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Energy Consumption and Economic Growth Nexus in the SAARC Region

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Abstract.

In recent years, demand for energy consumption has increased, especially in emerging countries such as the South Asian Association for Regional Cooperation (SAARC) member countries. This study thus aims to investigate the explicit relationship between energy consumption and economic growth in the SAARC countries. The researchers employed panel econometric techniques using data for the period 2002-2020. The study used pooled OLS, fixed effect and GLS estimators for estimation purposes. The pivotal results of the work revealed that the nexus of energy consumption with per capita income is not only significant but also takes an inverted u-shaped. As research evidence in the SAARC region is limited, we expect policymakers working in the energy sector to benefit significantly from the results of this study. This work contributes to the limited empirical studies exploring the impact of energy consumption on economic growth specifically in the SAARC region, with interesting findings that provide important insights to the SAARC region on electricity consumption and per capita income.

Keywords: energy consumption, economic growth, SAARC countries, panel data.

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1. Introduction

In recent decades, the world has experienced exceptional economic growth due to growing industrialization (Jan et al., 2021a; Lai et al., 2021; Mukhtar et al., 2023b; Mukhtar et al., 2023d). According to World Bank data, the global GDP increased from USD 37.224 trillion to USD 72.247 trillion between 1990 and 2014. Therefore, energy consumption around the globe has increased at a rapid pace. British Petroleum (BP) indicates that worldwide energy consumption increased from 8.133 billion tonnes to 12.928 billion tonnes during 1990-2014. Since the 1990s, there has been a significant amount of empirical investigation on the direct causality between energy consumption (EC) and economic growth (EG), but no conclusive findings nor clear explanations have emerged (Hamad et al., 2020; Jan et al., 2020; Jan et al., 2022b). The research endeavour, which

has greatly aided by newly created statistical tools, sought to determine if EG takes precedence over EC or whether EC can increase EG (Hondroyiannis et al., 2002). The advancement of analytical tools in recent years has prompted fresh empirical research (Tahir et al., 2020; Jan et al., 2021b; Shah et al., 2022c), yet the conclusions on EC and EG nexus remain unclear. In this regard, our underlying research question is how energy consumption affects the economic growth in countries/regions?

In literature, two opposing perspectives have been emerged on the nexus between EC and EG (Shah et al., 2022a). According to the first viewpoint, EC is a constraint to economic growth, whereas, the other viewpoint contends that EC has no effect on the growth. As per the growth hypothesis, EC is a critical determinant of growth, either directly or indirectly as a supplement to labour and capital as input variable of production. As a result, a decrease in EC leads to a decrease in EG. The economy is referred to as 'energy reliant' in this circumstance, and energy efficiency initiatives may be undertaken at the expense of real GDP. It has also been suggested that the potential impact of EC on EG will be determined by the economy's structure and the stage of development in the country. With the development in economies, the economy's production pattern is anticipated to shift toward services, that may not be energy-intensive operations (Denison, 1985; Cheng, 1995; Mukhtar et al., 2023a; Mukhtar et al., 2023c).

More research studies have been published that look at empirical links amid energy consumption and per capita income. In literature, there are 4 generations of research on "energy-use–economic-growth relationship". VAR methods (Sims, 1972) and Granger's causality tests were used in first-generation investigations, with the assumption that the set of data remained stationary (Eden S. H and Hwang, 1984; Erol and Yu, 1987). Cointegration is the proper approach for studying these interactions in second- and third-generation research since the variables in issue are non-stationary. When compared to the time series technique, 4^{th} generation studies use panel cointegration and error correction models to provide more strong tests, for instance, (Lee, 2005; Al-Iriani, 2006). According to the assessment of literature, utilization of energy is related to the economic growth. However, no obvious pattern is observed in the literature when it comes to determining whether utilization of energy is a consequence or a requirement for economic development.

There has been very limited research on the link between energy consumption and per capita income in the *South Asian Association for Regional Cooperation (hereafter SAARC)* countries. Indeed, it is pivotal to look at the explicit association of energy consumption with per capita income as the demand for energy is constantly increasing

especially in emerging economies. The SAARC member economies such as India, Pakistan, and Bangladesh are going through transitional stages. The consumption of energy has been increased significantly during the period 2002 to 2020. Accordingly, in this study, we aim to empirically examine the link between per capita income and energy consumption in SAARC member countries listed in Table 1, in order to make recommendations for how the problems may be addressed in the future. The motivation stems from the current study from the influential paper of Yoo and Lee (2010) who investigated the EKC relationship using a different set of countries. The current study specifically focuses on the member economies of the SAARC organization to test the EKC hypothesis using recent empirical data.

