Energy Consumption, Economic Growth, and Human Development Index Evidence from SAARC Economies

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ARTICLE INFO	ABSTRACT
  	The majority of energy used globally is attributed to human activities. To enumerate exactly how energy consumption affects the process of human development, however, may be necessary. There is much work to be done in this area of inquiry. The association between energy consumption, economic growth, and the HDI is therefore explored in this study. For this purpose, we used the panel data of SAARC countries from 1971 to 2019. Data is taken from the World Bank and human development reports. This purpose of study is to investigate the connections among energy use, economic growth, HDI, trade openness, environmental variables, and urbanization in the context of SAARC economies. In this work, we utilized the Housman test, the random effect model and the fixed effect model. This study shows that energy consumption has a negative but significant impact on the human development index.

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1.   Introduction

Pakistan is dependent on conventional energy resources. Abundant energy resources are available in the country. All kinds of renewable energy like Tidal, energies, geothermal, biomass waste to energy generation, biodiesel manufacturing, wind, solar, and micro canal reduction (Sheikh, 2010). Because industrialized economies have significant levels of environmental deterioration, they face a challenging scenario when it comes to sustainable industrial expansion (Naqvi et al., 2023). Pakistan has a wealth of resources for the generation of wind energy. Ambitions for the millennium Energy is essential for improving agriculture, transportation, and poverty eradication, and sustainable human development also promotes economic progress (Karekezi et al., 2012). The increase in renewable energy is mostly due to climate change, one of the biggest issues facing the globe today. Therefore, fossil fuels may be a contributing factor to climate change. The threat of climate change becomes one of sustainable growth (Kaygusuz, 2007). The government and policy invest in renewable energy, particularly in the most developed and emerging nations (Brazil and China).

Gross domestic product (GDP) and production function to illuminate the progress the latest literature suggests that trade openness can be involved. The foremost examine the vibrant association between economic development, trade and price of Malaysia, electricity generation Lean and Smyth (Lean & Smyth, 2010). Global warming is one of the utmost momentous continuing apprehensions in the 21st epoch due to climate change abolishing disastrous climate catastrophes that still threaten to wipe out the entire world. Greenhouse gases are the primary contributor to and danger from this expanding global warming (Bin et al., 2017). China shows the overall effect of the promotion of renewable energy construction and intake is one of the corrective actions that tends toward long-term growth. Between 1977 and 2011, As a result, if used in large amounts, energy can help to sustain economic expansion while also helping to

slow down China's rising carbon dioxide emissions (Tugcu & Topcu, 2018). The infrastructure needed to support a prospective hydrogen-based renewable energy organization must be altered technologically. (Bhutto et al., 2014).

A deliberate energy policy goal is to increase the utilization of renewable energy sources across several countries (Blazejczak et al., 2014). A variety of approaches are used in the literature and publications to examine the relationship between the development and usage of renewable energy sources (RES) and the features of national economies (Karger-Kocsis & Bárány, 2014). According to Lukaitytė (2011), the state import is 10 -15 percent of energy and the imports of Lithuania are around 77 percent of energy (Blazejczak et al., 2014). In a recent theory, Toman and Jemelkova (2003) contend that the majority of research on energy and economic development explores how development affects energy and vice versa. This theory demonstrates the impact of variations in the energy supply on global economic growth in both developing and industrialized nations. According to Toman and Jemelkova (2003), there isn't a lot of mainstream economics literature on this topic. The considerable talks about the productivity slowdown during the oil crisis of the 1970s were the exception. Fossil fuels are the main source of the growth in carbon dioxide (CO_2) emissions in the world's energy mix (Lin & Moubarak, 2014). Conventional and non-conventional sources of energy a continuing shift has been taking place during the last decade (Monroy et al., 2018). The negative influences of environmental and conventional energy forms of production are the decrease of conservative causes of energy, the requirement for renewable energy foundations (RESs), and the product of the environment (Papageorgiou et al., 2020). The research questions of the current study are (i) whether energy consumption hampers human development? (ii) Whether economic growth is a major factor influencing human development or not?

