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ELECTRICITY CONSUMPTION AND ECONOMIC GROWTH, IN SOUTH ASIAN AND LATIN AMERICAN COUNTRIES, EVIDENCE FROM PANEL STUDY[*]

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Abstract

A panel causality analysis is made in this paper, among the following variables - electricity consumption (proxy to energy consumption), per capita real GDP, trade openness and urbanization The analysis comprises the subsequent stages- at the initial step, test procedure is conducted to test if the respective variable encompasses a unit root, if the variables contain unit root then test for long run cointegration relationship is examined among the variables. If a long run relationship is established then the error correction model is framed and finally the causal relationship is inferred across the variables. The procedure is based on the methodology developed by Westerlund (2007). The countries utilized in the study are a group of Latin American countries and South East Asian countries. The reason for choosing these two sets of countries, namely Latin American countries and South East Asian countries are based on their symbiotic economic relations. For the full sample the results provides support to the growth hypothesis which confirms the importance of energy for sustaining the growth process. Moreover planned urbanisation process would enable to use judiciously the electricity for future growth in these countries.

Keywords: Time Series, Panel Causality tests, Latin America, South Asia.
JEL Classification: C01, C22, N7, N75, N76.

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1. Introduction

Most newly industrializing countries are facing rising demand for energy, this raises the concern for soaring prices for oil, climate change and pollution issues. A holistic energy policy will become imperative for most of these countries in the years to come. To derive policy consensus on energy utilization the well know methodology utilized in the literature is the long-run and short- run underlying associations concerning energy expenditure and major macro-economic variables This is because by observing the path of causation the policy suggestions can be prescribed. If a unidirectional causality is evident from economic progression to energy spending or if there is no causality association in either direction then this demonstrates less energy dependent economies. However if the causation takes route from energy utilization to economic progress then this signifies energy dependent economy and thus shortage of energy would reduce economic growth- here stress on reviewing energy policies is required.

In this study a panel causality analysis is made among the following variables - electricity consumption (proxy to energy consumption), per capita real GDP, trade openness and urbanization The analysis includes the subsequent stages- at the primary stage, test procedure is conducted to test if the individual dependent and independent variables comprises of a unit root, if the variables contain unit root then test for long run cointegration relationship is examined among the dependent and the independent variables. If in the long run an association is established then the error correction model is framed and finally the causal relationship is inferred across the variables. The investigation is framed on the methodology formulated in Westerlund (2007), where a panel Error Correction - Cointegration method is utilized to assess if electricity consumption, GDP, urbanization and trade in the international level are cointegrated, i.e. if there is a stationary linear pattern of the concerned explained and explanatory variables. The countries utilized in the study are a group of Latin American countries and South East Asian countries. The choice of these two sets of countries, namely Latin American countries and South East Asian countries are based on their symbiotic economic ties. Asia needs inputs for its factories and Latin America has abundant natural resources. Latin America has fertile land to meet the food needs for growing population of Asia. Technology transfer and Foreign Direct Investment from South East Asia to Latin America can promote competitive industrialization. Trade between the two regions has more than doubled over the last decade. The trade is expected to grow to $750 billion by 2020. One of the factors driving the buoyancy of these economies is the agreement of free trade (FTAs). However cross border cooperation needs to be improved to reap the full benefits of free trade agreements. The list of countries chosen here is provided in Table 1.

Table 1. List of countries and their current GDP Growth Rate, %, (2015)

LATIN AMERCIAN COUNTIRES		SOUTH EAST ASIAN COUNTRIES	
ARGENTINA	2.5	INDONESIA	4.7
CHILE	2.3	MALAYSIA	4.7
COLOMBIA	3.10	THAILAND	2.5
CUBA	1.30	SINGAPORE	2.20
MEXICO	2.50	BRUNEI	–1.20
PERU	3.30	PHILLIPPINES	5.90
URUGUAY	1.00		
VENEZUALA	–6.2		

Source: World Development Indicators

The paper contributes in the literature in several ways. First it uses a panel study of the group of Latin American countries and ASEAN which has not been attempted earlier, second it also produces individual results of the two groups of countries and the two groups as a whole. The econometric techniques applied take into account endogeneity problems across the variables.

The paper is designed as follows: after delving on the recent literature in Section 2, the research questions, the broad objectives, data sets utilized in the study and the methodology adopted is explained in Section 3. The major results are discussed in Section 4, the paper is finally concluded in Section 5.