This research adds to the existing knowledge by empirically investigating how energy utilisation is influencing the per capita income of SAARC region. The findings of the study endorsed the EKC hypothesis and revealed an inverted U-shaped link energy consumption and per capita income in the SAARC region. This is an emerging region from a growth perspective and hence investigation of such a relationship was indeed required. The findings of the study revealed that energy consumption has a significant influence over economic growth. We expect the policymakers of the SAARC region might be benefited significantly from the outcome of this study.

After introduction, remaining section of the work is organized as follows. The review of previous studies is done in section two. Section three highlights energy consumption in the SAARC region and its possible effect on the per capita income. A brief discussion on methodology and model specification is done in section four. Discussion of the study is carried out in the penultimate section and conclusion is drawn in the last section.

2. Literature Review

Over the few decades, researchers have been interested in examining the impact of energy consumption towards the economic growth (Aydin, 2019; Churchill and Ivanovski, 2020; Humbatova et al., 2020; Lawal et al., 2020). The survival of the modern globalized world is not possible without the consistent supply and consumption of energy. Evidence shows that energy has performed a vital role in recent years in the growth development of most of the developed countries. Yoo and Lee (2010) rightly treated energy as the foundation of economic growth and documented that it works significantly in the socio-economic development. The availability of energy ensures maximum industrial production, and the business activities get flourished. It is the energy that lightens the day-to-day appliances and runs machines.

There are various contending determinants of economic growth which are reviewed in the literature of growth. From past few decades, different researchers have focused on those determinants to explain variation in the growth process of nations (Barro, 1999; Dewan and Hussein, 2001; Barro, 2003). However, the growth process in the modern globalized world has various bases due to its complex nature. Tang (2008) documented that during the past few decades, international trade and foreign direct investment were thought to be responsible for economic prosperities, and however, in recent years the debate is shifted towards determining the relationship amid energy utilization and economic growth. Narayan et al. (2008) observed the reaction of real GDP to shocks in energy consumption and found that except for the USA, energy conservation policies will adversely influence real GDP in the context of G-7 countries. Shahbaz et al. (2012) provided evidence that sources of energy can add to economic growth in the context of Pakistan's economy. Aydin (2019) also investigated it in the context of OECD countries. It is revealed that link between economic growth and energy consumption is temporary, permanent causal and bidirectional. Churchill and Ivanovski (2020) probed the dynamics of energy consumption (long-term and short-term) on economic growth using panel data from seven Australian states. The results indicated that a positive relationship exists between energy consumption and economic output. Lean and Smyth (2010) suggested that the economy of Malaysia should adopt policies to enhance the investment in the energy infrastructure and step-up energy conservation policies to avoid the wastage of energy. The consistent and unbreakable supply of energy is indeed an important factor, and it helps to convert inputs into output by running the machines (Jan et al., 2022a). The availability of energy is the main component of infrastructure development. Furthermore, Apergis and Payne (2011) argued on the essence of energy that it is crucial for the production and consumption of goods and services.

3. Energy Consumption and Per Capita Income in SAARC Region

Prior studies have well-documented the factors affecting the relationship of energy consumption and financial (economic) growth (Lawal et al., 2020; Owoeye et al., 2020). However, the worldwide energy crises of 1973–1974 and 1978–1979 sparked interest in studies on exploring the nexus of energy consumption and financial growth (Lawal et al., 2016). The number of studies attempting to unveil the link amid energy and economic growth has been steadily increasing (Lawal et al., 2020). For instance, the studies by Al-Bajjali and Shamayleh (2018) and Murad et al. (2019) indicated the significance of energy

pricing, income, trade openness, population growth, and foreign direct investment (FDI) as important factors of energy consumption. Despite of exploring the nexus amid energy consumption and per capita income by other researchers, the results are controversial and inconclusive that what are the factors causing economic growth. Hence, the essence of our work is to employ panel data econometrics technique such as fixed effect modelling to uncover the association amid energy utilization and per capita income in the considered sampled countries.

The SAARC region includes the larger countries like India, Pakistan, and Bangladesh and small countries like Sri Lanka, Nepal, and Bhutan. All these countries are passing through the transitional stage of development. These economies are well equipped with greater potential in terms of huge population sizes and abundant land resources. Therefore, keeping the available potentials in mind, how the region is trying hard to accelerate the long-run economic growth by implementing various policies including energy. Table 1 reports the yearly energy consumption and per capita income for the SAARC region.

