JOURNAL OF ACADEMIC RESEARCH FOR HUMANITIES
ISSN 2663-192x

ORCID of the Journal: https://orcid.org/0009-0000-0723-9485
DOI Number of the Paper: https://zenodo.org/records/12734816
Edition Link: Journal of Academic Research for Humanities JARH, 4(3) July-Sep. 2024
Link of the Paper: https://jar.bwo-researches.com/index.php/jarh/article/view/426
HJRS Link: Journal of Academic Research for Humanities JARH (HEC-Recognized for 2023-2024)

ENERGY PRODUCTIVITY AND ECONOMIC GROWTH NEXUS: A CASE STUDY OF PAKISTAN FROM 1990-2018

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Paper Information

Citation of the paper:
(JARH) Arafat. Y., Amir. A. & Sami. F., (2024). Energy Productivity and Economic Growth Nexus: A Case Study of Pakistan from 1990-2018. in *Journal of Academic Research for Humanities*, 4(*3*), 106–117.

QR Code for the Paper:

Subject Areas for JARH:
1 Economics
2 Social Science

Timeline of the Paper at JARH:
Received on: 06-04-24
Reviews Completed on: 03-07-24
Accepted on: 20-07-24
Published: 24-07-24

Recognized for BWO-R:
HJRS HEC Journal Recognition System

Published by BWO Researches INTL.:
BWO RESEARCHES (PVT) LTD INTERNATIONAL

DOI Image of the paper:
DOI 10.5281/zenodo.12734816

Abstract

This study investigates the relationship between energy and economic growth in Pakistan from 1990 to 2018. Using Gross Domestic Product (GDP) as the dependent variable, the study examines the effects of gross fixed capital formation, labor productivity, energy balance, oil prices, and Foreign Direct Investment (FDI) in the energy sector as independent variables. The analytical framework employs the Auto Regressive Distributed Lag (ARDL) Model, while the stability of variables is assessed through CUSUM and CUSUM Square tests. Key findings reveal that labor force participation in the energy sector and rising oil prices have a sustained negative impact on economic growth. Conversely, gross fixed capital formation positively influences GDP both in the short and long term. Interestingly, FDI in the energy sector shows a negative effect on GDP in the short term but a positive effect in the long term. The study emphasizes the need for a comprehensive transformation of Pakistan's energy sector. It recommends a strategic shift from hydrocarbon-based energy to hydropower to stabilize oil prices and achieve significant, sustainable production increases in the long term. These findings provide critical insights into Pakistan's energy-economic relationship, offering valuable guidance for policymakers, scholars, and industry stakeholders.

Keywords: Energy, productivity, Growth, Hydropower, Prices

Introduction

Energy is widely considered the lifeblood of the economy, with its impact being undeniable across all sectors. In order to achieve long-term economic goals, it is imperative for a country to simultaneously focus on both energy and economic growth, while ensuring that the environment and its resources remain unharmed (Asghar & Zahid, 2018). Energy serves as a fundamental cornerstone of the modern industrial economy, playing an integral role in almost all human activities(Halbast, Hussein, Hamadamin, et. al. 2019). Consequently, any national economy is heavily reliant on the energy sector. The demand for energy, its supply, and pricing have a significant impact on economic growth, social well-being, standards of living, and the overall welfare of the population. The economic structure and macroeconomic conditions are vital determinants of energy demand and supply within a country (Doguwa & Disina, 2021). This current study aims to investigate the relationship between energy and economic growth in Pakistan from 1990 to 2018. The study uses Gross Domestic Product (GDP) as the dependent variable, with gross fixed capital formation, labor productivity, energy balance, oil prices, and Foreign Direct Investment (FDI) in the energy sector as independent variables. (Farah, Kashif, 2023,).

