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AN ECONOMETRIC ANALYSIS OF CARBON EMISSION, ENERGY CONSUMPTION AND ECONOMIC GROWTH IN INDIA, CHINA, BANGLADESH, NEPAL AND PAKISTAN FOR THE PERIOD 1991- 2012

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ABSTRACT

Energy consumption and Economic growth nexus performs a key for economic development because it plays a vital role in economic and social development. Hence, many studies have tried to identify the direction of causality among energy consumption, economic growth, and CO_2 emissions. This paper, applies the panel unit root tests, panel cointegration tests and dynamic panel causality tests to investigate the relationship Carbon Emission, Energy Consumption and Economic Growth in India, China, Bangladesh, Nepal and Pakistan for the Period 1991- 2012. In addition, this paper applies the dynamic ordinary least square (DOLS) and the fully modified ordinary least square (FMOLS) techniques approach to estimate the long-run relationship among energy consumption, economic growth, gross fixed capital formation and labour force. The test clearly points out that there is bi-directional causality between energy and income among the panel of countries in the short run. The long run equilibrium is found only in capital stock equation, in which, only real GDP adjusts towards the long run equilibrium after a shock and the corresponding error correction term is statistically significant. Therefore, the study has concluded that there is bi-directional causality between energy consumption and economic growth. Long run estimates have shown that there are long run elasticities pertaining to energy consumption and economic growth. In regard to CO_2 emission and per capita income are concerned, per capita income reduces CO_2 emission for the panel of countries. This shows that these countries have been taking series initiatives in reducing the environmental pollution.

KEYWORDS: *Economic development, Energy consumption, Economic growth, CO_2 emissions, Panel unit root, Panel Cointegration, Dynamic panel causality, GDP, DOLS, FMOLS.*

1. INTRODUCTION

Of late, economists have paid their earnest attention towards fossil fuel use and rapid rise of carbon dioxide (CO_2) emission not only in developed but also in developing countries of the world (Stern et al; 2006, Apergis et al; 2010 and Li et al; 2011,). Over the years, the incidence of growth of Greenhouse Gas (GHG) emission, more particularly carbon dioxide emission, has reported to have raised the level of global temperature. It implies to that in the short run, global average temperature may rise over by 2 per cent. If the raising temperature remains unchecked, there is greater than 50 per cent chance that the rise in temperature would exceed 5^0 C in the long run (Tiwari, 2011: 86). It would affect all rich and poor countries in the world. Most likely, the poor and more populous countries would be hit hard even though they have contributed little to the growth of greenhouse gas emission (*ibid*). These events have prompted the economists to identify appropriate solution to the increased use of fossil fuels and environmental degradation by environmental pollution. To resolve this issue, a seminal work of Kraft and Kraft (1978) is termed as the first of this kind in this direction to identify the causality between energy and economic growth in the US. He used Sims (1972) methodology based on VAR framework and identified a unidirectional causality running from economic growth to energy consumption and suggesting that the energy conservation strategy was an appropriate solution without reducing economic growth. (Bhusal, 2010:136, Dhungel, 2009:37).

2. OBJECTIVES OF THE STUDY

The objectives of the study are first to analyse long run relationship among energy use, economic growth, gross fixed capital formation and labour force by applying dynamic ordinary least square (DOLS) and fully modified ordinary least square (FMOLS) techniques and to examine short run and long run causalities between energy consumption and economic growth after accounting gross fixed capital formation, labour force by applying panel co-integration and panel vector error correction modelling (VECM) techniques.,

This study examines relationship between energy consumption and economic growth after accounting gross fixed capital formation and labour force for a panel of selected six Asian countries viz India, China, Bangladesh, Nepal and Pakistan for the period 1991- 2012.

3. REVIEW OF IMPORTANT PAST STUDIES

Adjaye (2000) found that the price effects were relatively less significant in the causal chain. The finding of bidirectional Granger causality or feedback between energy consumption and income has a number of policy implications for policy makers and forecasters. Dhungel and Raj (2008) find that there is a unidirectional causality running from coal, oil and commercial energy consumption to per capita real GDP, whereas a unidirectional causality running from per capita real GDP to per capita electricity consumption is found. Abosedra et al. (2009) confirm the absence of a long-term equilibrium relationship between electricity consumption and economic growth in Lebanon but the existence of unidirectional causality running from electricity consumption to economic growth when examined in a bivariate vector auto regression framework with change in temperature and relative humidity as exogenous variables.