2. Literature Review

The literature on the studies on the causality analysis between electricity spending and economic progress is huge. However there is no consensus either on the existence or on the course of connection amongst electricity utilization and economic progression. Some studies find interconnection succeeding from economic progress to electricity utilization, others find the association moving from electricity spending to economic progression and many studies fail to establish causality association across the variables. The notable works in the recent decade include the ASEAN countries analysis by Asafu-Adjaye (2000); Wolde-Rufael (2006) investigated causality analysis among 17 African countries. The paper concludes that there was a long run association between per capita electricity spending and real Gross Domestic Product for 9 nations and Granger causation for just 12 nations. For 6 nations there exists an affirmative one way causation moving from per capita Gross Domestic Product to per capita electricity utilization. Opposite causality is also found in 3 countries and the remaining 3 countries showed bivariate causality association. Narayan and Singh (2007) developed a study for Fiji islands. The paper concludes that in the long term association moves from electricity spending and labour participation to Gross Domestic Product thus the economy is energy dependent and policies to conserve energy will have baneful effect on the economic growth of the country. Narayan and Prasad (2008) made a causality investigation for 30 OECD countries. The results of this paper are mixed, energy conservation policies will negatively affect Italy, Iceland, Australia, the Czech Republic, the Slovak Republic, the United Kingdom, Portugal and Korea. Huang, Hwang, et al. (2008) conclude that for the low income countries there is absence of association between energy expenditure and per capita real Gross Domestic Product whereas for high and middle income group there exists one way causal association from per capita real Gross Domestic Product to energy utilization. Narayan and Smyth (2009) explore the causative relation between electricity expenditure, Gross Domestic product and exports for the Middle East countries through a panel based study. The broad conclusion of the concerned study is to develop energy conservation policies to prevent the baneful effect of reduction on electricity use on economic growth. Apergis and Payne (2010) explore the relation across energy utilization and economic progress for a set of nine countries in South America in a multivariate panel framework. Lean and Smyth (2010a) examine the association across output, electricity generation and exports. The study obtains one directional Granger causality moving from economic progress to electricity utilization**.** In another paper Lean and Smyth (2010b) examined the dynamic relationship between output, electricity consumption, exports, labour and capital in a multivariate framework for Malaysia. The paper concludes the need to step up electricity conservation polices to offset the negative effect of reducing electricity consumption on output. Acaravci and Ozturk (2010) study the long term association and causation across electricity utilization and economic progress across 15 transition countries. The paper interestingly concludes that electricity consumption related policies have no effect on real output for these group of countries in the long run. Sadorsky (2011) develops a panel cointegration method to observe how trade can affect energy consumption for 8 Middle East countries. For the long run both exports and imports affect energy consumption. Kouakou (2011) obtain the causation across the electric power industry and the economic growth of Cote d'Ivoire. Hossain and Saeki (2011) study the causation relation across electricity utilization and economic progression under a panel study for six south Asian countries. Abdoli, Gudarzi Farahani, et al. (2015) examine the association across electricity utilization and economic progress in OPEC nations, the conclusion demonstrates the existence of a long run association between real gross domestic product, electricity consumption and trade. Marques, Fuinhas, et al. (2014) studied the relation between electricity use and industrial production for Greece, using monthly frequency data covering the period 2004-2014. The variables demonstrated an integrating relation. Lin, Omoju, et al. (2016) observe for the Chinese economy that economic growth receives impetus from renewable electricity consumption but trade openness, foreign direct investment, financial development and fossil fuel energy consumption lower the demand for electricity consumption. Bento and Moutinho (2016) utilized a bivariate framework to determine the association across electricity utilization (hydro power) and economic progress. Interestingly, Gokten and Karatepe (2016) include current account deficit in electricity consumption function and obtains that there is unidirectional causation from electricity utilization to economic growth. Sbia, Shahbaz, et al. (2016) examine the relation across economic progress, urbanisation, financial expansion and electricity utilization for the United Arab Emirates during the period 1975-2011. The study concludes that urban expansion raises electricity utilization until a threshold level is reached after which demand for electricity falls.

3. Research Questions, Objectives and Data sources, and Methodology

3.1. Research Questions

From the discussion on the existing literature it has become important to discuss certain issues regarding the relationship between electricity consumption and economic growth. The following question arises:

I. To what extent has the consumption of electricity contributed to the countries' development?

II. To what direction is the causality link between the two variables?

III. What is the thrust of emphasis and what investment decisions should be taken to improve electricity consumption in the countries?

3.2. Objectives

Electric power is the mechanism that pushes industrialization, steady electric power supply for satisfactory consumption is the key to development. The country which faces acute electricity problems faces obstacle to development even if there are vast expanse of natural resources. Against the backdrop the broad research question is what has been the impact of electricity consumption on economic growth; what is the causality association across economic growth; electricity consumption and the concomitant process of urbanization. The objectives of the current study is to examine the relation between total electricity per capita and GDP per capita, to investigate the arrangement and trends of electricity consumption in the Latin American countries and South Asian countries and the two groups as a whole. Last, to specify promotional based electricity consumption policies.

