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INVESTIGATING THE IMPACT OF ENERGY CONSUMPTION ON ECONOMIC GROWTH OF PAKISTAN: AN ECONOMETRIC ANALYSIS

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ABSTRACT

The growth of any economy depends on energy. The energy crises can affect economic growth through higher energy prices that lead to an increase in the cost of production, a decrease in consumer spending, and unemployment. Pakistan is facing serious fuel and electricity shortages in all key industries. The aim of the present study was to investigate the impact of energy use, such as petroleum, gas, coal, and electricity consumption, on Pakistan's economic growth by employing the ARDL model using secondary data from 1981 to 2021. Our results indicated that in the long run, the effect of oil consumption, coal consumption, natural gas consumption, and total population on economic growth was positive and significant, while electricity consumption had a negative effect. In the short term, the total population had a negative impact on economic growth. However, electricity, natural gas, coal, and petroleum had a positive impact on economic growth, and all these factors were statistically significant. Based on the findings of the study, it was suggested that policymakers should promote investment in renewable energy sources for sufficient and effective energy supply for sustainable economic growth.

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INTRODUCTION

Energy plays a crucial role in the progress of a nation, consistently proving crucial for its development and expansion. A satisfactory energy provision is necessary to fulfill the country's requirements. Additionally, energy is vital for alleviating poverty. An abundance of energy implies sufficient access to water and electricity, a necessary condition for sustained growth (Ahmad et al., 2012). Energy is regarded as a foundation of any economy and assumes a significant function in the progress of a country's society and economy. Energy is important for operating all the resources, and a power crisis directly impacts all the domains of the economy, including the agricultural and industrial sectors, unemployment, poverty, lower GDP, and increased inflation (Naseem and Khan, 2015). As energy emerges as the primary driver for any country's economic advancement, it enhances the effectiveness and output of the country. The widespread industrial growth, urban growth, and escalating population dimensions have increased the utilization of additional energy, particularly in developing nations. The correlation between energy usage and economic expansion has been thoroughly examined in the past ten years and has garnered growing attention (Chaudhry et al., 2012). Economists have recently taken a keen interest in understanding the connection between economic expansion and energy use. This interest stems not only from the fact that energy usage exerts influence on various aspects of economic activity but also from the fact that it is important for sustainable economic growth and enhancing people's living standards (Rezitis and Ahammad, 2015). Numerous studies have explored the connection between energy use and economic development. Study results might differ because each country has its own way of doing things economically (Sari et al., 2008). Another factor contributing to these differences could be the diverse consumption patterns and energy sources in different economies. Consequently, the effects of various energy sources on a nation's economic output may vary (Ozun and Cifter, 2007). Kraft and Kraft (1978) discovered a one-way causation from Gross National Product (GNP) to energy consumption in the United States from 1947 to 1974. Their findings suggest that the US economy's relatively low dependence on energy allows it to pursue energy conservation policies without negatively impacting income (Jumbe, 2004). However, Akarca and Long (1980) did not identify a significant relationship between the variables using the same dataset for the USA. Similar results were also observed by Eden and Hwang (1984), Yu and Choi (1985), Erol and Yu (1987), Eden and Jin (1992), Cheng (1995), Asafu-Adjaye (2000), Soytas and Sari (2003), Altinay and Karagol (2004), Wolde-Rufael (2005) and Lee (2006). Erol and Yu (1987) investigated the energy consumption-GDP relationship for England, France, Italy, Germany, Canada, and Japan from 1952 to 1982. They discovered a two-way causal relationship for Japan, a one-way causal link from energy consumption to GDP for Canada, a one-way causal connection from GDP to energy consumption for Germany and Italy, and no causal relationship for France and England. Siddiqui (2004) concluded that various energy sources had different impacts on economic growth in Pakistan. Electricity and petroleum products substantially and positively affected the economy's expansion, noting a reciprocal relationship between petroleum goods and economic growth.

