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Energy Consumption and Four Growth Hypotheses: An Evidence from SAARC Nations

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ABSTRACT

The contemporaneous study investigates the directional relationship between economic growth and energy consumption for four selected SAARC nations from 1990 to 2018 within a panel-data framework. In the empirical literature, conservation, growth, feedback, and neutral hypotheses exist between energy and economic growth. First, study implies a Granger causality test to find the short-run directional relationship. Secondly, it checks the order of panel unit root that is a prerequisite condition for cointegration particularly when we have a long panel. In the end, based on panel unit root, the study estimates the model with the help of FMOLS to find a long-run relationship. The present study explores the conservation hypothesis in the short run at the regional level for Bangladesh and Pakistan. While the feedback hypothesis and neutral hypothesis exist in case of India and Sri-Lanka respectively. On the other hand, in the long run, there is cointegration between economic growth and energy use, while the direction conforms to the feedback hypothesis in our panel after allowing heterogeneous cross-sectional effect. Thus, energy and economic growth are coupled with each other in the long run at a regional level whereas, energy as a factor of the production process does not contribute significantly in the short run. It is because this region is labour abundant, therefore, the share of energy is significantly low in the final output as compared to developed nations. Consequently, the availability of energy at affordable prices truly matters for developing nations of SAARC.

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1. Introduction

Availability of energy at affordable prices is an important factor of the production process (Warr & Ayres, 2010). There are substantial empirical evidences about healthy relationship

between energy and economic growth (Al-mulali & Binti Che Sab, 2012; Alam, Begum, Buysse, Rahman, & Van Huylenbroeck, 2011; Alper & Oguz, 2016; Bhattacharya, Paramati, Ozturk, & Bhattacharya, 2016; Dogan, Sebri, & Turkekul, 2016; Koçak & Şarkgüneşi, 2017; Safdar, Asif, & Farooq, 2020). This relationship is further categorized into four growth hypotheses and each hypothesis can be tested (Apergis & Payne, 2009). The importance of energy consumption motivates this study to empirically estimate these hypotheses in case of selected South Asian Association for Regional Cooperation (SAARC) nations. This region is home to 23% of the World's population. From the last few decades, good economic performance of this region causes more energy consumption. In SAARC energy demand is growing with 5% growth rate while GDP per-capita growth rate is near to 5.2% (ISGF, 2018). Consistent and balanced economic growth is a prerequisite condition for poverty reduction in this region. Almost the whole block depends upon imported energy in the form of oil. It acquires more consensus on the directional relationship between these two. Kraft & Kraft, (1978) are the pioneers of the empirical work on energy and economic growth and then various studies try to find this directional relationship (Apergis & Payne, 2009; Belloumi, 2009; Hondroyiannis, Lolos, & Papapetrou, 2002; Huang, Hwang, & Yang, 2008; Imran & Siddiqi, 2010; C.-C. C. Lee, 2005; Masih & Masih, 1996). However, there are discrepancies in empirical literature in form of causal relation between these two which convert it into a nexus. The literature about growth nexus is divided into steady state effects and transitional impacts. In the transitional phase, there is debate among the researchers regarding the direction of causality. There are four growth hypotheses in literature. The first one is conservation hypothesis and it is basically one-sided causality that runs from economic growth to energy consumption (Y→ EC). In simple words it is national income (economic growth) that causes more energy consumption (Mozumder & Marathe, 2007). The second hypothesis is growth -hypothesis (Y←EC). Growth hypothesis means more energy consumption causes more economic growth. In this connection, the causal relationship is unidirectional but opposite in direction of conservation hypothesis. The third hypothesis is the feedback. It is bidirectional causal relationship that means energy use at national and economic growth cause each other (Y↔ EC) (Belloumi, 2009). When there is no causality between these two it is called neutral hypothesis.

Present study contributes to existing literature in two unique ways: first, to our knowledge, it is foremost an attempt to empirically analyze the relationship between energy and economic growth in terms of four growth hypotheses for selected SAARC nations. Second, study also contributes to growth theory by introducing energy consumption into neoclassical growth theory along with capital and labor stocks, especially for SAARC nations.

The structure of study will covere the different aspects in the form of sections. In following section 2 discuss the precise review of existing literature about energy-income nexus.. In section 3, describes the data and its source, model and different methods to estimate the model in the long and short run. Results and discussion along with some economic reasons are present in section 4. At the end, section 5 concludes this study and suggests some possible policy recommendations.

