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Exploring the Relationship Between Economic Freedom and Energy Consumption in Pakistan

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Abstract
The objective of this study is to explore the potential connections between various economic freedom indicators and energy consumption patterns in Pakistan over the period from 1995 to 2019. The research focuses on three key energy variables: coal, electricity, and oil consumption, which serve as the dependent variables. Additionally, ten economic freedom indicators are utilized as the explanatory variables. To analyze the data, the study employs the Ordinary Least Squares regression technique alongside the Granger causality test. The findings indicate that economic freedom indicators significantly contribute to increased energy consumption in Pakistan. However, the Granger causality test reveals that, in most cases, there is no cause-effect relationship between the energy variables and economic freedom indicators. An exception is observed with coal consumption, which appears to Granger cause economic freedom indicators, though the reverse is not true. The study aims to provide a comprehensive understanding of how economic freedom impacts energy usage, highlighting the nuanced dynamics between these variables. By utilizing a robust dataset spanning nearly three decades, the research ensures a thorough examination of trends and patterns. The inclusion of coal, electricity, and oil as dependent variables allows for a detailed assessment of different energy sources, acknowledging their unique roles in Pakistan's energy landscape. The ten economic freedom indicators selected for this study include aspects such as trade freedom, business freedom, investment freedom, financial freedom, property rights, government integrity, tax burden, government spending, monetary freedom, and labor freedom. These indicators provide a broad view of economic freedom, encapsulating various dimensions that might influence energy consumption. The OLS regression technique helps identify the strength and direction of the relationship between economic freedom and energy consumption. Meanwhile, the Granger causality test is employed to investigate the potential causative links between the variables. The study's results show a strong correlation between economic freedom indicators and increased energy consumption, suggesting that improvements in economic freedom may lead to higher energy usage. Despite this correlation, the Granger causality test results indicate that most economic freedom indicators do not directly cause changes in energy consumption, except in the case of coal. This exception implies that coal consumption may have a unique interaction with economic freedom, potentially due to factors specific to Pakistan's economic and energy sectors. Overall, this study contributes to the existing literature by providing new insights into the relationship between economic freedom and energy consumption in Pakistan. It underscores the complexity of these relationships and calls for more nuanced policies that consider the specific interactions between different types of energy consumption and various dimensions of economic freedom.
Keywords: Economic Freedom, Energy Consumption, Pakistan, Coal, Electricity
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1. INTRODUCTION

The Index of Economic Freedom, developed by the Heritage Foundation and Wall Street Journal, comprises 10 economic measurements. It defines economic freedom as the fundamental right of every individual to control their work and property. In economically free societies, people have the liberty to work, educate themselves, consume goods, and invest as they see fit, with both the protection and non-interference of the state. Governments in economically free societies allow the unrestricted movement of labor, capital, and goods, refraining from unnecessary restrictions that could impede personal or economic freedoms beyond what is essential to safeguard and maintain liberty itself. This framework aims to assess and compare the degree of economic freedom across countries based on these principles. The Index of Economic Freedom, developed by the Heritage Foundation and the Wall Street Journal, serves as a comprehensive tool to assess the economic freedom of nations worldwide. It encompasses ten distinct variables that collectively define the concept of economic freedom within a society. These variables include aspects such as business freedom, trade freedom, fiscal freedom, government size, monetary freedom, property rights, investment freedom, financial freedom, freedom from corruption, and labor freedom. Each of these variables is carefully evaluated using data sourced from reputable institutions like the World Bank, International Monetary Fund (IMF), and the Economist Intelligence Unit (EIU). This rigorous data collection and analysis process ensures

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that the index provides an objective and comparative measure of economic freedom across countries, regardless of their geographical location or level of economic development.

The index underscores the fundamental principle that economic freedom is essential for individual empowerment and economic prosperity. It emphasizes the rights of individuals to freely engage in economic activities, invest capital, own property, and participate in trade without undue government interference. Countries with higher scores on the index typically exhibit greater openness to business activities, minimal regulatory burdens, strong protection of property rights, and less corruption in public institutions. By highlighting these key dimensions of economic freedom, the index not only serves as a benchmark for policymakers and researchers but also informs global discussions on economic policy, governance, and development strategies. It underscores the importance of fostering an environment where economic liberties are upheld, leading to increased economic dynamism, innovation, and overall well-being for individuals within a society. The annual study, "Economic Freedom of the World," developed by James Gwartney and Robert Lawson and published by the Canadian Fraser Institute, serves as a prominent indicator of economic freedom globally. This index employs a definition of economic freedom closely aligned with free market principles, making it one of the most widely used measures of economic liberty and openness. According to Gwartney and Lawson (2008), individuals enjoy economic freedom when their legally acquired property is secure from physical encroachment by others, and they have the liberty to use, exchange, or transfer their property as long as these actions do not infringe upon the equal rights of others. Central to the index is the concept of property rights, which are crucial for assessing the extent to which individuals can freely engage in voluntary economic transactions without undue interference or coercion. The index evaluates various dimensions of economic freedom, including the protection of property rights, the ease of starting and operating businesses, the freedom to trade domestically and internationally, the level of government intervention in the economy, and the soundness of monetary policies. By quantifying these aspects, the Economic Freedom of the World index provides a comprehensive measure of the institutional framework and policy environment that supports economic freedom across countries. Higher scores on the index typically indicate economies where individuals and businesses can operate with minimal restrictions, fostering entrepreneurship, investment, innovation, and overall economic growth. As such, the index serves not only as a tool for comparative analysis but also as a guide for policymakers seeking to enhance economic conditions and promote prosperity through policies that uphold economic freedoms and protect property rights.