3.3. Data Sets

The focus of this paper is to examine the causality association across electricity utilization and growth of the economy including additionally urbanisation and trade openness in the model. It is obvious that rapid urbanisation and increase in trade volume is likely to manifest in rising electricity consumption. Here annual data for the period 1971-2013 is utilized. Data is obtained from World Bank, World Development Indicators (2015) online data base. The Table 1(a) explores the descriptive statistics developed in the study for the group as a whole. Further the Tables 1(b) and 1(c) discuss the descriptive statistics of the set of South East Asian countries and Latin American countries respectively.

Table 1(a). Descriptive Statistics: Summary Output of the Whole Sample

Variables	Observations	Mean	Std. Dev	Min	Max
E	602	2.945732	0.5954195	1.156806	3.986931
Y	602	4.599525	3.074977	0.9492257	11.30352
TR	602	1.410415	0.4332476	0.4386114	2.147481
U	602	1.686824	0.4203882	0.2825818	2.00000

Note: The Variables are reported in their Logarthimic form, Compilation Author. Source: World Bank (2015).

Table 1(b). Descriptive Statistics: Summary Output of the South East Asian Countries

Variables	Observations	Mean	Std. Dev	Min	Max
E	258	3.010243	0.6438642	1.156806	3.986931
Y	258	3.469644	2.828861	.9492257	10.27986
TR	258	1.450552	0.5060727	0.4386114	2.147481
U	258	1.694681	0.2003455	1.238999	2.0000

Note: The Variables are reported in their Logarthimic form, Compilation Author. Source: World Bank (2015).

Table 1(c). Descriptive Statistics: Summary Output of the Latin American Countries

Variables	Observations	Mean	Std. Dev	Min	Max
E	344	2.897348	0.552355	1.421225	3.588709
Y	344	5.446937	2.981828	2.538889	11.30352
TR	344	1.380312	0. 3672539	0. 6764457	1.908707
U	344	1.680931	0. 5286791	0. 2825818	1.96119

Note: The Variables are reported in their Logarthimic form, Compilation Author. Source: World Bank (2015).

3.4. Methodology

The following functional form is adopted in the study

$$E_t = f\,(Y_t, U_t, TR_t) \qquad (1)$$

where all the variables are transformed into logarithmic form for proficient empirical results.

The model to be estimated is as follows

$$\ln E_t = \alpha + \beta \ln Y_t + \eta \ln U_t + \gamma \ln TR_t + \mu_t\,, \qquad (2)$$

here α is the constant term and β, η and γ are the long-run elasticities of electricity demand with respect to real GDP, urbanization and trade openness, respectively. The Equation (2) is used to obtain the long-term association between ln E_t (natural log of electricity utilization (Kwt) per capita), ln Y_t (natural log of real per capita Gross Domestic Product), ln U_t (natural log of urbanization which equal to urban population/total population), ln TR_t (natural log of trade openness which equal to real exports plus real imports/total population) per capita and μ is the error term assuming to be normally distributed.

3.5. Econometric methodology

Here the cointegration and causality tests are performed, first a panel unit root test is performed to test whether the variables are stationary or not. Next cointegration tests are performed and finally after cointegration is established, we investigate the causal relationship among electricity consumption, output, urbanisation and trade openness.

On Panel Unit root tests

The important difference of panel unit root testing to that of the usual time series testing of the unit roots is that we have to take into consideration the asymptotic behaviour of the time sequence component T and the cross section component N. It is important to note the way T and N vary. This paper has utilized Breitung (2000) panel unit root test.

Breitung (2000) is as follows

$$y_{it} = \alpha_{it} + \sum_{k=1}^{p+1} \beta_{ik} \cdot X_{i,t-k} + \varepsilon_{it} . \qquad (3)$$

In equation (3) the Breitung (2000) test statistic tests the following null hypothesis to show the first difference of the variable is stationary

$$H_0 : \sum_{k=1}^{p+1} \beta_{ik} - 1 = 0.$$

The following test statistic is then constructed

$$\lambda_B = \frac{\sum_{i=1}^{N} \sigma_i^{-2} y_i^{*/} x_i^{*/}}{\sqrt{\sum_{i=1}^{N} \sigma_i^{-2} X_i^{*/} A^{/} X_i^{*}}} . \qquad (4)$$

The statistic follows a standard normal distribution.

On Panel Cointegration Tests

Once it is found from the unit root test that the variables are non-stationary, i.e., they are integrated in the order of one, then the subsequent procedure is to apply cointegration analysis to examine whether a long run cointegration relationship exists among those variables. The equations (4), (5), (6) and (7) describe the Error Correction Models where all the concerned variables are of the order *I*(1).

