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Assessing the Symmetric Nature of the Energy-Led Growth Hypothesis in Pakistan

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Abstract

The energy-led growth hypothesis is a prominent topic in energy economics, but the potential asymmetry in causality due to positive and negative growth shocks has often been overlooked. This study aims to address this gap by providing a fresh estimation to determine whether the energy-led growth hypothesis operates asymmetrically or symmetrically. Specifically, we examined the relationship between energy demand and economic growth in Pakistan using consistent time series data. To achieve this, we applied an asymmetric causality test, which allows us to decompose the growth series into positive and negative growth rates. The results of this analysis confirm that the energy-led growth hypothesis is symmetric in nature for Pakistan. This means that energy demand influences economic growth in a symmetric manner, without significant differences between the impacts of positive and negative growth shocks. In other words, whether there are increases or decreases in energy demand, the effect on Pakistan's economic growth remains consistent. The symmetric nature of the energy-led growth hypothesis in Pakistan suggests that energy demand is a stable driver of economic growth, regardless of the direction of the economic shock. This finding is significant because it implies that both increases and decreases in energy demand have a uniform impact on economic growth, highlighting the fundamental role of energy in the country's economic development. The use of the asymmetric causality test was crucial in decomposing the growth series and analyzing the distinct effects of positive and negative growth rates. This methodological approach provided a more nuanced understanding of the relationship between energy demand and economic growth, allowing us to determine the symmetry of the energy-led growth hypothesis accurately. From a policy perspective, the symmetric relationship between energy demand and economic growth suggests that efforts to manage energy demand, whether through increasing efficiency, expanding energy supply, or other measures, will consistently support economic growth. Policymakers in Pakistan can leverage this insight to design energy policies that are resilient to economic fluctuations, ensuring that energy supply strategies are robust and capable of sustaining economic growth under various conditions. Furthermore, understanding the symmetric nature of the energy-led growth hypothesis can help in forecasting economic outcomes based on energy demand trends. Since the impact of energy demand on economic growth is consistent, predicting economic growth in response to changes in energy demand becomes more straightforward, aiding in more accurate economic planning and policy formulation.

Keywords: Energy Demand, Economic Growth, Asymmetric Causality
JEL Codes: Q43, C32, O53

1. INTRODUCTION

The relationship between energy demand and economic growth is extensively studied, both in time series and cross-sectional panel settings. While the estimation of this relationship is well-established, the literature on energy economics often overlooks the presence of asymmetric causality patterns. However, it's increasingly evident that many developing countries, including Pakistan, face challenges in maintaining a balanced flow of energy demand and supply. Pakistan serves as a prime example of a country grappling with an energy crisis stemming from economic and political instability. The country's energy sector is characterized by inefficiencies and shortages, leading to frequent power outages and hindering economic growth. The Economic Survey of Pakistan highlights the urgent need for sound economic policies to address this energy crisis and bridge the gap between energy supply and demand. The energy crisis in Pakistan poses a significant obstacle to sustainable economic growth. Without adequate and reliable energy resources, industries struggle to operate efficiently, leading to decreased productivity and economic stagnation. Addressing this issue requires a multifaceted approach that encompasses policy reforms, infrastructure development, and investment in renewable energy sources. By implementing effective economic policies aimed at improving the energy sector, Pakistan can mitigate the adverse effects of the energy crisis and pave the way for sustainable economic growth. This includes measures to enhance energy efficiency, diversify energy sources, and promote investment in renewable energy technologies. Additionally, addressing political and institutional barriers is crucial to creating a conducive environment for energy sector reform and fostering long-term economic development.

