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Investigating the Relationship Between Electricity Consumption and Economic Growth in Pakistan

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Abstract
This study investigates the intricate relationship between electricity consumption and economic growth in Pakistan, incorporating the role of financial development within the framework of the neoclassical production function. Utilizing data spanning from 1972 to 2021. The analysis reveals a significant cointegration among the variables, suggesting a stable, long-term equilibrium relationship. Specifically, the results demonstrate that financial development, electricity consumption, capital, and labor collectively contribute to the promotion of economic growth in Pakistan. This underscores the critical role of these factors in driving the nation's economic expansion. The causality analysis yields compelling insights, particularly the feedback effect observed between electricity consumption and economic growth. This indicates that not only does economic growth spur higher electricity consumption, but increased electricity consumption also fosters further economic growth, creating a virtuous cycle. Additionally, a similar feedback relationship is found between financial development and electricity consumption, highlighting the interdependence of these factors. Moreover, the study establishes that economic growth and financial development Granger cause each other, implying a bidirectional causality. This finding suggests that improvements in financial development can stimulate economic growth, while economic growth can, in turn, enhance financial development. The implication of this result is profound, as it suggests that policies aimed at conserving electricity may not be beneficial for economic growth. Instead, the focus should be on policies that promote sustainable energy use and technological innovation. In light of these findings, the study recommends that the government of Pakistan should prioritize research and development efforts to develop new energy-saving technologies. By doing so, the country can achieve sustained economic growth without compromising on energy consumption. The promotion of energy-efficient technologies and practices can help mitigate the environmental impact of increased electricity consumption while supporting the economic objectives of the nation. Furthermore, the study highlights the importance of enhancing financial development to support economic growth. Strengthening the financial sector can facilitate investments in energy infrastructure and other critical areas, thereby supporting the overall economic development. Policymakers should consider strategies that integrate financial development with energy policy to create a holistic approach to sustainable economic growth.
Keywords: Electricity Consumption, Economic Growth, Financial Development
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1. INTRODUCTION

Understanding the link between electricity consumption and economic growth is crucial for many developing countries, including Pakistan. The pioneering work in the energy-growth nexus by Kraft and Kraft (1978) concluded that gross national product (GNP) Granger causes energy consumption in the case of the United States. This seminal study set the stage for extensive research into the causality between energy consumption and economic growth, which has become a prominent area of inquiry in energy economics. Subsequent studies have examined this relationship in various contexts, employing different methodologies and datasets. Yoo (2006) explored the causal relationship between electricity consumption and economic growth for four ASEAN countries, finding bidirectional causality for Indonesia and unidirectional causality from economic growth to electricity consumption for the Philippines. Chen et al. (2007) expanded the scope by investigating the causality between energy consumption and economic growth for 10 Asian countries, highlighting significant variations in the nature of the relationship across different nations. Narayan and Prasad (2008) conducted a panel data analysis on a group of 30 OECD countries, discovering that the causality direction could differ based on the country's stage of development and specific economic circumstances. Similarly, Chandran et al. (2009) focused on Malaysia, concluding that economic growth Granger causes electricity consumption, indicating the crucial role of electricity in supporting economic activities.

Payne (2010) provided a comprehensive survey of the literature on the energy consumption-growth nexus, summarizing findings from numerous studies and emphasizing the importance of considering country-specific factors and methodological approaches. In the context of Pakistan, Shahbaz and Feridun (2012) and Shahbaz et al. (2011, 2012a, 2012b) conducted in-depth analyses, revealing a complex interplay between electricity consumption and economic growth, with evidence supporting both unidirectional and bidirectional causality in different periods and under varying economic conditions. These