The Gross Domestic Product (GDP) represents the total monetary value of all goods and services produced within a country. It is a primary indicator of economic health and growth, reflecting the economic performance and standard of living in Pakistan (World Bank, 2021). Various factors influence GDP, including gross fixed capital formation, labor productivity, energy balance, oil prices, and foreign direct investment (FDI) in the energy sector. Gross fixed capital formation refers to the net investment in physical assets such as machinery, infrastructure, and buildings, which is crucial for increasing production capacity and fostering economic growth (OECD, 2021). Labor productivity measures the output per labor unit, indicating the efficiency and effectiveness of the labor force. High labor productivity is often associated with economic growth and competitiveness (ILO, 2021). Energy balance captures the equilibrium between energy production and consumption. A positive energy balance signifies energy sufficiency, while a negative balance indicates dependence on energy imports, affecting economic stability (IEA, 2021). Oil prices influence the cost of energy and production inputs, with fluctuations having significant impacts on the economy, particularly in energy-dependent countries like Pakistan (EIA, 2021). Lastly, FDI in the energy sector involves foreign investments in energy projects and infrastructure, enhancing energy production capacity, technology transfer, and overall economic growth (UNCTAD, 2021). Investment in physical assets, such as those measured by gross fixed capital formation, is expected to boost economic output by increasing production capacity, leading to higher GDP (Solow, 1956). Higher labor productivity contributes to economic growth by enhancing the efficiency and output of the workforce, resulting in an increased GDP (Krugman, 1994). A positive energy balance supports economic growth by ensuring a stable energy supply, essential for industrial and commercial activities, thereby positively affecting GDP (Stern, 2011). Fluctuations in oil prices impact production costs and consumer spending, with high oil prices potentially constraining economic growth by increasing costs, whereas low oil prices can stimulate growth by reducing expenses (Hamilton, 2009). FDI in the energy sector can stimulate economic growth by enhancing energy production, improving infrastructure, and fostering technological advancements, all of which contribute to an increased GDP (Borensztein et al., 1998). These relationships highlight the interconnectedness of these variables and their collective impact on Pakistan's economic performance.

Problem Statement

Before 1973, the global increase in energy consumption was in tandem with population growth. In response, various reforms were instituted, leading to a reduction in energy prices and an increase in the standard of living and income for people worldwide. Despite this, global energy demand continued to surge until the post-1973 era. The availability of low-cost electricity played a crucial role in strengthening industrialization and economic prosperity. However, the sharp increase in international oil prices in 1970 led to a corresponding increase in energy prices, which surged again in 1979 and 1980. These significant price hikes had a more profound impact on underdeveloped countries than their developed counterparts (Iwayemi, 1998). Like other underdeveloped countries, Pakistan faces significant obstacles in its economic development due to energy crises and high energy prices. The electricity crisis in Pakistan continues to worsen with each passing day, as the current production from all sources falls far short of the actual electricity demand.

Significance of the Study

Energy plays a crucial role in improving the economy and enhancing energy efficiency and productivity. As a result of industrialization, urbanization, and the continuous increase in energy consumption, energy consumption is increasing rapidly in all areas (Setiartiti, L., & Al-Hasibi, R. A.,2021). The relationship between energy consumption and economic instability has been the subject of increasing attention in recent years. However, there is no consensus on the direction and causality of this relationship for all energy sources in Pakistan. Inadequate investment in the energy sector and underdeveloped commercial energy infrastructures are major obstacles to the development of the energy sector (Amjed, S., Shah, I. A., & Riaz, A., 2022). It is now widely acknowledged that affordable access to energy services is essential for reducing poverty and a precondition for further economic growth. Thus, Pakistan is actively promoting regional energy integration to improve the standard of living for millions of people and increase the country's per capita energy consumption, leading to increased GDP.

Research Questions

i- What is the relationship between energy consumption and economic growth in Pakistan?

ii- How do factors such as gross fixed capital formation, labor productivity, energy balance, oil prices, and Foreign Direct Investment (FDI) in the energy sector impact GDP in Pakistan?

iii- What are the short-term and long-term effects of these variables on economic growth?

Objectives of Research

i- To investigate the relationship between energy consumption and economic growth in Pakistan from 1990 to 2018.

ii- To examine the effects of gross fixed capital formation, labor productivity, energy balance, oil prices, and Foreign Direct Investment (FDI) in the energy sector on GDP.

iii- To analyze these variables' short-term and long-term effects on economic growth.