$$\Delta E_{i,t} = \alpha_i^E + \lambda_i^E \left(E_{i,t-1} - \beta_i^E Y_{i,t-1} - \gamma_i^E TR_{i,t-1} - \eta_i^E U_{i,t-1} \right) + \sum_{j=1}^{n} \theta_{i,j}^E \Delta E_{i,t-j} + \sum_{j=1}^{p} \phi_{i,j}^E \Delta T_{i,t-j} + \sum_{j=1}^{m} \delta_{i,j}^E \Delta Y_{i,t-j} + \sum_{j=1}^{q} \chi_{i,j}^E \Delta U_{+i,t-j} + u_{i,t} \,, \quad (4)$$

$$\Delta Y_{i,t} = \alpha_i^Y + \lambda_i^Y \left(Y_{i,t-1} - \beta_i^Y E_{i,t-1} - \gamma_i^Y TR_{i,t-1} - \eta_i^Y U_{i,t-1} \right) + \sum_{j=1}^{m} \delta_{i,j}^Y \Delta Y_{i,t-j} + \sum_{j=1}^{n} \theta_{i,j}^Y \Delta E_{i,t-j} + \sum_{j=1}^{p} \phi_{i,j}^E \Delta T_{i,t-j} + \sum_{j=1}^{q} \chi_{i,j}^Y \Delta U_{+i,t-j} + \varepsilon_{i,t} \,, \quad (5)$$

$$\Delta T_{i,t} = \alpha_i^{TR} + \lambda_i^{TR} \left(TR_{i,t-1} - \beta_i^{TR} Y_{i,t-1} - \gamma_i^{TR} E_{i,t-1} - \eta_i^{TR} U_{i,t-1} \right) + \sum_{j=1}^{p} \phi_{i,j}^{TR} \Delta T_{i,t-j} + \sum_{j=1}^{m} \delta_{i,j}^{TR} \Delta Y_{i,t-j} + \sum_{j=1}^{n} \theta_{i,j}^{TR} \Delta E_{i,t-j} + \sum_{j=1}^{q} \chi_{i,j}^{TR} \Delta U_{+i,t-j} + e_{i,t} \,, \quad (6)$$

$$\Delta U_{i,t} = \alpha_i^U + \lambda_i^U \left(U_{i,t-1} - \beta_i^U Y_{i,t-1} - \gamma_i^U TR_{i,t-1} - \eta_i^U E_{i,t-1} \right) + \sum_{j=1}^{q} \chi_{i,j}^U \Delta U_{i,t-j} + \sum_{j=1}^{p} \phi_{i,j}^U \Delta T_{i,t-j} + \sum_{j=1}^{m} \delta_{i,j}^U \Delta Y_{i,t-j} + \sum_{j=1}^{n} \chi_{i,j}^U \Delta E_{+i,t-j} + \psi_{i,t} \,. \quad (7)$$

Here λ_i^k, $k \in \{E, Y, TR, U\}$ are the factors in the Error Correction (EC) term and provide the estimations of the pace of error correction to the long run equilibrium situation for country *i*, again $u_{i,t}$, $\varepsilon_{i,t}$, $e_{i,t}$, and $\psi_{i,t}$ are disturbance terms. Westerlund (2007) formulated panel cointegration test statistics as follows - (G_α, G_t, P_α and P_t).

The panel tests P_t and P_α assume that $\lambda_i^k = \lambda^k$ for all the *i*, so accordingly the alternative hypothesis is that change to equilibrium is homogeneous across cross section units.

Thus we test $H_0^G : \lambda_i^k = 0$ for all *i*; against $H_1^G : \lambda_i^k < 0$ for at least one of *i*.

Rejection of H_0 should make the evidence of cointegration in at least one of the cross section units. Next we test for $H_0^P : \lambda^k = 0$ against $H_1^P : \lambda^k < 0$. Here rejection of H_0 indicates existence of cointegration for panel as a whole.

On Panel Causality Tests

Once the test for cointegration is complete the next procedure is to set causality tests. Here panel causality test, Dumitrescu and Hurlin (2012), is applied. The null hypothesis of the test suggests that there exist no Granger association in the panel, the alternative hypothesis implies that there is a causal relation, of at least one, in the whole cross section. The central idea of the null hypothesis is the probable existence of homogeneous relation, whereas the alternative hypothesis tries to find a diverse relation. The basic hypothesis test statistic is the arithmetic mean of individual Wald statistic, hence

$$W_{N,T}^{H_{nc}} = \frac{1}{n}\sum_{i=1}^{N} W_{i,t} , \qquad (8)$$

where $W_{i,t}$ indicates the Wald test statistic for country *i* to examine causation.

Dumitrescu and Hurlin (2012) assessed consistent statistic for W^{HNC} by using estimated values of mean and variance of the distribution owing to no convergence to the similar chi-square of individual Wald statistics within a sample for T. This numerical equation is thus

$$Z_{N,T}^{HNC} = \frac{\sqrt{N}\left[W_{N,T}^{HNC} - N^{-1}\sum_{i=1}^{N} E\left(W_{i,t}\right)\right]}{\sqrt{N^{-1}\sum_{i=1}^{N} Var\left(W_{i,t}\right)}}, \qquad (9)$$

where *i* indicates entire set of countries. W demonstrate Wald statistics and T period numbers.