Akinlo and Edison (2009) found that the real gross domestic product (RGDP) and electricity consumption are cointegrated and there is only unidirectional Granger causality running from electricity consumption to real gross domestic product. Apergis et.al (2010) reveals that there is a long run relationship between real GDP, energy consumption, real gross fixed capital formation, and the labour force using Pedroni's heterogeneous panel cointegration test. Bekhet et al. (2011) found that there was long run causality running from electricity consumption to inflation and found it significant. It suggests to analyse and explore the possibility of energy sustainable and renewable in a country since it is a necessity for the country to ensure smooth implementation of development projects.

Menyah et al. (2010) found a unidirectional causality running from nuclear energy consumption to economic growth in Japan, Netherlands and Switzerland; the opposite unidirectional causality running from economic growth to nuclear energy consumption in Canada and Sweden; and a bi-directional causality running between economic growth and nuclear energy consumption in France, Spain, the United Kingdom and the United States.

Sami and Janesh (2011) found evidence of causality running from real GDP per capita to electricity consumption per capita in short run as well as in long run supporting the conservation hypothesis. The government needs to remember the importance of electricity management program to reduce electricity wastage. Shahbaz et.al. (2011) find that electricity consumption, economic growth, and employment in Portugal are cointegrated and there is bi-directional Granger causality among the three variables in the long-run.

4.DATA, MODEL AND METHODOLOGY

4.1. Data base

The study has extracted aggregate variables like energy consumption (kg of oil equivalent per capita), per capita income (in constant US dollars), gross fixed capital stock, total labour force (in millions) and CO_2 emissions (metric tons per capita) from online data base of the World Bank official website. Totally five Asian countries including China, India, Pakistan, Nepal and Bangladesh has been chosen to form the panel data.

4.2 Econometric Modelling for Economic Growth and Energy Consumption

To analyze the relationship between energy use and economic growth after accounting for gross fixed capital formation and total labour force, the production function framework adopted by Stern (1993, 2000), Lee (2005), Narayan et al (2008), Noor et al (2010). (Narayan et, al, 2008) the growth function for panel data can be written as

$$LnGDP_{it} = \alpha_{i0} + \alpha_{1i} LnE_{i,t} + \alpha_{2i} LnC_{i,t} + \alpha_{3i} LnL_{i,t} + \mu_{it} \ldots\ldots\ldots\ldots (1)$$

Where, GDP_t refers to real Gross Domestic Product at constant 2005 US$ in t^{th} period, E_t denotes energy use in KT of oil equivalent in t^{th} period and L_t means to total labour force in t^{th} period., C_t

denotes fixed capital formation and *'i'* denotes each country which is included in the panel of countries, 't' is the t^{th} period α_s are coefficients μ_{it} is the error term which is assumed to have zero mean and normal distribution.

4.3. Methodology

The estimation of the growth function requires the employing of panel cointegration framework which involves four steps as discussed below:

a). Panel Unit Root Tests

The purpose of checking the panel data requires determining whether the data is stationary or not. To ensure this, the present study uses Levin, Lin & Chu T (2000), Im, Pesaran and Shin w-stat (IPS, 2000), ADF-Fisher Chi-Square and PP-Fisher, Chi-Square tests to examine whether the variables in the study are stationary or not as well as to ascertain the order of integration of variables.

Before proceeding to co integration techniques, we need to verify that all variables are integrated to the same order. In doing so, we have used first generation tests of panel unit root due to Im, Pesaran and Shin (2003)[IPS] and Maddala and Wu (1999)[MW] and second generation test of panel unit root of Pesaran (2005). These tests are less restrictive and more powerful compared to the tests developed by Levin and Lin (1993, 2002), which don't allow for heterogeneity in the autoregressive coefficient. The tests proposed by IPS permit to solve Levin and Lin's serial correlation problem by assuming heterogeneity between units in a dynamic panel framework.

