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EXPLORING THE DYNAMICS OF ENERGY CONSUMPTION AND ECONOMIC GROWTH IN SOUTH ASIAN COUNTRIES: A PANEL DATA ANALYSIS

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ABSTRACT

Energy is pivotal for economies to function, providing the necessary inputs for manufacturing goods and services. It encompasses hydro, wind, geothermal, solar energy, nuclear power, and other nonrenewable and renewable energy sources. This study's goal is to investigate the relationship between economic growth and energy consumption in Asian nations (Pakistan, India, China, Sri Lanka, and Bangladesh) from 1998 to 2022, using secondary sources such as the World Development Indicator (WDI) and the International Energy Agency (IEA). The dependent variable, gross domestic product (GDP), is examined against the four independent variables gross capital formation, nonrenewable resources, renewable resources, and foreign direct investment. Various statistical methods including panel unit root, Granger causality test, panel least squares, and co-integration are employed. The estimated results of the panel least square model indicate that there is a moderate and significant correlation among variables. Non-renewable sources (0.0049) and REN (Renewable Energy sources) (0.0298) demonstrate weaker associations with the dependent variable. The coefficient for FDI (Foreign Direct Investment) is 0.677, which shows a positive relationship with the dependent variable. GFCF (Gross Fixed Capital Formation) variable, which exhibits a positive correlation with a coefficient of 0.0889. The results indicate a moderate and significant correlation among variables, with non-renewable and renewable energy sources demonstrating weaker associations with GDP. Foreign direct investment has a favorable association with GDP, as gross fixed capital formation. These findings of the study highlight a strong positive link between the independent and dependent variables.

Keywords: Energy consumption; Economic growth; South Asian countries; Panel data analysis.
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INTRODUCTION

Energy serves as the primary input for numerous production and consumption activities, thereby rendering it the primary driver of economic growth (Alper & Oguz, 2016). Since Adam Smith onward, economists have traditionally addressed land, labor, and capital as the three main inputs (Noor & Siddiqi, 2010; Hussain et al., 2023) for economic activity on the production side of the economy (Elliott et al., 2015; Saidi & Hammami, 2015). In the Keynesian perspective, Energy has grown as a fourth important element with the development of industrialized countries. Energy consumption in all its forms drives economic productivity, where consumption and income have a strong correlation (Noor & Siddiqi, 2010). The interaction of energy use and economic development in Asian countries is important for various reasons (Elliott et al., 2015) Asia has some of the fastest-growing economies in the world, and energy consumption is a key contributing factor in this expansion. However, there are worries that rapid economic expansion may result in excessive energy use and exacerbate climate change (Bhattacharya et al., 2015).

Energy encompasses the physical inputs required for the manufacturing of goods and services (Farooq et al., 2022). Nonrenewable resources like oil, coal, and natural gas or renewable energy sources including hydro, wind, geothermal, and solar energy all forms of energy are included in the energy sources (Nishat et al., 2023) The term "Non-renewable energy" talks about energy sources that have a finite supply and cannot be replenished quickly. Coal, oil, and natural gas are some examples of nonrenewable resources (Yu et al., 2023). Non-renewable energy sources are generally associated with high greenhouse gas emissions (Akpanke et al., 2023) and environmental impacts, and their extraction (Raihan & Tuspekova, 2022) and use can have significant economic and geopolitical implications (Parveen et al., 2020). Renewable energy refers to energy sources that are naturally replenished (Majewski et al., 2022). Energy security and job development are only two of the many economic advantages that come with using renewable energy sources, which are also consistently associated with fewer greenhouse gas emissions and environmental effects (Ali et al., 2022).

