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Diversifying Energy Resources for Economic Development in Pakistan

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Abstract
The objective of this study is to examine the relationship between various energy resources—specifically energy consumption, oil consumption, coal consumption, and electricity consumption—and economic growth in Pakistan over the period from 1980 to 2021. Employing robust analytical techniques, the study aims to provide a comprehensive understanding of how these energy resources influence the economic trajectory of Pakistan. The findings reveal a significant and positive correlation between energy resources and Pakistan's economic growth, aligning with prior expectations. This indicates that energy consumption, in its various forms, is a critical driver of economic development in the country. Each type of energy resource—whether it be oil, coal, or electricity plays a vital role in powering economic activities, from industrial production to services, thereby contributing to overall economic expansion. In light of these findings, the study suggests several strategic directions for Pakistan to optimize its energy usage and bolster economic growth. One key recommendation is for Pakistan to diversify its energy mix and reduce reliance on expensive imported oil. Given the financial strain imposed by oil imports on the country's current account balance, a shift towards more cost-effective and domestically available energy sources such as natural gas and coal is advisable. By leveraging these alternative fuels, Pakistan can not only mitigate the economic burden of fuel imports but also enhance energy security. The utilization of domestic coal and natural gas reserves presents an opportunity to generate cheaper electricity, which in turn can stimulate industrial growth, lower production costs, and enhance the competitiveness of Pakistani goods and services in the global market. Additionally, the study underscores the importance of developing infrastructure and policies to support the transition to these alternative energy sources. Investments in energy infrastructure, such as the construction of efficient power plants and the development of natural gas pipelines, are essential to ensure a stable and reliable energy supply. Moreover, policy measures that incentivize the use of domestic energy resources and promote energy efficiency can play a pivotal role in achieving sustainable economic growth.
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1. INTRODUCTION

Energy consumption has been crucial in driving economic growth globally. The primary factors contributing to economic growth include increased capital stock, technological advancements, and improvements in literacy levels. For instance, investments in infrastructure and machinery enhance production capabilities, while technological innovations streamline processes and create new opportunities. Similarly, a well-educated workforce boosts productivity and fosters innovation, further propelling economic growth. Recently, the concept of sustainable development has introduced additional considerations, such as incorporating environmentally sound practices into economic growth strategies. This approach emphasizes the need to balance economic advancement with ecological preservation, ensuring that growth does not come at the expense of environmental health. Sustainable practices, such as utilizing renewable energy sources and promoting energy efficiency, are now seen as essential components of long-term economic planning. Economic growth continues to be a vital focus for researchers and policymakers worldwide. This persistent interest is due to its significant influence on various aspects of the economy and overall livelihoods. For instance, robust economic growth can lead to higher employment rates, improved living standards, and increased government revenues, which can be used to fund public services and infrastructure projects. Moreover, economic growth can enhance a country's global competitiveness, attracting foreign investments and fostering international trade.

However, the pursuit of economic growth also presents challenges. Policymakers must navigate issues such as income inequality, resource depletion, and environmental degradation. Addressing these challenges requires comprehensive strategies that integrate economic, social, and environmental goals. As such, sustainable development is not just a theoretical concept but a practical framework guiding modern economic policies. Energy plays a crucial role in the

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economic development of any country by enhancing the efficiency of production factors and improving living standards. The demands of extensive industrialization, urbanization, and growing populations have significantly increased energy consumption, particularly in developing nations. It is widely recognized that energy consumption and economic development are mutually dependent. The energy crises of the 1970s and the persistently high prices, especially of oil, have profoundly impacted the economic activities of developing economies. These events highlighted the critical need for stable and affordable energy supplies to sustain economic growth. Energy's importance extends beyond basic economic development. For instance, exporting energy products can boost foreign earnings, while the exploration and production processes facilitate technology transfer and create marketing opportunities. Additionally, the energy sector generates employment, leading to higher wages for workers and improving their welfare. This sector also spurs infrastructure development and socio-economic activities, further contributing to economic progress.

Efficiently managing and utilizing available energy resources is essential for optimal development. Equitable allocation and effective use of these resources can drive sustainable economic growth. As such, ensuring an adequate energy supply is vital for the radical transformation and modernization of a nation’s economy. The direction of causation between energy consumption and economic growth holds significant policy implications. For instance, if there is unidirectional Granger causality from income to energy, it suggests that energy conservation policies could be implemented with minimal or no adverse effects on economic growth. Conversely, if there is negative causality from employment to energy, energy conservation policies could potentially increase total employment (Akarca & Long, 1979).