4. Results and Discussion

4.1. On Stationarity Tests

To check the stationarity properties of the concerned variables Breitung (2000) panel unit root test is performed. This test presumes that there is a common unit root process across the cross section.

For this test, the null hypothesis states that there is a unit root and the alternative hypothesis is there is no unit root. Table 2 shows the of the unit root tests. Table 2 results indicate that at level there is a unit root for E, Y, TR and U in panel data series , while after first difference all the variables are integrated of order one. The results are valid when the whole panel is considered or separate panels for the set of Latin American countries and South East Asian countries are examined.

Table 2. Bruiting's Panel Unit Root Test Results

Whole Panel		South East Asian Countries	Latin American Countries
Variables in Logs	Bruiting t -test	Bruiting t -test	Bruiting t -test
INE	12.1885 (0.94)	6.4974 (0.19)	9.3054 (0.98)
ΔINE	-15.5543 (0.0005)*	-3.5673 (0.0002)*	-4.4495 (0.0004)*
INY	8.5412 (0.19)	6.4974 (0.97)	5.569 (0.54)
ΔINY	-7.3400 (0.000)*	-4.3979 (0.0000)*	-4.961 (0.000)*
INTR	2.0067 (0.97)	2.3007 (0.98)	2.239 (0.52)
ΔINTR	-6.222 (0.000)*	-7.2148 (0.0001)*	-7.7108 (0.0001)*
INU	14.5826 (0.93)	8.9026 (0.54)	11.6114 (0.34)
ΔINU	-3.2100 (0.0002)*	-4.4567 (0.0001)*	-3.984 (0.0002)*

Notes: Null hypothesis: Unit root.

All unit root tests regressions are run with intercept.

P-value listed in parentheses. Critical value at the 1 percent level denoted by "*".

Automatic lag length selection based on SIC (Schwarz Information Criteria).

4.2. On Cointegration Tests

We now test whether E, Y, TR and U are cointegrated. Here the panel cointegration tests (Westerlund) is used. We use one lead and lag. The lag and lead orders were chosen from the minimum AIC (Akaike's Information Criterion). The cointegration test is done with a constant and with a trend. The robust P-values are also taken into consideration. This is obtained after bootstrapping utilising 800 replications subsequently examining for cross sectional requirement among the residuals. Results are reported in Table 3 for the entire sample and for the Latin American countries and South East Asian countries separately in Table 3(a) and 3(b), respectively.

Table 3. Panel Cointegration Tests (Westerlund method) (Full Sample)

Model E				
Statistic	Value of test	Z-value	p-value	Robust p-value
G_t	-3.541	-1.881	0.0234	0.0101
G_a	-3.94	0.186	0.06	0.001
P_t	-4.62	-4.884	0.002	0.042
P_a	-4.736	-3.651	0.001	0.047
Model Y				
Statistic	Value of test	Z-value	p-value	Robust p-value
G_t	-2.873	-1.726	0.0234	0.08
G_a	-5.564	4.639	0.11	0.11
P_t	-10.298	-1.149	0.012	0.09
P_a	-5.517	3	0.11	0.936
Model TR				
Statistic	Value of Test	Z-value	p-value	Robust p-value
G_t	-2.827	-1	0.029	0.041
G_a	-5.719	4,567	0.12	0.11
P_t	-9.042	-2.186	0.057	0
P_a	-6.043	3	0.99	0
Model U				
Statistic	Value of Test	Z-value	p-value	Robust p-value
G_t	-1.547	-5	0.045	0.0021
G_a	-5.77	4.5	0.11	0
P_t	-6.102	-3.31	0.092	0.001
P_a	-9.3	-1	0.133	0.11

Note: Here xtwest command in Stata is used, following Persyn and Westerlund (2008) to test for cointegration, using the AIC criteria for lag and lead length. Here G_t is (Group mean statistics), G_a is (Group standard error statistics), P_t is (Panel mean) statistics & P_a (panel standard) error statistics.

Results obtained from Table (3) for the panel taken as a whole indicate that there is a long run cointegrating association on E for the series taken into question based on equation (4). The P_t and P_a statistics show the null hypothesis of no cointegration for E should be overruled at the $P<0.01$ level. As far as the income model (Y) is concerned for the statistics P_t and P_a the strong P values specify that the null hypothesis of no cointegration cannot be excluded for the whole sample. For the trade model (TR) there exists cointegration for the panel for the whole sample. Therefore the null hypothesis of no cointegration is rejected at $P<0.01$ level. For the U model (urbanization) the p-values show that the test statistics are not significant. For G_t and G_a test statistics show that the null hypothesis can be disallowed for the E model for the whole sample when the robust p value is examined. It must be noted that because of difference in construction the group mean value and the panel statistics can give different results. The existence of cointegrating relation implies that there is a steady equilibrating relation among the variables in the long run based on equation (4) for the whole sample.