The International Renewable Energy Agency (IREA) computes that by 2030 the usage of renewable energy will boost employment opportunities, improve human welfare globally by about 3.7 percent, and increase global GDP by around 1.1 percent (Xie et al., 2022; Farooq et al., 2022). The world is moving towards using renewable energy due to rising environmental dangers and carbon and greenhouse gas emissions from nonrenewable energy sources (Xu et al., 2022). The world's energy consumption has increased, because of an increase in population growth. Renewable energy boosts economic development as well as economic expansion and lowers carbon emissions (Abbasi et al., 2020; Tu et al., 2022; Zhao et al., 2022). Globally, the use of renewable energy sources, such as solar, geothermal, wind, and hydropower, is rising in an effort to diversify energy sources and reduce greenhouse gas emissions (Farooq et al., 2022). Despite a decline in total energy consumption in 2020 as a result of the COVID-19 epidemic, the use of renewable energy increased by 3% (Nishat et al., 2023; Hussain et al., 2023).

In 2020 gross domestic product (GDP) was -1.27% due to the COVID-19 pandemic. Pakistan's GDP increased by 6.49% in 2021 which was 7.76% more than in 2020. In June 2023, Pakistan's Gross Domestic Product (GDP) increased by 1.7% after increasing by 4.7% in 2022. The Pakistani government with China's assistance has developed a strategy to deal with the current energy crisis by utilizing possible potential CPEC opportunities (Zeng et al., 2012). BRI includes large-scale initiatives like the development of railroads, highways, and thermal, nuclear, and hydropower plants. The belt and road routes have the potential to significantly enhance trade, foreign investment, and citizen living standards (Yang & Cui, 2022) and boost economic growth. Additionally, it wants to create heavy industry, lay down oil and gas pipelines, perform mining activities, and establish energy transmission networks (Zubedi et al., 2022).

The GDP growth rate for Sri Lanka in 2021 was 3.33%, up 6.8% from the previous year. In 2020, Sri Lanka's GDP growth rate was -3.47%, a decrease of 3.25% from 2019. Sri Lanka's GDP growth rate for 2019 was negative two percent, down 2.53 percent from 2018. The GDP growth rate for Sri Lanka in 2018 was 2.31%, down 4.15% from 2017. Sri Lanka consumes less energy than Pakistan, due to its smaller population and economy (Usman et al., 2023). Sri Lanka consumes less energy than Pakistan. Developing nations Pakistan, Emerging countries Pakistan, Sri Lanka, and most other non-oil-producing countries import a large portion of their energy requirements (Gokmenoglu & Sadeghieh, 2019). Pakistan utilizes more energy overall than Sri Lanka. Pakistan utilized 77.6 million metric tons of oil equivalent (Mtoe) overall in 2018, according to the World Bank's estimation. Pakistan's economy has grown to various degrees over time. The World Bank reported that Pakistan's GDP expanded by 5.8% in 2018. Sri Lanka uses far less energy as compared to Pakistan. According to the World Bank, Sri Lanka used approximately 10.3 Mtoe of energy in 2018. Sri Lanka's economy has grown, but far more slowly than Pakistan's. According to estimates from the World Bank, Sri Lanka's GDP grew by 3.3% in 2018 (Saidi & Hammami, 2015). The nation's energy mix consists of fossil fuels like coal and oil in addition to hydroelectric, solar, and wind power. To lessen its reliance on imported nonrenewable resources, Sri Lanka has put more of an emphasis on renewable energy (Noor & Siddiqi, 2010).

The International Energy Agency (IEA) estimates that in 2020, India was the third largest primary energy consumer in the world. It makes for around 5.8 percent of the world's energy usage. India's economy has recently had some of the fastest growth among developed nations. India's Gross Domestic Product (GDP) was roughly $2.7 trillion in the fiscal year 2020–2021. The COVID-19 epidemic, however, caused India's GDP growth rate to decline by 7.3 percent during that fiscal year. One of the world's top energy consumers is India. Due to its vast population and developing industrial and commercial sectors, the nation has a significant demand for energy (Narayan et al., 2019).