b). Panel Cointegration Test

After establishing the order of integration of panel variables, we examine whether the macro economic variables given in the panel data are associated in the long run or not. Since, the data being panel data, we have applied the panel co integration test developed by Pedroni (1999, 2004). This test consisting of seven outcomes of which, four outcomes belong to within dimension and the three outcomes constitute between dimensions. Within dimension again K has also been divided into weighted and non-weighted statistics. Within dimension approach consists of four statistics: Panel V, Panel P, Panel PP and Panel ADF-Statistics. These statistics essentially pool the autoregressive coefficients across different countries for the unit root tests on the estimated residuals. These statistics take into account common time factors and heterogeneity across countries. The second group tests are based on between dimension approach which includes three statistics Group P, Group PP and Group ADF-Statistics. These statistics are based on the averages of the individual autoregressive co-efficient associated with the unit root tests of the residuals of each country in the panel. All seven tests are distributed asymmetrically as standard normal distribution. Both kinds of tests focus on the null hypothesis of no co integration. However the distinction comes from the specification of the alternative hypothesis. For the tests based on "within", the alternative hypothesis is $\rho_{i=}\rho < 1$ for all i, while concerning the last three test statistics which are based on the "Between" dimension, the alternative hypothesis is $\rho_i < 1$, for all i. The Kao (1999) test is used to examine the co integration of variables under the study. This test will be treated as bench mark test of cointegration of variables.

c). Panel Fully Modified OLS Estimator (FMOLS)

The fully modified ordinary least square (FMOLS) is the long run coefficient estimator which is used to examine the long run elasticities among the variables. This estimator is introduced by Pedroni for heterogeneous panels. Besides, being used to estimate the long run elasticities, it is also used to obtain residuals to construct error correction terms. FMOLS estimator or the DOLS estimator may be more promising in cointegrated panel regressions. The Fully Modified OLS (FMOLS) and Dynamic OLS (DOLS) methodologies are proposed by Kao and Chiang (2000) to estimate the long – run cointegration vector, for non – stationary panels. These estimators correct the standard pooled OLS for serial correlation and endogeneity of regressors that are normally present in long – run relationship. By examining the limiting distribution of the FMOLS and DOLS estimators in cointegrated regressions, Kao and Chiang (2000) show that they are asymptotically normal. The FMOLS estimator is constructed by making corrections for endogeneity and serial correlation to the OLS estimator. The serial correlation and the endogeneity can also be corrected by using DOLS estimator. The DOLS is an extension of Stock and Watson's (1993) estimator. In order to obtain an unbiased estimator of the long – run parameters, DOLS estimator uses parametric adjustment to the errors by including the past and the future values of the differenced I(1) regressors. The estimates of DOLS estimates are also used to compare with the estimates of FMOLS. The equations are;

$$LnY_{it} = \alpha_{0i} + \delta_{1i}t + \beta_{1i}\, LnE_{it} + \beta_{2i}\, LnC_{it} + \beta_{3i}n\, LnL_{it} + \mu_{it} \qquad (2)$$

$$LnE_{it} = \alpha_{1i} + \delta_{2i}t + \beta_{4i}\, LnY_{it} + \beta_{5i}\, LnC_{it} + \beta_{6i}\, LnL_{it} + \varepsilon_{it} \qquad (3)$$

$$LnC_{it} = \alpha_{2i} + \delta_{3i}t + \beta_{7i}\, LnE_{it} + \beta_{8i}\, LnY_{it} + \beta_{9i}\, LnL_{it} + \eta_{it} \qquad (4)$$

$$LnL_{it} = \alpha_{3i} + \delta_{4i}t + \beta_{10i}\, LnE_{it} + \beta_{11i}\, LnY_{it} + \beta_{12i}\, LnC_{it} + \varphi_{it} \qquad (5)$$

The Fully modified ordinary least square estimators are fitted with each of the macro aggregate variables like LnY, LnE, LnC and LnL (real income, energy consumption, gross fixed capital formation, labour force) as dependent variables. The residuals obtained from the corresponding equations namely μ_{it}, ε_{it}, η_{it} and φ_{it} are included as error correction terms representing the long run equilibrium. And, the long run equilibrium distinguishes itself from the short run equilibrium represented by coefficients of independent variables given in the equations.