2. Literature Review

First time Kraft & Kraft (1978) empirically finds conservation hypothesis in case of the United States. Then a stream of empirical attempts is taken in this regard. Like, Oh & Lee, (2004) find neutral hypothesis in short run and conservation hypothesis in the long run in case study of Korea. Furthermore, the same hypothesis is also found by Paul & Bhattacharya, (2004) for India by using time series data. Likewise, Lee, (2005) investigates the same causal relationship for eighteen Asian countries and finds conservation hypotheses in short run as well as in long run. In this connection, Lee & Chang, (2008) re-investigates the same relationship for sixteen Asian nations and finds cointegration.

Additionally, Khan & Qayyum, (2007) investigate the impact of energy use on economic growth in selected countries of SAARC and find conservation hypothesis in this region. Likewise, Jamil & Ahmad, (2011) analyze the impact of energy price and real GDP on energy consumption in case of Pakistan and also examine causality from GDP to energy consumption (conservation hypothesis). There are many other empirical attempts that support the conservative hypothesis (Huang et al., 2008; Kasman & Duman, 2015; Narayan, Narayan, & Popp, 2010; Shahbaz & Feridun, 2012). Empirical literature also supports the growth hypothesis (Apergis & Payne, 2009; Aslan, Apergis, & Yildirim, 2014; Ouedraogo, 2013; Ozturk et al., 2010). There is positive and bidirectional and cointegration between energy consumption and output of cement industry India (Mandal & Madheswaran, 2010). Similarly, some studies support the feedback hypothesis that means bidirectional causal relationship exists between growth-energy (Belke et al., 2011; Coers & Sanders, 2013). Zhang et al., (2011) find feedback hypothesis at industrial level of Beijing province of China. The feedback hypothesis explores for Belgium (Dogan et al., 2016). Menegaki & Tugcu, (2016) support the neutral hypothesis for a panel of forty two sub-Saharan states. Streimikiene & Kasperowicz, (2016) find the growth hypothesis in panel data analysis of 38 renewable energy consumer states. At last, few researchers discuss neutral impact and argue in favor of the neutrality hypothesis (Kahsai et al., 2012; Śmiech & Papież, 2014; Wolde-Rufael, 2009).

There are two types of growth theories in literature, endogenous and exogenous growth theory (Romer, 2018). Both theories try to explain factors of growth of the real World. Once their focus on the aggregate level of savings as well as technology. In this connection, the both schools totally ignore the importance of energy in the production process (C.-C. Lee & Chang, 2008). However, after the oil crisis of the 70s, there is a healthy debate among economists about the value of energy. Because this oil shock harmed the growth process of oil imported nations. It was Stern, (1993) who introduced energy as an additional factor in production process. According to Stern, productivity of energy matters for growth rather than energy consumption. Additionally, energy augmented labor introduced as a factor of production by a physicist economist (Pokrovski, 2003). The economy wide output is determined by its labor force and available energy resources (Pokrovski, 2003). From literature; we can conclude that strength and directions of relationship between energy and economic growth vary over society and over period of time.

Overall, the literature of energy and economic growth shows some similar results by covering the time span of 19070-2014. Therefore, the possible reason for this kind of results can introduce some biases by adopting the same methodology. Therefore, this innovative work extended this debate by introducing new variables and new econometric models because these variables are important for SAARC nations.

3. Data, Model and Method to Estimate Growth Hypotheses

To check the impact of energy on economic growth, this study is using panel data of four selected countries over the period of 1990 to 2018. Unfortunately, the data of total labor force is started from 1990 to onward for each cross section. The annual data are obtained from the World Development indicators (WDI 2018) for Bangladesh, India, Pakistan and Sri Lanka. The following multivariate model is used for analysis purposes.

$$Y_{it} = \beta_0 + \beta_1 GFC_{it} + \beta_2 LF_{it} + \beta_3 EC_{it} + \mu_{it} \quad (1)$$

Equation(1) states that energy consumption (EC), gross capital formation (GFC), and labor force (LF) are the main factors to derive GDP (Y) (Omri, 2013). Both Y and GFC are in constant 2010 U.S. Dollars. GFC is a proxy of capital stock (Apergis & Payne, 2009). While EC is total energy consumption

in ton oil equivalent (TOE). Evaluating the impacts of energy will help in redesigning the energy sector and introducing the new environmental strategies and policy tools. Energy production and energy consumption are playing a critical role to meet the environmental challenges. Usually, capital is categorised into physical and human capital. Governments play a key role in providing physical or public capital, like telecommunications and electricity. Therefore, the availability of physical capital affects the economic growth since it is assumed that public capital is an essential component of the production process. Additionally, the labor force is affecting growth positively in production. It means labor, capital, and energy consumption are considered critical inputs for the production process. We have long panel data sets, so the real issue of such type of data is heterogeneity.