The study by Akpanke et al. (2023) uses non-renewable energy (NRE) sources, which release carbon dioxide (CO_2) into the atmosphere and contribute to climate change. Global warming is mostly due to the environmental damage brought on by the usage of NREs. NRE is a significant factor in the shortening of life expectancy (Raihan & Tuspekova, 2022). The Joint Research Centre of the European Union (EU) estimates that 90% percent of global CO2 emissions are caused by the burning of fossil fuels. Environmental degradation in recent decades has primarily been the fault of the most developed economies; however, emerging countries have also seen an increase in the ratio of CO2 emissions (IEA International Energy Agency). The future primary energy sources would come from renewable sources including solar, wind, and tidal energy. The carbon emissions would be greatly decreased if these sources were to take the place of non-renewable energy sources (Ahmad & Ahmed, 2004; Faheem et al., 2022; Nathaniel et al., 2020). As a result of their heavy reliance on fossil fuels, which are subject to supply disruptions, many Asian nations are likewise concerned about the issue of energy security. Therefore, investigating the relationship between energy use and economic growth can yield strategies for reducing reliance on fossil fuels and enhancing energy security (Noor & Siddiqi, 2010; Majewskiet al., 2022). This study's primary goal is to calculate the effect of energy consumption on economic growth in South Asian nations and to recommend policy based on the results of this study.

METHODOLOGY

Data Collection: Secondary data on economic growth (GDP) and independent variables (RR, NRR, and FDI) are collected from WDI.

Model Estimation: E-views, a computer program, is utilized for model estimation, diagnostic tests, and graphical analysis. The Augmented Dickey-Fuller (ADF) lag model is employed to check for stationary between the dependent variable and independent variables.

Model Selection

For all types of model estimation, diagnostic tests, and graphing, a computer program like E-view is used. To identify the various trends of energy consumption ADF lag model was used to check the stationary between dependent variable and independent variables.

We have explored the impact of energy consumption on economic expansion graphically.

If variables are mixed at both I(0) and I(1) then the panel least square method could be applied.

If variables show the co-integration in long run then the next step is to apply the pedroni co-integration technique for the determining short run link between variables.

Model specification

The model equation is expressed as follows:

$$GDP_{it} = C + \beta_1 NR_{it} + \beta_2 REN_{it} + \beta_3 FDI_{it} + \beta_4 GFCF_{it} + \mu_t \quad (1)$$

This equation aims to describe the impact of non-renewable resources (NR_{it}), renewable resources (REN_{it}), foreign direct investment (FDI_{it}), and gross fixed capital formation ($GFCF_{it}$) on GDP for the specified time period. β_1, β_2, β_3, and β_4 are the coefficients of the respective independent variables. Here, C and μ_t represent the intercept and error term.

RESULTS AND DISCUSSION

The descriptive statistics for whole variables were utilized. The descriptive analysis gives statistical measures including Gross fixed capital formation (GFCF) and foreign direct investment (FDI) GDP, non-renewable resources (NR), and renewable resources (REN) for a variety of economic indicators.

Table 1. Descriptive analysis.

Descriptive Stat.	GDP	NR	REN	FDI	GFCF
MEAN	5.877466	38.33960	66.96951	1.519275	29.84116
MEDIAN	6.184416	43.36000	65.95640	1.188103	30.23976
MAX.	14.23086	60.53440	89.90870	4.554254	46.66012
MIN	-6.596081	11.34000	38.92736	0.095579	13.98000
S.D.	2.864397	13.13563	13.19176	1.081123	9.159369

Table 1 shows that the GDP (5.88), NR (38.34), REN (66.97), FDI (1.52), and GFCF (29.84) are the mean or average values for the metrics. These figures depict the data's central tendency, demonstrating the typical or average value for each indicator. The average GDP, for example, indicates that the country's economic output is comparatively high. The median values for GDP (6.18), NR (43.36), REN (65.96), FDI (1.19), and GFCF (30.24) provide another indication of central tendency. The similarity of the median and mean values indicates that the data is relatively symmetrical, with no large outliers skewing the results.

The maximum and minimum values give insights into the range of each indicator. For instance, the maximum GDP recorded is 14.23, while the minimum is -6.60. This indicates that the country has experienced both high economic growth and negative growth in the past. Similarly, the highest and lowest values for NR, REN, GFCF, and FDI provide information about the upper and lower bounds of these indicators.

Table 2. Panel unit root test results.