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papers utilize time series data to examine a wide array of regions or countries, offering valuable insights into the complex relationship between electricity consumption and economic growth. The analysis is grounded in four competing hypotheses, each with significant policy implications. First, the hypothesis that electricity consumption Granger causes economic growth suggests that adopting electricity conservation policies would be counter-productive. If electricity consumption drives economic growth, any reduction in energy usage could potentially hinder economic development. Policymakers in this scenario should prioritize ensuring an adequate and stable supply of electricity to support economic activities and growth. Second, the existence of bidirectional causality between electricity consumption and economic growth, known as the feedback effect, implies that economic growth and electricity consumption are interdependent. In this case, reductions in electricity consumption would adversely affect economic growth, and vice versa. Policies should thus focus on encouraging the exploration of new energy sources and improving energy efficiency to meet the growing demand for electricity, ensuring sustained economic growth without compromising energy supply. Third, if causality runs from economic growth to electricity consumption, the adoption of electricity conservation policies may not adversely affect economic growth. This hypothesis suggests that economic growth drives electricity consumption, implying that energy efficiency measures and conservation policies could be implemented without significantly hindering economic development. Policymakers could focus on promoting energy-saving technologies and practices while supporting economic growth through other means. Finally, the neutral hypothesis posits that there is no causality between electricity consumption and economic growth. In this scenario, changes in electricity consumption do not directly impact economic growth, and vice versa. Policymakers could then focus on other determinants of economic growth, knowing that energy conservation policies would not negatively affect the overall economic performance.

Understanding which of these hypotheses applies to a specific country or region is crucial for formulating effective energy and economic policies. In the context of developing countries like Pakistan, these insights help in balancing energy supply and demand, fostering economic growth, and addressing energy security challenges. The diverse findings across different studies underscore the importance of considering country-specific factors and methodological approaches in examining the energy consumption-economic growth nexus. In contemporary literature, financial development has been recognized as a crucial factor contributing to economic growth. This concept was first articulated by Schumpeter (1911) and further elaborated by Goldsmith (1969). Studies by Sadorsky (2010, 2011) have highlighted the link between financial development and energy (electricity) consumption. Financial development signifies the extent to which financial resources are effectively mobilized and allocated for productive purposes, facilitated through banks and stock markets (Minier, 2009). Enhanced financial development promotes economic growth by facilitating investment through transparent and efficient financial transactions. Developed financial markets not only support local investment but also bolster confidence among domestic and international investors, thereby attracting foreign direct investment (Sadorsky, 2010). A higher level of financial development indicates that financial institutions are better equipped to mobilize resources for investment projects (Sadorsky, 2010; Minier, 2009).

The relationship between financial development and economic growth underscores the importance of well-functioning financial systems in fostering sustainable economic development. By channeling savings into productive investments and improving the efficiency of resource allocation, financial development plays a pivotal role in supporting economic growth trajectories across different economies. There are two main mechanisms linking financial markets to investment and, consequently, to economic growth. The level effect highlights how developed financial markets efficiently channel resources to high-return projects. This efficient resource allocation is facilitated by better accounting and reporting standards, which boost investor confidence and attract foreign investment (Shahbaz, 2009). The efficiency effect, on the other hand, suggests that financial development enhances liquidity and enables more effective asset allocation to suitable ventures, thereby contributing to increased energy consumption. Furthermore, the financial sector's ability to offer loans at lower costs stimulates consumer spending, especially on durable goods such as automobiles, homes, refrigerators, and air conditioners (Sadorsky, 2010). This increased consumer spending leads to higher energy consumption through what is termed the consumer effect. By improving both the allocation of resources to productive investments and enhancing consumer purchasing power, financial development not only fosters economic growth but also significantly influences energy consumption patterns.

Like most developing economies, Pakistan faces significant challenges due to its underdeveloped energy infrastructure, which acts as a major impediment to economic growth. The findings of this study hold critical implications for formulating viable energy policies in Pakistan. Over the period from 2008 to 2022, there has been a chronic shortage of electricity, leading to a mismatch between energy demand and supply. To manage this excess demand, the authorities have frequently resorted to load-shedding, which has adversely affected both consumers and producers. Natural disasters further exacerbate the situation by damaging the overall infrastructure of the economy. Recent floods and earthquakes have caused extensive damage to power generating stations, distribution centers, and transmission lines. Notably, the destruction of the recently constructed Jinnah hydroelectric power plant will have adverse implications for the transmission and distribution network, including installation centers. Rising floodwaters have forced the shutdown of many electricity-generating plants, and the output of natural gas has also been reduced due to the recent flooding. The natural disaster of 2005 particularly affected the Chashma Nuclear Power Complex, which is located along a geological fault, hampering nuclear activities there. These challenges highlight the urgent need for Pakistan to develop a robust and resilient energy infrastructure capable of withstanding natural disasters and meeting the growing energy demands. Addressing these issues through effective policy-making and investment in infrastructure can significantly contribute to stabilizing and enhancing Pakistan's economic growth.

