India all over the world fear that such policy measure will harm their economic development. Also a major part of the GDP of different SAARC countries including Bangladesh, India, and Pakistan comes from the manpower supply in Middle East and other countries. Thus the most import question arises whether the new energy policy and policy for reducing the GHG's emissions and also political crises in Libya, Egypt, Tunisia, and Middle East will strike the economic growth of SAARC countries. One of the best known methods is to investigate the short-run and long-run causal relationships between economic growth, energy consumption, export values and workers' remittance for a panel of SAARC countries using the time series data.

That is why in this paper the principal purpose is made to investigate the dynamic causal relationships between economic growth, electricity consumption, export values and workers' remittance for a panel of three SAARC countries namely Bangladesh India and Pakistan using the time series data from 1976 to 2009. Due to the data problem other SAARC countries cannot be included for this empirical study. On the basis of the modern econometrics techniques, the dynamic causal relationships between electricity consumption and economic growth are examined. The organizational structure of the paper is as: Section 2 discusses the literature review; Section 3discusses data sources and descriptive statistics; Section 4 provides econometric modeling framework with empirical analysis and finally section 5 concludes with a summary of the main findings and policy implications.

2. Literature review

The causal relationships between two variables economic growth and energy consumption are investigated widely in economic literature. The enormous amount of empirical literatures to examine the causal relationship between economic growth and energy consumption fall into four categories; (i) no causal relationship between economic growth and energy consumption (ii) unidirectional causality from economic growth to energy consumption, (iii) unidirectional causality from energy consumption to economic growth and (iii) bidirectional causality between economic growth and energy consumption. In applied econometrics most recent causality studies have tended to focus by using panel data and employing panel cointegration and panel-base VAR and VEC models which provide more powerful tests compared to a time series approach to investigate causal relationship between two variables X and Y. The panel estimation can take heterogeneous country effect into account in a single estimation by allowing for individuals specific variable. Moreover, the model estimation allows greater degrees of freedom. As far it is known that a few panel causality studies are conducted in the fields of economics, finance and energy. The direction of causality between economic growth and energy/electricity consumption of different time series and panel studies are summarized below in Table 1.

Table 1: Summary of literature review on causality between energy consumption and economic growth

Previous Studies	Countries	Time Period	Variables	Methodology	Results
Time Series and Panel Studies					
Yang (2000)	Taiwan	1954-1997	E, Y	Hsiao's Granger (B)	E↔Y
Asafu & Adjaye (2000)	Thailand	1971-1995	E, Y, P	Cointegration (M)	E↔Y
Aqueel & Butt (2001)	Pakistan	1955-1996	E, Y	Hsiao's Granger (B)	E→Y
Ghosh (2002)	India	1950-1997	E, Y	Cointegration (B)	Y→E
Soytas and Sari (2003)	G-7 : Argentina, Turkey France, German, Japan Italy, South Korea,	1960-1995	E, Y	Cointegration Granger (B)	 E↔Y E→Y Y→E
Morimoto &Hope(2004)	Sri Lanka	1960-1998	E, Y	Granger (B)	E→Y
Wolde-Rufael (2004)	Shanghai	1952-1999	E, Y	Toda & Yamamoto's Granger (B)	E→Y
Jumbe (2004)	Malawi	1970-1999	E, Y	Cointegration (B)	E↔Y
Altinay & Karagol (2005)	Turkey	1950-2000	E, Y	Dolado-Lukepohl's Granger (B)	E→Y
Narayan & Smyth (2005)	Australia	1966-1999	E, Y, EM	Cointegration (M)	Y→E
Lee (2005)	Panel of	1971-	E, Y	Panel Unit Root	Y→E

	18Countries[1]	2002		(LLC, IPS, Hadri) Panel cointegration FMOLS (Pedroni) Panel Causality (Granger (B), GMM)	
Lee & Chang (2007)	Taiwan	1954-2003	E, Y	Cointegration (B)	E→Y
Yoo (2005)	South Korea	1970-2002	E, Y	Cointegration (B)	E↔Y
Al-Iriani (2006)	Panel of 6 GCC countries[2]	1971-2002	E, Y	Panel unit root (IPS), Panel cointegration (Pedroni), Panel causality Granger , GMM (B).	Y→E
Wolde-Rufael (2006):	16 African Countries: Algeria ,Congo RP, Kenya , Sudan Benin , Congo ,Tunisia Cameroon, Ghana, Nigeria , Senegal, Zambia , Zimbabwe Egypt , Gabon , Morocco	1971-2001	E, Y	Toda & Yamamoto's Granger (B)	E◊Y E◊Y E→Y E↔Y E↔Y E↔Y E↔Y E↔Y
Yoo (2006)	4 Asian Countries Indonesia, Thailand Malaysia, Singapore	1971-2002	E, Y	Hsiao's Granger (B)	Y→E E↔Y
Chen et al.	10 Asian	1971-	E, Y	Cointegration,	

(2007)	countries: China, Hong Kong Taiwan, Thailand Indonesia India, Malaysia Philippines Korea, Singapore	2001		Granger causality (B)	E◊Y E◊Y E→Y Y→E Y→E E↔Y
Chontanawat et al (2007)	Panel of 30 OECD[3] Panel of 78 non-OECD[4]	1971-2003	E, Y	Panel unit root (LLC, IPS), Panel cointegration, FMOLS (Pedroni), Panel causality (Granger, EG). (B)	E↔Y E↔Y
Chontanawat et al (2007)	Panel of G7 Countries[5] Panel of 12 AsianDeveloping Countries[6]	1960-2003 1971-2003	E, Y	Panel unit root (LLC, IPS), Panel cointegration, FMOLS (Pedroni), Panel causality (Granger, EG). (B)	Y→E E↔Y
Chen et al. (2007)	Panel of 7 Asian countries[7]	1971-2002	E, Y	Cointegration, Granger causality (B)	Y→E
Halicioglu (2007)	Turkey	1968-2005	E, Y	Bounds testing approach and Granger causality(B)	E→Y
Joyeux and Ripple (2007)	Panel of 7 East Indian Ocean Countries[8]	1971-2001	E, Y	Panel Unit root and cointegration (B)	Elec◊Y
Lee & Chang (2007)	Panel of 22 DCs[9] Panel of 18 LDCs[10]	1965-2002 1971-2002	E, Y	Panel causality (Granger, GMM).(B)	E↔Y Y→E
Mehrara (2007)	Panel of 11 Oil	1971-	E, Y	Panel unit root (LLC,	Y→E

	exporting countries[11]	2002		IPS), Panel cointegration, FMOLS (Pedroni), Panel causality (Granger, EG). (B)	
Narayan and Singh (2007)	Fiji	1971-2002	E, Y	Bounds testing approach to cointegration (B)	E→Y
Squalli (2007)	OPEC: Algeria, Iraq, Kuwait Libya Iran, Qatar, Saudi Arabia Indonesia, Nigeria, UAE	1980-2003	E, Y	Bounds testing approach, Toda &Yamamoto's Granger (B)	 Y→E Y→E Y→E E↔Y E↔Y E→Y
Naranyan et al. (2008)	G7 countries USA The rest	 1970-2002 1960-2002	E, Y	Structural vector autoregressive (SVAR), (B)	 E→Y E◊Y
Huang et al. (2008)	Panel of 19 low income Countries[12] Panel of 23 lower middle income countries[13] Panel of 15 upper middle income countries[14] Panel of 20 high income countries[15]	1972-2002		GMM-system approach (B)	E◊Y Y→E Y→E Y→E