3.1 Unit Root

First of all, we have to check the integrated level of all variables of our model that is a prerequisite for estimating the long run and short run relationships. we have to check the order of integration of each variable. For this purpose, in literature, many tests of panel unit root have been developed to check the order of integration. When we deal with long panel, generally it suffers from autocorrelation. According to Engle & Granger, (1987), OLS provides spurious results in nature when estimating the model of non-stationary variables. On the same token, this spuriousness may also appear in the long-panel. In this study, we compute five different types of panel unit root tests Levin-Lin-Chu (LLC), Im, Pesaran and Shin (IPS), BU, Augmented Dickey Fuller (ADF) and Phillips Parron (PP) (Breitung, 2005; Im, Pesaran, & Shin, 2003; Levin, Lin, & Chu, 2002; Maddala & Wu, 1999). Each test assumes that every cross section of panel follows the same unit root process except IPS. IPS treats each cross sectional as a separate entity and estimates separate regression for each cross section. The equation of IPS test is replication ADF test of time series data. However the following equation (2) is to be estimated for the IPS panel unit root (Apergis & Payne, 2009).

$$\Delta Z_{it} = \alpha_i + \rho_i Z_{it-1} + \sum_j^k Z_{it-j} + v_{it} \qquad (2)$$

Here, i and t represent cross section and time series. We test the null hypothesis is $\rho_i = \rho = 0$ for all cross sections in case of LLC and UB unit root tests and the alternative hypothesis is ρ < 0. On the other hand, the null is $\rho_i = 0$ against the alternative $\rho_i <$ 0 for each cross section in case of IPS, Fisher-ADF, and Fisher-PP tests (C.-C. C. Lee, 2005).

3.2 Granger Causality

Granger causality is a useful test for forecasting the dependent variable on the basis of available information of independent variable (Peng et al., 2016). According to Liu, (2018) the Granger causality test can be used to find the causal relationship in short run between two or more than two variables. Engle and Granger causality test for our panel as well as for each cross section is applied to check unidirectional and bidirectional relationship of energy and income. Let, we have total energy consumption and economic growth and both series are integrated at level I (1). It means both series are nonstationary at level but stationary at first difference. If the linear combination of two series is stationary at level I (0) then it implies there is cointegration (or long run relationship between two series). At least there would be one sided or unidirectional causal relationship between the two series (Engle & Granger, 1987). If this causal relationship is just running from energy to economic growth, then it is a growth hypothesis. If this causal relationship is reversed, then it is a conservation hypothesis. If both cause each other then it is a feedback-hypothesis.

3.3 Cointegration Analysis

$$\boldsymbol{Y_{it} = \lambda_i + \delta_i t + \beta_i Z_{it} + V_{it}} \quad (3)$$

Above equation (03) is heterogeneous panel cointegration and it allows different cross section effects (Pedroni, 2000). It is an extension of Engle Granger framework in panel setup (Liddle, 2012). There is "no cointegration" between $\boldsymbol{Y_{it}}$ and $\boldsymbol{Z_{it}}$ is null hypothesis of cointegration test. It means the predicted value of residual ($\hat{V}_{it}$) is also non-stationary at level like $\boldsymbol{Y_{it}}$ and $\boldsymbol{Z_{it}}$. If $\hat{V}_{it}$ is stationary at level, then there is cointegration or long run relationship between $\boldsymbol{Y_{it}}$ and $\boldsymbol{Z_{it}}$. In the above equation, λ_i and $\delta_i$are parameters to capture cross-section fixed effects and deterministic trends of each cross section respectively. In other words, these parameters capture the heterogeneity among the cross sections and time specific heterogeneity (Apergis & Payne, 2009; Pedroni, 2000).