Table 3(a). Panel Cointegration Tests (Westerlund method) (South East Asian Countries)

Model E				
Statistic	Value of test	Z-value	p-value	Robust p-value
G_t	-2.645	0.165	0.56	0
G_a	-5.549	-3.042	0.49	0.002
P_t	-3.871	-2.298	0.98	0
P_a	-4.435	-2.698	0.99	0
Model Y				
Statistic	Value of test	Z-value	p-value	Robust p-value
G_t	-2.758	-0.153	0.43	0.021
G_a	-6.657	2.704	0.4	0.09
P_t	-6.257	-0.237	0.99	0.27
P_a	-6.291	2	0.971	0.77
Model TR				
Statistic	Value of Test	Z-value	p-value	Robust p-value
G_t	-3.019	-1	0.188	0
G_a	-7.441	2.465	0.99	0.01
P_t	-6.947	-0.97	0.166	0
P_a	-8.139	1	0.009	0.003
Model U				
Statistic	Value of Test	Z-value	p-value	Robust p-value
G_t	-2.14	2	0.09	0
G_a	-11.493	1.23	0.089	0
P_t	-3.99	2.163	0.98	0
P_a	-10.902	0	0.65	0

Note: Here xtwest command in Stata is used following Persyn and Westerlund (2008) to test for cointegration, using the AIC criteria for lag and lead length. Here G_t is (Group mean statistics), G_a is (Group standard error statistics), P_t is (Panel mean) statistics & P_a (panel standard) error statistics.

Based on Table 3(a) the E model shows robust p-values to be statistically significant for all the test statistics. So the null hypothesis of no cointegrating relation can be excluded at $P<0.01$ level. Except for Y model both the trade and urbanization model shows the existence of cointegrating relation when robust p-values are concerned for the South East Asian countries only. For the Latin American countries except for the income model all other models namely electricity, trade and urbanization show robust p values for the statistics to be significant. So the null hypothesis of no cointegration can be excluded at level of $P<0.01$ in the case of Latin American countries, based on Table 3(b). Summarily for all three groups of sample the equation based on electricity demonstrates cointegrating relation when the robust p-values are considered. After establishing the existence of panel cointegration the Westerlund (2007) Error Correction estimates are subsequently applied.

Table 3(b). Panel Cointegration Tests (Westerlund method) (Latin American Countries)

Model E				
Statistic	Value of test	Z-value	p-value	Robust p-value
G_t	-1.41	4	0.89	0.042
G_a	-5.328	3.59	0.992	0
P_t	-4.705	2.404	0.05	0
P_a	-4.196	2.961	0.99	0.001
Model Y				
Statistic	Value of test	Z-value	p-value	Robust p-value
G_t	-2.959	-0.828	0.204	0.12
G_a	-4.745	3.795	0.98	0.99
P_t	-8.153	-1.26	0.104	0.081
P_a	-5.254	3	0.99	0.92
Model TR				
Statistic	Value of Test	Z-value	p-value	Robust p-value
G_t	-2.683	0	0.537	0
G_a	-4.427	3.907	1	0
P_t	-6.363	0.642	0.74	0
P_a	-5.3	3	0.99	0
Model U				
Statistic	Value of Test	Z-value	p-value	Robust p-value
G_t	-1.176	5	0.001	0.021
G_a	-2.17	4.702	1	0
P_t	-4.2	2.941	0.005	0.007
P_a	-4.184	3	0.99	0

Note: Here xtwest command in Stata is used following Persyn and Westerlund (2008) to test for cointegration, using the AIC criteria for lag and lead length. Here G_t is (Group mean statistics), G_a is (Group standard error statistics), P_t is (Panel mean) statistics & P_a (panel standard) error statistics.

4.3. On Error Correction Model (ECM) Estimates

Table 4 reports the results of ECM estimates for the full sample, Tables 4(a) and 4(b) present the results of ECM estimates for South East Asian countries and Latin American countries respectively. The results of these tables can be interpreted as short run fluctuations from the view point of long run equilibrium relationships of E, Y TR and U. Following Table 4 the assessed adjusted parameters (i.e. the coefficient of the Error Correction Term is negative and statistically significant for all the variables except when U is considered as the dependent variable). When E is shown as the dependent variable the error correction term has large negative value for the full sample compared to the groups considered in Tables 4(a) and 4(b), respectively. This suggests that a far longer time will be needed for equilibrium to be reinstated subsequent any deviance from the long term equilibrium of E with Y ,TR and U for the Latin American Countries, followed by South Asian Countries. The speed of adjustment is quickest for the full sample. So there is variation in the speed of adjustments across the groups and for the whole sample, this empirical exposition is crucial for policy suggestions.