Narayan & Smyth (2009)	Panel of 6 Middle Eastern Countries[16]	1974-2002	E, Y, EX	Panel unit root (Breitung), FMOLS(Westerlund), Panel causality (Granger, EG). (M)	E↔Y
Hossain (2011)	Panel of 9 NIC[17]	1971-2007	E, Y, CO2, UR, OPEN	Panel unit root (LLC, IPS, MW, Choi) Panel cointegration, Panel causality (Granger, EG, GMM). (M)	Y→E
Hossain & Saeki (2011)	Panel of 6 South Asian countries[18]	1971-2007	E, Y	Panel unit root (IPS, MW, Choi) Panel cointegration, Panel causality (Granger, EG, GMM). (B)	E→Y

Note: ◊ refers to 'no causality'; → refers to 'unidirectional causality'; ↔ refers to 'bi-directional causality'; B denotes bivariate model, M denotes multivariate model.

1: This includes South Korea, Singapore, Hungary, Argentina, Chile, Colombia, Mexico, Peru, Venezuela, Indonesia, Malaysia, India, Philippines, Thailand, Pakistan, Sri Lanka, Ghana and Kenya.

2: This panel includes Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates (UAE).

3: This includes Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

4: This includes Albania, Algeria, Angola, Argentina, Bahrain, Bangladesh, Benin, Bolivia, Brazil, Brunei, Bulgaria, Cameroon, Chile, Colombia, China, Congo, Congo Rep., Costa Rica, Cote d'Ivoire, Cuba, Cyprus, Dominican rep., Ecuador, Egypt, El Salvador,

Ethiopia, Gabon, Ghana, Gibraltar, Guatemala, Haiti, Honduras, Hong Kong, India, Indonesia, Iran, Iraq, Israel, Jamaica, Jordan,

Kenya, Kuwait, Lebanon, Libya, Malaysia, Malta, Morocco, Mozambique, Myanmar, Nepal, Nicaragua, Nigeria, Oman, Pakistan,

Panama, Paraguay, Peru, Philippines, Qatar, Romania, Saudi Arabia, Senegal, Singapore, Sri Lanka, Sudan, Taiwan, Tanzania,

Thailand, Togo, Trinidad Tobago, Tunisia, United Arab Emirates, Uruguay, Venezuela, Vietnam, Yemen, Zambia, Zimbabwe.

5: This refers to Canada, France, Germany, Italy, Japan, United Kingdom and United States.

6: These countries are Bangladesh, India, Indonesia, Malaysia, Myanmar, Nepal, Pakistan, China, Philippines, Sri-Lanka, Thailand and

Vietnam

7: This includes Hong Kong, Korea, Indonesia, India, Singapore, Taiwan and Thailand.

8: This refers to India, Indonesia, Burma, Bangladesh, Malaysia, Thailand and Singapore.

9: This includes Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Iceland, Ireland, Italy, Japan, Luxembourg,

Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.

10: This includes Argentina, Chile, Colombia, Ghana, India, Indonesia, Kenya, Malaysia, Mexico, Nigeria, Pakistan, Peru, Philippines,

Singapore, Sri Lanka, Thailand, Turkey and Venezuela.

11: This includes Iran, Kuwait, Saudi Arabia, United Arab Emirates, Bahrain, Oman Algeria, Nigeria, Mexico, Venezuela and Ecuador.

12: Low income group means Congo rep., Nepal, Nigeria, Togo, Zambia, Ghana, Kenya, Bangladesh, Benin, Zimbabwe, India,

Pakistan, Senegal, Haiti, Congo rep., Cameroon, Indonesia, Cote d'Ivoire and Nicaragua.

13: Lower middle income group means China, Sri Lanka, Honduras, Syria, Bolivia, Philippines, Morocco, Ecuador, Egypt, Arab rep.,

Paraguay, Algeria, Guatemala, Thailand, El Salvador, Colombia, Peru, Tunisia, Dominican rep., Jamaica, Turkey, South Africa and

Gabon.

14: Upper middle income group means Malaysia, Brazil, Costa Rica, Panama, Venezuela, Hungary, Chile, Mexico, Trinidad and Tobago, Uruguay, Oman, Argentina, Saudi Arabia, Malta and Korea rep.

15: High income group means Portugal, Greece, New Zealand, Spain, Israel, Australia, Italy, Canada, Singapore, Ireland, France,

Belgium, Finland, Germany, Netherlands, UK, Austria, HK, China and Sweden.

16: This includes Iran, Israel, Kuwait, Oman, Saudi Arabia and Syria.

17: This includes Brazil, China, India, Malaysia, Mexico, Philippines, South Africa, Thailand, and Turkey

18: This includes Bangladesh, India, Nepal, Pakistan and Sri-Lanka.

The existing literature reveals that due to the application of different econometric methodologies and different sample sizes the empirical results are very mixed and even vary for the same country and same panel and are not conclusive to present policy formulation that can be applied over the countries. Thus this study tries to overcome the shortcoming literature related with the linkage between electricity consumption and economic growth for the panel of SAARC countries. Also this empirical study will be important to formulate policy recommendation from the point of view of electricity consumption and economic growth, export values and remittance for the panel of SAARC countries.

2. Data sources and descriptive statistics

Annual data for per capita real GDP (PGDP) (constant 2000 USD), per capita electricity consumption (EC) (kWh), export values of goods and services (EX) (constant 2000 USD) and workers' remittance receipt (RE) (in USD) are downloaded from the World Bank's Development Indicators. The data is for the period from 1976 to 2009. Due to the data problem only three SAARC countries namely Bangladesh, India and Pakistan are considered for the panel analysis. Some descriptive statistics of all variables for individuals and also for panel are given below in Table (2)

Table 2: Descriptive statistics for individuals and also for panel

	Descriptive Statistics	PGDP	EC	EX	RE
Bangladesh	Min	216.6887	15.5288	768645026.3	18761275.1
	Max	482.6105	214.4	15649927542.0	10510108316.0
	Mean	296.8801	71.3234	4793708947.2	1987328497.8
	Std. Dev.	76.6714	53.5847	4520743859.7	2493240816.4
	CV.	25.8257%	75.1292%	94.3058%	125.4569%