3.4 Fully Modified Ordinary Least Square

After confirmation of the short run directional and long run deterministic relationship by Granger Causality and Pedroni tests, the next step is to find consistent and unbiased estimators of model. For this purpose, study uses the group mean panel Fully Modified Ordinary Least Square (FMOLS). This method was developed by Phillips and Hansen (1990). FMOLS is modified version of OLS that can asymptotically provide consistent, efficient (free from serial correlation) and free from endogeneity parameters of cointegration equation when we have non-stationary as well small data (Liddle, 2012; Pedroni, 2000; Ramirez, 2007).

4. Results and Discussion

4.1 Panel Unit Root

The following table 1 summarizes the results of five panel unit root tests that are discussed in the previous section. All tests fail to reject the null hypothesis of unit root at level with no time effects and with fixed time effects. However, all tests reject the null hypothesis of unit root at first difference. It implies that all variables are non-stationary at level. The basic framework LLC and UB test are the same while IPS, Fisher-ADF, and Fisher-PP follow different frameworks that allow cross section heterogeneity. While all tests treat each time series separately and allow heterogeneity then to combine the P-values for an overall test. If we apply conventional panel estimation techniques on such data (like pooled least square etc.) then outcomes will be inconsistent as well as biased. So, it is recommended whenever two or more series are no stationary then it is necessary to move towards the test of cointegration (Liu, 2018).

Table 1 Panel Unit Root

Level	**No time effects**				**Fixed time effects**			
	GDP	**EC**	**GFC**	**LF**	**GDP**	**EC**	**GFC**	**LF**
LLC	6.31	3.69	3.74	-1.03	2.53	0.19	1.34	-3.74
UB	8.51	4.51	4.03	1.64	1.88	2.78	0.55	-0.85
IPS	9.25	6.63	3.73	1.73	6.05	4.31	-0.51	0.49
Fisher-ADF	4.96	1.12	4.08	1.96	3.28	2.49	2.18	0.62
Fisher-PP	5.35	0.77	4.76	0.20	3.71	2.33	2.83	1.34
	No time effects				**Fixed time effects**			
ΔLLC	-1.41	-6.01	-8.01*	-4.2**	-6.06**	-8.85*	-8.67*	-4.57*
ΔUB	0.96	-3.74*	-2.67*	-2.62*	-0.265	-3.53*	-4.04*	-1.79**
ΔIPS	-0.99	-3.81*	-5.04*	- 2.53*	-2.76**	-5.16*	-4.38*	-1.2***
ΔFisher-ADF	-5.33*	-4.06*	-1.30***	-2.73*	-6.32*	-5.45*	-1.32 ***	-1.3***
ΔFisher-PP	-3.54*	-7.64*	-2.85*	-4.34*	-6.319*	-9.16*	-3.17**	-2.63*

Notes: *, ** and *** represents significance at the 1%, 5% and 10% levels, respectively.

4.2 Granger Causality

It is necessary that series should be stationary to apply the Granger-Causality test for short run analysis. Therefore, we are using the first difference of all variables because at first difference they are stationary. In the following table 2, the results of Granger-Causality test for the overall panel and for each country are presented. At regional level, study finds unidirectional causality running from economic growth to energy consumption and it is classified as conservation hypothesis. The conservation hypothesis is a serious threat for environmental sustainability if this relation prevails in the long run. At cross sectional level, study finds conservation hypothesis in the case of Bangladesh and Pakistan. While in the case of India, there is a growth hypothesis at two percent level of significance, however, feedback hypothesis exists at 12% level of significance. In case of Sri Lanka, there is neutral hypothesis (see also: Lee & Chiu, 2011). The main reason for neutral hypothesis in Sri-Lanka is terrorism activities in our selected time span.

Table 2 Granger Causlity Test

Dependent variable (↓)	GDP	EU	GFC	LF	Remarks
GDP		0.66 (0.52)	1.05 (0.35)	0.77 (0.47)	**Conservation Hypothesis**
EU	**2.46*(0.08**)		4.55**(0.012)	0.38 (0.68)	
GFC	0.31 (0.73)	1.27 (0.28)		17.32** (0.00)	
LF	0.27 (0.76)	0.24 (0.79)	0.50 (0.61)		
Bangladesh					**Conservation Hypothesis**
GDP		0.23 (0.80)			
EU	**6.33**(0.005)**				
India					**Feedback Hypothesis at 12%**
GDP		**4.47** (0.021)**			
EU	**2.30 ***(0.12)**				
Pakistan					**Conservation Hypothesis**
GDP		1.05 (0.37)			
EU	**3.62* (0.039)**				
Sri Lanka					**Neutral Hypothesis**
GDP		1.22 (0.32)			
EU	0.81 (0.46)				

Notes: *, ** and *** represent significance at the 5%, 10% and 12% levels, respectively.