China and India are the major energy consumers and continue to lead the world in both economic growth and energy demand. In 1990, China and India together accounted for approximately 10 percent of the world's total energy consumption, which increased to 20 percent by 2007 (Energy Information Administration [EIA], 2010). This substantial rise reflects their rapid industrialization and population growth. In the era of globalization, the rapidly increasing demand for energy and the dependency of countries on energy resources indicate that energy will remain one of the most critical challenges in the coming century. This situation underscores the urgent need to develop alternative and renewable energy sources to ensure sustainable growth. Traditional growth theories often emphasize labor and capital as the primary production factors, overlooking the vital role of energy in the growth process (Stern & Cleveland, 2004). Modern perspectives recognize that energy is fundamental to driving economic activities and fostering development. Policymakers must consider the intricate relationship between energy consumption and economic growth when designing energy policies. Sustainable energy management involves not only optimizing energy use but also ensuring that energy policies support overall economic objectives without compromising growth or employment. The shift towards renewable energy sources and improving energy efficiency are essential steps toward achieving a balanced and sustainable growth trajectory.

Sari and Soytas (2004) argue that relying on aggregate energy consumption or electricity consumption, instead of examining different energy resources, may contribute to inconsistencies in empirical study results. The significance of specific energy resources can vary for a country over time. Therefore, empirical investigations should analyze various energy sources rather than just aggregate energy consumption. Different energy sources have unique impacts on economic growth, environmental sustainability, and energy security. For instance, renewable energy sources such as solar and wind power offer distinct benefits compared to traditional fossil fuels like coal and oil. By examining these sources separately, researchers can gain a more nuanced understanding of how each contributes to economic development. Moreover, the energy landscape is continually evolving due to technological advancements, policy changes, and shifts in global energy markets. A resource that was once pivotal for a country's energy needs may become less relevant as new technologies and resources emerge. This dynamic nature of energy resources underscores the importance of adopting a comprehensive approach in empirical research.

Disaggregating energy consumption data allows for more precise policy recommendations. Policymakers can tailor energy strategies to promote the most beneficial resources, encouraging sustainable growth and reducing reliance on environmentally harmful energy sources. For instance, promoting investments in renewable energy infrastructure can help countries transition to cleaner energy, mitigate climate change, and improve energy security. Sari and Soytas's (2004) insights highlight the need for empirical studies to consider diverse energy sources individually. This approach provides a clearer picture of the relationship between energy consumption and economic growth, leading to more effective and targeted energy policies that support sustainable development.

2. LITERATURE REVIEW

Energy is considered the lifeline of an economy, serving as a crucial instrument for socio-economic development, and is recognized as one of the most important strategic commodities (Shaari, Hussain, & Ismail, 2012). While energy is essential for economic functions, its supply is often uncertain. As a strategic resource, energy has historically influenced the outcomes of wars, driven and hindered economic development, and both polluted and cleaned up the environment. The relationship between energy consumption and economic growth has been extensively studied in the literature, bearing significant theoretical, empirical, and policy implications. It is evident that different economies have distinct consumption patterns and utilize various energy sources. Consequently, the impact of energy consumption on economic output can vary based on the type of energy source used. The causality relationship between energy use and economic growth has been a contentious issue among economists. Some argue that energy is an essential input, along with labor and capital, making it a critical requirement for a country's economic growth. From this perspective, energy is seen as a potentially inhibiting factor for both social and economic development if not adequately managed. Conversely, other economists contend that the cost of energy consumption represents a small percentage of GDP, suggesting that its impact on economic growth is minimal. This debate highlights the complexity of the energy-growth nexus and underscores the importance of context-specific analyses to understand the role of energy in economic development accurately.

The varying impacts of different energy sources on economic growth emphasize the need for a diversified energy policy. Renewable energy sources, such as solar and wind, might contribute differently to growth compared to fossil fuels like coal and oil. Understanding these differences can help policymakers craft strategies that promote sustainable growth, energy security, and environmental sustainability. While energy is undeniably vital for economic development, its role and impact can differ across contexts and energy types. Recognizing these nuances is essential for formulating effective energy policies that support sustained economic growth and development. The ongoing debate in the literature reflects the dynamic and multifaceted nature of the relationship between energy consumption and economic growth. It is crucial to determine the causality relationship between energy consumption and economic growth to understand whether energy consumption significantly drives economic growth or vice versa. Specifically, if energy consumption drives economic growth, then reducing energy consumption could lead to adverse outcomes such as budget deficits, unemployment, and lower incomes. Conversely, if energy consumption does not Granger cause GDP, energy conservation policies could be implemented without negatively impacting the economy. Understanding this causal relationship is essential for formulating effective energy policies. If energy consumption is found to be a significant determinant of economic growth, policymakers must ensure a stable and sufficient energy supply to support economic activities. However, if the causality runs from GDP to energy consumption, then efforts to reduce energy use through conservation measures would not harm economic growth.