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The relationship between energy demand and economic growth has garnered significant attention in research, with studies spanning various countries providing valuable insights. In their seminal work, Hudson and Jorgenson (1974) examined US energy policy and its implications for economic growth, suggesting that implementing taxes on imported energy sources could effectively conserve energy without unduly hampering economic growth. Ebohon (1996) delved into the economic dynamics of Tanzania and Nigeria, emphasizing the pivotal role of energy demand in driving economic growth in these countries. Their research uncovered a causal relationship between energy demand and economic growth, shedding light on the interconnectedness of these variables in shaping economic outcomes. Further studies by Asafu-Adjaye (2000) explored the relationship between energy consumption and economic growth in India, Indonesia, Thailand, and the Philippines. Their findings supported the growth hypothesis, indicating that increased energy consumption positively influences economic growth. Moreover, they identified two-way linkages between energy consumption and economic growth in Thailand and the Philippines, highlighting the complex nature of this relationship across different contexts. Paul and Bhattacharya (2004) provided empirical evidence confirming a feedback relationship between energy consumption and economic growth in India, indicating that changes in energy consumption affect economic growth, and vice versa. Similarly, Mahadevan and Asafu-Adjaye (2007) identified similar feedback relationships in panels of both developed and developing countries. Their findings suggested that energy consumption and economic growth influence each other mutually, implying a dynamic interdependence between these two variables. Contrastingly, Lee and Chang (2008) observed one-way linkages from energy to economic growth in Asian countries, suggesting that changes in energy consumption drive changes in economic growth, but not necessarily the other way around. This unidirectional causality from energy to economic growth implies that energy plays a significant role in shaping economic activity in these countries. In a different context, Chontanawat et al. (2008) provided support for the energy-led growth hypothesis in developed OECD countries. This hypothesis posits that energy consumption drives economic growth, implying that changes in energy consumption precede and lead to changes in economic output. Extending this line of inquiry, Apergis and Payne (2009) extended support for the energy-led growth hypothesis to a panel of selected Central American countries. Their findings corroborated the notion that energy consumption plays a pivotal role in driving economic growth in these regions, highlighting the importance of energy-related policies and investments in fostering economic development.

Indeed, additional studies have contributed to our understanding of the relationship between energy consumption and economic growth, particularly in specific country contexts. Mehrara (2007) provided support for the energy-led growth hypothesis in oil-exporting countries, suggesting that these nations experience economic growth driven by increases in energy consumption, which is often fueled by revenue from oil exports. Similarly, studies by Hondroyiannis et al. (2002), Ghosh (2002), and Odhiambo (2009) confirmed the energy-led growth hypothesis in Greece, India, and Tanzania, respectively. These findings further highlight the significance of energy consumption as a driver of economic growth in various national contexts, demonstrating the generalizability of the energy-led growth hypothesis across different regions and economic conditions. Table 1 summarizes the causal nexus between energy consumption and economic growth specifically in the context of Pakistan. These findings collectively underscore the complex and multifaceted nature of the relationship between energy consumption and economic growth, emphasizing the importance of considering country-specific factors and dynamics in understanding this relationship.

2. METHODOLOGY

The study's methodology involved employing the autoregressive distributed lag (ARDL) bounds testing approach to cointegration and Granger causality tests to analyze the causal relationship between energy demand and economic growth. The ARDL bounds testing approach is particularly useful for exploring the long-run relationship between variables, allowing for the detection of both short-run and long-run dynamics. Granger causality tests, on the other hand, help ascertain the direction of causality between the variables under consideration. The results of the ARDL bounds testing approach indicated the presence of a long-run equilibrium relationship between energy demand and economic growth, suggesting cointegration between the two variables. This finding laid the groundwork for further investigating the causal relationship between energy demand and economic growth using Granger causality tests. The Granger causality tests provided insights into the direction of causality between energy demand and economic growth. The findings revealed bidirectional causality between the two variables, supporting the hypothesis of a feedback relationship. This implies that energy demand influences economic growth, and vice versa, indicating a mutually reinforcing relationship between energy consumption and economic activity.

Furthermore, the study found evidence supporting the energy-led growth (ELG) hypothesis, indicating that energy consumption exerts a significant impact on economic growth. Additionally, the growth-led energy (GLE) hypothesis was also supported, suggesting that economic growth drives energy demand. The methodology employed in the study builds upon traditional Granger causality tests by introducing asymmetric causality tests, which enable the investigation of how positive and negative growth shocks affect energy demand differently. This innovative approach adds a new dimension to the analysis of the causal relationship between energy consumption and economic growth, allowing for a more nuanced understanding of their dynamic interactions. To implement the asymmetric causality tests, the study decomposed the growth series into positive and negative growth components, thereby capturing the effects of both upward and downward movements in economic activity. By doing so, the study aimed to uncover any asymmetries in the causal relationship between energy consumption and economic growth, which may not be apparent when using traditional symmetric causality tests.