Hypothesis

This study hypothesizes that:

i- Labor force participation in the energy sector and rising oil prices hurt economic growth.

ii- Gross fixed capital formation positively influences GDP both in the short and long term.

iii- FDI in the energy sector has a negative effect on GDP in the short term but a positive effect in the long term.

Limitation of the Study

This study on the relationship between energy and economic growth in Pakistan from 1990 to 2018 has several limitations. The reliance on historical data may result in inaccuracies and gaps affecting the robustness of the results. The selected variables, while significant, do not encompass all potential factors influencing economic growth, such as technological advancements and regulatory changes. Findings specific to Pakistan may not be generalizable to other countries with different contexts. Additionally, the study does not account for exogenous shocks like political instability or global economic crises, which can significantly impact energy production and economic growth. Lastly, while policy recommendations are based on empirical findings, their practical effectiveness may vary due to implementation challenges and unforeseen socio-economic factors.

Literature Review

The relationship between energy and economic growth has been the subject of various studies. Kraft and Kraft were among the first to investigate this relationship in the United States. Their study examined the relationship between electricity and GDP in all states of the USA from 1947 to 1974 and found that GDP and electricity capacity were closely related. The increase in wealth was found to lead to economic growth in the USA (Kraft and Kraft, 1978). Dizdarević and Žiković investigated the impact of energy on Croatia's economic growth using time series data from 1993 to 2006. They used co-integration analysis to examine the long-run relationship between GDP and energy consumption by households, industries, energy production, energy imports, and oil consumption. The ADF test was employed to determine the presence of a unit root and to identify the appropriate order of integration (Dizdarević and Žiković, 2010). Similarly, Naseem and Khan examined the effect of the energy crisis on Pakistan's economic growth using sample data from 1982 to 2011. They used energy consumption as an independent variable and GDP as the dependent variable. The data was analyzed using descriptive statistics, correlation, and regression tests. Their findings indicated that an increase in energy consumption by a 1-kilo ton of oil equivalent would lead to a $2.517 million increase in GDP. These studies highlight the significance of the relationship between energy and economic growth and the importance of investigating this relationship in different contexts (Naseem & Khan,2015; Susilo, Y. S., Kartawinata, M., & Herawan, J. E, 2024). Alam, Shahbaz & Abbas, investigated the energy-growth nexus in the context of the BRICS countries. Using panel cointegration and causality tests, the research revealed a bidirectional causal relationship between energy consumption and economic growth in the long run. The findings emphasized the importance of addressing energy efficiency and sustainability in the economic development strategies of BRICS nations (Alam, Shahbaz &Abbas; 2020, Mu, 2024). Lee, Lee & Ning, Focusing on Taiwan, Lee and colleagues explored the long-run relationship between energy consumption, economic growth, and financial development from 1971 to 2018. Employing the autoregressive distributed lag (ARDL) approach, the study highlighted a positive and significant relationship between energy consumption and economic growth, with financial development acting as a contributing factor (Lee, Lee &Ning,2020). Narayan & Smyth, examined the energy-growth nexus in 93 countries, with a particular focus on renewable energy. Utilizing panel data analysis, the research found evidence of bidirectional causality between renewable energy consumption and economic growth. The study emphasized the potential of renewable energy to positively impact economic development globally. Amri & Shahbaz, Investigated the Middle East and North Africa (MENA) region, Amri and Shahbaz studied the dynamics between energy consumption, economic growth, and CO2 emissions. The research, using panel data analysis, revealed a long-run positive relationship between energy consumption and economic growth, underscoring the challenges and opportunities for sustainable development in the MENA region (Amri & Shahbaz,2020). Mollick, Aslam, & Balcilar, conducted a study on the energy-growth nexus in a sample of European countries. Employing panel cointegration techniques, the research identified a bidirectional causality between energy consumption and economic growth, emphasizing the need for coordinated energy policies at the regional level to foster sustainable economic development (Mollick, Aslam, & Balcilar, 2020). Apergis & Ewing investigated the role of energy consumption in promoting economic growth in European countries. Using panel data and causality tests, the study found evidence of bidirectional causality, suggesting a mutually reinforcing relationship between energy consumption and economic growth in the EU (Apergis & Ewing 2021; Khan, M. B., Saleem, H., Shabbir, M. S., & Huobao, X, 2022). Doguwa & Disina, examined the energy-growth nexus in the context of Nigeria, considering the role of financial development. Applying autoregressive distributed lag (ARDL) modeling, the research identified a positive long-run relationship between energy consumption and economic growth, with financial development playing a complementary role (Doguwa &Disina,2021). Feng & Dong, investigating the dynamics in China, Feng and Dong explored the relationship between energy consumption, economic growth, and environmental pollution. Utilizing advanced econometric techniques, the study highlighted the trade-offs between economic development, energy consumption, and environmental sustainability, providing insights for policymakers navigating these challenges (Feng & Dong, 2021). Kumar & Stauvermann focused on the relationship between energy consumption and economic growth in the Association of Southeast Asian Nations (ASEAN) region. Using panel cointegration analysis, the research revealed a positive and significant long-run relationship, emphasizing the need for coordinated energy policies to support sustainable economic development in ASEAN countries(Kumar & Stauvermann, 2021). Hafeez & Bashir, exploring the energy-growth nexus in Pakistan, the study employed time series data and autoregressive distributed lag (ARDL) modeling. The study found evidence of a positive long-run relationship between energy consumption and economic growth, with implications for energy policy and sustainable economic development in Pakistan(Hafeez & Bashir,2021).