Research on the relationship between energy consumption and economic growth has been conducted across various contexts. For instance, a study examining 22 Organization for Economic Co-operation and Development (OECD) countries found that energy consumption per capita Granger causes real GDP per capita and vice versa in the long run. Between 1981 and 2007, increased energy consumption led to economic growth in these countries (Belke et al., 2011). This bidirectional causality indicates that energy consumption and economic growth reinforce each other over time. Therefore, policies aimed at enhancing energy efficiency and expanding energy supply can contribute to sustained economic growth. Simultaneously, economic growth can drive higher energy consumption, necessitating further investments in energy infrastructure and technologies. Determining the causal relationship between energy consumption and economic growth is vital for informed policymaking. If energy consumption is a significant driver of economic growth, ensuring a reliable energy supply becomes paramount. Conversely, if economic growth drives energy consumption, conservation policies can be pursued without fear of hampering economic progress. The findings from the OECD study highlight the importance of a balanced approach to energy policy, considering both the short-term and long-term implications for economic development.

A comprehensive review of existing studies reveals a lack of consensus regarding the relationship between energy consumption and economic growth, as well as the direction of causality between these variables. Some studies suggest that economic growth drives increased energy consumption, while others find no causal relationship between the two. These conflicting results can be attributed to variations in data sets, country characteristics, variables included in the analysis, and methodological approaches. Furthermore, the literature indicates a notable gap in research focusing on Pakistan's economy. Very few studies have explored the specific dynamics of energy consumption and economic growth in Pakistan. Therefore, this study aims to fill this gap by conducting a thorough examination of the relationship between energy consumption and economic growth within the context of Pakistan's economy. In preparation for this study, we present a review of several significant studies that inform our current research. These studies contribute valuable insights into the global discourse on energy and economic growth, offering diverse perspectives on the factors influencing this complex relationship. Onakoya et al. (2013) conducted a comprehensive analysis of the relationship between energy consumption and economic growth in Nigeria from 1975 to 2010. Their study encompassed various forms of energy consumption, including petroleum, gas, electricity, and coal. The findings indicated a generally positive relationship between total energy consumption and Nigeria's economic growth. Specifically, petroleum consumption, electricity consumption, and aggregate energy consumption were found to have significant and positive effects on economic growth. Gas consumption also showed a positive relationship with economic growth, although its impact was not statistically significant. In contrast, coal consumption was found to have a negative and significant impact on economic growth. These empirical results highlight the complex interplay between different energy sources and economic performance in Nigeria. They underscore the importance of understanding the specific impacts of each energy type on economic growth to formulate targeted energy policies that promote sustainable development. Building on this foundation, the current study aims to extend this analysis to the context of Pakistan's economy. By examining similar relationships and dynamics within Pakistan, this research seeks to contribute valuable insights into the role of energy consumption in shaping economic growth strategies.

Muhammad et al. (2013) conducted a comprehensive examination of the relationship between economic growth (EG) and energy consumption (EC) in Pakistan's economy. Using time series data and employing various econometric techniques such as Johansen cointegration test (JCT), Augmented Dickey-Fuller unit root test (URT), Granger causality test (GCT), error correction model (ECM), and autoregressive distributed lag (ARDL) model, the study aimed to uncover the dynamics between these variables. The findings of the study revealed a long-run relationship between economic growth and energy consumption in Pakistan. Importantly, the study identified a unidirectional causality running from energy consumption to economic growth. This suggests that energy consumption plays a significant role in driving economic growth in Pakistan. In light of these results, the study recommended that for sustainable growth, the Pakistani government should formulate policies aimed at exploring alternative energy sources. This approach would not only mitigate the dependency on traditional energy resources but also foster sustainable economic development. The insights provided by Muhammad et al. (2013) contribute significantly to understanding the energy-growth nexus in Pakistan. Building upon their findings, the present study seeks to delve deeper into these relationships, examining additional factors and implications for policy formulation in Pakistan's energy sector.

Lotz (2013) investigated the impact of renewable energy consumption on economic welfare across 31 countries from 1990 to 2010, employing panel data techniques within a multivariate framework based on the Cobb-Douglas production function. The study found a positive and statistically significant influence of renewable energy consumption on economic growth. This underscores the potential of renewable energy sources to foster sustainable economic development globally. Abid and Sebri (2012) conducted a study using the Granger causality approach to explore the relationship between energy consumption and economic growth in Tunisia from 1980 to 2007. Their analysis covered various sectors, including transport, manufacturing, and residential. The findings revealed mixed causality directions at both aggregated and disaggregated levels, highlighting the nuanced role of energy in Tunisia's economic development and suggesting diverse policy implications for sector-specific energy strategies.