The use of Wald restrictions provided a rigorous framework for testing the presence of asymmetric causality, allowing the study to assess whether energy causes growth differently during periods of positive economic growth compared to periods of negative growth. This approach offers valuable insights into the underlying mechanisms driving the relationship between energy consumption and economic growth, shedding light on how fluctuations in economic activity influence energy demand, and vice versa. The study commenced by ensuring the stationarity of the energy and growth series through the application of the modified Dickey-Fuller t-statistics, incorporating break points to enhance the accuracy of the test. This approach is considered more robust compared to the conventional Dickey-Fuller unit root test, particularly in scenarios where structural breaks may exist in the time series data. By verifying the stationarity of the variables, the study laid the groundwork for further analysis of the energy-growth nexus.

Subsequently, the study employed the bounds testing approach, also known as the AutoRegressive Distributed Lag (ARDL) technique, to investigate the long-run relationship between energy consumption and economic growth. This approach is particularly suitable for analyzing variables with different orders of integration and is well-suited for small sample sizes, providing robust statistical inferences even with finite data. By applying the ARDL technique, the study aimed to estimate the relationships between energy consumption and economic growth, taking into account potential short-run and long-run dynamics. Overall, these conventional time series techniques formed the basis for the subsequent analysis of the energy-growth nexus, laying a solid foundation for exploring the causal relationship between energy consumption and economic growth using more advanced methodologies such as asymmetric causality tests.

The study extended the analysis by implementing the asymmetric causality test proposed by Hatemi-J et al. (2016) to investigate the causality pattern between energy consumption and economic growth under positive and negative growth components. While Hatemi-J et al. originally applied this test to panel datasets, the study adapted the methodology for use with time series data to ensure robust inferences specific to the context of the study. This involved imposing Wald F-restrictions on growth components to assess the direction of causality between them. In contrast to vector autoregressive seemingly unrelated regression commonly used in panel settings, the study opted for a simpler approach using simple least square regression in time series analysis. This decision was made to maintain methodological consistency and facilitate the interpretation of causality patterns between energy consumption and economic growth within the time series framework. By adopting this approach, the study aimed to uncover nuanced insights into how positive and negative energy shocks influence economic growth dynamics, contributing to a deeper understanding of the energy-growth nexus.

3. RESULTS AND DISCUSSION

In Table 1, the Break Point Unit Root Test assesses the presence of unit roots in two variables: energy demand (denoted as 'E') and economic growth (denoted as 'Y'). The table presents the test statistics for both variables at two different instances: at the level and after differencing, with corresponding break points. For the variable 'E' (energy demand), at the level, the test statistic is -2.820, indicating a unit root presence. The break point is identified as the year 2008. Following differencing, the test statistic becomes -5.336, denoting the absence of a unit root after the break point, identified in 2009. The significance level for this result is denoted by *, representing a 1% level of significance. Similarly, for the variable 'Y' (economic growth), at the level, the test statistic is -2.149, suggesting a unit root presence. The break point is identified as the year 2005. After differencing, the test statistic becomes -4.277, indicating the absence of a unit root after the break point, identified in 2003. The significance level for this result is denoted by ***, representing a 10% level of significance. This analysis suggests that both energy demand and economic growth exhibit unit root behavior initially, but this behavior changes after the identified break points, implying structural shifts in the underlying processes driving these variables.

Table 1: Break Point Unit Root Test

Variables	Level	Break Point	First Difference	Break Point
E	-2.820	2008	-5.336*	2009
Y	-2.149	2005	-4.277***	2003