TABLE 1: Statistics on energy consumption (KWh per capita) and per capita income (constant US $).

Years	Bangladesh		India		Nepal		Pakistan		Sri Lanka	
	PCGDP	elect	PCGDP	elect	PCGDP	elect	PCGDP	elect	PCGDP	elect
2002	431.62	118.92	609.03	416.98	299.57	69.28	603.53	371.83	1086.86	305.37
2003	444.99	125.30	646.65	437.46	306.02	72.12	621.46	397.13	1136.29	327.12
2004	461.51	160.34	687.30	459.33	315.26	75.91	655.51	417.01	1182.01	353.48
2005	485.15	171.04	740.11	476.52	321.45	78.44	693.17	451.15	1242.42	398.08
2006	511.33	191.60	797.25	519.10	327.83	85.23	722.57	475.25	1323.28	399.78
2007	541.48	200.80	863.46	553.00	334.89	89.09	743.52	470.43	1400.46	416.18
2008	568.18	202.91	885.17	573.67	351.28	84.80	742.23	433.79	1468.62	420.87
2009	590.72	220.80	947.74	613.70	363.12	98.17	749.40	450.62	1505.42	418.33
2010	616.94	248.12	1031.56	657.42	376.34	103.18	748.01	458.20	1610.11	450.97
2011	649.36	259.29	1086.04	713.46	384.77	115.33	755.40	450.19	1724.84	490.82
2012	683.51	279.60	1126.90	759.92	398.77	119.20	768.83	447.24	1883.03	526.81
2013	715.83	299.92	1189.78	806.37	409.04	123.07	789.58	444.28	2004.25	562.79
2014	750.42	320.23	1262.63	852.82	426.48	126.94	818.87	441.32	2135.65	598.78
2015	1248.45	301.88	1605.60	763.98	901.74	134.67	1356.66	444.39	3843.78	527.04
2016	1322.69	308.01	1719.31	777.56	897.40	139.26	1402.08	449.90	3972.10	527.95
2017	1403.86	310.03	1816.73	782.02	964.89	140.13	1449.53	447.26	4067.99	528.69
2018	1498.38	306.64	1915.43	774.52	1021.33	138.02	1502.89	447.18	4157.28	527.89
2019	1603.95	308.23	1972.75	778.03	1069.78	139.14	1487.35	448.12	4225.10	528.18
2020	1625.67	308.30	1797.76	778.19	1028.46	139.10	1465.88	447.52	4052.74	528.25

Source: World Development Indicators

Table 1 shows statistics on per capita income (Constant US $) and per capita energy consumption (KWh per capita) for all sampled countries over the study period of 2002-2020. Three years moving averages are used to generate the missing values of energy consumption from 2015 to 2020. It can be seen from Table 1 that there is an increasing trend for all countries both in per capita income and per capita energy consumption. The energy consumption has been increased from 118.92 in 2002 to 308.30 in 2020 while per capita income is increased from 431.62 dollars to 1625.67 dollars in constant prices for the economy of Bangladesh. Similarly, the Indian economy has also observed an increasing trend both in per capita income and energy consumption throughout study. The energy consumption and per capita income in the context of Pakistan's economy have been increased but marginally. This could be the possible reason why the economy of Pakistan is not doing well economically in recent years. The statistics reported in Table 1 further shows that Sri Lanka and Nepal have experienced an increase both in per capita income and also in energy consumption. Overall, for the sample as a whole, the mean of per capita GDP is 1527.440 (constant US $) and per capita, energy consumption is 380.136 (KWh per capita).

In the next step, we have plotted per capita income and per capita energy consumption using a line graph to note their behaviour over the years. The red line stands for the per capita GDP while the blue line indicates energy consumption for the sampled countries. It can be seen from the graph that energy consumption and per capita income are directly related to each other. Similarly, the correlation coefficient between the two series is 0.486 which is sufficiently strong. In other words, energy consumption and per capita income are moving in the same direction. Individual graphs for all countries are reported in Figure 2 in the appendix section.

4. Model Specification

There are 8 countries in the SAARC region but only five are picked for this study owing to the unavailability of data. Afghanistan, Maldives, and Bhutan are dropped, and the rest of the countries are taken into the sample. The model that could be used in the present study will be a panel model as the data is comprised on the two dimensions i.e., time series and cross-sectional. Mentioned below is the model specified for analysis.