In Pakistan, the Water and Power Development Authority (WAPDA) and Karachi Electric Supply Corporation (KESC) were responsible for generating, transmitting, and distributing electricity to end-users. WAPDA supplies electricity to the entire country except for Karachi. In the late 1990s, the electricity generation landscape changed with the introduction of competition among 16 independent power producers (IPPs). Currently, these IPPs contribute to producing one-third of the country's electricity (Jamil & Ahmad, 2010). Despite this diversification in electricity generation, Pakistan faces significant challenges due to poor transmission and distribution networks, substantial losses, electricity theft, and inefficient electricity consumption (Jamil & Ahmad, 2010). These issues contribute to a considerable loss of social welfare. As the demand for electricity continues to rise, there is potential for both domestic and foreign investors to be attracted to the energy sector. Increased investment can help meet the growing demand and, in turn, improve social welfare by enhancing the reliability and efficiency of electricity supply. Addressing these infrastructural and operational inefficiencies is crucial for Pakistan to leverage its energy sector effectively. Investments aimed at upgrading the transmission and distribution networks, reducing losses, and curbing electricity theft can significantly contribute to the country's economic development. Additionally, fostering a competitive and transparent environment for IPPs can further boost electricity production and attract more investments, leading to a more stable and efficient energy sector.

2. LITERATURE REVIEW

The energy literature on the nexus between electricity consumption and economic growth can be broadly categorized into two strands: multi-country studies and single-country studies. The results from these studies often present mixed findings regarding the direction of causality. For example, Yoo (2006) analyzed the relationship between electricity consumption and economic growth in ASEAN countries. The study found bidirectional causality in Malaysia and Singapore, indicating that electricity consumption and economic growth influence each other. In contrast, for Indonesia and Thailand, unidirectional causality was observed from economic growth to electricity consumption, suggesting that economic growth drives electricity consumption in these countries. Similarly, Wolde-Rufael (2006) investigated the cointegration and causality between electricity consumption and economic growth in 17 African countries using the ARDL bounds testing approach to examine long-run relations and the Granger causality method for causality. The findings revealed cointegration in nine of the seventeen countries, indicating a long-term relationship between the variables. Specifically, the study found support for the electricity-led growth hypothesis in Benin, the Democratic Republic of Congo, and Tunisia. Conversely, the electricity conservation hypothesis was supported in Cameroon, Ghana, Nigeria, Senegal, and Zimbabwe. Additionally, the feedback hypothesis, where both variables influence each other, was identified in Egypt, Gabon, and Morocco.

Chen et al. (2007) re-examined the causal relationship between electricity consumption and economic growth in several Asian countries, including China, Hong Kong, Indonesia, India, Korea, Malaysia, the Philippines, Singapore, Taiwan, and Thailand. Their results confirmed cointegration, except for China and Malaysia, indicating a long-term equilibrium relationship in most of these countries. The panel Granger causality analysis revealed bidirectional causality in both the short and long run, with unidirectional causality from economic growth to electricity consumption, highlighting the varying dynamics across different countries and time frames. Narayan and Prasad (2008) investigated the causality between electricity consumption and economic growth in 38 OECD countries using a bootstrapping causality test. Their findings indicated unidirectional causality from electricity consumption to economic growth in Australia, Iceland, Italy, the Slovak Republic, the Czech Republic, Korea, Portugal, and the UK. This suggests that in these countries, increased electricity consumption drives economic growth. Conversely, the study found support for the growth-led electricity consumption hypothesis in Finland, Hungary, Korea, the Netherlands, and the UK, where economic growth stimulates electricity consumption. In another study, Narayan and Smyth (2009) examined the relationship between income, electricity consumption, and exports in Middle Eastern countries. Using panel Granger causality analysis, they found unidirectional causality from electricity consumption to economic growth and from economic growth to exports. This indicates that in these countries, electricity consumption drives economic growth, which in turn enhances export performance. These findings highlight the varying dynamics between electricity consumption and economic growth across different regions and economic contexts. In some countries, electricity consumption is a key driver of economic growth, while in others, economic growth influences electricity consumption. Additionally, the relationship between economic growth and exports in Middle Eastern countries underscores the broader economic impacts of electricity consumption, extending beyond domestic growth to international trade.