These recent studies contribute to the evolving understanding of the energy-growth relationship, considering various geographical contexts, energy sources, and additional factors such as financial development and environmental sustainability. The methodologies employed in these studies provide nuanced insights for policymakers and researchers working towards balanced and sustainable economic development.

Material And Methods

1.1 Data Description

In this study, an analysis of time series data on energy production, demand, and supply as well as gross domestic product (GDP) was conducted in Pakistan covering the period from 1990 to 2018. The data was obtained from various authoritative entities such as the Pakistan Bureau of Statistics, National Transmission and Dispatch Company Limited, WAPDA, World Bank, and WDI. As with most time series analyses, the problem of heteroscedasticity arose, which can lead to biased results. To address this, variables were log-transformed to reduce heteroscedasticity and ensure statistical reliability of the results. After transforming the data, an econometric model was estimated to determine the relationship between the variables and provide insight into the energy and economic situation in Pakistan during the study period (Wanke, Tan, Antunes, et. al. 2024).

1.2 Specification of the Model

The endogenous growth model underlying this suggests that economic growth is influenced by macroeconomic variables outside the economy. In other words, factors outside the domestic economy play a vital role in determining economic prosperity. This approach was first introduced by Romer in 1994 and has since become an important framework for the study of economic growth. The model assumes that knowledge and technology are key drivers of growth and that economic agents can create and accumulate knowledge over time to increase productivity. To estimate the model, the study will use several statistical techniques like Co-integration to analyze the relationship between the variables (Romer, P.M. 1994). Taken together, the endogenous growth model provides a theoretical basis for understanding the factors that drive economic growth. By examining the relationship between key macroeconomic variables, this study aims to provide insight into the drivers of economic growth in the context of Pakistan. The use of advanced statistical techniques i.e. co-integration technique will help ensure reliable and trustworthy results that can inform policy decisions and contribute to the ongoing debate on economic growth in the country.

1.2.1 *An Econometric Model*:

To find out the relationship between energy production and GDP, the endogenous growth model is used, which is shown below:

$$Y= \alpha\,(GFCFt) + \beta\,(LPf) + \gamma\,(At) + \theta\,(FDIt) + \pi\,(OPt) + \mu t \text{----------------- (1)}$$

were

Yt = output measured in terms of GDP
GFCFt= ('Gross Fixed Capital Formation'/GDP is used as a proxy for fixed capital
LPf= Labor Force Participation
At = total factor productivity (supply and demand (electricity consumption) + machinery and tools)
FDIt= foreign direct investment
OPt = Average Oil Prices in Pakistan

To achieve the objectives of the study, the above model is transformed into a logarithmic form to avoid the problem of heteroscedasticity and to bring the non-linear variables into a linear form.