India	Min	218.8990	126.0977	9044664320	641780814.4
	Max	766.3755	778.7100	302812652359	49179627878.0
	Mean	384.1765	320.9439	55594385824	10541613422.7
	Std. Dev.	154.2683	153.0350	71798335694	12981427922.8
	CV.	40.1556%	47.6828%	129.1467%	123.1446%
Pakistan	Min	290.1789	101.3298	1920244102.0	411736924.6
	Max	656.8739	479.6571	19099569944.0	9960000000.0
	Mean	473.5847	293.7112	8800785985.5	2842223483.69
	Std. Dev.	107.4918	119.4579	5316245965.9	2202974790.20
	CV.	22.6975%	40.6719	60.4065	77.5089%
Panel	Min	216.6887	15.5288	768645026	18761275.1
	Max	766.3755	778.7100	302812652359	49179627878.0
	Mean	384.8804	228.6595	23062960252	5123721801.4
	Std. Dev.	136.8488	160.8644	47300185190	8580325420.9
	CV.	35.5562%	70.3511%	205.0916%	167.4627%

Min: indicates minimum value, Max: indicates maximum value, Std. Dev.: indicates standard deviation, CV: indicates coefficient of variation

The reported mean per capita GDP in Table (2) is highest for Pakistan followed by India and Bangladesh and the mean per capita GDP for the panel is greater than Bangladesh and India but less than Pakistan. In respect of economic growth it is found that the volatility is highest for India followed by Bangladesh and Pakistan indicates that Indian economy among SAARC countries is growing at a faster rate. The coefficient of variation for the panel variable economic growth is 35.5562% which indicates the existence of huge differential among the SAARC countries. The range of per capita GDP for panel is 549.6868 USD which indicates the significant differential among SAARC countries. The per capita mean electricity consumption recorded is highest for India and followed by Pakistan and Bangladesh. In respect of electricity consumption the low income countries are more volatile than high income countries indicates that high income countries are consuming more electricity consumption. The mean electricity consumption for this panel is 228.6595 kwh, which is lower than India and Pakistan but higher than Bangladesh. The volatility for this panel in respect of electricity consumption is 70.3511% which indicates the existence of huge differences in respect of per capita electricity consumption among SAARC countries. It is found that the export values of goods and services and workers' remittance are higher for high income and lower for low income SAARC countries. The volatility of export values of goods and services is highest for India followed by Pakistan and Bangladesh and also the volatility of remittance is highest for Bangladesh followed by India and Bangladesh which indicate that the export values of high income countries higher than low income countries.

The volatility of export values and remittance for the panel indicate that the existence of huge differential among high income and low income SAARC countries.Since the average electricity consumption, export values and workers' remittance of high income countries are relatively higher among SAARC countries thus a general question arises in our mind whether these variables cause economic growth for the panel of SAARC countries. Thus to give the answer of the question, the principal purpose of this study is made to investigate empirically the dynamic causality relationship between economic growth, electricity consumption, export values of goods and services and workers' remittance for the panel of three SAARC countries based on the modern econometric techniques.

3. Empirical model

In order to find the relationship between economic growth, electricity consumption, export values and remittance for the panel of three SAARC countries the following model is proposed;

$$PGDP_{it} = A_0 EC_{it}^{\alpha_{1i}} EX_{it}^{\alpha_{2i}} RE_{it}^{\alpha_{3i}} e^{\varepsilon_{it}}$$

(1)

The logarithmic transformation of equation (1) is given by;

$$\ln(PGDP_{it}) = \alpha_0 + \alpha_{1i}\ln(EC_{it}) + \alpha_{2i}\ln(EX_{it}) + \alpha_{3i}\ln(RE_{it}) + \varepsilon_{it}$$

(2)

where, $\alpha_0 = \ln(A_0)$,the subscript i represents ith country and t represents time period for each country.

PGDP indicates per capital real GDP, EC indicates per capita electricity consumption, EX indicates total export values of goods and services and RE indicates workers' remittance. Here α_1, α_2, and α_3 represents the long-run elasticities of economic growth with respect to EC, EX, and RE respectively.

4. Econometric methodology

The empirical investigation of the dynamic causal relationship between economic growth, electricity consumption, export values, and remittance using modern econometrics techniques involves the following three steps. At the first step whether each panel variable contains a unit root is examined. If the variables contain a unit root, the second step is to test whether there is a long run-cointegration relationship between the panel variables. If a long-run relationship between the variables is found, the final step is to estimate panel vector error correction model in order to infer the Granger causal relationship between the variables. Finally using the GMM technique the long-run and short-run elasticities of economic growth with respect to electricity consumption, export values and remittance are estimated for the panel. In this paper the software RATS, EViews and STATA are used for empirical analyses.

4.1 Panel unit root tests

Since none of the panel unit root test is free from some statistical shortcomings in terms of size and power properties, so it is better for us to perform several unit root tests to infer an overwhelming evidence to determine the order of integration of the panel variables. In this paper four panel unit root tests: Levin, Lin and Chu (LLC, 2002) , Im, Peasaran and Shin (IPS, 2003), Maddala and Wu (MW, 1999), and Choi (2006) tests are applied.

The LLC test is based on the assumption that the persistence parameters ρ_i are common across cross-sections so that $\rho_i=\rho$ for all i, but this assumption is not true for several variables. The second and third tests assume cross-sectional independence. This assumption is likely to be violated for the income variable. It has been found by Banerjee, Cockerill and Russell (2001) that these tests have poor size properties and have a tendency to over-reject the null hypothesis of unit root if the assumption of cross-section independence is not satisfied. Peasaran (2003) and Choi (2006) are derived other tests statistics to solve this problem.

Levin, Lin and Chu (LLC, 2002) considered the following regression equation

$$\Delta y_{it} = \alpha y_{it-1}+\sum_{j=1}^{p_i}\gamma_{ij}\Delta y_{it-j}+X_{it}'\delta+\varepsilon_{it}$$

(3)

where, $\Delta y_{it}=y_{it}-y_{i,t-1}$, here the assumption is $\alpha=\rho-1$ i.e. $\rho_i=\rho$ for all i, but allow the lag order for the difference terms p_i, to vary across cross-sections. Here the null hypothesis to be tested is $H_0 : \alpha = 0$; against the alternative hypothesis is that $H_1 : \alpha < 0$. The null hypothesis indicates that there is a unit root while the alternative hypothesis indicates that there is no unit root. To perform the test statistic at first they regress Δy_{it} and y_{it-1} on the lag terms Δy_{it-j} (j = 1, 2,….., p_i) and the exogenous variables X_{it} which are given by;

$$\Delta y_{it} = \sum_{j=1}^{p_i} \gamma_{ij} \Delta y_{it-j} + X'_{it}\delta + u_{it}$$

(4)

$$y_{it-1} = \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{it-j} + X'_{it}\lambda + v_{it}$$

(5)

The estimated equations are given by;

$$\Delta \hat{y}_{it} = \sum_{j=1}^{p_i} \hat{\gamma}_{ij} \Delta y_{it-j} + X'_{it}\hat{\delta}$$

(6)

$$\hat{y}_{it-1} = \sum_{j=1}^{p_i} \hat{\beta}_{ij} \Delta y_{it-j} + X'_{it}\hat{\lambda}$$