An energy problem is characterized by an escalation in the cost of energy sources or a substantial deficit in the provision of energy resources. Typically, it refers to a deficiency in electricity, oil, natural gas, and various other natural resources. With the complete transformation brought about by globalization, numerous challenges have surfaced, among which energy has garnered noteworthy consideration from researchers (Naseem and Khan, 2015). The earth is fighting an energy predicament due to a boost in the worldwide demand for energy, continuous reliance on fossil-derived fuels for energy production and transportation, and growth in the global population, surpassing seven billion individuals and continually expanding. The excessive burning of fossil fuels is exhausting natural reserves and causing a step-by-step rise in carbon dioxide emissions, a phenomenon that experts attribute to the shoot-up of average global temperatures (Coyle and Simmons, 2014). The impact of the energy deficiency was amplified amid the COVID-19 pandemic. The energy deficit contributed to the rise of electricity and hydrocarbon prices. The difficulty was increased by the 2022 conflict between Russia and Ukraine and the restrictions imposed on Russia. This disturbance disrupted the provision of Russia's hydrocarbon-based energy to European nations relying on Russia for their energy needs. Consequently, there was an additional rise in the worldwide energy cost. These occurrences highlighted that the withdrawal from hydrocarbon-based energy sources occurred prematurely, as it transpired at a juncture when the global sustainable energy sector was either still in its nascent stages or inadequately developed (Ozili and Ozen, 2023).

Pakistan faces its most severe energy problem in its historical timeline. Like other progressing nations, Pakistan is characterized as an energy-intensive booming economy, and its energy requirements are satisfied through substantial volumes of imported oil, much like in most non-oil-producing nations. The energy framework in Pakistan is not adequately advanced and is evidently administered ineffectively. In spite of the rise in population, economic expansion, and heightened demand over the preceding decades, there has been a notable absence of concerted attempts for energy generation. Furthermore, the difficulty is provoked by electricity hijacking and transmission losses due to antiquated infrastructure (Naseem and Khan, 2015). From 2006 onward, Pakistan has been fighting with an energy crisis. The primary causes include the inefficiency of expanded capacity, constrained research assets, suboptimal utilization of hydro and coal, ineffective consumption of energy, and underutilization of renewable resources (Nadeem and Munir, 2016). In Pakistan, where nature has been awarded too many natural energy resources, including oil, coal, gas, wind, water, wood, and sunlight, these reservoirs remain largely unutilized and improperly harnessed over many years. As a result, Pakistan faces substantial energy shortfalls due to insufficient investments in energy infrastructure. Pakistan's deficient energy services pose a huge hurdle to economic growth and development. There is a notable lack of investment in the energy sector, with a significant portion of commercial energy infrastructure remaining underdeveloped. Acknowledging that entry to reasonably priced energy services is crucial for diminishing poverty and a fundamental requirement for enduring economic advancement, Pakistan is presently actively advocating regional energy integration. The objective is not only to increase the delivery of energy services to millions of individuals in Pakistan but also to raise per capita energy utilization, consequently reinforcing the nation's GDP (Chaudhry et al., 2012).

Aqeel and Butt (2001) examined the links involving energy use and employment as well as energy use and economic development in Pakistan. The results revealed that neither economic expansion nor gas consumption has an impact on one another; economic expansion does result in an increase in petroleum use. Khoshnevis and Shakouri (2017) conducted research to identify the direct relationship between economic development and energy consumption from renewable sources in Iran. The study demonstrated that economic growth is favorable for the expansion of the renewable energy sector. Economic growth has been negatively impacted by using energy from renewable sources both in the short run and long run. Odhiambo (2023) analyzed the impact of energy consumption on economic development in South Africa using time-series data from 1975 to 2017. The study discovered that both unexpected events, both negative and positive, in the consumption of oil and electricity had a substantial short-term effect on the economic development in South Africa. Khan et al. (2020) studied Pakistani economic development and energy usage. This research tries to look into Pakistan's economy and gross domestic product from the perspective of the neoclassical Solow growth model. The research examined time-series data from 1975 to 2017. The findings of the research show that energy consumption, labor force, investment stocks, and innovation have considerably and positively affected Pakistan's gross domestic product expansion. Chaudhry et al. (2012) studied empirical data from Pakistan regarding the relationship between economic development and energy usage. The major goals of this research are to evaluate causal relationships between variables and evaluate the consequences of the utilization of energy on the economy. Based on yearly data from 1972 to 2012, the research examined the link between Pakistan's energy consumption and the economy's progress. The results demonstrated a significant relationship between economic expansion and resource use. Zeshan and Ahmed (2013) studied Pakistan's economy and energy use. Using yearly data from 1971 to 2012, the research examined the effects of the real overall economic output, the stock of assets, and labor forces on the usage of energy. Shahbaz et al. (2020) investigated a long-term link between using energy from renewable sources and economic expansion. The study reexamined the link between sources of renewable energy usage and economic development in 38 nations from 1990 to 2018. The usage of clean energy has a favorable effect on economic development for fifty-eight percent of the surveyed nations, whereas fossil fuels, capital, and manpower also have positive effects. Abosedra et al. (2015) investigated the link between Lebanon's energy utilization, financial progress, and economic expansion. This study showed co-integration and an unidentified structural gap. The study's findings demonstrated that there was substantial and positive empirical evidence of a link between the variables.