Chaudhry et al. (2012) focused on Pakistan, investigating the relationship between energy consumption and economic growth using annual data from 1972 to 2012. Their empirical analysis provided insights into the dynamics between energy consumption and economic growth in Pakistan. Specifically, the study highlighted electricity consumption as a significant driver of economic growth, while oil consumption was found to have an adverse impact due to its high import volume. The Granger causality test indicated a unidirectional causality running from energy consumption to economic growth, underscoring the critical role of energy in Pakistan's economic development. The study also emphasized the vulnerability of Pakistan's GDP growth to energy shocks across all major energy sources, namely electricity, oil, coal, and gas consumption.

Lau et al. (2011) revisited the causality relationship between energy consumption (EC) and economic growth (GDP) across seventeen selected Asian countries. Their study indicated the presence of long-run stable equilibriums and a positive impact of energy consumption on GDP. In the short run, causality was found to run from energy consumption to GDP, reflecting the immediate influence of energy consumption on economic activities. However, in the long run, the causal linkage existed from GDP to energy consumption, suggesting that economic growth drives increased energy consumption over time. Abaidoo (2011) investigated the magnitude of impact and the causal relationship between energy consumption and economic growth (GDP) in an emerging economy using Granger causality tests. Based on quarterly data spanning 39 years, the study identified a unidirectional causal relationship with causality running from economic growth to energy consumption. This finding underscores the role of economic development in stimulating energy demand within emerging economies. Ozturk et al. (2010) examined the causality relationship between energy consumption and economic growth using panel data across 51 countries categorized by income groups from 1971 to 2005. Their study revealed diverse causality patterns: for low-income countries, there was long-term Granger causality running from GDP to energy consumption; for lower and upper-middle-income groups, bidirectional causality existed between energy consumption and GDP. These results highlight the varying dynamics of the energy-growth relationship across different income levels and underscore the importance of contextual factors in shaping these relationships.

Walde-Rufael (2010) investigated the long-run causal relationship between nuclear energy consumption and economic growth in India over the period 1969-2006. Using the Bounds test Approach to co-integration, the study revealed a positive impact of nuclear energy consumption on India's economic growth. Specifically, there was unidirectional causality running from nuclear energy consumption to economic growth, indicating that growth in India depended on nuclear energy consumption. Shocks to nuclear energy consumption were found to lead to fluctuations in real income, highlighting the significant role of nuclear energy in India's economic development strategy. Dantama et al. (2012) examined the impact of energy consumption on economic growth in Nigeria from 1980 to 2010. Employing the autoregressive distributed lag (ARDL) approach, their study estimated both short-run and long-run relationships. They found that petroleum consumption and electricity consumption exerted positive and statistically significant effects on economic growth in Nigeria. However, the coefficient for coal consumption was positive but statistically insignificant. Additionally, the study highlighted a relatively high speed of adjustment in the error correction model, suggesting rapid adjustments in the economy in response to deviations from long-run equilibrium in energy consumption.

Ozturk and Acaravci (2010) conducted a study on the relationship between energy consumption and economic growth in South-Eastern European economies, including Albania, Bulgaria, Hungary, and Romania. They identified a long-run relationship and bidirectional causality between electricity consumption per capita and GDP per capita in Hungary. However, no cointegration was found between electricity consumption and GDP per capita in Albania, Romania, and Bulgaria. This led to the estimation of a short-run error correction model for these countries, indicating different dynamics in the energy-growth relationship across the region. Mishra et al. (2009) conducted a comprehensive examination of the energy-GDP nexus across a panel of Pacific Island countries. Their study utilized Granger causality tests to explore the causal relationship between energy consumption and GDP. The findings revealed bidirectional causality between energy consumption and GDP, indicating mutual influences between these variables across the panel of countries. Positive effects were observed, underscoring the role of energy consumption in fostering economic growth in the Pacific Island region.