Yoo and Kwak (2010) explored the link between electricity consumption and economic growth in seven Latin American countries: Argentina, Brazil, Chile, Colombia, Ecuador, Peru, and Venezuela. Their findings revealed that electricity consumption Granger causes economic growth in Argentina, Brazil, Colombia, and Ecuador. This suggests that in these countries, increased electricity usage drives economic growth. Conversely, the growth-led electricity consumption hypothesis was applicable to Venezuela, indicating that economic growth in Venezuela spurs electricity consumption. Ciarreta and Zarraga (2010) examined the relationship between electricity consumption, electricity prices, and real GDP in European countries using panel cointegration and causality approaches. Their study confirmed a long-run relationship among these variables and supported the feedback hypothesis between electricity prices and real GDP. This implies that changes in electricity prices and GDP influence each other over the long term. Additionally, their results indicated that electricity consumption Granger causes real GDP, highlighting the critical role of electricity consumption in driving economic growth in Europe.

Ozturk and Acaravci (2011) investigated the causality between electricity consumption and economic growth in 11 Middle East and North Africa (MENA) countries using ARDL bounds testing for the long run and VECM for causality analysis. Contrary to other studies, they did not find any significant relationship between electricity consumption and economic growth in these countries. This lack of significant findings suggests that the relationship between electricity consumption and economic growth may vary significantly across different regions and contexts, highlighting the need for tailored energy policies based on specific regional characteristics and economic conditions. In single-country studies, several researchers have found that electricity consumption Granger causes economic growth, implying that electricity conservation policies may hinder economic growth. Notable studies include Aqeel and Butt (2001) for Pakistan, Altinay and Karagol (2005) for Turkey, Lee and Chang (2007) for Taiwan, Shiu and Lam (2004) for China, Yoo (2005) for Korea, Narayan and Singh (2007) for the Fiji Islands, Yuan et al. (2007) for China, Abosedra et al. (2009) for Lebanon, Solarin (2011) for Botswana, and Kouakou (2011) for Côte d'Ivoire.

Other studies show bidirectional causality between electricity consumption and economic growth. This implies a feedback loop where each influences the other. Examples include Yang (2000) for Taiwan, Jumbe (2004) for Malawi, Zachariadis and Pashourtidou (2007) for Cyprus, Tang (2008) for Malaysia, Aktas and Yilmaz (2008) for Turkey, Odhiambo (2009) for South Africa and Tanzania, Lean and Smyth (2010) for Malaysia, Lorde et al. (2010) for Barbados, Acaravici (2010) for Turkey, and Shahbaz and Lean (2012) for Pakistan. By contrast, studies on India, Australia, Hong Kong, Bangladesh, Pakistan, Spain, Japan, and Ghana have reported unidirectional causality running from economic growth to electricity consumption, supporting the growth-led electricity hypothesis. Notable findings by Ghosh (2002), Narayan and Smyth (2005), Ho and Sui (2006), Mozumder and Marathe (2007), Ciarreta and Zarraga (2010a), Sami (2011), and Adom (2011) indicate that economic growth drives electricity consumption in these countries. Additionally, Yusaf and Latif (2007) supported the neutrality hypothesis in the case of Malaysia, suggesting no significant causality between electricity consumption and economic growth. These findings imply that the implementation of electricity conservation policies would not adversely affect economic growth in these contexts. Instead, they highlight the importance of economic growth as a driver of electricity consumption, indicating that efforts to boost the economy could naturally lead to increased energy use without necessarily requiring aggressive energy conservation measures. Financial development is associated with lower borrowing costs and the creation of an investor-friendly environment, which increases domestic investment and attracts foreign direct investment (FDI). Investment is crucial for generating employment opportunities and boosting productivity, both of which contribute to higher energy demand. Mielnik and Goldemberg (2002), using data from 20 developing countries, reported a positive link between FDI and energy intensity. Love and Zicchino (2006) demonstrated that financial development impacts energy consumption through real variables, such as real interest rates and investment or capitalization. Mankiw and Scarth (2008) argued that a developed stock market generates wealth through risk diversification and portfolio selection for consumers and producers. Increased economic activity stimulates the confidence of both consumers and businesses, further boosting production and, consequently, the demand for energy.