Several research studies have pointed out the connection between Pakistan's economic expansion and utilization of energy. Khan et al. (2020) analyzed the impact of energy consumption on economic growth in Pakistan from 1975 to 2017. Parveen et al. (2021) studied the impact of energy use on foreign direct investment, economic expansion, and external deterioration: Pakistani perspectives from 1975 to 2018. The primary distinction of this study was that it examined the data from 1981 to 2021. This research concentrated on how the usage of energy affects growth in the economy. There was a significant gap since past research in Pakistan did not concentrate on and distinguish between proxy variables for energy use like coal, oil, gas, and

power. These energy-related factors have a significant influence on Pakistan's economic development.

METHODOLOGY

The study covered the investigation of Pakistan's economic growth and the effects of energy usage through econometric testing. The yearly time series data were taken from 1981 to 2021. Data were collected from the World Development Indicator (WDI); Naseem and Khan (2015) also took data from the World Development Indicator for their study on the impact of Pakistan's energy crisis on economic development. Data were also collected from the BP Statistical Review of World Energy 2022 and the State Bank of Pakistan (SBP). All variables are not in the same unit, so we take the natural log of all variables.

For graphing, a computer program, MS Excel, was used. E-views were employed for estimations and diagnostic testing for various models. For its first purpose, the research used graphics to examine the link between economic expansion and energy sectors such as coal, oil, gas, and electricity usage. All the variables were integrated at both I (0) and I (1). The ARDL approach was utilized to analyze the relationship among variables. The ARDL model was also employed in the analysis of energy consumption and economic growth (Chaudhry et al., 2012). The second goal of the study was to employ the Autoregressive Distributed Lag model to examine the correlation between energy and economic development in both the short and long run. The variables showed co-integration in the long run; the next step was to apply the Error Correction Model (ECM) to determine the short-run relationship among variables; the study on energy and economic growth in Pakistan also used the ECM model (Siddiqui, 2004). After estimating the long-run and short-run conclusions, this study suggested suitable policies.

Model Specification

The econometric model is given below:

GDP= f (EC, NGC, OC, CC, TP)

$$GDP = \beta_0 + \beta_1(EC) + \beta_2(NGC) + \beta_3(OC) + \beta_4(CC) + \beta_5(TP) + \mu_t \quad (1)$$

Where

GDP = Economic growth in billion dollars

EC = Electricity consumption

NGC= Natural gas consumption

OC= Oil consumption

CC= Coal consumption

TP= Total population

μ= Stochastic Error Term

β_1, β_2, $\beta_3, \beta_4,, \beta_5$ are the respective parameters of model.

Units of variables are not the same so we convert the above equation into Log form as:

$$LNGDP = \beta_0 + \beta_1(LNEC) + \beta_2(LNNGC) + \beta_3(LNOC) + \beta_4(LNCC) + \beta_5(LNTP) + \mu_t \quad (2)$$

Table 1. Variables used in the econometric model, symbols, and sources.

Variables	Symbols	Units	Data Sources
Dependent Variable			
Economic growth	GDP	Billions USD	WDI
Independent Variables			
Electricity consumption	EC	GWH	SBP
Natural gas consumption	NGC	BCF	BP Statistics
Oil consumption	OC	Exajoules	BP Statistics
Coal consumption	CC	Exajoules	BP Statistics
Total population	TP	In numbers	WDI

RESULTS AND DISCUSSION

Before conducting the co-integration test (ARDL technique), the variables economic growth (GDP), electricity consumption (EC), natural gas consumption (NGC), oil consumption (OC), coal consumption (CC), and total population (TP) had to be checked for stationery. This section deals with the analysis of data and the interpretation of findings. The unit root test, ARDL, the Error Correction Method, and the Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) unit root tests were all included in the data analysis procedure.