(7)

Then they define $\Delta \bar{y}_{it}$ by taking Δy_{it} and removing the autocorrelations and deterministic components using the first set of auxiliary estimates:

$$\Delta \bar{y}_{it} = \Delta y_{it} - \sum_{j=1}^{p_i} \hat{\gamma}_{ij} \Delta y_{it-j} - X'_{it}\hat{\delta}$$

(8)

Analogously they also define

$$\bar{y}_{it-1} = y_{it-1} - \sum_{j=1}^{p_i} \hat{\beta}_{ij} \Delta y_{it-j} - X'_{it}\hat{\lambda}$$

(9)

The proxies are obtained by standardizing both $\Delta \bar{y}_{it}$ and $\bar{y}_{it-1}$ dividing by the regression standard error i.e. $\Delta \tilde{y}_{it} = \frac{\Delta \bar{y}_{it}}{s_i}$; and $\tilde{y}_{it-1} = \frac{\bar{y}_{it-1}}{s_i}$; where s_i are estimated the standard errors from estimating each ADF in equation (3) . Finally an estimate of the coefficient α may be obtained from the pooled proxy equation

$$\Delta\tilde{y}_{it} = \alpha\tilde{y}_{it-1} + \eta_{it}$$

(10)

LLC show that under the null hypothesis, a modified *t*-statistic for the resulting $\hat{\alpha}$ is asymptotically normally distributed which is given by;

$$t_{\alpha}^{*} = \frac{t_{\alpha} - (n\tilde{T})S_n\hat{\sigma}^{-2}se(\hat{\alpha})\mu_{m\tilde{T}}^{*}}{\sigma_{m\tilde{T}}^{*}} \sim N(0, 1)$$

(11)

where t_{α} is the standard t-statistic for H_0: $\alpha = 0$, $\hat{\sigma}^2$ is the estimate variance of the error term η, $se(\hat{\alpha})$ is the standard error of $\hat{\alpha}$, S_n is the mean of the ratios of the long-run standard deviation to the innovation standard deviation for each individual. Its estimate is derived using kernel-based techniques

$$\tilde{T} = T - \frac{\sum_{i=1} p_i}{n} - 1$$

(12)

$\mu_{m\tilde{T}}^{*}$ and $\sigma_{m\tilde{T}}^{*}$ are the two adjusted factors for the mean and standard deviation.

Im, Pesaran and Shin (IPS, 2003) proposed the test statistic using the following model;

$$\Delta y_{it} = \alpha_i y_{it-1} + \sum_{j=1}^{p_i} \gamma_{ij}\Delta y_{it-j} + X'_{it}\delta + \varepsilon_{it}$$

(13)

where, $\Delta y_{it} = y_{it} - y_{i,t-1}$, y_{it} (i = 1, 2,………..,n; t = 1, 2,……….,T) is the series under investigation for country i over period t, p_i is the number of lags in the ADF regression and the ε_{it} errors are assumed to be independently and normally distributed random variables for all i's and t's with zero mean and finite heterogeneous variance σ_i^2 . Both α_i and p_i in equation (13) are allowed to vary across countries. The null hypothesis to be tested is that each series in the panel contains a unit root, i. e. H_0: $\alpha_i = 0 \ \forall \ i$. Against the alternative hypothesis that some of the individual series to have unit root but not all

$$H_1: \begin{cases} \alpha_i = 0; \text{ for some i's} \\ \alpha_i < 0; \text{for at least one i} \end{cases}$$

There are two stages for constructing the t-bar statistic which is proposed by Im, Pesaran and Shin (2003). At the first stage the average value of the individual ADF t-statistic for each of the countries in the sample is calculated which is given by

$$\bar{t}_{nT} = \frac{1}{n}\sum_{i=1}^{n} t_{iT_i}(p_i)$$

(14)

where $t_{iT_i}(p_i)$ is the calculated ADF test statistic for country i of the panel (i = 1, 2, ……,n). The second step is to calculate the standardized t-bar statistic which is given by;

$$Z_{\bar{t}_{nT}} = \frac{\sqrt{n}\left[\bar{t}_{nT} - \frac{1}{n}\sum_{i=1}^{n} E(\bar{t}_{iT}(p_i))\right]}{\sqrt{\frac{1}{n}\sum_{i=1}^{n} \mathrm{var}(\bar{t}_{iT}(p_i))}} \sim N(0, 1)$$

(15)

where n is the size of the panel, which indicates the no. of countries, $E(\bar{t}_{iT}(p_i))$ and $\mathrm{var}(\bar{t}_{iT}(p_i))$ are provided by IPS for various values of T and p. However, Im, et al. (2003) suggested that in the presence of cross-sectional dependence, the data can be adjusted by demeaning and that the standardized demeaned t-bar statistic converges to the standard normal in the limit.

Maddala and Wu (MW, 1999) proposed a Fisher-type test which combines the p-values from unit root tests for each cross-section i. The test is non-parametric and has a chi-square distribution with 2n degrees of freedom, where n is the number of countries in the panel. The test statistic is given by;

$$\lambda = -2\sum_{i=1}^{n} \log_e(p_i) \sim \chi^2_{2n(d.f.)}$$

(16)

where p_i is the p-value from the ADF unit root tests for unit i. The Maddala and Wu (1999) test has the advantage over the IPS (2003) test that it does not depend on different lag lengths in the individual ADF regressions.

In addition Choi (2006) derived another test statistic which is given by;

$$Z = \frac{1}{\sqrt{n}}\sum_{i=1}^{n} \Phi^{-1}(p_i) \sim N(0, 1)$$

(17)

where, Φ^{-1} is the inverse of the standard normal cumulative distribution function.

We know macroeconomic variables tend to exhibit a trend over time, thus it is more appropriate to consider the regression equation with constant and trend terms at level form. Thus for panel unit root tests, in the paper two cases are considered in level form. In case one both constant and trend terms are included in the equation and in case two only constant term is included in the equation. Since first differencing is likely to remove any deterministic trends in the variable, regression should include only constant term. The ADF test results for individuals and also the tests results for panel are given below in Table (3) and (4) respectively.