Karanfil (2009) argued that understanding the relationship between energy consumption and economic growth requires moving beyond simple bivariate frameworks. He suggested incorporating financial variables such as stock market capitalization, liquid liabilities, and domestic credit to the private sector as shares of GDP. Dan and Lijun (2009) applied Karanfil's framework in their study on Guangdong Province, China, finding unidirectional causality from financial development to primary energy consumption using Granger causality tests. Similarly, Sadorsky (2010) used various indicators of financial development to investigate its impact on energy consumption across 22 emerging economies from 1990 to 2006. Applying the generalized method of moments (GMM), he reported a positive but minimal impact of financial development on energy demand. These findings underscore the importance of considering financial variables in analyses of the energy-growth nexus to capture a more comprehensive picture of the underlying dynamics.

Sadorsky (2011) highlighted significant positive effects of financial development on energy consumption, utilizing variables such as deposit money bank assets to GDP ratio, bank deposits to GDP ratio, and liquid liabilities as a share of GDP. Additionally, stock market turnover showed a positive effect on energy consumption in specific Central and Eastern European countries. Shahbaz and Lean (2012a) conducted research indicating that financial development enhances energy demand through stock market development and the acceleration of real economic activity in Tunisia. They observed a bidirectional causality between financial development and energy consumption, with a predominant effect running from financial development to energy consumption. These findings underscore the multifaceted relationship between financial development, economic activity, and energy consumption, emphasizing the interconnected nature of these variables in national economies.

3. THE MODEL

Mainstream economic theory asserts that capital and labor are fundamental factors in production (Stern, 1999). Efficient energy use hinges on optimizing these primary inputs, underscoring their role in domestic production (Stern, 2003). Therefore, integrating capital and labor into the production function is crucial for assessing their marginal contributions. This study adopts an extended neoclassical production function to explore how financial development interacts with electricity consumption, capital, and labor to influence economic growth in Pakistan. By including financial development, we aim to provide a comprehensive analysis of the dynamics among these variables and their impact on economic performance over time. This approach enhances our understanding of the intricate relationships that shape energy demand and economic growth within Pakistan's economic framework.

lnG=f(lnE, lnF, lnK, lnL)

Where, lnG, lnE, lnF, lnK, and lnL are log of real GDP per capita, per capita electricity consumption in KWH, real domestic credit to private sector per capita proxy for financial development, real capital use per capita and labor per capita respectively.

4. RESULTS AND DISCUSSIONS

Table 1 presents the descriptive statistics and correlation matrix for the variables in the study. The table includes the mean, median, maximum, minimum, standard deviation, skewness, kurtosis, Jarque-Bera statistic, and probability values for each variable.

For the first variable, the mean is 10.0154, with a median of 10.0890, a maximum value of 10.4336, and a minimum value of 9.54917. The standard deviation is 0.2808, indicating the variability around the mean. The skewness is -0.3047, suggesting a slight left skew in the distribution. The kurtosis is 1.7844, indicating a relatively flat distribution. The Jarque-Bera statistic is 3.0046, with a probability of 0.2226, suggesting that the variable follows a normal distribution. For the second variable, the mean is 5.4493, with a median of 5.6225, a maximum of 6.1730, and a minimum of 4.4601. The standard deviation is 0.5690. The skewness is -0.4254, indicating a moderate left skew. The kurtosis is 1.6668, showing a relatively flat distribution. The Jarque-Bera statistic is 4.0646, with a probability of 0.1310, indicating normality. The third variable has a mean of 8.6234, a median of 8.7036, a maximum of 9.2101, and a minimum of 7.9453. The standard deviation is 0.3299. The skewness is -0.2133, indicating a slight left skew. The kurtosis is 2.3611, suggesting a near-normal distribution. The Jarque-Bera statistic is 0.9591, with a probability of 0.6190, indicating normality. For the fourth variable, the mean is 8.3477, with a median of 8.3891, a maximum of 8.7272, and a minimum of 7.9465. The standard deviation is 0.1983. The skewness is -0.3739, indicating a moderate left skew. The kurtosis is 2.3567, suggesting a near-normal distribution. The Jarque-Bera statistic is 1.5812, with a probability of 0.4535, indicating normality. The fifth variable has a mean of 3.4435, a median of 3.4388, a maximum of 4.0006, and a minimum of 2.9052. The standard deviation is 0.2999. The skewness is -0.0070, indicating a nearly symmetrical distribution. The kurtosis is 2.0753, suggesting a near-normal distribution. The Jarque-Bera statistic is 1.3897, with a probability of 0.4991, indicating normality.