Variable	LLC		IPS	
	TT-Statistics/P-value (Level)	T-Statistics/ P-Value (1st difference)	T-Statistics/P-Value (Level)	T–Statistics/P- Value (1st Difference)
GDP	-3.27434 (0.0005)*	-.34509 (0.0000)*	2.74439 (0.0030)*	-7.12754 (0.0005)*
NR	-3.0465 (0.0012)*	-6.06768 (0.0000)*	-1.4312 (0.0753)***	-5.72233 (0.0000)*
REN	-7.54165 (0.0428)**	-7.54165 (0.0000)*	0.9393 (0.8262)***	-7.03963 (0.0000)*
FDI	-1.83584 (0.0332)**	-5.9118 (0.0000)*	-1.9120 (0.0279)**	-5.7593 (0.0000)*
GFCF	-1.4361 (0.0755)***	-6.5952 (0.0000)*	-0.1829 (0.4269)***	--6.86128 (0.0000)*

Note: *', **, and *** reveal the significance level at 1%, 5%, and 10%.

The most important step is to check the unit root test in a dynamic panel analysis model. In this test, the authors examine the order of variables whether it is at level, first difference, or 2nd difference. After collecting the data, we applied by views software panel unit root. The main two tests, IPS and LLC are used to check the order of integration. Our data is from five countries selected South Asian Countries. Pakistan, Sri Lanka, China, India and Bangladesh. THE result of these two tests is mentioned in Table 2. Some variables are integrated at the first difference and some at the level. We will explain one by one each variable.

The results of panel unit root tests showed that none of the variables are level stationary. The P-value for both panel unit root tests at the first difference is less than 0.05, indicating that the unit root null hypothesis is rejected and that the data are stationary at the first difference. In the current study, a panel least squares model is employed to assess the connection between the variables.

First of all, we applied panel unit root test which indicates that all variables are integrated in the same order (1) and some at the level. Then panel least square model was applied to identify the relationship among the variables and then apply Pedroni Co-integration test to confirm whether the variables were co-integrated or not. At the end, we applied the Granger causality test which indicates the cause and effect among variables given in the study.

In Table 2 it is commented that gross domestic product in percentage form has no unit root at the level and the next independent variable non-renewable resources is stationary at first difference. The next renewable energy source which is a proxy of energy consumption in the proposed model is also first difference. The next regress or foreign direct investment is at level but the gross fixed capital formation is at first difference. The order of integration is mixed order.

Table 3. Panel least square method.

Variables	Coefficients	Standard Error	T- Statistics	P- Value
FDI	0.677680	0.251376	2.695883	0.0080
GFCF	0.088984	0.030630	2.905162	0.0044
NON	0.004998	0.011776	0.424408	0.6720
REN	0.029895	0.015892	1.881204	0.0623

Table 3 examine the association between multiple variables, the Panel least squares method was utilized. The coefficients calculated for each variable indicate their influence on the dependent variable. The coefficient for FDI (Foreign Direct Investment) is 0.677680, demonstrating a positive association with the dependent variable. The standard error for FDI is 0.251376, indicating that the coefficient estimate is reliable.

The dependent variable and FDI have a statistically significant association, according to the t-statistic of 2.695883 and the p-value of 0.0080 (Bakhsh et al. 2022; Tariq et al. 2023). The same is true for the GFCF (Gross Fixed Capital Formation) variable, which exhibits a positive correlation with a coefficient of 0.088984, a small standard error of 0.030630, a high t-statistic of 2.905162, and a significant p-value of 0.0044 (Xin-gang & Jin, 2022; AlDarraji & Bakir, 2020; Yu et al. 2023). On the other hand, as shown by their lower coefficients, greater standard errors, lower t-statistics, and non-significant p-values, non-renewable sources and REN (Renewable Energy sources) demonstrate weaker associations with the dependent variable. Overall, NONE and REN have less of an impact than FDI and GFCF, which appear to have the greatest overall impact on the dependent variable (Anser et al., 2021; Asif et al., 2021; Mughal et al., 2022).