Table 3: ADF unit root test results for the individuals

	lnPGDP	lnEC	lnEX	lnRE
	Case 1: Model with constant and trend terms [Level form]			
Bangladesh	1.18047	-3.16457	-1.81564	-2.11814
India	-0.83406	-1.23936	0.27128	-1.33020
Pakistan	-2.09580	-0.75828	-2.09923	-2.53095
	Case 2: Model with only constant term [Level form]			
Bangladesh	3.51189	0.72764	1.42222	-0.59181
India	3.24760	0.77323	3.81261	0.14687
Pakistan	-2.33388	-2.93351	-1.94144	-1.93318
	Model with only constant term [First differenced]			
	Δ lnPGDP	Δ lnEC	Δ lnEX	Δ lnRE
Bangladesh	-2.95197*	-5.65153**	-3.34448*	-3.51876*
India	-2.95804*	-2.97630*	-4.66677**	-3.57036*
Pakistan	-2.59738	-0.73597	-3.75593**	-6.69558**

*: indicates significant at 5% level, **: indicates significant at 1% level

Table 4: LLC, IPS, MW and Choi panel unit root tests results

	Case 1: Model with constant and trend terms [Level form]							
	LLC Test	Prob.	IPS Test	Prob.	MW Test	Prob.	Choi Test	Prob.
lnPGDP	0.98638	0.8380	3.0526	0.9989	1.3755	0.9673	2.9836	0.9986
lnEC	0.82305	0.7948	0.5693	0.7154	6.8588	0.3341	0.6749	0.7501

lnEX	-0.0325	0.4870	1.1669	0.8784	2.1850	0.9019	1.2234	0.8894
lnRE	3.1616	0.9992	0.3565	0.6393	3.9803	0.6793	0.3573	0.6396
	Case 2: Model with only Constant Term [Level form]							
lnPGDP	3.8851	0.9999	6.1057	1.0000	3.5669	0.735	5.0312	1.000
lnEC	-1.0822	0.1396	1.5095	0.944	7.9128	0.2446	1.3924	0.9181
lnEX	1.8347	0.9667	3.7070	0.9999	2.3457	0.8853	3.3710	0.9996
lnRE	0.9750	0.8352	1.3850	0.9170	2.6959	0.8459	1.3825	0.9166
	Model with only constant term [First differenced form]							
Δ lnPGDP	-0.2487	0.4018	-1.6466*	0.0498	12.0049**	0.0619	-1.7150*	0.0432
Δ lnEC	-0.8648	0.1926	-2.8384*	0.0023	24.7577*	0.0004	-2.4572*	0.0070
Δ lnEX	-2.9907*	0.0014	-4.5740*	0.0000	31.7422*	0.0000	-4.3945*	0.0000
Δ lnRE	-2.0168*	0.0219	-5.9574*	0.0000	43.1814*	0.0000	-5.2413*	0.0000

*: indicates significant at 1% level, **: indicates significant at 5% level., ***:indicates significant at 10% level

The ADF test results for individuals support that all the variables are integrated of order 1 for Bangladesh and India but for Pakistan the variables economic growth and electricity consumption are integrated of order two and the variables export values and remittance are integrated of order 1. The panel unit root tests results support that all the panel variables are integrated of order 1.

4.2 Panel cointegration

From the panel unit root tests results it is found that all the panel variables are integrated of order (1). Therefore the cointegration analysis is conducted to examine whether there is a long-run relationship among the variables using the Kao (1999) ADF type test and Johansen Fisher panel cointegration test proposed by Maddala and Wu (1999).

The Kao (1999) ADF type test can be computed from the following regression equation

$$e_{it} = \rho e_{it-1} + \sum_{j=1}^{p} \gamma_{ij} \Delta e_{it-j} + v_{it}$$

(18)

where e_{it} 's are the estimated residuals from the panel static regression equation;

$y_{it} = \mu_i + x'_{it}\beta + u_{it}$; i = 1, 2,........,n; t = 1, 2,....,T;

(19)

where β: (m, 1) vector of the slope parameters μ_i: intercepts, u_{it}: stationary disturbance terms. Here x_{it} is a (m, 1) integrated process of order 1 for all i, i.e. $x_{it} \sim I(1)\ \forall\, i,\ \Rightarrow\ x_{it} = x_{it-1} + \varepsilon_{it}$, $\{y_{it}, x_{it}\}$ are independent across cross-sectional units and $\omega_{it} = \left(u_{it}, \varepsilon'_{it}\right)'$ is a linear process. Then, the long-run covariance matrix of $\{\omega_{it}\}$ is denoted by Ω and is given by; $\Omega = \sum_{j=-\infty}^{\infty} E(\omega_{ij}, \omega'_{i0}) = \begin{pmatrix} \Omega_u & \Omega_{u\varepsilon} \\ \Omega_{\varepsilon u} & \Omega_\varepsilon \end{pmatrix}$ and $\Sigma = E(\omega_{i0}\omega'_{i0}) = \begin{pmatrix} \Sigma_u & \Sigma_{u\varepsilon} \\ \Sigma_{\varepsilon u} & \Sigma_\varepsilon \end{pmatrix}$

The null hypothesis of no cointegrationcan be written as

$H_0: \rho = 1$

Against the alternative hypothesis is

$H_1: \rho < 1$

With the null hypothesis of no cointegration, the Kao (1999) ADF test statistics can be constructed as follows;

$$\text{ADF} = \frac{t_{\hat{\rho}} + \sqrt{6n}\hat{\sigma}_v / 2\hat{\sigma}_{0v}}{\dfrac{2\hat{\sigma}_{0v}}{\sqrt{\hat{\sigma}^2_{0v} / 2\hat{\sigma}^2_v + \left(3\hat{\sigma}^2_v / 10\hat{\sigma}^2_{0v}\right)}}} \sim N(0,1)$$

(20)

where, $\hat{\sigma}^2_v = \hat{\Sigma}_u - \hat{\Sigma}_{u\varepsilon}\hat{\Sigma}^{-1}_\varepsilon$ and $\hat{\sigma}^2_{0v} = \hat{\Omega}_u - \hat{\Omega}_{u\varepsilon}\hat{\Omega}^{-1}_\varepsilon$

The Johansen Fisher panel cointegration test is based on the aggregates of the p-values of the individual Johansen maximum eigenvalues and trace statistic. If p_i is the p-value from an individual cointegration test for cross-section i, under the null hypothesis the test statistic for the panel is given by;

$$-2\sum_{i=1}^{n} \log(p_i) \sim \chi^2_{2n}$$

(21)

In the Johansen type panel cointegration tests results heavily depends on the number of lags of the VAR system. The results are obtained here use one lag and are given below in Table (4) for individuals and in Table (5) for panel.

Table 4: Results of the individuals cointegration tests

Hypothesis: No cointegration	Model 1				Model 2			
Country	Trace Test	Prob.	Max-Eigen Test	Prob.	Trace Test	Prob.	Max-Eigen Test	Prob.
Bangladesh	76.3021*	0.0000	31.7416*	0.0039	88.0784*	0.0000	34.4052*	0.0080
India	53.5980*	0.0013	24.7300*	0.0418	75.6313*	0.0002	35.7767*	0.0051
Pakistan	55.8481*	0.0007	29.5387*	0.0085	65.4300*	0.0035	29.5627*	0.0374
Hypothesis: At most one cointegration equation					Hypothesis: At most one cointegration equation			
Bangladesh	44.5605*	0.0000	24.9843*	0.0035	53.6732*	0.0002	27.1754*	0.00096
India	28.8688*	0.0123	18.4258*	0.0402	39.8545*	0.0146	18.4446	0.1586
Pakistan	26.3094	0.0273	20.0422*	0.0226	35.8673*	0.0422	23.1833*	0.0376
Hypothesis: At most two cointegration equation					Hypothesis: At most two cointegration equation			
Bangladesh	19.5762*	0.0026	19.4758*	0.0015	26.4978*	0.0060	20.2721*	0.0096
India	10.4422	0.1012	9.3859	0.1035	21.4100*	0.0346	14.8768**	0.0716
Pakistan	6.2671	0.4042	4.550	0.5429	12.6839	0.3896	10.5882	0.2838
Hypothesis: At most three cointegration equation					Hypothesis: At most three cointegration equation			