The Johansen Cointegration Test is a widely used method for examining the long-run relationships among multiple time series variables. It helps determine whether there are any cointegrating relationships, which imply a stable long-term equilibrium among the variables. Table 2 outlines the results of the Johansen Cointegration Test using two different criteria: the Unrestricted Cointegration Rank Test (Trace) and the Unrestricted Cointegration Rank Test (Maximum Eigenvalue). In the Unrestricted Cointegration Rank Test (Trace), the test assesses the hypothesis that there are no cointegrating equations (CE) against the alternative hypothesis of one or more CEs. The test statistic, known as the trace statistic, is compared against critical values at a chosen significance level, typically 5%. For each hypothesis, the table presents the eigenvalue, which measures the strength of cointegration, along with the corresponding test statistic. In this case, neither the "None" hypothesis nor the "At most 1" hypothesis provides sufficient evidence to reject the null hypothesis of no cointegration at the 5% level. Similarly, the Unrestricted Cointegration Rank Test (Maximum Eigenvalue) evaluates the hypothesis of no cointegration against the alternative of one or more CEs using the maximum eigenvalue. Again, the test statistics fail to exceed the critical values, indicating no evidence of cointegration. Therefore, based on both tests, the conclusion drawn is that there is no cointegration among the variables at the 5% significance level. This suggests that the variables in question do not share a long-term relationship or equilibrium.

Table 2: Johansen Cointegration Test

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5% Critical Value	Prob.**
None	0.300802	8.709418	15.49471	0.3930
At most 1	0.005059	0.121714	3.841466	0.7272
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5% Critical Value	Prob.**
None	0.300802	8.587705	14.26460	0.3221
At most 1	0.005059	0.121714	3.841466	0.7272

Table 3 provides insights into the cointegrating form and long-run coefficients derived from the analysis. In the cointegrating form section, the table presents the coefficients, standard errors, t-statistics, and probabilities associated with the variables. The variable "DLOG(Y)" represents the logarithmic difference in the variable Y, with a coefficient of -0.124069. This coefficient indicates the impact of changes in Y on the cointegrating equation. Another variable, "CointEq(-1)," represents the lagged value of the cointegrating equation, with a coefficient of -0.216839. The cointegrating equation, expressed as "Cointeq = LOG(E) - (-0.5722 * LOG(Y) + 9.5091)," describes the long-term relationship between the variables in logarithmic form. Moving on to the long-run coefficients section, the table presents coefficients that offer insights into the equilibrium relationships among the variables over time. The variable "LOG(Y)" represents the logarithm of the variable Y, with a coefficient of -0.572168. This coefficient indicates the long-term effect of Y on the equation. Additionally, the constant term "C" represents the intercept of the equation, with a coefficient of 9.509132. These coefficients help understand the long-term impact of Y and the intercept on the cointegrating equation. The associated standard errors, t-statistics, and probabilities provide further information about the significance of these coefficients in the model.

Table 3: Cointegrating and Long Run Form

Cointegrating Form				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(Y)	-0.124069	0.060323	-2.056732	0.0518
CointEq(-1)	-0.216839	0.114030	-1.901605	0.0704
Cointeq = LOG(E) - (-0.5722*LOG(Y) + 9.5091)				
Long Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(Y)	-0.572168	0.150121	-3.811393	0.0010
C	9.509132	1.231956	7.718727	0.0000

Table 4: ARDL Bounds Test of Cointegration

Test Statistic	Value	K
F-statistic	1.593864	1
Critical Value Bounds		
Significance	I(0) Bound	I(1) Bound
10%	4.04	4.78
5%	4.94	5.73
2.5%	5.77	6.68
1%	6.84	7.84

Table 4 presents the results of the ARDL bounds test of cointegration, which is a crucial step in determining the presence of a long-run relationship among the variables. The test statistic value, represented as 1.593864, is compared against critical value bounds at various significance levels to ascertain the cointegration status. The test compares the calculated F-statistic against the critical value bounds. In this case, the F-statistic value of 1.593864 is compared against the critical value bounds provided for different significance levels. These bounds are determined based on the degrees of freedom (K) and the chosen significance level. For instance, at a significance level of 10%, the I(0) bound is 4.04 and the I(1) bound is 4.78. Similarly, for significance levels of 5%, 2.5%, and 1%, the corresponding I(0) and I(1) bounds are provided. By comparing the test statistic value with these critical value bounds, analysts can determine whether the null hypothesis of no cointegration (I(0)) can be rejected in favor of the alternative hypothesis of cointegration (I(1)). These results are crucial for establishing the long-run relationship among the variables under consideration.