$Y_{it} = \beta_0 + \beta_1 Income_{it} + \beta_2 Income_{it}^2 + U_{it}$ Where Y_{it} represent energy consumption per capita in KW and stands for income per person and its square term. For the EKC to be held in the SAARC region, the coefficient attached with the linear term of income (β_1) should exceed zero and the coefficient attached with the square term of the income

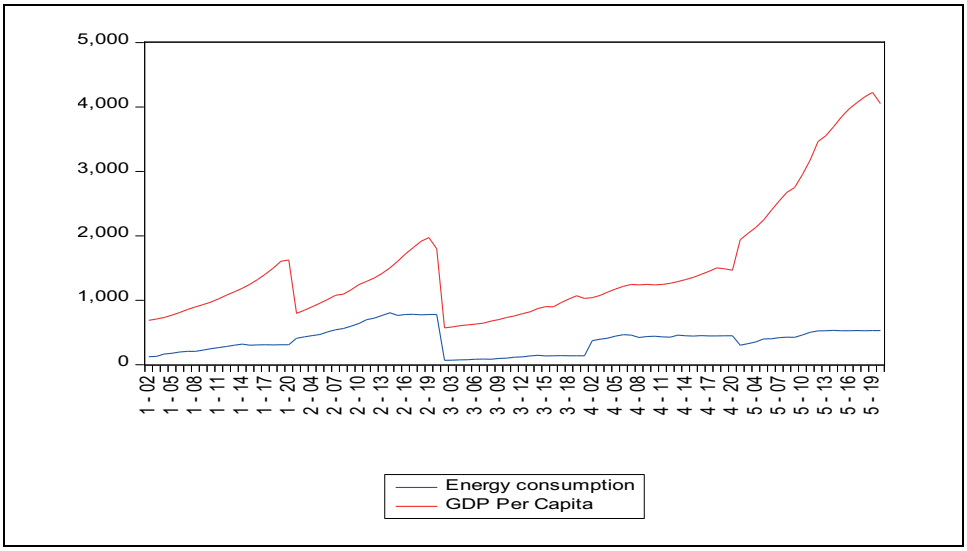

Figure 1: The behaviour of per capita income and per capita energy consumption for all countries.

(β_2) should be less than zero. Data on the mentioned variables are taken from World Bank development indicators.

4.1. Estimating Methodology

The specified equation for this work is a panel data model based on time series and cross-sectional dimensions and hence requires panel econometric techniques for estimation. Dewan and Hussein (2001) documented that for panel data, two econometric techniques, either fixed-effect model (FEM) or random-effect model (REM) can be used. The FEM is suitable in such cases when there is corelation between cross-section specific error term and independent variables. Whilst REM is applicable when there is no correlation between cross-section specific error term and the independent variables (Shah et al., 2018). When serial correlation spots between explanatory variables and error term, it is safer to employ FEM for the analysis (Hill et al., 2018). However, the decision about the appropriateness of FEM or REM would be made by employing the Hausman (1978) specification test (Jan et al., 2019; Shah et al., 2021; Shah et al., 2022b; Shahzad et al., 2022; Shah et al., 2023; Tahir et al., 2023). The results of the Hausman test reported in Table 2 shows a Chi-sq value 10.82 and probability less than 5 percent, therefore, FEM is preferred over the REM. Further, in the panel data, cross sections more often lead to the problem of heteroscedasticity. Tahir et al. (2018) argues that when heteroscedasticity issue occurs, standard errors not only invalidate the significance but also leave no influential impact on the coefficients of independent variables. To overwhelm this issue, White (1980) robust estimator is used to address

the problem of heteroscedasticity. The empirical results are reported in the Table2. In addition, we have also employed the Generalized Least Squares (GLS) estimator to check the sensitivity of the results.

Table 2: Main results.

Variable	Pooled least squares	Fixed effects	GLS
Constant	-59.105	-13.395	-10.788
Income	16.876***	4.462***	3.745***
$Income^2$	-1.086***	-0.248***	-0.199***
Diagnostic tests	Adj-R-Squared=0.703 F-test= 112.500***	Adj-R-Squared=0.984 F-test= 1008.106***	Adj-R-Squared=0.985 F-test= 1040.253***
Hausman test	Chi-sq. statistics= 9.866***		
No of observations No of cross-sections	N=95 5		

Note: *The dependent variable is per capita energy consumption. The null hypothesis of the poolability test is rejected*

5. Results and Discussion

Table 2 reports the regression results based on both pooled least squares estimation as well as the fixed effects estimation. The pooled least squares results show that the relationship between per capita income and energy consumption is not only positive but also statistically significant. Similarly, the square term of per capita income is negatively associated with the dependent variable as expected. The initial knowledge regarding the relationship independent and dependent variables are obtained using pooled regression models as documented by Chen and Gupta (2009).