2. Literature Review

Kristjanpoller et al. (2018) investigated the dynamic interactions between energy use and economic expansion the result is that there is bi-causality in the long-term components, although only short- and medium-term fundamental relationships between GDP and energy consumption are acknowledged. Z. Wang et al. (2018) concluded that using renewable energy has a detrimental consequence on both human growth and economic growth. Adams et al. (2018) worked on economic development, non-renewable energy regimes, and renewable energy regimes. The results demonstrate that mutually renewable and nonrenewable energy abstain a sizable progressive impact on economic expansion. Gozgor et al. (2018) proposed the OECD countries' energy use and economic progression are assessed using new data. The study discovers that a faster rate of economic progress is correlated with both non-renewable and renewable energy consumption, regardless of how complicated the economy is.

Liu and Hao (2018) assess the energetic associations amongst energy use, CO_2 emissions, and economic progression in the Belt and Road countries. Jenniches (2018) looked at a literature analysis examining the provincial economic effects of renewable energy sources. B. Wang et al. (2018) major findings of the study demonstrate that GDP per capita greatly increases the utilization of renewable energy. Lin and Benjamin (2018) using MINT data, panel dynamic ordinary least square models were utilized to look at the causal relationship between energy use, foreign direct investment, and economic growth. Pradhan et al. (2018) examined the connection between economic growth, financial sector development, and energy consumption habits in FATF member nations. Tugcu and Topcu (2018) studied the relationship between total energy use, including that from renewable and non-renewable sources, and economic expansion. Zafar et al. (2018) reviewed Pakistan's adopted renewable energy policy was analyzed. According to the study's findings, as governments are more inclined toward the production of thermal power to close the enormous supply-demand gaps in energy, and to construct the green road, substantial political and financial commitments are needed. Afonso et al. (2017) explored methods for integrating renewable energy foundations with economic growth. The results confirm the generally accepted benefit of non-renewable energy on economic expansion.

Alvarez-Herranz et al. (2017) focused on reducing air pollution through renewable energy consumption and energy innovation. The results of this study show how energy innovation reduces environmental pollution. The utilization of renewable energy benefits the environment, it is stated last. Furuoka (2017) investigated in the Baltic countries were the rise in economic

output and the utilization of renewable electricity. The results of this analysis suggested that there was a unidirectional fundamental association between the convention of renewable energy in these nations and economic progress. The absorption of greenhouse gas (GHG) discharges in the troposphere has significantly increased as a result of human activity during the past two decades. The amount of CO_2 that is typically emitted increases significantly while fossil fuels are scorched. For 10,000 years, the level of accumulated CO_2 emissions was between 260 and 290 parts per million, but it dramatically increased during the 19th century. Future CO_2 concentrations are above 385 and rising by an average of 2 parts per million annually (Intergovernmental Panel on Climate Change, IPCC 2007). The worst impact on climate change, according to IPCC, will result in an 80% reduction in global greenhouse gas emissions by 2050 (Ahn et al., 2015).

Shafiq et al. (2020) examined a rise in the use of renewable energy sources, and economic growth is associated with a drop in CO_2 emissions. Moreover, urbanization and the growth of the service sector industry raise carbon dioxide emissions. Osobajo et al. (2020) Economic expansion and energy use both significantly reduce CO_2 emissions. Otim et al. (2022) proposed the causal relationship between energy consumption and economic growth has been examined in this study. Volkan and Javakhishvili (2022) studied that while an increase in energy consumption is beneficial to economic expansion, it is detrimental to the advancement of finance. Farooq et al. (2023) conclude that environmental taxes play a crucial role in promoting environmental sustainability. Health indicators get a lot better when environmental rules are followed (Wang et al., 2023). Nazir et al. (2023) studied environmental laws have a direct impact on lowering emissions. The study's conclusions have a big impact on how pollution is controlled by enforcing environmental laws and promoting innovation.