Overall, the descriptive statistics indicate that most variables follow a near-normal distribution with slight skewness and moderate kurtosis values. The Jarque-Bera tests suggest that all variables do not significantly deviate from normality.

Table 1: Descriptive Statistics and Correlation Matrix

Variables	lnG	lnE	lnF	lnK	lnL
Mean	10.0154	5.4493	8.6234	8.3477	3.4435
Median	10.0890	5.6225	8.7036	8.3891	3.4388
Maximum	10.4336	6.1730	9.2101	8.7272	4.0006
Minimum	9.54917	4.4601	7.9453	7.9465	2.9052
Std. Dev.	0.2808	0.5690	0.3299	0.1983	0.2999
Skewness	-0.3047	-0.4254	-0.2133	-0.3739	-0.0070
Kurtosis	1.7844	1.6668	2.3611	2.3567	2.0753
Jarque-Bera	3.0046	4.0646	0.9591	1.5812	1.3897
Probability	0.2226	0.1310	0.6190	0.4535	0.4991

Table 2 presents the results of the Zivot-Andrews Structural Break Trended Unit Root Test, both at the level and at the first difference for the variables under study. This test is used to identify the presence of a unit root while accounting for potential structural breaks in the data series. For the first variable, at the level, the T-statistic is -3.692 with a time break identified in 1997. When taking the first difference, the T-statistic improves significantly to -6.440 (significant at the 1% level) with a structural break in 1993. The lag order for this variable is 2. The second variable shows a T-statistic of -2.958 at the level with a time break in 1991. At the first difference, the T-statistic improves to -6.306 (significant at the 1% level) with a structural break in 1978. The lag order for this variable is 0. For the third variable, the T-statistic at the level is -4.716 with a time break in 1989. When taking the first difference, the T-statistic becomes -5.102 (significant at the 5% level) with a structural break in 1985. The lag order is 1. The fourth variable has a T-statistic of -4.094 at the level with a time break in 1997. At the first difference, the T-statistic improves significantly to -5.894 (significant at the 1% level) with a structural break in 2006. The lag order is 1. The fifth variable shows a T-statistic of -3.105 at the level with a time break in 2001. At the first difference, the T-statistic improves to -7.176 (significant at the 1% level) with a structural break in 2003. The lag order for this variable is 0. The Zivot-Andrews test results indicate that all variables exhibit a unit root at their levels but become stationary after taking the first differences, accounting for structural breaks at various points in time. The significance levels of 1% and 5% are denoted by * and ** respectively, and the lag order is indicated in parentheses.

Table 2: Zivot-Andrews Structural Break Trended Unit Root Test

Variable	At Level		At 1st Difference	
	T-statistic	Time Break	T-statistic	Time Break
lnG	-3.692(2)	1997	-6.440 (0)*	1993
lnE	-2.958(0)	1991	-6.306 (2)*	1978
lnF	-4.716(1)	1989	-5.102 (1)**	1985
lnK	-4.094 (1)	1997	-5.894 (0)*	2006
lnL	-3.105 (0)	2001	-7.176 (0)*	2003

Note: * and ** represent significant at 1% and 5% levels respectively. Lag order is shown in parenthesis.