Augmented Dickey-Fuller and Phillips Perron tests

The statistical analysis known as the Augmented Dickey-Fuller test, or ADF, is used to identify if a time series is stationary or not. The test, which is named after the economists David Dickey and Wayne Fuller, is frequently used in econometrics and finance to analyze time series data. It was created in 1979. In econometrics, the PP test refers to the Phillips-Perron test, which is a study of statistics used to evaluate whether time series include unit roots data. It was created in 1988 by Pierre Perron and Peter C.B. Phillips. The ADF and PP tests are used to ascertain the stationarity of the variables. The outcomes of the ADF and PP tests determine if the data is stationary and if the test results are both below the critical level. The stationarity of the variables and the sequence of integration are displayed in Table 2.

Table 2 displays the combined outcomes of the ADF and PP tests. Results showed that LNGDP, LNNGC, and LNCC were stationary at the first difference while remaining variables like LNEC and LNTP were stationary at the level, and LNOC was stationary both at the level and at the first difference.

Table 3 shows that the Breusch-Godfrey Serial Correlation LM Test was used to check for autocorrelation in a model with regression. There was no indication of serial correlation among the residuals if the p-value was higher than 0.05. So, in this case, the P-value is 0.292, which was greater than 0.05. Therefore, there was no serial correlation between the residuals and the model.

Table 4 shows that the first step of the ARDL model was a bound test that determined the link between the dependent and independent factors throughout the time. The alternative theory explained that there was no presence of a long-run relationship, including both dependent and independent variables. Multiple hypotheses were evidence of the long-range relationships between variables. Lower and upper values showed the confidence interval of the ARDL model. If the value of F-statistics was below the lower value, it showed that the association across the independent and dependent factors was not sustained across time. If the calculated value of F-statistics was in the middle of the range values, then the results were inconsistent. If the value of F-statistics was above the upper value, then it showed both independent and dependent factors had a long-term connection with one another. In this study, the value of F-statistics is 5.518, which was, above all, the lower and upper critical values. Therefore, there was a long-term connection between internal and external factors.

Table 2. Result of ADF and PP tests.

Variables	ADF level	ADF 1st Difference	PP level	PP 1st Difference	Order of Integration	Results
LNGDP	0.962	0.000	0.971	0.000	I(1)	Stationary
LNEC	0.004	0.496	0.004	0.530	I(0)	Stationary
LNNGC	0.641	0.000	0.683	0.000	I(1)	Stationary
LNOC	0.065	0.007	0.007	0.018	I(0,1)	Stationary
LNCC	0.005	0.000	0.943	0.000	I(1)	stationary
LTNP	0.009	0.015	0.000	0.292	I(0)	Stationary

Table 3. Breusch-Godfrey serial correlation LM test.

F-statistic	0.753	Prob. F(1,25)	0.393
Obs*R-squared	1.111	Prob. Chi-square (2)	0.292

Table 4. Result of ADRL bound test approach.

F-Bounds Test (Null Hypothesis: No Levels Relationship)		
Test Statistics	Value	
F-Statistics	5.518	
	K	5
Significance	I(0)	I(1)
10%	2.08	3
5%	2.39	3.38
2.50%	2.7	3.73
1%	3.06	4.15

LNGDP = 14.772- 2.581LNEC+0.773LNNGC+1.336LNOC+1.016LNCC + 2.094LNTP

The Table 5 depicts the coefficients corresponding to the long-term in the ARDL model. The coefficients for the use of coal, natural gas, petroleum, and total population were positive, indicating a positive association with economic expansion. The coefficient of electricity consumption was negatively connected with economic expansion, with a -2.581 value, signifying that an increment of one percent in electricity consumption caused a -2.58 percent decrease in economic growth. Similar to previous studies that explained a negative connection between Electricity Consumption and economic expansion (Ashraf et al., 2013). Electricity consumption was negative for a variety of reasons. Limited Power Accessibility: A large section of the population in Pakistan still does not have access to power. Rural regions' lack of electricity limits economic activity and affects human development, which slows the rate of total economic expansion. The coefficient value of oil consumption was 1.336, indicating that a one percent increase in oil consumption caused a 1.33 percent increase in economic growth. Same as previous studies explained the positive relationship between oil consumption and economic growth (Okoye et al., 2021). The primary argument is that oil consumption may boost Pakistan's GDP. Oil is an essential source of energy that is important for many economic sectors, including transportation, industry, and agriculture. The proper operation of these industries is ensured by a sufficient and consistent supply of oil, which boosts productivity and economic production. The coefficient of coal consumption was 1.016, which means that a one percent increase in coal consumption caused a 1.01 percent increase in economic growth. Same as earlier research explained the positive connection between Coal Consumption and economic growth (Chaudhry et al., 2012). For a variety of reasons, coal usage may benefit Pakistan's GDP. First off, coal is a sizable source of energy used in many industries, such as manufacturing, power generation, and industrial operations. Consuming enough coal guarantees a consistent and inexpensive energy supply, which is essential for sustaining and growing economic activity. As a result, there is a rise in production and industrial output, which eventually supports GDP growth. The coefficient of Total Population was 2.094, which showed that a one percent increase in Total Population increased GDP by 2.09 percent. The coefficient of Natural Gas Consumption was 0.773, which shows that a one percent increase in Natural Gas Consumption caused a 0.77 percent increase in growing economies. Same as previous studies explained the positive connection between the use of gas from the earth and growth in the economy (Çıtak et al., 2020).