LogYt= α log (GFCFt) + β log (LPt) + γlog (At) + θ log (FDIt) +π log (OPt) +μt ----- (2)

Were LYt= Log of output measured in terms of GDP LGFCFt = Log of ('Gross Fixed Capital Formation' / GDP is used as a proxy for fixed capital) Log LPf= log of Labor Force Participation
LAt= Log of Total factor Productivity (supply and demand (electricity consumption) + machines and tools)
Log FDIt= Record of foreign direct investments
LOPt = log of average oil prices in Pakistan
μt = error term that is normally "distributed" with "mean" zero (μ=0) and variance "sigma" squared (σ2).
α, β, γ, θ, π and £ show the elasticity of Y, i.e. output with capital, labor productivity, investment, average oil productivity, and price shocks.

2. Methodology of Econometrics

In addition to ensuring that the data are stationary and free of unit root problems, other problems arise with time series analysis. Heteroscedasticity is a common problem that can occur when analyzing time series data. This occurs when the error variance in the data is not constant over time. To solve this problem, one possible solution is to transform the data by logarithmizing the variables. In addition, modeling techniques such as autoregressive integrated moving averages (ARIMA) can be used to identify patterns in data and generate forecasts. It is important to note that when analyzing time series, proper interpretation of the results is essential, and care must be taken not to draw misleading conclusions.

3. Finding And Discussion

3.1. *Root unit test*

One of the most important initial steps in time series analysis is to ensure that the variables are stationary. This process involves performing a unit root test, usually through the Augmented Dickey-Fuller (ADF) test. The presence of a unit root in the data indicates that the data is non-stationary. Table 4.1 presents the results of the ADF test performed in both level and first difference. Almost all variables are observed to be stationary at the first difference except for energy demand which is stationary at the level (with a significant level of 5%). Variables that were not stationary at the level were further analyzed at the first difference and second difference where necessary.

It is worth noting that once the variables reach I (0) and I (1) integration, they become stationary, allowing the use of the ARDL (Autoregressive Distributed Lag) model. Therefore, it is important to ensure that the variables are stationary before performing any time series analysis to avoid generating erroneous results.

Table 3.1: Unit Root Test

See Annex A

The table given above indicates that most of the variables in this study are integrated of order I (1), except energy demand which is integrated at level or order I(0). This characteristic of the variables justifies the use of the autoregressive distributed lag (ARDL) model to explore the relationships between them. To determine the appropriate lag length for this analysis, the Akaike Information Criterion (AIC) was used, resulting in the selection of a lag length of (1 1 1 1 0 1 1) for the variable of interest (Y GFCF LP FDI ES). ED and EB) respectively.

The general-to-specific method was then used to remove any insignificant variables from the model. The final model was selected based on satisfactory diagnostic tests, such as the Jarque-Bera test for normality, heteroscedasticity, and serial correlation. Furthermore, the CUSUMSQ and CUMSUM statistics indicate that there was no structural instability or misspecification during the estimated period.

Overall, these steps ensure the validity and accuracy of the findings from the ARDL model, ultimately leading to a comprehensive understanding of the relationships between the variables under investigation.

3.2. Short-run and long-run relationship

The primary objective of this study is to investigate the complex nexus between energy production and economic stability in Pakistan. To accomplish this task, the dependent variable, which is an indicator of economic growth, is denoted by the symbol "Y". The explanatory variables employed in this analysis include Gross Fixed Capital Formation (GFCF), Labor Participation (LP), Oil Prices (OP), Energy Balance (EB), and Foreign Direct Investment (FDI) within the energy sector. All variables of interest have been expressed in logarithmic form, to avoid the issue of heteroscedasticity and to transform non-linear variables into linear form.