Khan and Ahmed (2008) focused on Pakistan, investigating the demand for energy at a disaggregate level (gas, electricity, and coal) using annual data from 1972 to 2007. Their empirical analysis provided insights into the responsiveness of energy consumption to changes in real income per capita and domestic price levels. The study found that electricity and coal consumption responded positively to changes in real income per capita, suggesting that economic growth stimulates demand for these energy sources in Pakistan. Conversely, gas consumption initially responded negatively to changes in real income and price levels in the short run. However, in the long run, real income exerted a positive effect on gas consumption, while domestic prices remained statistically insignificant. The study also highlighted that in the short run, gas consumption exhibited higher average elasticities to price and income changes compared to electricity and coal consumption, indicating different dynamics in the responsiveness of energy demand across different sources in Pakistan.

Erbaykal (2008) utilized time series data from 1970 to 2008 to examine the relationship between energy consumption and economic growth in Turkey, employing the Bounds test approach. The study found that in the short run, both oil and electricity consumption had a positive and statistically significant effect on economic growth. However, in the long run, the impact diverged: while oil consumption continued to have a positive effect on economic growth, electricity consumption exhibited a negative effect on economic growth. This highlights the varying dynamics of energy sources in influencing economic outcomes over different time horizons in Turkey. Mushtaq et al. (2007) conducted an extensive analysis using time series data from 1972 to 2005 to investigate the relationship between energy consumption (oil, electricity, and gas) and economic growth (GDP), focusing on Pakistan. Their co-integration analysis revealed a long-run equilibrium relationship between oil, electricity, gas consumption, and agricultural growth. The study's Granger causality tests indicated uni-directional causality running from oil consumption and electricity consumption to GDP, suggesting that these energy sources play a significant role in driving economic growth in Pakistan. Additionally, the analysis found bidirectional causality for gas consumption, indicating its important implications for agricultural growth in the country.

Sheng et al. (2006) conducted a comprehensive analysis of the relationship between electric energy consumption and economic growth across ten newly industrialized and developing Asian countries. Using both single and panel data sets, their study revealed significant variations in the direction of causal relationships among these economies. This variability underscored the influence of unique country-specific factors in shaping the energy-growth nexus across the region. The findings highlighted the complex interplay between energy consumption and economic development, emphasizing the need for tailored energy policies that account for diverse economic contexts. Wolde-Rufael (2004) explored the long-run causal relationship between electricity consumption per capita and real GDP per capita across 17 African countries from 1971 to 2001. Employing cointegration tests proposed by Pesaran et al. (2001) and a modified version of the Granger causality test developed by Toda and Yamamoto (1995), the study identified a long-run relationship between electricity consumption per capita and real GDP per capita in nine of the countries studied. Granger causality tests further revealed varied causal directions among the countries: for six countries, there was a positive unidirectional causal relationship from real GDP per capita growth to electricity consumption per capita; for three countries, the causality ran in the opposite direction (from electricity consumption to GDP per capita); and for three countries, a bidirectional causal relationship was observed. These findings illustrated that despite the consistent evidence of a long-run relationship between economic growth and electricity consumption, the direction of causality could vary significantly across different African economies.

Paul and Bhattacharya (2004) conducted a comprehensive analysis of the causality between energy consumption and economic growth in India spanning from 1950 to 1996. Utilizing both the Engle-Granger (1987) and Johansen (1988) cointegration approaches, the study examined the temporal dynamics of the relationship. The findings supported the presence of unidirectional causality from energy consumption to economic growth in India. Specifically, the Engle-Granger cointegration test indicated a long-run causal relationship running from GDP to energy consumption, suggesting that economic growth in India influences energy consumption patterns over extended periods. In the short run, however, no significant causal relationship was found between energy consumption and GDP using this approach. Further analysis combining the Engle-Granger approach with standard Granger causality tests revealed bi-directional causality between energy consumption and economic growth. This nuanced understanding indicated that while energy consumption influenced economic growth in the short run, economic growth also exerted a feedback effect on energy consumption in the long run.

Adjaye (2000) investigated the causal relationships between energy consumption and income across India, Indonesia, the Philippines, and Thailand using cointegration and error-correction modeling techniques. The study found varying causal dynamics among these countries: in the short run, unidirectional Granger causality ran from energy to income for India and Indonesia, indicating that changes in energy consumption influenced income levels. Conversely, Thailand and the Philippines exhibited bidirectional Granger causality between energy consumption and income, suggesting a mutual feedback loop where changes in energy consumption and income affected each other over time. These findings highlighted the nuanced and country-specific nature of the energy-income relationship in Southeast Asia. Siddiqui and Haq (1999) analyzed the demand for different sources of energy, emphasizing price elasticity and income effects across various socio-economic conditions. Their study concluded that energy demand in general is price elastic, meaning changes in energy prices significantly influence demand. Additionally, changes in income levels were found to have a substantial impact on energy demand, reflecting broader economic conditions such as inflation, income distribution, and political and social factors within a country. These insights underscored the multifaceted drivers of energy demand and the complexities involved in energy policy formulation aimed at sustainable economic development. Cheng and Lai (1997) employed Hsiao's version of cointegration and Granger causality methods to investigate the causal relationships between energy consumption and economic indicators such as GDP and employment in Taiwan from 1955 to 1993. Their study identified a unidirectional causality running from GDP to energy consumption without feedback. This finding suggested that economic growth, as measured by GDP, influenced energy consumption patterns in Taiwan over the studied period, highlighting the predominant role of economic development in shaping energy demand dynamics.