Table 5. ARDL long run coefficients.

Variables	Coefficients	Std. Error	T- Statistics	Prob.
LNEC	-2.581	0.601	-4.298	0.000
LNNGC	0.773	0.399	1.937	0.064
LNOC	1.336	0.428	3.120	0.004
LNCC	1.016	0.194	5.223	0.000
LNTP	2.094	1.153	1.817	0.081
C	14.772	21.496	0.687	0.498

Table 6. Results of Error Correction Model.

Variables	Coefficient	Std. Error	T-statistics	Prob.
D(LNEC)	0.315	0.152	2.064	0.049
D(LNNGC)	0.333	0.131	2.540	0.017
D(LNOC)	0.574	0.159	3.6178	0.001
D(LNCC)	0.096	0.066	1.447	0.160
D(LNTP)	-12.795	2.288	-5.591	0.000
CointEq(-1)**	-0.430	0.062	-6.895	0.000
R^2 = 0.58; Adj R^2 = 0.51; SE of regression =0.05; DW = 2.27; AIC = -2.92				

Table 6 displayed the short-run result, indicating that the total population had a negative impact on the expansion of the economy, whereas the usage of power, Natural gas consumption, Coal consumption, and Petroleum usage contributed to economic growth. All variables were statistically significant. R2 was 0.58, indicating that 58 percent of the dependent parameters might vary due to distinct parameters. The ECM coefficient was -0.43 with a T- ratio of -6.895. The ECM coefficient reflected the speed of adjustments and a long-term association link between the consumption of electrical power and growing economies. According to the ECM coefficients, modifications would occur in the long term at a 95 percent rate. Durbin Watson had a value of 2.27. It means that there was no autocorrelation in the model.

CONCLUSIONS AND POLICY RECOMMENDATIONS

The study attempted to assess the significance of energy consumption on Pakistan's economic growth. Before examining the causal link between increasing usage of energy and increasing Gross Domestic Product, the study first determined the association's strength by comparing energy consumption and growth in the economy. In conclusion, the reverse conjunction, over time, positive shocks to the use of petroleum and negative fluctuations to the usage of power, while positive changes to coal and the usage of natural gas and total population all have a big influence on growth. The utilization of energy, such as electricity, natural gas, oil, and coal, has an important impact on Pakistan's economic development. A sufficient and effective energy supply is essential for supporting economic growth, encouraging industrial expansion, and raising productivity. The findings indicate that whereas electricity consumption is adversely correlated with economic growth, oil, coal, natural gas, and population growth are positively correlated.

Government actions that increase domestic energy sources and expand imports to include natural gas, coal, and electricity should be pursued for the purpose of guaranteeing the availability of resources. Due to the high cost of energy, there should be a switch from costly imported gasoline to locally accessible alternative fuel. Additionally, coal is a less expensive indigenous resource that must be utilized, and Pakistan would save a sizable amount of foreign reserve if energy consumption was shifted towards indigenous resources. The government should work together with international organizations and partners to exchange information, technology, and best practices in the energy industry. Participating in international programs and agreements on sustainable energy can assist in coordinating national policies with international sustainability objectives and promote the switch to cleaner energy sources.

Authors Contributions

Writing–original draft and analysis: Alina Razaq; Writing–review and editing: Muhammad Bilal Saleem; Methodology: Muhammad Awais Jameel; Supervision: Abdus Samie and M. Amjed Iqbal; Results and interpretation: Muhammad Yousuf and Muhammad Qadeer Ashraf. All authors have read and agreed to the published version of the manuscript.

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