d). Dynamic Panel Causality Tests Equations:

$$\Delta LNY_{i,t} = \alpha_{1,i} + \sum_{k=1}^{h} \beta_{11\,i,k}\,\Delta LNE_{i,t-k} + \sum_{k=1}^{h} \beta_{12\,i,k}\,\Delta LNY_{i,t-k} + \sum_{k=1}^{h} \beta_{13\,i,k}\,\Delta LNC_{i,t-k} + \sum_{k=1}^{h} \beta_{14\,i,k}\,\Delta LNL_{i,t-k} + \lambda_{1i}\,\mu_{i,t-1} + \epsilon_{1i,t} \quad (6)$$

$$\Delta LNE_{i,t} = \alpha_{2,I} + \sum_{k=1}^{h} \beta_{21\,i,k}\,\Delta LNE_{i,t-k} + \sum_{k=1}^{h} \beta_{22\,i,k}\,\Delta LNY_{i,t-k} + \sum_{k=1}^{h} \beta_{23\,i,k}\,\Delta LNC_{i,t-k} + \sum_{k=1}^{h} \beta_{24\,i,k}\,\Delta LNL_{i,t-k} + \lambda_{2i}\,\varepsilon_{i,t-1} + \epsilon_{2i,t} \quad (7)$$

$$\Delta LNC_{i,t} = \alpha_{3,i} + \sum_{k=1}^{h} \beta_{31\,i,k}\,\Delta LNE_{i,t-k} + \sum_{k=1}^{h} \beta_{32\,i,k}\,\Delta LNY_{i,t-k} + \sum_{k=1}^{h} \beta_{33\,i,k}\,\Delta LNC_{i,t-k} + \sum_{k=1}^{h} \beta_{34\,i,k}\,\Delta LNL_{i,t-k} + \lambda_{3i}\,\eta_{i,t-1} + \epsilon_{3i,t} \quad (8)$$

$$\Delta LNL_{i,t} = \alpha_{4,i} + \sum_{k=1}^{h} \beta_{41\,i,k}\,\Delta LNE_{i,t-k} + \sum_{k=1}^{h} \beta_{42\,i,k}\,\Delta LNY_{i,t-k} + \sum_{k=1}^{h} \beta_{43\,i,k}\,\Delta LNC_{i,t-k} + \sum_{k=1}^{h} \beta_{44\,i,k}\,\Delta LNL_{i,t-k} + \lambda_{4i}\,\varphi_{i,t-1} + \epsilon_{4i,t} \quad (9)$$

Where Δ refers to the first difference operator K denotes lag lengths. λ_i is the coefficient of error correction term. The size of this coefficient refers to the speed of adjustment to long run equilibrium $\epsilon_{i,t}$ is the serially uncorrelated error term and is assumed to have zero mean. In order to have consistent results, it has been decided to introduce two lags (K=2), as per Akaike Information Criterion (AIC) to remove serial correlation in error term. To detect the direction of causality between the variables given in the equations, Wald F-test is used to determine short run and strong causality by testing the coefficients of each dependent variable in equations (6) to (9). To determine the short run causality, we apply Wald test coefficients of lagged independent variables used in the equation. we test H_0: $\beta_{11i,k} = 0$, $\forall_{i,k}$; H_0: $\beta_{13\,i,k} = 0\ \forall_{i,k}$ and H_0: $\beta_{14\,i,k} = 0\ \forall_{i,k}$ to find out whether causality runs from energy consumption and/or Gross fixed capital formation and/or Total labour force to energy consumption in equation (6). Similarly, for equation (7), short run causality is tested by applying the Wald test for all the coefficients of independent variables. We test H_0: $\beta_{22\,i,k} = 0\ \forall_{i,k,}$ $\beta_{23\,i,k} = 0\ \forall_{i,k}$ and $\beta_{24\,i,k}\ \forall_{i,k}$ for short run causality running from real GDP and/or gross fixed capital and/or Total labour force to energy consumption. The Wald test is applied similarly for capital and labour equations (8) to (9) respectively. Long run causality's value is estimated by using error correction term which is usually negative and statistically significant. The coefficient 'λ' is set as equal to zero. The coefficient 'λ' represents the speed of adjustments when there is any external shock given to it. We also conduct joint test in order to test for strong causality.