Table 4. Results of ECM Estimates, Full Sample

REGRESSORS	ΔE	ΔY	ΔTR	ΔU
CONSTANT	-5.48	-10.13	-18.49	-5.02
Et-1	**-0.37**	0.45	-1.09	10.33
Yt-1	-1.11	**-0.29**	0.2	0.721
TR-1	-0.21	0.75	**-0.26**	-0.18
Ut-1	0.14	0.13	2.92	**0.19**
ΔEt-1	0.12	-0.42	-0.02	-0.7
ΔYt-1	-1.1	-0.43	0.03	-4.07
ΔTR-1	0.63	0.086	0.5	-8.4
ΔUt-1	0.02	0.017	-0.088	0.077
ΔE		0.45	-1.09	10.33
ΔY	-2.09		0.03	-4.07
ΔTR	-0.75	0.21		0.18
ΔU	0.043	0.002	-0.21	

Note. The xtwest Stata command is used. Figures in bold indicate the coefficient of Error Correction term.

Table 4(a). Results of ECM Estimates, South East Asian Countries

REGRESSORS	ΔE	ΔY	ΔTR	ΔU
CONSTANT	-8.69	-19.06	9.5	-0.84
Et-1	**-0.15**	0.21	0.41	0.32
	(0.01)	(0.002)	(0.19)	(0.001)
Yt-1	0.08	**0.26**	-0.18	-3.02
TR-1	0.72	0.046	**-0.14**	-1.23
Ut-1	4.12	-4.3	1.28	**-0.21**
ΔEt-1	-5.1	0.26	0.23	-0.008
ΔYt-1	-0.06	-0.47	-0.09	0.001
ΔTR-1	0.54	0.042	-0.57	0.007
ΔUt-1	0.94	-2.77	1.01	-0.09
ΔE		0.49	0.21	0.33
ΔY	0.09		0.16	-5.94
ΔTR	-0.05	-0.69		1.28
ΔU	-0.004	-0.001	0.03	

Note: The xtwest Stata command is used. Figures in bold indicate the coefficient of Error Correction term.

Table 4(b). Results of ECM Estimates, Latin American Countries

REGRESSORS	ΔE	ΔY	ΔTR	ΔU
CONSTANT	-10.54	-22.5	-14.5	-0.99
Et-1	**-0.077**	0.12	0.17	3.01
	(0.002)	(0.54)	(0.21)	(0.002)
Yt-1	6.5	**-0.065**	0.93	-3.1
TR-1	-0.22	0.24	**-0.21**	-29.6
Ut-1	-0.019	-0.16	0.19	**-0.39**
ΔEt-1	-0.47	5.8	0.11	-0.01
ΔYt-1	0.03	-0.45	-0.13	-0.01
ΔTR-1	0.05	-0.06	-0.57	-0.01
ΔUt-1	-0.07	-10.5	-14.6	0.12
ΔE		0.23	0.69	0.018
ΔY	-0.018		0.04	0.01
ΔTR	-0.35	0.6		28.2
ΔU	12.62	-5.5	-0.18	

Note. The xtwest Stata command is used. Figures in bold indicate the coefficient of Error Correction term.

Table 5. Estimated Long – run ECM coefficients

	Full Sample				South East Asian Countries				Latin American Countires			
Variables	α_i^k	β_i^k	γ_i^k	η_i^k	α_i^k	β_i^k	γ_i^k	η_i^k	α_i^k	β_i^k	γ_i^k	η_i^k
E	3.7	2.09	21.2	0.8	0.08	0.23	0.59	0.13	0.10	6.5	0.042	0.019
Y	0.45	0.29	75.6	2.4	1.52	2.1	18.7	0.4	0.12	0.93	-22.8	0.01
TR	-1.09	0.02	2.6	14.4	0.72	12.3	0.046	0.08	0.17	0.65	27.1	-0.06
U	10.3	-7.21	-18.9	1.28	4.12	-3.2	-26.5	0.12	3.01	-30.0	-29.6	0.99

Note: Self compilation.

According to Table 5 for the full sample 1 percent increase in Y will generate electricity requirements by 0.29 kilo watt, which indicates how income will influence electricity generation for the future. The increase in Y will generate disequilibrium in E by (37%) as per error correction, in each period. The need for electricity requirements is highest for one unit increase in trade performance in the long run for the whole sample. The response is lowest for the Latin American countries.

4.4. On Short Run Causality Tests

The results of short run causality tests are reported in Table 6 for the full sample and Tables 6(a) and 6(b), respectively for the South East Asian Countries and Latin American Countries, where the direction of causal relationship is indicated by (→→). The causality test formulated by Dumitrescu and Hurlin (2012) was used for this part of the discussion. According to Table 6 bidirectional causality exists across electricity consumption and income, electricity consumption and trade further electricity consumption and urbanization.