To unravel the complex relationship between the variables of interest, the Autoregressive Distributed Lag (ARDL) model was chosen as the appropriate modeling approach. The estimated results of this modeling analysis are presented in Table 4.2 as follows:

Table 3.2: ARDL Co-integrating and Long Run Form

See Annex B

The table presented indicates that Gross Fixed Capital Formation (GFCF) has a significant and positive impact on economic growth, specifically at a lag of 2. This means that a 1% increase in capital stock results in a 0.54% increase in economic growth. In this study, the energy balance serves as a proxy for factor productivity, and the results show that it is not significantly associated with Y in level, lag 1, or lag 2. Moreover, labor participation in the energy sector and an increase in oil prices have negative impacts on economic growth in the long run, reducing it by 0.08% and 0.21%, respectively. On the other hand, capital formation has a positive effect, resulting in a short-term GDP increase of 0.54% and a long-term increase of 0.88%. Interestingly, the effect of Foreign Direct Investment (FDI) is surprising, as it initially leads to a decrease in GDP by 0.13% in the short run but has a positive impact of 0.59% in the long run. This may be due to the continuous depreciation of Pakistan's currency, which affects both investors and the real value of money. Additionally, the agreement between the government and investors to pay them according to their capacity results in reduced GDP in the short run since many private sector entities produce electricity below their actual capacity. Finally, the table indicates that an increase of 1% in capital stock can increase economic growth by 0.30% over time. In the long run, labor participation in the energy sector exhibits a negative and insignificant association with economic growth. Additionally, the relationship between energy demand and oil prices in Pakistan differs from other countries, as an increase in oil prices leads to a decrease in economic growth over time. This can be attributed to the fact that most power generation in Pakistan is hydel-based and uses furnace oil as a backup source, resulting in an increase in per unit productivity of electricity with an increase in oil prices. However, studies by Rasmussen and Roitman in 2011 indicate that oil prices hurt real GDP in the long run, but have a positive effect in the short term. (Rasmussen and Roitman, 2011)

FDI is recognized as a crucial element in driving a country's economic growth. Many nations prefer to attract more FDI to not only increase inflows but also to bring economic stability. Several economists believe that FDI is most beneficial for the host country's development. Furthermore, it is observed that the impact of FDI on GDP is significant and positive in the long run, making it a vital component of economic growth.

3.3 *Stability Test for Economic Growth*

The current study uses CUSUM and CUSUM of square tests to evaluate the stability and specification of variables in the model. These tests provide a graphical representation of the variables in the model, allowing for an analysis of their variation over time. Through the CUSUM and CUSUM of square tests, the study finds that there are no issues of stability or misspecification of variables in the model. The results of these tests suggest that the model and variables are perfectly stable, thus ensuring the reliability and accuracy of the study's findings. Overall, the use of CUSUM and CUSUM of square tests in this study serves as a valuable tool in evaluating the stability and specification of variables in the model. By providing a graphical representation of the variables over time, these tests allow for a clear analysis of the data, contributing to the overall strength and rigor of the research.

Figure 1: CUSUM Test

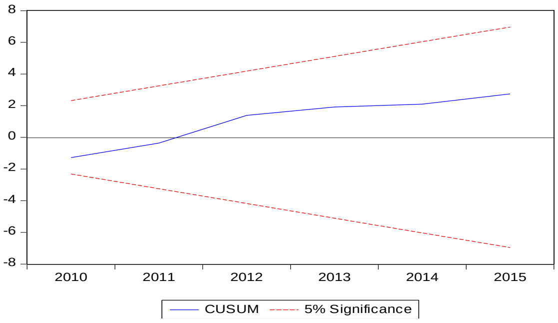
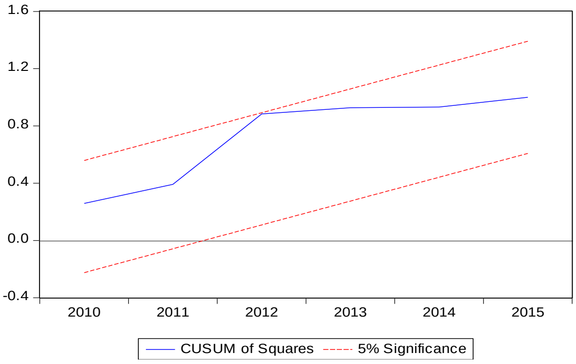