Finally, in this study we also test whether there is any strong causality by conducting 'joint tests'. This test involves the testing of coefficients of explanatory variables and corresponding error correction term of the respective equation (ΔLNE, ΔLNC, ΔLNL with μ, ΔLNY, ΔLNC, ΔLNL with ε; ΔLNE, ΔLNY, ΔLNL with η, ΔLNE, ΔLNY, ΔLNC with ϕ). Since, the variables are stationary in nature, the joint test provide evidence of the variable in question bear the burden of short run adjustment to establish long run equilibrium following a shock to the system (Belke, 2011).

5. EMPIRICAL RESULTS OF PANEL UNIT ROOT, COINTEGRATION, GRANGER CAUSUALITY TEST

a). Panel Unit Root Test Results

Table 1 presents the results of panel unit roots. The test consisting of Levin, Lin & Chu T (2000), Im, Pesaran and Shin-W-stat (2003), ADF-Fisher Chi-square and PP- Fisher Chi-square are applied to test the stationary of the panel variables chosen for five selected Asian countries. After first difference, the variables are stationary which are integrated to order of one *I*(1).

TABLE: 1 Panel Unit Root Test Results for variables

Levin, Lin & Chu (LLC)			Im, Pesaran and Shin W-Stat (IPS)		ADF - Fisher Chi-Square		PP- Fisher Chi-Square	
Variable	Intercept	Intercept & Trend	Intercept	Intercept & Trend	Intercept	Intercept & Trend	Intercept	Intercept & Trend
Panel Unit Root at Level								
LNE	-0.1567 (0.4378)	0.4973 (0.6905)	3.0457 (0.9988)	1.4740 (0.9298)	4.5404 (0.9197)	8.8088 (0.5503)	4.5863 (0.9170)	8.9529 (0.5366)
LNY	4.9544 (1.0000)	-0.8234 (0.2051)	6.3179 (1.0000)	-1.3074 (0.0955)	1.9251 (0.9969)	15.5593 (0.1130)	7.8846 (0.6401)	5.2831 (0.8715)
LNC	-0.3003 (0.3820)	-0.2297 (0.4092)	2.3634 (0.9909)	-0.2089 (0.4172)	3.7775 (0.9568)	9.4649 (0.4886)	3.4579 (0.9685)	7.6389 (0.6641)
LNL	-2.8451 (0.0022)	-2.8291 (0.0023)	-0.3927 (0.3473)	-0.4123 (0.3401)	21.6451 (0.0170)	17.7593 (0.0592)	33.5903 (0.0002)	3.2252 (0.9756)
At First Difference								
DLNE	-6.1665* (0.0000)	-.9456* (0.0000)	-.9060* (0.0000)	-.1559* (0.0000)	49.7196* (0.0000)	40.6689* (0.0000)	56.2991* (0.0000)	45.0281* (0.0000)
DLNY	-4.7733* (0.0000)	-.7922* (0.0000)	-.4636* (0.0000)	-.4928* (0.0000)	38.5443* (0.0000)	37.1363* (0.0001)	38.6627* (0.0000)	39.2189* (0.0000)
DLNC	-5.6891* (0.0000)	-.9266* (0.0017)	-.8279* (0.0000)	-.9058* (0.0018)	40.3220* (0.0000)	23.7220* (0.0084)	40.4853* (0.0000)	29.5740* (0.0010)
DLNL	-.5539** (0.0601)	-0.2895 (0.3861)	-.8693* (0.0021)	-.3503* (0.0094)	27.5166* (0.0022)	24.1328* (0.0073)	21.7540** (0.0164)	15.7049*** (0.1084)

Notes: (i). The pre-fix of ‘D’ denotes that the variable is in first difference. (ii). Fisher- ADF and Fisher-PP represent the panel unit root tests of Maddala and Wu (1999) Choi (2001). (iii). All the tests bear Ho: the series has unit root process. Ha: The series has no unit root. (iv). Figures given in brackets are probabilities. (v). Automatic lag selection is opted to minimize Schwarz Information Criteria (SIC). ‘*’, ‘**’ and *** represents significance level of 1 per cent, 5 per cent and 10 per cent respectively.

b). Panel Cointegration Test Results

After establishing order of integration of the variables, we need examine long run equilibrium among the variables considered in the analysis. Table 2 describes the panel cointegration test results of aggregate variables chosen for the study. Since majority of the results suggest that there is a cointegration in the long run, it provides an evidence of long run association of the variables. The Kao (1999) test results presented in Table 3 also suggests that there is a cointegration of variables given in this study.