4.3 Panel Cointegration Test

To examine the long run relationship or cointegration, present study employs the Pedroni cointegration test (Pedroni, 2000). The results of the Pedroni test have three columns. The second column is labeled with panel statistics that further four test values. In panel statistics, it is assumed that autoregressive term AR (1) is identical across the cross sections. This first-order autoregressive term can be varying in case of group statistics. If the null hypothesis is rejected, then it implies that variables are cointegrated for all cross sections. On the same token, if the null hypothesis is rejected in case of group statistics then it implies that there is cointegration among variables at least in case of one cross section. The PP and ADF statistics confirm the cointegration in the panel. The null hypothesis is rejected in both cases at five percent level of significance. It means there is a long run relationship between energy consumption and economic growth in panel as well as in each cross section.

Table 3 Cointegration Test

	Panel statistics	Weighted statistics	Group Statistics
Variance Ratio	-0.06 (0.52)	0.57 (0.28)	-----
Rho statistic	0.15 (0.55)	-0.48 (0.32)	0.39 (0.65)
PP Statistics	-1.87*(0.03)	-2.17*(0.02)	-1.90* (0.029)
ADF Statistics	-1.88*(0.03)	-2.31*(0.01)	-1.58* (0.057)

4.4 Fully Modified Ordinary Least Square (FMOLS)

For long run, we estimate two separate equations with the help of FMOLS. In following table 4 the long run coefficients along with t-values for each estimated equation are presented. There is significant role of energy use, capital stock and labor in shaping the growth path of SAARC region. This situation also confirms the neoclassical or exogenous growth theory. Energy as a factor of production plays a significant role to achieve goal of economic convergence. On the other hand, the second equation confirms that economic growth, capital stock and labor force have also statistically significant impact on regional level energy use. It is implying that there is feedback hypothesis exist. Moreover, capital stock causes more energy consumption in the long run that further deteriorate the regional environmental situation. Our long run results confirm the feedback hypothesis. It means the promotion of energy consumption policies are effective in terms of economic growth, which in reward further expands the energy demand through dynamic process in the long run.

Table 4 FMOLS

GDP	EC	t-value	GDP	t-value	GFC	t- value	LFT	t-value
	5.02 *	2.79			151.36*	4.21	0.017*	3.68
EC			0.02 7	2.21	36.56	2.61	0.001	2.85

Gross fix capital (GFC) and Labor force (FT) are in natural log form. *indicates coefficients are significance at the 1% level.

5. Conclusion and Policy Recommendations

Analyzing the income-energy nexus is necessary for effective energy and environment related policies. After the 70s oil shock researchers realized the importance of energy and a stream of research endeavored to investigate this nexus. However, the present study tries to investigate this relationship in form of four growth hypotheses (conservation, feedback, growth, and neutral hypothesis). For this analysis, study selects Pakistan, India, Bangladesh, and Sri-Lanka from the SAARC region. In the panel, there are four developing economies and data are collected from WDI from 1990 to 2018. First, the study checks the unit root level of each variable as it is a prerequisite for panel dynamic analysis. Then for short run analysis, the study used the Granger causality test and finds conservation hypothesis for the panel. The same hypothesis exists in the case of Bangladesh and Pakistan and feedback hypothesis for India. Neutral hypothesis holds in case of Sri Lanka. The short run results reveal a variation across the cross sections in terms of energy-income. The study finds a balanced state relationship between energy consumption and economic growth in this region by using the heterogeneous panel cointegration technique. Moreover, to check the cointegration in panel, the study has used Pedroni cointegration test and found the feedback hypothesis in our panel the long run. Therefore, energy and economic growth have strong relationship in the long run. This effective relation boosts the demand for labor and increases the productivity of labor and capital of this region. The intra-regional energy trade

is about five percent of total regional trade among the SAARC nations. However, there are several hidden opportunities for member states to promote regional energy trade and cooperation for better future of this region and humanity. In the following years, the expected rate of economic growth will be increased in SAARC region leading to serious concerns related to sustainability of environment. Therefore, active energy conservation policies should be opted at regional level as well as at national level. To achieve the unique goal of sustainability, there should be regional cooperation among SAARC members.

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