3.   Theoretical Framework

The effect of economic advancement and the use of renewable energy on human development has been extensively studied. Growth theory, which explains the true pattern of growth rates, and time series investigation demonstrate that energy and GDP co-integrate and that, when additional variables like energy costs or other production inputs are taken into account, energy use Granger affects GDP. The potential for additional significant reductions in the energy intensity of economic activity is considered in light of theory and empirical findings. Solow (1988) neoclassical exogenous growth models require that the economy achieve a stationary point when no net investment is made.

Capital ↑ Labour productivity Growth ↑

According to the Arrow (1962) model, as more capital goods are cumulatively produced, their productivity increases with time. According to Hicks (1932), technological innovation rises when the cost of an input, such as energy, goes up. The saving rate has a long-lasting impact on the growth rate; a higher saving rate boosts economic growth.

Technology ↑ Energy input ↑ Savings rate ↑ Growth ↑

Keynes' theory of domestic consumption, spending, gross investment in the private sector, government spending, and net export. Keynesian economic growth or expansion is more influenced by the effective demand for the production factors of labor, capital, natural resources, and technology. The aggregate supply theory and the neoclassical and contemporary theory are the two main theories of economic growth. The amount of labor and capital are thought to have a significant impact on output growth in neoclassical theory. Capital can be referred to as either money or physical assets. Constant other factors will boost output by adding more workers and capital.

Capital ↑ Labour ↑ Output ↑ Growth ↑

The three most important components of production in the neoclassical growth model are capital, labor, and land, although energy is seen as a transitional contribution that is ultimately created by the primary factors of production. Energy and capital, according to neoclassical economics, are completely interchangeable. Human capital stock and labor force are the two production factors. Only capital and human capital have a progressive link with economic development among the factors of production. The formula Y=AK can be used to

express the link between capital and output. In contrast to the neoclassical paradigm, the capital, K, is defined more widely

$$Primary\ input \uparrow Energy\ Growth \uparrow$$

Machmud and Sidharta (2016) present human development theory. The idea of "basic need development" actually heralded the emergence of the human being as the primary objective of progress. The infant mortality rate, life expectancy, and literacy rate are the three variables used in the feature of life index; it is used to evaluate the development paradigm's effectiveness. The low quality of human resources and tendency toward electricity consumption is caused by low economic growth, which is a relationship or interdependence between economic growth and human assets. To quantify how renewable energy consumption affects the process of human development in Pakistan, theories looked at the relationship between renewable energy consumption, economic growth, and human development (Ghali & El-Sakka, 2004). According to the Canadian theory, the amount of energy and electricity consumed per person is strongly connected with economic growth and markers of modern living, with the implication that the more energy, particularly in the form of electricity, is consumed, the better the lifestyle.

## 4.	Data and Methodology
We used unbalanced panel data from the years 1971 to 2019 for our investigation. The World Bank has been used to extract the variables' data. Data from the human development report (World Bank, 2020) is used to calculate the HDI value as a measure of the human development process. The model that this study used to for analysis is given below:

$$HDI_{it} = \alpha_0 + \alpha_1 LE_{it} + \alpha_2 GDPC_{it} + \alpha_3 AL_{it} + \alpha_4 EC_{it} + \alpha_5 UBN_{it} + \alpha_6 TO_{it} + \varepsilon_{it} \qquad (1)$$

Where;

HDI = Human Development Index, LE = Life expectancy, GDPC = Gross domestic product per capita, AL = Adult literacy rate, EC = Energy consumption, UBN = Urbanization, TO = Trade openness and ε = error term.

### 4.1.	Research Methodology
4.1.1. Fixed Effect Regression Model Approach
When the default for time-series, cross-section, and punitive data, the results of the fixed effects modeling demonstrate this. Accepting alteration inside and amongst properties is critical when choosing modeling approaches.