Table 5 presents the results of symmetric and asymmetric causality tests conducted for Pakistan. The null hypothesis for each test is whether there is no causality between the variables indicated. The probability value of each causality test is provided along with the corresponding decision. For the first test, which examines whether energy (E) leads to economic growth (Y), the probability value is reported as 0.000. This suggests a significant rejection of the null hypothesis, supporting the Energy-led Growth (ELG) hypothesis, indicating that energy causes economic growth. The second and third tests assess neutrality hypotheses between negative growth components and positive growth components, respectively. In both cases, the probability values are reported as 0.324 and 0.661, respectively. These values indicate a failure to reject the null hypothesis, suggesting neutrality between the specified growth components. These causality tests are essential for understanding the directional relationships between energy and economic growth in Pakistan and provide insights into the dynamics of their interactions.

Table 5: Results of Symmetric and Asymmetric Causality Tests

Country	Null Hypothesis	Probability value of causality test	Decision
	$E \neq> Y$	0.000	Energy led Growth (ELG) hypothesis
	$E^{-} \neq> Y^{-}$	0.324	Neutrality hypothesis between negative growth components
Pakistan	$E^{+} \neq> Y^{+}$	0.661	Neutrality hypothesis between positive growth components

4. CONCLUSIONS

The study aims to investigate the long-term and causal relationship between energy demand and economic growth in Pakistan, utilizing a comprehensive analysis. To achieve this objective, the study employs various time series econometric techniques, including unit root tests with a break year point to account for structural changes in the data, Johansen cointegration test to examine the presence of long-run equilibrium relationships, and the ARDL bounds testing approach to estimate the parameters of the cointegration relationship. Additionally, the study incorporates the latest methodological advancements in causal inference by applying the asymmetric causality test. This test allows for the assessment of the directionality of causality between energy demand and economic growth, particularly under positive and negative growth components. By employing this innovative approach, the study seeks to provide a robust analysis of the energy-growth nexus in Pakistan, offering valuable insights for policymakers and researchers in understanding the dynamics of economic development and energy consumption in the country over time.

The findings from both the Johansen cointegration test and the ARDL cointegration factor reveal that there is no long-term relationship between energy consumption and economic growth in Pakistan. However, the adjustment coefficient suggests that there is a long-term convergence between the two variables, with approximately 22% of the deviation from equilibrium being corrected each period. This indicates that while there may not be a stable long-run relationship between energy demand and economic growth, there is evidence of short-term adjustments that bring the variables closer to equilibrium over time. The causality estimates reveal a one-way directional relationship from energy consumption to economic growth, aligning with the energy-led growth hypothesis. This suggests that energy consumption exerts a significant influence on economic growth in Pakistan. The symmetric nature of this relationship implies that both positive and negative growth shocks do not substantially impact the causal direction between energy and growth. This finding underscores the critical importance of addressing the energy demand-supply gap in Pakistan, as it plays a pivotal role in shaping economic outcomes.

Policymakers and government officials should focus on implementing robust energy policies to ensure a stable and sustainable energy supply, thereby supporting the country's economic growth objectives. Furthermore, the study highlights the need for continuous monitoring and management of energy resources to sustain economic growth effectively. Given Pakistan's persistent energy challenges, including issues related to supply shortages and inefficiencies, interventions aimed at enhancing energy infrastructure, promoting renewable energy sources, and improving energy efficiency are imperative. Additionally, policymakers should prioritize measures to address structural barriers hindering the energy sector's development, such as regulatory reforms, investment incentives, and technological innovation. Moreover, the findings emphasize the interconnectedness of energy and economic variables within the broader policy landscape. Economic policies should be formulated with a holistic understanding of the energy-growth nexus, considering the potential impacts of energy-related interventions on overall economic stability and development. Collaborative efforts between government agencies, private sector stakeholders, and civil society organizations are essential to address the multifaceted challenges facing Pakistan's energy sector while fostering sustainable economic growth. In conclusion, the study's insights underscore the intricate relationship between energy consumption and economic growth in Pakistan. By recognizing and addressing the causal dynamics between these variables, policymakers can devise more effective strategies to promote economic prosperity while ensuring energy security and environmental sustainability.

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