Bangladesh	0.1004	0.7944	0.1004	0.7944	6.2257	0.1740	6.2257	0.1740
India	1.0552	0.3534	1.0562	0.3534	6.5332	0.1534	6.5332	0.1534
Pakistan	1.7171	0.2234	1.7171	0.2234	2.0957	0.7586	2.0957	0.7586

Model 1: No intercept or trend in cointegration equation and VAR, Model 2: Intercept (no trend) incointegration equation no intercept in VAR

Table 5: Results of the Johansen based panel conintegration test

	Model 1				Model 2			
Number of Coint. Eqn.	Trace Test	Prob.	Max-Eigen Value Test	Prob.	Trace Test	Prob.	Max-Eigen Value Test	Prob.
None	55.22*	0.0000	26.99*	0.0001	53.17*	0.0000	26.80*	0.0002
At Most 1	35.93*	0.0000	25.31*	0.0003	31.79*	0.0000	19.53*	0.0034
At Most 2	18.31*	0.0055	18.81*	0.0045	18.33*	0.0045	17.09*	0.0090
At Most 3	5.539	0.4768	5.539	0.4768	7.800	0.2531	7.800	0.2531
	Kao cointegration Test Statistic				Probability			
	-2.9985*				0.0014			

Model 1: No intercept or trend in cointegration equation and VAR, Model 2: Intercept (no trend) incointegration equation no intercept in VAR

The results of the individual cointegration tests in Table (5) indicate that all the variables are cointegrated for Bangladesh, India and Pakistan. The Kao and Johansen Fisher panel cointegration tests results confirmed that there is a long-run cointegration relationship among the panel variables.

4.3 Granger causality

The cointegration relationship indicates the existence of causal relationship but it does not indicate the direction of causal relationship between variables. Therefore it is common to test for detecting the causal relationship between variables using the Engle and Granger test procedure. In the presence of cointegration relationship the application of Engle and Granger (1987) causality test in the first differenced variables by means of a VAR will misleading the results, therefore an inclusion of an additional variable to the VAR system such as the error correction term (ECM) would help us to capture the long-run relationship. The augmented form of the Granger causality test involving the ECM is formulated in a multivariate pth order vector error correction (VEC) model given below;

$$\begin{bmatrix} \Delta \ln PGDP_{it} \\ \Delta \ln EC_{it} \\ \Delta \ln EX_{it} \\ \Delta \ln RE_{it} \end{bmatrix} = \begin{bmatrix} C_1 \\ C_2 \\ C_3 \\ C_4 \end{bmatrix} + \sum_{k=1}^{p} \begin{bmatrix} \beta_{11k} & \beta_{12k} & \beta_{13k} & \beta_{14k} \\ \beta_{21k} & \beta_{22k} & \beta_{23k} & \beta_{24k} \\ \beta_{31k} & \beta_{32k} & \beta_{33k} & \beta_{34k} \\ \beta_{41k} & \beta_{42k} & \beta_{43k} & \beta_{44k} \end{bmatrix} \begin{bmatrix} \Delta \ln PGDP_{it-k} \\ \Delta \ln EC_{it-k} \\ \Delta \ln EX_{it-k} \\ \Delta \ln RE_{it-k} \end{bmatrix} + \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \end{bmatrix} ECM_{it-1} + \begin{bmatrix} \varepsilon_{1it} \\ \varepsilon_{2it} \\ \varepsilon_{3it} \\ \varepsilon_{4it} \end{bmatrix}$$

(22)

where i = 1, 2,……..,n; t = p+1, p+2, p+3,……….,T; .The C's, β's and λ's are the parameters to be estimated. Δ stands for first difference, ECM_{it-1} represents the one period lagged error-term derived from the cointegration vector and the ε's are serially independent with mean zero and finite covariance matrix. From the equation (22) given the use of a VEC structure, all variables are treated as endogenous variables.

The F test is applied here to examine the direction of any causal relationship between the variables. The electricity consumption does not Granger cause economic growth in the short run, if and only if all the coefficients β_{12k}'s $\forall$ k are not significantly different from zero in equation (22). Similarly the economic growth does not Granger cause electricity consumption in the short run if and only if all the coefficients β_{21k}'s $\forall$ k are not significantly different from zero in the equation (22). They are referred to as the short-run Granger causality test. The coefficients on the ECM represent how fast deviations from the long-run equilibrium are eliminated. Another channel of causality can be studied by testing the significance of ECM's. This test is referred to as the long run causality test. The short-run and long-run Granger causality tests results are reported below in Table (6) for individuals and in Table (7) for panel

Table 6 Granger F-test results for individuals

	Bangladesh				
	ΔlnPGDP	ΔlnEC	ΔlnEX	ΔlnRE	ECM
ΔlnPGDP		2.1162 (0.1454)	2.9579** (0.0738)	2.6579** (0.09867)	-0.14769 (0.8839)
ΔlnEC	0.3150 (0.7332)		0.8602 (0.4374)	0.7068 (0.5045)	0.55035 (0.5878)
ΔlnEX	0.0101 (0.990)	1.2326 (0.3117)		0.0567 (0.9451)	0.45856 (0.65126)
ΔlnRE	1.6185 (0.2219)	0.2219 (0.9953)	0.6300 (0.5423)		0.62609 (0.5380)
	India				
ΔlnPGDP		0.3221 (0.5752)	0.9240 (0.3452)	0.1371 (0.7142)	-0.47816 (0.6365)
ΔlnEC	0.0327 (0.8578)		0.6514 (0.4269)	0.8444 (0.3665)	-0.52912 (0.6012)
ΔlnEX	0.0230 (0.8805)	0.0560 (0.8148)		1.2844 (0.2674)	3.2366* (0.0032)
ΔlnRE	1.7754 (0.1942)	2.3844 (0.1346)	2.3108 (0.1523)	2.5325 (0.1236)	0.83988 (0.4086)
	Pakistan				
ΔlnPGDP		0.7770 (0.3864)	0.6094 (0.4423)	0.0347 (0.8536)	-3.0826* (0.0049)
ΔlnEC	3.3572** (0.0788)	0.6506 (0.4275)		2.1974 (0.1507)	1.5330 (0.13783)
ΔlnEX	1.3419 (0.2576)	0.0932 (0.7627)	0.0044 (0.9474)		-0.08391 (0.9337)
ΔlnRE	0.0021 (0.9634)	2.2391 (0.1471)	0.0224 (0.8821)		0.16906 (0.8671)

*: indicates significant at 5% level and **: indicates significant at 10% level.