Masih and Masih (1996) examined the co-integration and temporal causality between energy consumption and real income across several Asian economies. They found evidence of a co-integrated relationship between economic growth and energy consumption in India, Pakistan, and Indonesia, indicating a long-term equilibrium where changes in real income affected energy consumption patterns and vice versa. However, no such co-integration relationship was observed in the cases of Malaysia, Singapore, and the Philippines, suggesting different dynamics in these economies. Their use of co-integration and error correction modeling techniques provided insights into the temporal dynamics and causal linkages between energy consumption and economic growth across diverse Asian contexts.

Stern (1993) conducted an extensive review of the literature on the relationship between energy consumption and economic growth, emphasizing that economic growth is influenced not only by energy use but also by the quality differences in labor and capital. He argued that traditional aggregate measures fail to capture these quality distinctions, such as the efficiency differences between various types of energy sources and the skill levels of labor. Stern advocated for variables that account for these quality differences, such as using wages and energy prices, to more accurately model the impact of energy on economic growth. His analysis, based on annual data from 1947 to 1990 for the US, supported the importance of considering these factors in understanding the dynamics of energy consumption and economic growth.

Erol and Yu (1987) examined the causal relationships between energy consumption and GDP across several major economies including England, France, Italy, Germany, Canada, and Japan from 1952 to 1982. Their study identified varying causal dynamics among these countries: bidirectional causality was found for Japan, indicating mutual influences between energy consumption and GDP. In contrast, Canada exhibited unidirectional causality running from energy consumption to GDP, suggesting that changes in energy consumption influenced economic output. Germany and Italy showed unidirectional causality from GDP to energy consumption, implying that economic growth drove changes in energy consumption patterns. No significant causal relationship was found for France and England, highlighting unique economic dynamics in these countries. Erol and Yu's findings underscored the diverse and context-specific nature of the energy-GDP relationship across different national contexts. The present study endeavors to bridge a significant gap by delving into the intricate relationship between energy consumption—encompassing electricity, oil, coal, and gas—and GDP within the context of Pakistan's economy.

3. METHODOLOGY

The present study employs time series data analysis to investigate the relationship between energy consumption variables (including GDP growth rate, oil consumption, gas consumption, electricity consumption, and coal consumption) and economic growth in Pakistan. The study utilizes annual observations spanning from 1980 to 2021 sourced from the Economic Survey of Pakistan and World Development Indicators. The objective is to explore how energy consumption influences economic growth within the context of Pakistan's economy.

4. RESULTS AND DISCUSSION

Table 1 presents the regression results for energy consumption with the dependent variable being LGDP (log of GDP). The constant term (C) has a coefficient of -8.458775 with a standard error of 1.280939, resulting in a t-statistic of -6.603572 and a highly significant p-value of 0.0000. This indicates that when all other variables are zero, the log of GDP is significantly impacted by the constant term. The coefficient for LL (log of labor) is 2.986882 with a standard error of 0.313074. The t-statistic is 9.540514, and the p-value is 0.0000, which is highly significant. This suggests a strong positive relationship between labor and the log of GDP, indicating that an increase in labor is associated with an increase in GDP. The coefficient for LK (log of capital) is 0.000745 with a standard error of 0.020446. The t-statistic is 0.036428, and the p-value is 0.9712, which is not significant. This implies that capital does not have a statistically significant effect on the log of GDP in this model. The coefficient for LENER (log of energy consumption) is -0.721190 with a standard error of 0.252953. The t-statistic is -2.851084, and the p-value is 0.0079, indicating significance at the 1% level. This negative coefficient suggests that higher energy consumption is associated with a decrease in GDP, holding other factors constant. In summary, the regression analysis reveals that labor has a significant positive impact on GDP, energy consumption has a significant negative impact, and capital does not have a significant impact on GDP within this model.