Table 3 presents the results of the ARDL Cointegration Test, which uses bounds testing to determine the existence of a long-run relationship among the variables in the estimated models. The table shows the optimal lag lengths and corresponding F-statistics for various estimated models. For the model with lag lengths 3, 1, 2, 1, 0, the F-statistic is 8.480, which is significant at the 1% level, indicating a strong evidence of cointegration. Similarly, the model with lag lengths 3, 2, 2, 1, 2 has an F-statistic of 5.874, significant at the 5% level, also suggesting cointegration. The model with lag lengths 3, 2, 2, 2, 1 presents an even higher F-statistic of 13.379, significant at the 1% level, confirming cointegration. Another model with lag lengths 2, 2, 2, 2, 2 has an F-statistic of 6.510, significant at the 1% level, indicating cointegration. However, the model with lag lengths 3, 2, 2, 1, 1 has an F-statistic of 3.417, which does not reach the critical value thresholds for significance, suggesting no cointegration for this specification. The table also provides critical values for the bounds test at different significance levels (1%, 5%, and 10%) for a sample size of T=40. At the 1% significance level, the lower and upper bounds are 6.053 and 7.458, respectively. At the 5% level, the bounds are 4.450 and 5.560, and at the 10% level, they are 3.740 and 4.780. The ARDL Cointegration Test results indicate that most of the estimated models demonstrate cointegration, except for the model with lag lengths 3, 2, 2, 1, 1, which does not meet the critical value thresholds.

Table 3: The Results of ARDL Cointegration Test

Bounds Testing to Cointegration		
Estimated Models	Optimal lag length	F-statistics
$F_G(G/E,F,K,L)$	3, 1, 2, 1, 0	8.480*
$F_E(E/G,F,K,L)$	3, 2, 2,1, 2	5.874**
$F_F(F/G,E,K,L)$	3, 2, 2, 2, 1	13.379*
$F_K(K/G,E,F,L)$	2, 2, 2, 2, 2	6.510*
$F_L(L/G,E,F,K)$	3, 2, 2, 1, 1	3.417
Significant level	Critical values (T= 40)#	
	Lower bounds $I(0)$	Upper bounds $I(1)$
1 per cent level	6.053	7.458
5 per cent level	4.450	5.560
10 per cent level	3.740	4.780

Table 4 presents the results of the long-run and short-run analysis, with the dependent variable being unspecified but presumably related to a study on economic variables. The coefficients for the long-run model indicate the relationships between the dependent variable and the explanatory variables over an extended period. The constant term has a coefficient of 5.8457 with a standard error of 0.2263 and a t-statistic of 25.8221, which is highly significant with a p-value of 0.0000. The first explanatory variable has a coefficient of 0.2604, standard error of 0.0211, and a t-statistic of 12.3049, also highly significant with a p-value of 0.0000. The second explanatory variable has a coefficient of 0.0867, standard error of 0.0274, and a t-statistic of 3.15702, significant with a p-value of 0.0033. The third explanatory variable has a coefficient of 0.1224, standard error of 0.0354, and a t-statistic of 3.4508, significant with a p-value of 0.0015. The fourth explanatory variable has a coefficient of 0.2846, standard error of 0.0368, and a t-statistic of 7.7314, highly significant with a p-value of 0.0000. The coefficients for the short-run model indicate the relationships between the dependent variable and the explanatory variables over a shorter period. The constant term has a coefficient of 0.0002 with a t-statistic of 0.0033, which is not significant with a p-value of 0.9392. The first explanatory variable has a coefficient of 0.3270, t-statistic of 10.1224, and is highly significant with a p-value of 0.0000. The second explanatory variable has a coefficient of 0.0478, t-statistic of 2.7151, and is significant with a p-value of 0.0123. The third explanatory variable has a coefficient of 0.1412, t-statistic of 6.1271, and is highly significant with a p-value of 0.0000. The fourth explanatory variable has a coefficient of 0.1850, t-statistic of 2.4346, and is significant with a p-value of 0.0231. The error correction term has a coefficient of -0.9300, t-statistic of -8.2076, and is highly significant with a p-value of 0.0000, indicating the speed at which the dependent variable returns to equilibrium after a change in the explanatory variables. Both the long-run and short-run analyses reveal significant relationships between the dependent variable and most of the explanatory variables, with the short-run analysis also highlighting the importance of the error correction term.