Table 7 Panel Granger F-test results

	ΔlnPGDP	ΔlnEC	ΔlnEX	ΔlnRE	ECM
ΔlnPGDP		0.0189	3.2289**	2.1737	-0.72673

		(0.8910)	(0.0757)	(0.1438)	(0.4692)
ΔlnEC	0.0179 (0.8937)		0.89377 (0.1835)	1.4314 (0.2346)	-0.06127 (0.95127)
ΔlnEX	8.2109* (0.0051)	0.0671 (0.7961)		0.8640 (0.3551)	-0.21695 0.82873
ΔlnEX	1.2043 (1.2043)	1.4655 (0.2292)	0.2701 (0.6045)		1.2183 (0.2262)

The reported values in parentheses are the p-values of the test. * : indicates significant at 5% level, ** : indicates significant at 10% level

The findings in Table (6) indicate that there is only short-run causality running from export values and remittance to economic growth in Bangladesh, only long-run causality from economic growth to export values in India, only unidirectional short-run causality from economic growth to electricity consumption in Pakistan. The findings in Table (7) indicate that there is panel short-run bidirectional causality between economic growth and export values but there is no evidence of long-run causal relationship.

4.4 Short-run and long-run elasticity

The short run elasticity can be obtained by estimating the following error correction model

$$\Delta \ln PGDP_{it} = \alpha_1 \Delta \ln EC_{it} + \alpha_2 \Delta \ln EX_{it} + \alpha_3 \Delta \ln RE_{it} + \lambda ECM_{it-1} + \varepsilon_{it}$$

(23)

where ε_{it} is the random error terms, α_1, α_2, α_3, and λ are the parameters to be estimated. The parameter λ represents speed of adjustment for short-run to reach in the long-run equilibrium.

The long-run elasticity can be obtained by estimating the following regression equation

$$\ln PGDP_{it} = \mu_i + \beta_1 \ln EC_{it} + \beta_2 \ln EX_{it} + \beta_3 \ln RE_{it} + \sum_{j=-k_i}^{k_i} \gamma_{ij} \Delta \ln EC_{it-j} + \sum_{j=-p_i}^{p_i} \lambda_{ij} \Delta \ln EX_{it-j} + \sum_{j=-p_i}^{p_i} \delta_{ij} \Delta \ln RE_{it-j} + u_{it}$$

(24)

The GMM is applied to estimate both equation which control the problem of endogeneity and serial correlation of regressors. The estimated results are given below in Table (8)

Table 8 Individuals and panel short-run and long-run elasticities

	Short-run elasticity [ΔlnPGDP is the dependent variable]			
	ΔlnEC	ΔlnEX	ΔlnRE	ECM

	Coeff.	t-Test	Coeff.	t-Test	Coeff.	t-Test	Coeff.	t-Test
Bangladesh	0.0878	2.8575*	0.11647	3.3922*	0.0027	0.1947	-0.2641	-3.1941*
India	0.3032	4.5646*	0.14254	4.0873*	0.0257	1.0300	-0.2243	-1.2019
Pakistan	0.4263	7.1861*	0.00824	0.29404	0.0028	0.00284	-0.3169	-1.7204
Panel	0.1845	4.9564*	0.1049	5.7950*	0.01033	2.3843*	-0.0551	-4.0048*
	Long-run elasticity [lnPGDP is the dependent variable]							
	lnEC		lnEX		lnRE			
	Coeff.	t-Test	Coeff.	t-Test	Coeff.	t-Test		
Bangladesh	0.0493	1.3507	0.08677	2.5018*	0.16564	15.693*		
India	0.00224	0.0304	0.07246	1.3473	0.00919	0.4362		
Pakistan	0.09205	1.655**	0.01348	0.5361	0.01296	3.4739*		
Panel	0.30020	6.4132*	0.09350	1.59817	0.09852	1.78017**		

*: indicates significant at 5% level, **: indicates significant at 10% level.

From the estimated results in Table (8) it is found that the variable electricity consumption has short-run positive significant impact on economic growth for Bangladesh, India and Pakistan. The range of short-run elasticity is 0.4263 for India to 0.0878 for Bangladesh. The variable export values have short-run significant positive impact on economic growth for Bangladesh and India. The impacts of the variable remittance are not statistically significant for Bangladesh, India and Pakistan. It is found that it takes about 3.79 years for Bangladesh, 4.46 years for India and 3.16 years for Pakistan to reach in the long-run equilibrium and statistically significant only for Bangladesh.

For panel analysis, it is found that the short-run elasticities of economic growth with respect to electricity consumption, export values and remittance are positively significant also for panel estimation the ECM is statistically significant.

For long-run, it is found that the variables export values and remittance have significant positive impacts on economic growth in Bangladesh, none of the variable has significant impact one economic growth in the long-run for India, the variables electricity consumption and remittance have significant positive impacts on economic growth for Pakistan.

For panel estimation the variables electricity consumption and remittance have significant positive impact on economic growth and the export values have positive impact in the long-run but not significant. It is found that the long-run elasticity of economic growth with respect electricity consumption and remittance are higher than short run elasticity. This means that over time higher electricity consumption and remittance from manpower supply in the panel of SAARC countries give rise to more economic growth.

5.Conclusions and policy implications

This paper attempts to empirically examine the short-run and long-run causal relationship between economic growth, energy consumption, export values and workers' remittance receipt for the panel of three SAARC countries using the time series data for the period 1971- 2009 on the basis of modern econometric techniques. Also this study attempts to examine the new approach which is proposed by Narayan and Narayan (2010). Before testing for any causal relationship among the variables within a VAR model structure at the first stage panel unit root tests and at the second stage panel cointegration analysis are done. Four different panel unit root tests, Levin, Lin and Chu (LLC, 2002), Im, Peasaran and Shin (IPS, 2003), Maddala and Wu (1999), and Choi (2006) tests are applied. The tests results support that all the panel variables are integrated of order one. The ADF test results support that all the variables are integrated of order 1 for Bangladesh and India but the variable economic growth and electricity consumption are integrated of order 2 for Pakistan.

The Kao and the Johansen Fisher panel cointegration tests results support that all the panel variables are cointegrated. Also the individual cointegration tests results support that all the variables are cointegrated for Bangladesh, India and Pakisatn.

From the individual Granger F-test results, only short-run causality running from export values and remittance to economic growth at 10% level in Bangladesh, long-run causality from economic growth to export values in India, and unidirectional short-run causality from economic growth to electricity consumption in Pakistan. The panel Granger F-test results support the bidirectional short-run causal relationship between economic growth and export values but there is no evidence of long-run panel causal relationship among the variables. This evidence indicates that there are inter-dependencies between exports and economic growth in the panel of SAARC countries. The main reason for this, economic growth causes expansion in the commercial and industrial sectors and vice versa.