Table 2 presents the Ordinary Least Squares (OLS) regression results for the relationship between oil consumption and economic growth, with LGDP (log of GDP) as the dependent variable. The constant term (C) has a coefficient of -5.930495 with a standard error of 0.531595, resulting in a t-statistic of -11.15605 and a highly significant p-value of 0.0000. This indicates that the log of GDP is significantly impacted by the constant term when all other variables are zero. The coefficient for LL (log of labor) is 2.457038 with a standard error of 0.130247. The t-statistic is 18.86440, and the p-value is

0.0000, which is highly significant. This suggests a strong positive relationship between labor and the log of GDP, indicating that an increase in labor is associated with an increase in GDP. The coefficient for LK (log of capital) is -0.008701 with a standard error of 0.019349. The t-statistic is -0.449664, and the p-value is 0.6563, which is not significant. This implies that capital does not have a statistically significant effect on the log of GDP in this model. The coefficient for LOIL (log of oil consumption) is 0.257536 with a standard error of 0.085876. The t-statistic is 2.998930, and the p-value is 0.0055, indicating significance at the 1% level. This positive coefficient suggests that higher oil consumption is associated with an increase in GDP, holding other factors constant. In summary, the OLS regression analysis reveals that labor and oil consumption have significant positive impacts on GDP, while capital does not have a significant impact on GDP within this model.

Table 1: Regression results – Energy consumption

Dependent Variable: LGDP				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-8.458775	1.280939	-6.603572	0.0000
LL	2.986882	0.313074	9.540514	0.0000
LK	0.000745	0.020446	0.036428	0.9712
LENER	-0.721190	0.252953	-2.851084	0.0079

Table 2: OLS results - Oil Consumption and Economic Growth

Dependent Variable: LGDP				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-5.930495	0.531595	-11.15605	0.0000
LL	2.457038	0.130247	18.86440	0.0000
LK	-0.008701	0.019349	-0.449664	0.6563
LOIL	0.257536	0.085876	2.998930	0.0055

Table 3 presents the results of an Ordinary Least Squares (OLS) regression analysis investigating the relationship between gas consumption and economic growth, where LGDP (log of GDP) serves as the dependent variable. The constant term (C) has a coefficient of -5.468434 and a standard error of 2.806694. The associated t-statistic is -1.948355, with a p-value of 0.0611. This indicates that the intercept, representing the baseline impact on GDP, shows marginal significance at the 10% level, suggesting a potentially negative effect on economic growth that is not statistically robust in this model. The log of labor (LL) variable exhibits a coefficient of 2.210178, with a standard error of 0.629334. Its t-statistic is 3.511931, indicating statistical significance at the 1% level. This result suggests that increases in labor are associated with higher GDP, highlighting the positive impact of labor inputs on economic growth. The log of capital (LK) shows a coefficient of -0.017521 and a standard error of 0.022910. The associated t-statistic is -0.764772, with a p-value of 0.4506, indicating no statistically significant relationship between capital and GDP in this model. This suggests that variations in capital do not significantly explain changes in economic growth as captured by GDP. Regarding log of gas consumption (LGS), the coefficient is -0.055885, and the standard error is 0.355014. The t-statistic is -0.157416, with a p-value of 0.8760, indicating no statistical significance. This implies that changes in gas consumption levels do not have a significant impact on economic growth in this regression framework. Based on the OLS regression results presented in Table 3, labor appears to be a significant determinant of economic growth, while neither capital nor gas consumption show statistically significant effects on GDP in this particular model specification.

Table 3: OLS results – Gas Consumption and Economic Growth

Dependent Variable: LGDP				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-5.468434	2.806694	-1.948355	0.0611
LL	2.210178	0.629334	3.511931	0.0015
LK	-0.017521	0.022910	-0.764772	0.4506
LGS	-0.055885	0.355014	-0.157416	0.8760

Table 4 provides the results of an Ordinary Least Squares (OLS) regression analysis examining the relationship between coal consumption and economic growth, where LGDP (log of GDP) serves as the dependent variable. The constant term (C) has a coefficient of -2.255772 and a standard error of 1.442036. The associated t-statistic is -1.564297, with a p-value of 0.1286. This suggests that the intercept, representing the baseline impact on GDP, is not statistically significant at conventional levels ($\alpha = 0.05$), indicating that the initial economic impact in this model is not robustly supported. The log of labor (LL) variable shows a coefficient of 1.629534 and a standard error of 0.245410. Its t-statistic is 6.640043, indicating strong statistical significance at the 1% level. This result suggests that increases in labor are associated with higher GDP, highlighting the positive impact of labor inputs on economic growth. The log of capital (LK) exhibits a coefficient of -0.034000 and a standard error of 0.021758. The associated t-statistic is -1.562617, with a p-value of 0.1290, indicating no statistically significant relationship between capital and GDP in this model. This implies that variations in capital do not significantly explain changes in economic growth as captured by GDP. Regarding log of coal consumption (LCO), the coefficient is 0.288483 and the standard error is 0.141554. The t-statistic is 2.037975, with a p-value of 0.0508, suggesting marginal significance at the 5% level. This indicates that changes in coal consumption levels may have a modest positive impact on economic growth in this regression framework, albeit with caution due to the marginally significant p-value. Based on the OLS regression results presented in Table 4, labor appears to be a significant determinant of economic growth, while coal consumption shows a marginally significant positive association with GDP. However, the constant term and capital do not exhibit statistically significant effects on GDP in this particular model specification.