Figure 2: CUSUM of Square Test



3.4 *Serial correlation (LM test)*

After examining the stability and specifications of the model, the study examined the issue of serial correlation with the estimation of the new model. The results of this analysis are shown in Table 4.4 and highlight the issue of serial correlation in the model. Although the F statistic is not significant, the Langrage Multiplier (chi-square likelihood) (LM) is significant, indicating that we cannot reject the null hypothesis of serial correlation. In situations where one test gives a significant result and another test gives a non-significant result, the best thing to do is to rely on theory. The theoretical guidance is that if one test rejects the null hypothesis and another test accepts the alternative hypothesis, the chi-square probability should be trusted as a powerful tool for accepting or rejecting the null hypothesis. Therefore, this finding shows that the studied model is affected by serial correlation issues.

Table: 3.4: Breusch Godfrey Serial Correlation (LM Test)

See Annex C

3.5 *Removal of Serial Correlation / Autocorrelation*

The findings of the study indicate that the model has encountered the problem of serial correlation, as highlighted in Table 4.5. To address this issue, the researchers have transformed all the variables into the first difference form and have also estimated the model with the intercept term. This approach is expected to alleviate the problem of serial correlation and enhance the reliability and accuracy of the results.

Table: 3.5 Breusch - Godfrey Serial Correlation LM Test

See Annex D

The results in Table 4.5 show that both the probability of F-statistics and the observation of R-squared values are greater than 5 percent, indicating that the study must reject the null hypothesis and accept the alternative hypothesis that there is no serial correlation. model. This is a positive result because it shows that the model is free from serial correlation problems and that the estimates are reliable and accurate. Research can now proceed with confidence in the validity of its findings.

3.6 *Co-integration Analysis (Test of Bounds)*

To investigate whether there is a long-run relationship between the variables in the model, the present study conducted a Boundary test. The results of this test are shown in Table 4.6, which shows that the F-statistic value obtained is 4.977647. This value is higher than the upper critical limit value (3.79) and the lower limit value (2.62), rejecting the null hypothesis that the variables in the model are not integrated in the long term. Instead, the alternative hypothesis of cointegration between the variables in the model is considered. These findings indicate that variables are likely to have long-term relationships with each other, which is an important consideration for future model analysis and interpretation.

Table: 3.6 ARDL Bound's Test

See Annex E

Conclusion and Recommendations

In conclusion, this study delved into the intricate dynamics of energy growth in Pakistan, uncovering key influencers such as foreign direct investment (FDI), capital formation, labor participation rates, and oil prices. Notably, FDI and capital formation emerged as substantial drivers, fostering growth in the energy sector and attracting increased investment. However, challenges such as low labor participation rates and volatile oil prices were identified as impediments to sustained GDP growth through energy production.

The study highlighted the precarious nature of oil prices in Pakistan, reminiscent of J.M. Keynes' observations in "The General Theory of Employment, Interest, and Money." Additionally, wages in the energy sector were revealed to be tied to productivity and production capacity, presenting a potential deterrent to robust labor force engagement in this critical industry. Moreover, the empirical findings underscored the nuanced impact of various factors on economic growth. Labor participation and oil prices were associated with potential long-term declines in economic growth, emphasizing the need for stability in these dimensions. Conversely, capital formation exhibited a positive short-term and long-term correlation with GDP, signifying its pivotal role in driving economic expansion. The unexpected short-term decline in GDP due to FDI was counterbalanced by a positive long-term effect, highlighting the complex nature of its influence on economic growth.

Recommendations

i- Given the vulnerability of oil prices to fluctuations, it is imperative for the Government of Pakistan to implement measures that promote stability. Strategic initiatives and policies should be devised to minimize volatility, fostering an environment conducive to sustained economic growth.

ii- Recognizing the potential adverse impact of low labor participation rates, concerted efforts should be directed toward incentivizing and promoting workforce engagement in the energy sector. This could involve skill development programs, improved working conditions, and targeted policies to enhance the attractiveness of employment in the industry.

iii- The study underscores the positive correlation between capital formation and economic growth. Policymakers should focus on streamlining processes and providing incentives to encourage increased capital formation in the energy sector, both in the short and long term.

iv- To harness the long-term benefits of FDI, the Government of Pakistan should create a more favorable and stable environment for foreign investors. Unnecessary restrictions should be removed during policy formulation, facilitating the operation of energy plants in areas most conducive to their effectiveness.