The results of fixed effects show that the linear term of income level is positively and significantly related to energy consumption as expected. The point estimate suggests that an increase in per capita income would bring a huge increase in energy consumption. In other words, the demand for energy consumption will be accelerated in the upward direction. Further, the results show that the square term of the income level bears not only a negative coefficient but is also different from zero at the standard level of significance. The negative relationship between the square term of income and per capita energy consumption signifies an inverted U-shaped relationship. An inverted U-shaped association amid per capita income and energy consumption signifies the EKC hypothesis that is existed in the SAARC region. In other words, the EKC hypothesis

holds for the sampled countries. Yoo and Lee (2010) also reached a similar conclusion. The results depicted in last column of Table 2 also showed that inverted U-Shaped EKC is existing in the SAARC region as the coefficient of income per capita is positive and significant while the coefficient of the square of income is both negative and statistically significant. Moreover, inverted U-shaped nexus amid per capita income and energy consumption indicates that the consumption of energy accelerates but at a diminishing rate with the income per capita. Energy consumption increases but eventually it falls with increasing income. Therefore, it is vital for policymakers to be aware regarding the nexus of energy consumption and economic growth. Moreover, they should keep in mind the diminishing property while devising policies related to the energy sector.

6. Conclusion

This research seeks to inspect the nexus between per capita income and energy consumption in SAARC region. The SAARC member economies are chosen as a sample and the empirical data utilized were from 2002 to 2020. Panel econometric techniques are employed for estimation. It has been found that there is an inverted U-shaped relationship between energy consumption and per capita income in the SAARC region. The SAARC region is an emerging region from a growth perspective and hence investigation of such a relationship was indeed required. The results imply that the relationship between energy consumption and per capita income is non-linear. Policymakers in energy sectors are, therefore, suggested to consider the non-linear relationship found in this study while devising and implementing policies related to energy consumption. Different policies can be used to influence linear and non-linear relationships between the variables. Therefore, policymakers will be in a better position to meet the consumption and demand of energy using the available knowledge about the explicit linkage amid energy consumption and economic growth.

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Appendix

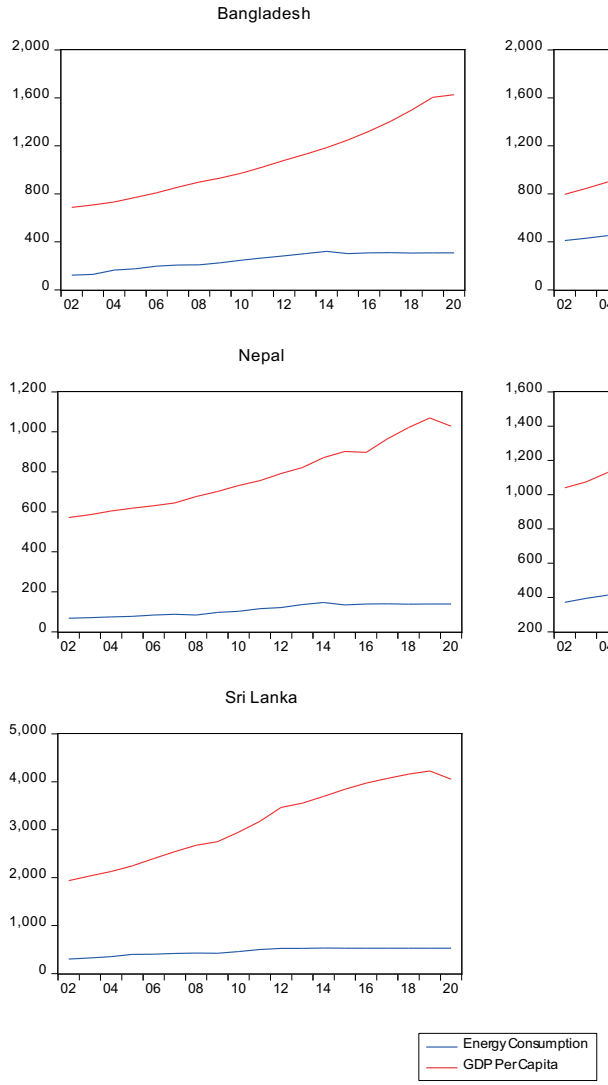

Figure 2: The behaviour of per capita income and per capita energy consumption for individual countries.

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