It is found that the long-run elasticity of economic growth with respect to electricity consumption (0.30020) and remittance (0.09852) are higher than short run elasticity of

(0.1845) and (0.01033). This means that over time higher electricity consumption and higher remittance from man power supply in the panel of SAARC countries gives rise to more economic growth. It is found that it takes about 3.79 years for Bangladesh, 4.46 years for India and 3.16 years for Pakistan to reach in the long-run equilibrium position and statistically significant only for Bangladesh. Thus it can be said that a policy to increase investment in the electricity supply is likely to stimulate economic growth for SAARC countries.

From the analytical results it can be concluded that due to any restriction on energy use, the economic growth of SAARC countries will not be affected directly but due to restriction on energy use, if the export values declined both the variables will be affected simultaneously. From the analytical results it can be concluded that policies to increase investment in commercial and industrial sectors to construct large, medium and small scale factories to accelerate output should be implemented to keep pace with economic expansion in SAARC countries.

References:

Al-Iriani, M. A., 2006. Energy–GDP relationship revisited: an example from GCC countries using panel causality. Energy Policy34, 3342–3350.

Altinay , G., Karagol, E., 2005. Electricity consumption and economic growth: evidence from Turkey. Energy Economics 27, 849-856.

Aqueel, A., Butt, M. S., 2001. The relationship between energy consumption and economic growth in Pakistan.Asia-Pacific Development Journal8, 101-109.

Asafu-Adjaye, J. , 2000. The relationship between energy consumption, energy prices and economic growth: Time series evidence from Asian developing countries. Energy Economics22, 615-625.

Banerjee, A., Cockerill, L., Russell, B., 2001. An I(2) analysis of inflation and the markup. Journal of Applied Econometrics 16, 221–240.

Chen, S.-T., Kuo, H.-I., Chen, C.-C., 2007.The relationship between GDP and electricity consumption in 10 Asian countries.Energy Policy 35, 2611–2621.

Chontanawat, Hunt, L.C., Pierse, R.G. (2006). “Causality between Energy Consumption and Economic Growth: Evidence from 30 OECD and 78 non- OECD Countries.” Discussion paper 113, Surrey Energy Economic Centre (SEEC), Department of Economics, University of Surrey, UK.

Chontanawat, J., Hunt, L.C., Pierse, R.G., 2007a. Causality between energy consumption and economic growth in OECD and non-OECD countries: a panel cointegration approach. Proceeding paper at the 27th USAEE/IAEE North American Conference on 'Developing & Delivering Affordable Energy in the 21st Century', Houston, Texas, USA, 16-19 September.

Chontanawat, J., Hunt, L.C., Pierse, R.G., 2007b. Exploring the relationship between energy second International Association for Energy Economics (IAEE) Asian Conference: Energy Security and Economic Development under Environmental Constraints in the Asia-Pacific Region

Chontanawat, J., Hunt, L. C., Pierse, R. G., 2008. Does energy consumption cause economic growth? : evidence from a systematic study of over 100 countries." Journal of Policy Modeling 30(2), 209-220.

Engel, R.F., Granger, C.W.J., 1987. Cointegration and error correction: representation, estimation and testing. Econometrica 55, 251–276.

Ghosh, S., 2002.Electricity consumption and economic growth in India.Energy Policy 30, 125-129.

Halicioglu, F., 2007. Residential electricity demand dynamics in Turkey. Energy Economics 29, 199-210.

Huang, B-N., Hwang, M. J.,Yang, C.W., 2008. Causal relationship between energy consumption and GDP growth revisited: a dynamic panel data approach. Ecological Economics 67, 41-54.

Hossain, Md. S., 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.

Hossain, Md., S., 2011.Panel estimation for CO_2 emissions, energy consumption, economic growth, trade openness and urbanization of newly industrialized countries. Energy Policy 39 (11), 6991-6999.

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

Joyeux,R., Ripple,R.D., 2007. Household energy consumption versus income and relative standard of living: a panel approach. Energy Policy 35, 50–60.

Jumbe, C.B.L., 2004. Cointegration and causality between electricity consumption and GDP: empirical evidence from Malawi. Energy Economics 26, 61-68.

Lee, C. C., 2005. Energy consumption and GDP in developing countries: a cointegrated panel analysis. Energy Economics 27, 415-427.

Lee. C. C., Chang, C.P., 2007. Energy consumption and GDP revisited: a panel analysis of developed and developing countries. Energy Economics 29, 1206-1223.

Levin, A., Lin, C.F., Chu, C.S., 2002. Unit root tests in panel data: asymptotic and finite sample properties. Journal of Econometrics 108, 1–24.

Maddala, G.S., Wu, S., 1999. A Comparative study of unit root tests with panel data and a new simple test. Oxford Bulletin of Economics and Statistics 61, 631–652.

Mehrara, M., 2007. Energy consumption and economic growth: The case of oil exporting countries. Energy Policy35, 2939–2945.

Morimoto, R., Hope, C., 2004. The impact of electricity supply on economic growth in Sri Lanka. Energy Economics 26, 77–85.

Narayan, P. K., Prasad, A., 2008. Electricity consumption–real GDP causality nexus: evidence from a Bootstrapped causality test for 30 OECD countries. Energy Policy 36, 910–918.

Narayan, P. K., Smyth, R., 2005. Electricity consumption, employment and real income in Australia: evidence from multivariate Granger causality tests. Energy Policy 33, 1109–1116.

Narayan, P.K., Smyth, R., 2009. A multivariate Granger causality between electricity consumption, exports and GDP: evidence from a panel of Middle Eastern countries. Energy Policy37, 229–236

Narayan, P.K., Smyth, R., Prasad, A., 2007. Electricity consumption in the G7 countries: a panel cointegration analysis of residential demand elasticities. Energy Policy35, 4485–4494.

Narayan, P.K., Smyth, R., Prasad, A., 2008. A structural VAR analysis of electricity consumption and real GDP: evidence from the G7 countries. Energy Policy 36, 2765–2769.

Narayan, P.K., Singh, B., 2007. The electricity consumption and GDP nexus for the Fiji Islands.Energy Economics 29: 1141–1150.

Soytas, U., Sari, R. 2003. Energy consumption and GDP: causality relationship in G-7 countries and emerging markets. Energy Economics 25, 33-37.

Squalli, J., 2007. Electricity consumption and economic growth: bounds and causality analysis of OPEC countries. Energy Economics 29, 1192–1205.

Wolde-Rufael, Y., 2004.Disaggregated industrial energy consumption and GDP: The case of Shanghai, 1952-1999."Energy Economics 26, 69-75.

Wolde-Rufael, Y., 2006. Electricity consumption and economic growth: a time series experience for 17 African countries." Energy Policy 34, 1106–1114.

Yang, H.Y., 2000.A note on the causal relationship between energy and GDP in Taiwan. Energy Economics 22 (3), 309–317.

Yoo, S., 2005. Electricity consumption and economic growth: evidence from Korea. Energy Policy 33, 1627–1632.

Yoo, S., 2006.The causal relationship between electricity consumption and economic growth in ASEAN countries."Energy Policy 34, 3573–3582.