- 	A large number of parameters
- 	More reasonable assumption
- 	Precludes time-invariant regression

There are numerous possibilities for using the panel data technique, depending on our assumptions on the intercept, the slope of the coefficient, and the error term. Assume that the error term captures variations over time and individuals and that the intercept and slope coefficient are constant throughout space and time. The intercept fluctuates between individuals while the slope coefficients remain fixed. The intercept changes over time while the slope coefficients remain fixed. Each coefficient's intercept and slope coefficient are different for each individual. Over time and between individuals, the slope coefficient and intercept change. The intercept for each company and the slope coefficient is constant across firms, indicating the collective independence of all companies or each cross-sectional entity. We have a subscript I on the four firms' intercepts, which could be different. Write the equation as:

$$y_{it} = \beta_{1i} + \beta_2 X_{2it} + \beta_3 X_{3it} + \varepsilon_{it} \qquad (2)$$

Although the intercept may vary between the four organizations, the term "fixed effect" describes the notion that because each specific intercept is time-invariant, it does not change over time. It will be implied that each company's or person's intercept is time-variant if we write the intercept as β_1. Assume that the repressors' slope coefficients don't change over time or between individuals.

4.1.2. Random Effect Regression Model Approach

Bias is an omitted variable in random effect modeling that correlates lower covariates and higher-level residuals. A small number of parameters

- Efficient estimation
- Objectionable assumption

The primary goal of employing panel data in many applications is to enable the overlooked result to be associated with the descriptive variables. The essential premise of ECM is the error term. Is selected at random from an abundant bigger population. However, this may not always be the case. Consider the scenario where we need to research the lawbreaking ratio in each of the 50 US states. The 50 states are not a representative sample of all states in this situation, it cannot be assumed. We write the equation:

$$y_{it} = \beta_1 + \beta_2 X_{2it} + \beta_3 X_{3it} + \varepsilon_i + v_{it} \tag{3}$$

The method suggested by proponents of the so-called error component model or random effect model may be appropriate if the dummy variables do indeed indicate ignorance of the true model. We presume that β_{1i} is a random variable with a mean value of β_1 no subscript rather than treating it as fixed. I here. The error term ε_i reflects the unique variations in the intercept value of each organization.

5. Results and Discussion

The descriptive statistics for the model are presented in Table 1. The table presents the mean, median, maximum, minimum, and standard deviation values for both the dependent and independent variables in each row. The mean is calculated by dividing the sum of all observations by the total number of observations. It represents the mean value across all categories. A mean is associated with each variable. Skewness is a statistical term that quantifies the degree of asymmetry or unevenness present in a given series. A skewness score of 0 suggests that the variables exhibit a symmetrical distribution. If the tail of the distribution exhibits a leftward skew, it can be inferred that the data itself is also skewed to the left. Conversely, when the tail of the distribution exhibits a rightward skew, it can be inferred that the data is also skewed to the right.

Table 1: Descriptive Statistics

	Mean	Mini	Max	Std. dev	Skewness	Kurtosis
HDI	0.572	0.487	0.836	0.324	0.386	2.392
LE	0.169	-0.039	29.478	1.234	19.081	345.964
GDPC	111.236	0.263	1486.395	25656718	2.024	16.348
AL	94.956	9.678	431.234	66.846	2.447	11.787
EC	6.834	0.450	41.856	4.235	2.136	9.796
UBN	1.037	0.996	11.930	1.246	2.567	6.196
TO	2.034	0.987	10.680	1.235	1.068	6.135

Based on the information shown in the table 2, the null hypothesis is rejected and the alternative hypothesis is accepted due to the reported P-value being lower than the predetermined level of significance of 5%. Consequently, the fixed effect model demonstrates greater presentation compared to the random effect model. Consequently, we proceed to estimate the fixed effect model and subsequently analyze and interpret the obtained results.