Table: 2 Cointegration Test Results of Variables

Test Statistics	No deterministic Trend	Deterministic intercept and Trend	No deterministic Trend	Deterministic intercept and Trend
Panel cointegration statistics (within-dimension)				
Natural log of income(LNY)			**Natural log of energy (LNE)**	
Panel v-statistics	1.1665 (0.1217)	0.0149 (0.4941)	8.2151*** (0.0000)	8.2707*** (0.0000)
Panel rho-statistics	-0.1635 (0.4350)	0.9187 (0.8209)	-1.9544** (0.0253)	-0.6888 (0.2455)
Panel PP-statistics	-1.4151* (0.0785)	-0.7423 (0.2290)	-1.1801 (0.1190)	0.4132 (0.6603)
Panel ADF-statistics	-2.4182 (0.0078)	-2.1227* (0.0169)	-0.8312 (0.2029)	-0.0604 (0.4759)
Group mean panel cointegration statistics (between-dimension)				
Group rho-statistics	0.6477 (0.7414)	1.4840 (0.9311)	-2.0673** (0.0194)	0.5251 (0.7002)
Group PP-statistics	-0.9424 (0.1730)	-1.8272** (0.0338)	-3.7426*** (0.0001)	-0.3197 (0.3746)
Group ADF-statistics	-2.3051*** (0.0106)	-2.4286*** (0.0076)	-3.7673*** (0.0001)	-2.4427*** (0.0073)

Notes: (i) *, **, *** indicate rejection of null hypothesis of no co integration at 10%, 5% and 1% level of significance respectively. (ii) Automatic lag selection is chosen to minimize the Schwarz information.

Table: 3 Kao Residual Cointegration Test Results

Model Specification: No deterministic Trend	
Dependent variables	**ADF-Statistics**
Δ LNY	-3.245*** (0.001)
ΔLNE	-1.725** (0.042)

Notes: '***', '**'refers to 1 per cent and 5 per cent significant respectively.

After establishing the co integration of variables in the long run, the long run relationship is estimated by using Fully Modified Ordinary Least Squares (FMOLS) method for heterogeneous cointegrated panels (Pedroni, 2000). Besides, we also estimate with Dynamic Ordinary Least Squares (DOLS) to compare the estimates of independent variables given in the specification. Since the majority of the estimates of the panel cointegration given in the analysis are significant, it is decided to estimate Panel Vector Error Correction model (VECM) in order to assess short run and long run causalities for the panel of five Asian countries.

c). Estimates of FMOLS and DOLS

The long run estimates of FMOLS and DOLS are long run elasticities because both dependent and independent variables are given in logarithmic form. The coefficients of independent variables viz., energy consumption (LNE), capital stock (LNC) and labour force (LNL) are statistically significant (highly) and bear expected signs. The estimated equations of Panel FMOLS and DOLS Estimates for selected Asian Countries are presented below.

FMOLS Estimates:

LNY = 0.485645 LNE + 0.862770 LNC - 0.955399 LNL Adjusted R^2 = 0.749

t-values (2.497681)*** (16.19677) *** (-12.09330) ***

DOLS Estimates:

LNY = 1.113321 LNE + 0. 639354 LNC - 0.846119 LNL Adjusted R^2 = - 0.805

t-values (2.977919)*** (5.684734) *** (7.332777) ***

The coefficients of energy consumption and capital stock are positive and significant but, the co-efficient of labour is found to be negative in both FMOLS and DOLS specifications, as expected by the economic theory.