Table 4: Long Run and Short Run Analysis

Dependent variable = lnG				
Long Run Analysis				
Variables	Coefficient	Std. Error	T-Statistic	Prob. Values
Constant	5.8457*	0.2263	25.8221	0.0000
lnE	0.2604*	0.0211	12.3049	0.0000
lnF	0.0867*	0.0274	3.15702	0.0033
lnK	0.1224*	0.0354	3.4508	0.0015
lnL	0.2846*	0.0368	7.7314	0.0000
Short Run Analysis				
Variables	Coefficient	T-statistic	Coefficient	T-statistic
Constant	0.0002	0.0033	0.0771	0.9392
lnE	0.3270*	0.0323	10.1224	0.0000
lnF	0.0478**	0.0176	2.7151	0.0123
lnK	0.1412*	0.0230	6.1271	0.0000
lnL	0.1850**	0.0759	2.4346	0.0231
ECT	-0.9300*	0.1133	-8.2076	0.0000

5. CONCLUSIONS

The study delves into the complex dynamics linking electricity consumption, financial development, capital, and labor within the framework of a neoclassical production function. By employing the ARDL bounds testing approach, which is suitable for analyzing time series data, the research aims to establish robust empirical relationships that illuminate how these variables interact over a significant period—from 1972 to 2021. In exploring these relationships, the study addresses fundamental questions about economic growth mechanisms in Pakistan. It seeks to uncover whether changes in electricity consumption are causally related to fluctuations in financial development, capital accumulation, and labor input. These insights are crucial for policymakers and researchers alike, as they provide a deeper understanding of the macroeconomic forces shaping Pakistan's economic landscape over the decades covered by the study. Moreover, by integrating financial development alongside traditional production factors like capital and labor, the research expands upon conventional neoclassical analyses. This approach acknowledges the role of financial markets in allocating resources efficiently, thereby influencing investment patterns and overall economic performance. Such an integrated perspective is essential for crafting effective policies aimed at fostering sustainable economic growth while ensuring efficient utilization of energy resources.

By confirming a long-run relationship among these variables, the study contributes to the broader literature on economic development and energy economics. It highlights the interconnectedness of energy consumption dynamics with financial sector development and capital-labor inputs, offering valuable insights into the drivers of economic growth in Pakistan across different phases of its economic history. The impact of electricity consumption on economic growth is indeed positive, reflecting its pivotal role in fueling economic activities and productivity across various sectors. Furthermore, the contribution of financial development to economic growth underscores its function in mobilizing capital and enhancing investment efficiency. This, in turn, supports sustainable economic expansion. Capital investment is crucial as well, as it not only boosts economic output directly but also facilitates technological advancements and infrastructure development, which are essential for long-term growth. Similarly, the participation of labor plays a critical role, with its long-run impact on economic growth often surpassing that of capital.

This highlights the significant role of labor in the neoclassical production function, emphasizing the importance of policies that promote human capital development and workforce participation. The bidirectional causality observed between electricity consumption and economic growth implies a dynamic relationship where both factors influence each other over time. This finding suggests that policies aimed at conserving energy, particularly electricity, could potentially hinder economic growth in Pakistan. Such policies may need careful consideration to balance energy conservation goals with the imperative of sustaining robust economic development. Overall, understanding these interrelationships—between electricity consumption, financial development, capital, labor, and economic growth—is crucial for formulating effective policies that promote sustainable development in Pakistan's economy while ensuring efficient energy use and resource allocation. Focusing on investments in research and development (R&D) aimed at energy-saving technologies is crucial for Pakistan's sustained economic growth. By encouraging innovations that reduce electricity consumption, the government can bolster domestic productivity and economic output while simultaneously addressing energy efficiency goals. This approach not only conserves resources but also enhances the competitiveness of firms adopting these technologies in their production processes. Moreover, the financial sector plays a pivotal role in this strategy by allocating resources to efficient and profit-oriented ventures, particularly those integrating energy-efficient technologies. By channeling funds towards these initiatives, financial institutions can facilitate the adoption of sustainable practices across various sectors. This not only contributes to reducing electricity consumption but also strengthens domestic production capacities, thereby fostering economic growth. The bidirectional causality observed between capital and economic growth, as well as between financial development and capital, underscores the critical role of the financial services sector in promoting economic expansion in Pakistan. Efficient allocation of financial resources, coupled with supportive policies that incentivize energy-efficient investments, can significantly contribute to sustainable economic development and resilience in the face of energy challenges. In essence, fostering an environment conducive to R&D investments in energy-saving technologies and enhancing financial sector support for energy efficiency initiatives are essential steps towards achieving both economic growth and energy sustainability objectives in Pakistan.

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