Table 2: Hausman Test

Test-summary	Chi-sq. stat	Chi sq. d.f	P-value
Cross section random	132.314	4	0.000

After determining the results of the Hausman test, we calculated the fixed effect approach, the results of which are provided in table 3. The findings derived from the application of a fixed effect model. The results indicate that the independent variables, namely life expectancy, gross domestic product, adult literacy, urbanization, and trade openness, exhibit a positive correlation with the dependent variable. Conversely, energy consumption demonstrates a negative correlation with the dependent variable, specifically the human development index (HDI).

Table: 3 FEM Results

Variables	Coeff.	St. Error	t-Stat	P-value
LE	0.024	7.802	13.877	0.002
GDPC	0.035	9.532	4.236	0.010
AL	0.041	0.013	-5.438	0.000
EC	-0.026	0.045	-2.424	0.031
UBN	0.022	0.032	-6.124	0.000
TO	0.036	0.057	-5.143	0.000
C	0.561	0.016	36.445	0.000
R-square	0.811		F statistic	132.839
Adj R-square	0.928		Prob(F-statistics)	0.000

Note: Variables are significant at level of 5%, Dependent variable: Human Development Index

When considering life expectancy, the coefficient of 0.024 reveals a statistically significant positive association with the dependent variable. The findings indicate that a one-unit increase in life expectancy is associated with a 0.024 rise in human development. The findings of our study align with previous research, such as the work conducted by Thurow (1992), which corroborated the favorable association between life expectancy and human development. The regression coefficient of GDPC is 0.035, indicating a positive and statistically significant relationship with the dependent variable of human development. According to the findings of the Gross Domestic Product per Capita (GDPC) analysis, an increase of one unit in GDPC is associated with a corresponding rise of 0.035 in human development. The findings of our research align with the study conducted by Klasen (2000), which substantiated a positive correlation between Gross Domestic Product per Capita (GDPC) and human development.

The coefficient of the adult literacy rate is 0.041, indicating a positive and statistically significant association between adult literacy and human development. The findings suggest that a one-unit gain in adult literacy is associated with a corresponding rise of 0.041 in human development. The findings of our study align with the research conducted by Khan et al. (2019), which substantiated a positive correlation between the rate of adult literacy and indicators of human development. There is a statistically significant negative relationship between energy use and human progress (energy consumption coefficient = -0.026). The study's findings imply a negative association between energy consumption and human development, with a decline of -0.026 in human development for every one unit increase in energy consumption. Our results are in line with those of Al-Nasser (2012) who also found a negative and statistically significant correlation between energy consumption and human progress. The coefficient of urbanization has been determined to be 0.022. The coefficient of urbanization exhibits a statistically significant positive relationship between the level of urbanization and the degree of human development. The study's results suggest that an increase in urbanization by one unit is linked to a proportional rise in human development by 0.022. The results of this study align with the studies undertaken by Naz et al. (2012) and Bandiera and Natraj (2013), which demonstrated a favorable and statistically significant association between urbanization and human development. The analysis ultimately demonstrates a noteworthy and statistically significant association with the degree of trade openness.

6. Conclusion

This study aims to analyze the relationship between energy consumption, economic growth, and HDI in the context of SAARC economies from 1971 to 2019 while taking into account trade openness, environmental concerns, and urbanization. The fixed effect model, random effect model, and Hausman test are used to examine the aforementioned relationships. First, the human development index is significantly impacted favorably by economic expansion. Growth in the economy promotes human development. Increased energy use also impedes the process of human development. However, it is determined that this statistical evidence is not substantial. More intriguingly, trade impedes the process of human development. It is crucial to provide a set of policy recommendations that can improve Pakistan's human development conditions in light of the study's findings. Based on the analysis, the following policies are advised. The majority of people's standard of living can be raised by the implementation of policies for the efficient use of renewable energy. The amount of renewable energy in the mix of energy sources should be increased by the government, and it's crucial to enable its usage in industries crucial to human development, such as the health and education sectors. To maintain a clean, safe, and healthy environment while also boosting economic growth and overall energy

output, policymakers must implement a revolution in the renewable energy industry. GDP is a key indicator for policy. Therefore, policies that might increase national income will encourage the process of human development in SAARC economies.

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