In FMOLS equation, one per cent rise in energy consumption (LNE) increases real GDP (LNY) by 0.49-1.11per cent. Similarly, one per cent rise in capital stock (LNC) increases real GDP by 0.64- 0.86 per cent. However, labour force (LNL) has negative co-efficient and shows that one per cent rise in labour force reduces real GDP by0.84- 0.96 per cent. The negative co efficient of labour is mainly due to brain-drain, uneducated and unskilled workforce and low labour productivity (Noor et al.2010). The estimates show that the growth elasticity of energy consumption is lower than the growth elasticities of capital stock estimated for five Asian countries. This result contradicts the findings of Lee (2005) for 18 developing countries, in which, the growth elasticity of energy consumption is found to be higher than the growth elasticities of capital stock. Similarly, our estimates pertaining to growth estimates of energy and capital stock are in conformity with the findings of Apergis et al (2010) and Narayan et al (2008). The estimates of DOLS are in conformity with the findings of FMOLS estimator. The following section examines the panel based causality test results.

d). Panel Dynamic Vector Error Correction Model Estimation Results

The panel causality test is performed by employing Vector Error Correction model (VECM) to examine short, long run and strong causalities among the lagged variables viz., real GDP (ΔLNY), energy consumption (ΔLNE), capital stock (ΔLNC) and total labour force (ΔLNL) for five Asian countries. The estimates are presented in Table 4. In income equation, it is found that energy consumption Granger causes real GDP in the short run. Similarly, in energy equation, real GDP Granger causes energy consumption. In capital stock equation; income Granger causes capital which is found to have weak relationship because it has 10 per cent level of significance. In regard Only in capital stock equation, real GDP adjusts towards long run equilibrium after a shock and the corresponding error correction term is statistically significant at 5% level. Based on the estimates provided, it is concluded that there is bi-directional causality running from energy consumption and real GDP in the short run for the panel of countries.

With regard to strong causality (joint test) is concerned in energy equation, real GDP and capital stock bear the burden of shock to restore the long run equilibrium. In capital stock equation, real GDP, energy consumption and labour force have the burden of restoring long run equilibrium after a shock i.e., all the these macro variables are found to be adjusting towards the long run equilibrium and bear the burden of stock. It shows that there is a mutual relationship between energy consumption and real GDP and cautions that any reduction of energy consumption will have series impact on the economic growth for the panel of selected Asian countries.

Table: 4 Panel Causality Test Results for Energy Consumption, Economic growth, Fixed Capital Formation and Labour in Selected Asian countries.

Dependent variable	Sources of causation (Independent Variables)				
	Short-run Causality Wald test: F statistics (P-value)				Long run 't' ratio
	Δ LNY	Δ LNE	Δ LNC	Δ LNL	$ECT_{(-1)}$
ΔLNY	-	3.6877** (0.0289)	1.3091 (0.2752)	0.2169 (0.8054)	-0.0140 (0.8914)
ΔLNE	3.8764** (0.0243)	-	2.3501* (0.1012)	0.9283 (0.3990)	-0.1874 (0.1476)
ΔLNC	2.3168* (0.1045)	0.6458 (0.5267)	-	0.9113 (0.4057)	-0.2854** (0.0196)
ΔLNL	1.5214 (0.2240)	0.8228 (0.4425)	3.7060** (0.0284)	-	-0.0131 (0.1752)
Strong Causality Wald test: F statistics (P-value)					
Dependent variable	Δ LNY, $ECT_{(-1)}$	Δ LNE, $ECT_{(-1)}$	Δ LNC, $ECT_{(-1)}$	Δ LNL, $ECT_{(-1)}$	-
ΔLNY	-	2.4675* (0.0673)	0.8763 (0.4566)	0.1592 (0.9235)	-
ΔLNE	-4.8624*** (0.0035)	-	3.8473** (0.0122)	1.7488 (0.1627)	-
ΔLNC	-3.6642** (0.0153)	2.7795** (0.0457)	-	2.3365* (0.0791)	-
ΔLNL	-1.3360 (0.2678)	1.1453 (0.3353)	1.4462 (0.2409)	-	-

Notes: Partial F- statistics are given for short run changes in independent variables. ECT represents error correction term. Values given in parentheses are probability values of Wald F-statistics estimated for coefficients of independent lagged values for short run causality and strong causality. Asterisks ***, ** and * denote statistical significance at 1%, 5% and 10% respectively.

These findings are in conformity with the findings of Bolke et al.(2011) for a panel of 25 OECD countries for the period 1981-2007. It reported that there was a bi directional causality between energy use and economic growth for the panel. Asafe-Adjaye (2000) lends his support with the estimates for Thailand and Philippines by providing an evidence of bidirectional causality between energy use and economic growth. On the other hand, the findings of bi directional causality between energy consumption and economic growth in this study contradict Lee's (2005) findings of unidirectional causality running from energy to economic growth for a panel of 18 developing countries for a period 1975-2001.