Granger causality is a term that Clive Granger devised to study causal relationships in the social and economic sciences. The test was designed to find out whether past values of one variable may yield additional predictive information about another variable beyond what could be inferred from the past values of that second variable alone.

The results of the Granger causality test (Table 4) determine whether or not different variables are causally related. The null hypothesis for each test states that one variable does not cause another to Granger cause itself. The F-statistics and p-values are shown for every test. The F-statistic of 3.99552 with a p-value of 0.0211 indicates that there is enough evidence to reject the null hypothesis that FDI does not cause GDP. Hence, FDI and GDP have a statistically significant causal relationship. This suggests that variations in FDI may influence or forecast changes in GDP.

Table 4. Granger causality test.

Null Hypothesis	F-Statistics	P- Value
FDI does not Granger Cause GDP_	3.99552	0.0211
GDP_ does not Granger Cause FDI	8.23326	0.0005
GFCF does not Granger Cause GDP_	1.43346	0.2429
GDP_ does not Granger Cause GFCF	0.23662	0.7897
NON does not Granger Cause GDP_	7.50471	0.0009
GDP_ does not Granger Cause NON	10.2853	8.E-05
REN does not Granger Cause GDP_	3.80297	0.0253
GDP_ does not Granger Cause REN	0.27247	0.7620
GFCF does not Granger Cause FDI	5.73106	0.0043
FDI does not Granger Cause GFCF	0.19991	0.8191
NON does not Granger Cause FDI	1.69432	0.1885
FDI does not Granger Cause NON	0.45643	0.6347
REN does not Granger Cause FDI	1.34941	0.2637
FDI does not Granger Cause REN	1.11710	0.3309
NON does not Granger Cause GFCF	5.06470	0.0079
GFCF does not Granger Cause NON	3.30033	0.0406
REN does not Granger Cause GFCF	2.50198	0.0866
GFCF does not Granger Cause REN	0.42532	0.6546
REN does not Granger Cause NON	4.13697	0.0185
NON does not Granger Cause REN	0.25727	0.7736

The F-statistic of 8.23326 with a p-value of 0.0005 suggests that there is significant evidence to reject the null hypothesis that GDP does not cause FDI. As a result, there is a considerable causal link between GDP and FDI. This indicates that fluctuations in GDP can influence or anticipate fluctuations in FDI. The F-statistic of 1.43346, with a p-value of 0.2429, is insufficient to reject the null hypothesis that GFCF does not cause GDP. As a result, there is no significant causal link between GFCF and GDP.

Similarly, the F-statistic of 0.23662 with a p-value of 0.7897 is insufficient to reject the null hypothesis that GDP does not cause GFCF. As a result, there is no significant causal link between GDP and GFCF.

In conclusion, the Granger causality test results show that there is a causal relationship between FDI and GDP in both directions. Changes in FDI can have an impact on GDP, and changes in GDP can have an impact on FDI. However, there is compelling evidence of a link between GFCF and GDP, GFCF and FDI, or GFCF and other variables. Similarly, there is substantial evidence of causal links between GDP and GFCF, GDP and other factors, or other variables and GDP. It should be emphasized that while these findings give statistical evidence of potential causality, they do not clarify the direction or mechanism of the causal links.

CONCLUSIONS

The importance of energy consumption in a country's development cannot be disputed. Energy is comparable to an economy's vital force. In order to accomplish the primary goal of this study, panel data from five Asian nations encompassing the years 1998 to 2022 are used. The statistics of South Asian nations and the world development indicator were used to compile the data for these variables. NONE and REN have less impact than FDI and GFCF, which appear to have the greatest overall impact on the dependent variable. The coefficient for FDI (Foreign Direct Investment) is 0.677680, showing a positive relationship with the dependent variable that indicates the coefficient estimate is reliable. GFCF (Gross Fixed Capital Formation) variable, which exhibits a positive correlation with a coefficient of 0.088984. Non-renewable sources and REN (Renewable Energy sources) demonstrate weaker associations with the dependent variable. To achieve a sustainable environment and development, it is essential to shift production percentages from non-renewable to renewable sources of energy. An excellent and effective method of Government has a proportionate impact on economic expansion.

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