Table (6): Dumitrescu - Hurlin Panel Granger Causality Test Results, Full Sample

Direction of causality					
			Wbar	Zbar	Prob*
Y	→→	E	2.1	3.07	0.01
E	→→	Y	2.02	3.01	0.002
E	→→	TR	2.008	2.66	0.007
TR	→→	E	2.61	4.2	0
E	→→	U	4.6	9.5	0.01
U	→→	E	4.2	9.8	0.02
Y	→→	TR	4.9	10.3	0.01
TR	→→	Y	1.33	0.88	0.37
Y	→→	U	6.9	15.6	0.01
U	→→	Y	4.9	4.3	0
U	→→	TR	2.8	4.9	0.01
TR	→→	U	9.5	22.6	0

Note:* Indicates significance result of 1%.

Testing the unit root and cointegration theories by using panel data as an alternative of individual time series encompasses numerous added difficulties. Panel data usually present a considerable volume of over looked, heterogeneity, generating the parameters of the model exclusive to cross section specifications. Moreover, in several empirical uses it is unsuitable to adopt that the cross section units are independent. To reduce these problems, this paper uses Westerlund‘s method that accept diverse methods of cross sectional dependence. Again, the panel test results are time and again challenging to infer, when the null of the unit root or cointegration is rejected. Further, with not observable nonstationary collective features influencing several or all the variables in the panel, it is correspondingly essential to deliberate upon the possible occurrence of cointegration amongst the variables across the groups (cross section cointegration) as well as within group cointegration.

Table 6(a). Dumitrescu - Hurlin Panel Granger Causality Test Results, South Asian Countries

Direction of causality					
			Wbar	Zbar	Prob*
Y	→→	E	2.52	2.64	0.008
E	E does not Granger cause Y	Y	1.74	1.28	0.19
E	→→	TR	2.98	3.44	0.0001
TR	TR does not Granger cause E	E	1.95	1.65	0.09
E	→→	U	7.9	12.1	0.001
U	→→	E	8.6	13.1	0
Y	Y does not Granger cause TR	TR	1.2	0.38	0.6
TR	→→	Y	3.08	3.16	0.003
Y	→→	U	6.9	10.2	0.01
U	→→	Y	5.9	8.6	0.01
U	→→	TR	2.28	2.12	0.02
TR	→→	U	13,2	21.2	0.001

Note:* Indicates significance result of 1%.

The literature also develops a homogenous framework, implying that the cointegration vectors are supposed to be alike for all panel units, but the short-run parameters are subject to panel specifications. The task is to categorize the parameters which are analogous across panel, at the same time heterogeneity across parameters must be examined. The Westerlund method is designed to test the null hypothesis of no cointegration by extrapolating if the error correction term in a conditional error correction model (ECM) is equal to zero. The test is adept to consider individual precise short-run dynamics, which includes serially correlated error terms and weakly exogenous regressors. Panel cointegration techniques have been used to a smaller degree to observe the dynamic causation between electricity utilization and GDP in the existing literature. In this paper panel data has shown more powerful test statistics, the test statistics asymptotically follow a normal distribution instead of non-conventional distributions. This test allows for cross section dependencies across panel data. The Westerlund application is meaningful in this study because it allows considerable degree of heterogeneity both for the long run cointegrating relation and short run dynamic specification. Few attempts have been made to utilize Weterlund's technique in electricity consumption and gross domestic product dynamics, so by applying such methodology the paper obtains high power cointegration tests, reducing the endogeneity problem.

Table 6(b). Dumitrescu - Hurlin Panel Granger Causality Test Results, Latin American Countries

Direction of causality					
			Wbar	Zbar	Prob*
Y	Y does not Granger cause E	E	1.8	1.7	0.07
E	→→	Y	2.4	2.9	0.003
E	→→	TR	2.3	2.6	0.007
TR	→→	E	2.04	2.09	0.03
E	→→	U	16.5	31.1	0.0001
U	U does not Granger cause	E	1.6	1.2	0.2
Y	Y does not granger cause TR	TR	1.4	0.83	0.4
TR	→→	Y	6.2	10.5	0
Y	→→	U	6.9	11.8	0
U	→→	Y	2.1	2.3	0.01
U	→→	TR	3.3	4.6	0
TR	→→	U	6.6	11.3	0

Note:* Indicates significance result of 1%

5. Conclusion

This paper provides new empirical perceptions into the examination of the underlying relation across electricity consumption, economic growth, trade openness and urbanization when a sample of Latin American countries and South East Asian countries are considered. Standard results for non stationarity and panel cointegration is obtained for the whole sample and the two sub samples based on the group of countries considered during the period 1971-2013. The existence of cointegrating relation motivates the use of Westerlund (2007) Error Correction estimates and Dumitrescu-Hurlin Panel Granger Causality Test. The empirical analysis carried for the whole sample as well as for the sub samples show interesting results which should be used to calculate income elasticity of electricity consumption for policy design. In the presence of two way causality between electricity use and economic growth for the whole sample energy conservation policies will be harmful to economic growth. The abundance of natural resources in Latin America has driven its economic growth however economic fortunes of many of these countries rest on the sustainability of electricity utilisation. For the full sample the results provides support to the growth hypothesis which confirms the importance of energy for sustaining the growth process.

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