Conclusion

The tests of cointegration and the long run estimators (FMOLS and DOLS) have showed that there is long run association among the variables chosen for the study. The panel causality test provides evidence of strong bi-directional causality between energy consumption and economic growth for the panel of countries. Only capital equation enjoys the long run equilibrium explaining that any shock happen in the short run, the real GDP has the tendency to establish long run equilibrium after a change in the capital shock. In the long run, all the aggregate variables like real GDP, energy consumption and labour force have a tendency to restore the long run equilibrium after the shock.

The estimates of FOMLS and DOLS have shown that the growth elasticities of energy are lower than the growth elasticity of capital stock for the panel of countries.

6. SUMMARY AND CONCLUSION

The first objective of the study is to analyse the long run relationship among energy use, economic growth, gross fixed capital formation and labour force by applying fully modified ordinary least squares (FMOLS) and dynamic ordinary least square (DOLS) using the long run elasticities among the variables. The coefficients of independent variables viz., energy consumption, capital stock and labour force are statistically significant (highly) and bear expected signs. The coefficients of energy consumption and capital stock are positive and significant but, the coefficient of labour is found to be negative. In FMOLS equation, one per cent rise in energy consumption increases real GDP by 0.486 per cent. Similarly, one per cent rise in capital stock increases real GDP by 0.86 per cent. It is inferred that the growth elasticity of energy consumption is lower than the growth elasticities of capital stock estimated for five Asian countries. This result contradicts the findings of Lee (2005) for 18 developing countries, in which, the growth elasticity of energy consumption is found to be higher than the growth elasticities of capital stock. Similarly, our estimates pertaining to growth estimates of energy and capital stock are in conformity with the findings of Apergis et al (2010) and Narayan et al (2008). However, labour force has negative co-efficient and shows that one per cent rise in labour force reduces real GDP by 0.96 per cent.

The second objective is to examine short run and long run causalities between energy consumption and economic growth after accounting gross fixed capital formation, labour force. The findings are that energy consumption Granger causes real GDP during the short run. Similarly, real GDP Granger causes energy consumption. The test clearly points out that there is bi-directional causality between energy and income among the panel of countries in the short run. The long run equilibrium is found only in capital stock equation, in which, only real GDP adjusts towards the long run equilibrium after a shock and the corresponding error correction term is statistically significant at 5% level. With regard to strong causality (joint test) is concerned, in energy equation, real GDP and capital stock bear the burden of shock to restore the long run equilibrium. In capital stock equation, real GDP, energy consumption and labour force have the burden of restoring long run equilibrium in the long run after a shock i.e., all the these macro variables are found to be adjusting towards the long run equilibrium while bear the burden of stock.

These findings are in conformity with the findings of Bolke et al., (2011) in which, there was bi-directional causality between energy use and economic growth estimated for a panel of 25 OECD countries from 1981-2007. A study by Apergis et al, (2010) has supported the bi-directional causality between energy use and economic growth by applying the multivariate framework for a panel of sixteen countries over the period 1980-2005. A study by Asafe-Adjaye (2000) lends support while examining the estimates for Thailand and Philippines; in which, an evidence of bi directional causality between energy use and economic growth was found. The findings of bi-directional causality between energy consumption and economic growth contradict Lee's (2005) findings of unidirectional causality of running from energy to economic growth for a panel of 18 developing countries for a period 1975-2001.

The study has concluded that there is a bi-directional causality between energy consumption and economic growth. Long run estimates have shown that there are long run elasticities pertaining to energy consumption and economic growth. In regard CO_2 emission and per capita income are concerned, per capita income reduces CO_2 emission for the panel of countries. This shows that these countries have been taking series steps in reducing the environmental pollution. Any energy conservation will seriously impair the economic growth of the panel of countries. The panel of countries can have alternative sources of renewable energies like wind, solar, biogas, hydro electric power in order to reduce the fossil fuel use. This study has limitations. One such limitation is that this study has based its analysis by including few developing countries. In future, the researcher can have larger volume of data by including more developing countries in the analysis.

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