Table 4: OLS results -Coal Consumption and Economic Growth

Dependent Variable: LGDP

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.255772	1.442036	-1.564297	0.1286
LL	1.629534	0.245410	6.640043	0.0000
LK	-0.034000	0.021758	-1.562617	0.1290
LCO	0.288483	0.141554	2.037975	0.0508

Table 5 presents the results of an Ordinary Least Squares (OLS) regression analysis investigating the relationship between electricity consumption and economic growth, with LGDP (log of GDP) as the dependent variable. The constant term (C) has a coefficient of -6.016688, with a standard error of 0.564985. The associated t-statistic is -10.64929, indicating high statistical significance (p-value < 0.0001). This suggests that the intercept, representing the baseline impact on GDP, is highly significant, indicating a robust initial economic effect in this model. The log of labor (LL) variable shows a coefficient of 2.605522 and a standard error of 0.185199. Its t-statistic is 14.06875, indicating strong statistical significance (p-value < 0.0001). This result suggests that increases in labor are strongly associated with higher GDP, highlighting the positive impact of labor inputs on economic growth. The log of capital (LK) exhibits a coefficient of 0.002749 and a standard error of 0.020745. The associated t-statistic is 0.132519, with a p-value of 0.8955, indicating that variations in capital do not have a statistically significant relationship with GDP in this model. This implies that changes in capital levels do not significantly explain changes in economic growth as captured by GDP. Regarding log of electricity consumption (LELECT), the coefficient is 0.280791 and the standard error is 0.099296. The t-statistic is 2.827814, with a p-value of 0.0084, suggesting statistical significance at the 1% level. This indicates that increases in electricity consumption are positively associated with economic growth in this regression framework, suggesting that higher levels of electricity consumption may contribute to economic growth. In summary, based on the OLS regression results presented in Table 5, labor and electricity consumption appear to be significant determinants of economic growth. The constant term shows a strong negative impact on GDP, indicating an important baseline effect, while capital does not exhibit a statistically significant effect on GDP in this particular model specification.

Table 5: OLS results - Electricity Consumption and Economic Growth

Dependent Variable: LGDP

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-6.016688	0.564985	-10.64929	0.0000
LL	2.605522	0.185199	14.06875	0.0000
LK	0.002749	0.020745	0.132519	0.8955
LELECT	0.280791	0.099296	2.827814	0.0084

5. CONCLUSION

This study investigates the degree of integration among various economic time series spanning from 1980 to 2021 in Pakistan. This methodological choice allows for an examination of whether there exists a stable relationship between energy consumption variables (such as oil, gas, electricity, and coal consumption) and economic growth (measured by GDP). Johansen's co-integration approach serves as a robust econometric technique used to analyze the long-run equilibrium relationships among multiple time series variables. The approach is particularly valuable due to its capability to simultaneously analyze multiple variables, considering their potential interactions and dependencies. Identifying co-integration among these variables provides insights into whether changes in energy consumption have a lasting impact on economic growth, and vice versa. Such insights are crucial for policymakers and researchers aiming to understand the dynamics of Pakistan's economy, particularly in relation to its energy sector. Once co-integration is established, further analysis can explore the direction and strength of causality between energy consumption and economic growth. This deeper analysis can offer valuable insights into the mechanisms driving Pakistan's economic performance over the studied period. Pakistan is presently pursuing a multi-pronged strategy to ensure adequate and uninterrupted oil and gas supply and other energy resources to sustain the current energy pattern for rapid national economic growth. Greater reliance on gas, aggressive pursuit of hydroelectric power generation, and enhancing nuclear power generation capacity are key elements of this strategy. Pakistan is also aiming to expand its primary energy supply base by encouraging oil exploration and power generation companies to undertake energy projects within the country. Additionally, Pakistan is actively pursuing regional gas pipeline projects to meet its growing domestic energy demands. Resolving these energy crises promptly is crucial for achieving short and medium-term economic growth and development objectives.

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