Innovation of the Study

The innovation of this study lies in its comprehensive analytical framework that integrates multiple macroeconomic variables and their effects on GDP within the context of Pakistan's unique energy sector challenges. By employing the Auto Regressive Distributed Lag (ARDL) Model, this study not only captures the short-term and long-term dynamics of these relationships but also assesses the stability of variables through CUSUM and CUSUM Square tests. This methodological approach provides a nuanced understanding of how different factors interact to influence economic growth, offering novel insights for policymakers and stakeholders aiming to address energy-related economic issues in developing countries. Moreover, the study's findings on the impact of FDI in the energy sector, which contrasts short-term negative effects with long-term positive outcomes, add a new dimension to the existing literature on energy economics.

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Appendix

Annex A

Table 3.1 Unit Root Test

Variables	Lags	Level	First Difference	Order Of Integration
Economic Growth (Y)	2 (AIC)	-2.163271	-4.242615**	I (1)
Gross fix Capital formation (GFCF)	0 (AIC)	-2.372401	-3.528510**	I (1)
Labor Participation (LP)	0 (AIC)	-3.478211	-4.632513**	I (1)
Foreign Direct Investment (FDI)	0 (AIC)	-4.257142	-3. 482631**	I (1)
Energy Supply (ES)	0 (AIC)	-2.163521	-4.582741**	I (1)
Energy Demand (ED)	8 (AIC)	-4.605314**	-	I (0)
Energy Balance (Eb)	0 (AIC)	-1. 427421	-4.751482**	I (1)

Annex B

Table 3.2: ARDL Co-integrating and Long Run Form

Co-integrating Form				
Variable	Coefficient	Std. Error	t- Statistic	Prob.
D(LY(-1))	-0.224615	0.234200	-3.496162	0.0129
D(LGFCF)	0.543614	0.061137	1.558052	0.1702
D(LKT(-1))	0.301732	0.073824	4.114292	0.0063
D(LP)	-0.001216	0.004244	-0.001812	0.9986
D(LP(-1))	-0.014283	0.005067	-2.139679	0.0762
D(LOP)	0.042572	0.021779	2.293068	0.0617
D(LOP(-1))	-0.084721	0.024315	-3.346211	0.0155
D(LEB)	-0.022763	0.023701	-1.265365	0.2527
D(LEB(-1))	0.074201	0.030517	2.304906	0.0607
D(LFDI)	-0.134261	0.039650	-3.335632	0.0157
D(LFDI(-1))	0.055442	0.023721	2.003862	0.0919

Cointeq = LY - (0.8884*LKT -0.0519*LLP -0.2164*LOP + 0.2041*LEB +0.5900*LFDI + 6.2137)

Long Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LKT	0.882173	0.187352	4.754621	0.0042
LLP	-0.054613	0.024621	-3.284624	0.0633
LOP	-0.214613	0.133852	-4.586421	0.0036
LEB	0.203617	0.074261	2.825732	0.0321
LFDI	0.591624	0.065184	9.674728	0.0003
C	6.242714	1.323725	4.695363	0.0025

Annex C

Table: 3.4: Breusch Godfrey Serial Correlation (LM Test)

F-statistic	2.143505	Prob. F(2,4)	0.2130
Obs*R-squared	12.41561	Prob. Chi- Square (2)	0.0030

Annex D

Table: 3.5 Breusch - Godfrey Serial Correlation LM Test

F-statistic	2.830907	Prob. F(2,16)	0.0886
Obs*R-squared	5.449829	Prob. Chi-Square (2)	0.0656

Annex E

Table: 3.6 ARDL Bound's Test

Test Statistic	Value	K
F-statistic	4.97764	5