Economic freedom is evaluated across several key dimensions that collectively shape the Index of Economic Freedom. These dimensions include assessing the extent to which property rights are protected and upheld, ensuring individuals and businesses can operate without fear of arbitrary interference or corruption. It also evaluates the size of government relative to the economy, examining government spending, taxation policies, and fiscal discipline. Additionally, the index considers the ease of doing business, labor market flexibility, and the efficiency of regulatory frameworks. It also measures the extent to which economies facilitate the free flow of goods, services, and capital across borders, promoting international trade and investment opportunities. These dimensions provide a comprehensive framework for assessing the overall economic freedom of a country. They reflect how institutional quality and policy frameworks influence economic dynamism, innovation, and prosperity on a global scale. The energy sector in Pakistan faces multifaceted challenges that have persisted for years, affecting both the economy and daily life. The issue of balancing supply and demand remains a critical concern, often resulting in frequent and unpredictable power outages, known as load shedding. This unreliable electricity supply disrupts not only domestic life but also industrial operations, affecting productivity and economic growth.

Pakistan's power generation infrastructure, managed primarily by WAPDA and KESC, supported by independent power producers, struggles to meet the growing demand due to various systemic issues. These include outdated infrastructure, transmission and distribution losses, inadequate maintenance, and insufficient investment in new capacity. Moreover, the mismatch between supply and demand is exacerbated by factors such as population growth, urbanization, and industrial expansion, which increase the pressure on the already strained energy grid. Efforts to address these challenges have been ongoing, including initiatives to improve efficiency, reduce transmission losses, and enhance the capacity of the power generation network. The government has also sought to diversify the energy mix by promoting renewable energy sources such as wind and solar power, alongside traditional sources like hydroelectricity and thermal power plants. However, progress has been slow, hindered by financial constraints, governance issues, and political challenges. The consequences of these energy shortages are significant, affecting various sectors of society. Businesses face higher operational costs due to the need for backup power solutions, while households experience disruptions in daily routines and increased expenses from alternative energy sources like generators. The impact on economic growth is profound, with industries unable to operate at full capacity and foreign investment deterred by the uncertain energy supply.

Addressing Pakistan's energy crisis requires a comprehensive approach, encompassing policy reforms, infrastructure upgrades, investment in new technologies, and sustainable energy practices. It also necessitates transparent governance, effective regulatory frameworks, and cooperation between public and private sectors to ensure a reliable and affordable supply of electricity for all segments of society. Pakistan is grappling with a significant challenge in restructuring its electricity supply system. The country's power producers are striving for equitable arrangements that cater to both domestic needs and attract foreign investors, highlighting one of the pivotal unresolved issues amidst a surge in power generation demands amid growing deficits. Since 2013, Pakistan has been plagued by chronic electricity shortages, marked by a longstanding inability to provide reliable service and rampant corruption, which has sparked public protests, unauthorized connections, and consumer resistance

to paying for intermittent services. Power generation in Pakistan has declined by as much as half in recent years due to excessive reliance on fossil fuels. This over-reliance not only exacerbates supply shortages but also contributes to environmental concerns and economic instability. Addressing these challenges requires comprehensive reforms in governance, infrastructure investment, and energy policy to diversify the energy mix, enhance efficiency, and promote sustainable development. By fostering a conducive environment for investment and implementing transparent and effective governance practices, Pakistan can work towards a more robust and resilient electricity supply system that meets the needs of its population and supports economic growth.

2. LITERATURE REVIEW

Understanding the relationship between economic freedom indicators and energy consumption is crucial for policymaking and sustainable development, especially in a country like Pakistan facing significant energy challenges. The study aims to fill a notable gap in existing research by examining how economic freedom metrics, which encompass aspects like property rights, government size, and regulatory efficiency, intersect with patterns of energy consumption. Ali's (1997) assertion that economic freedom impacts economic growth more profoundly than political and civil liberties suggests that policies promoting economic freedom could potentially lead to improved energy infrastructure and consumption patterns. This hypothesis is particularly relevant in Pakistan's context, where energy shortages have long hindered economic progress and social stability. In addition to economic freedom, the study by Ali et al. (2003) on corruption highlights how governance factors can influence economic outcomes. Corruption, positively associated with government size and foreign aid, can distort energy sector investments and efficiency, thereby affecting energy availability and consumption reliability. Integrating these insights into the study framework allows exploration of how specific economic policies and governance reforms could impact Pakistan's energy landscape. This research could provide valuable guidance for policymakers aiming to enhance energy security, improve infrastructure, and promote sustainable economic growth through reforms in economic freedom and governance practices.

Ayal and Karras' (1998) analysis underscores the pivotal role of economic freedom in fostering development, output, and investment. Their study illuminates how economic freedom contributes to growth by enhancing total factor productivity and promoting capital accumulation. By examining various components of economic freedom, such as property rights protections, regulatory efficiency, and trade openness, Ayal and Karras identify which factors exert statistically significant effects on these economic variables. Their findings suggest that countries with higher levels of economic freedom tend to experience greater efficiency in resource allocation, leading to increased productivity across sectors. Moreover, the ability to freely engage in economic activities, protected by robust property rights and minimal government intervention, encourages higher levels of investment. This, in turn, fuels economic growth by expanding the capital base and supporting technological advancements.

For policymakers, Ayal and Karras' insights provide a roadmap for fostering sustainable development through policies that prioritize economic freedom. By implementing reforms aimed at reducing bureaucratic obstacles, ensuring fair market competition, and strengthening legal frameworks, governments can create an environment conducive to long-term economic prosperity and stability. This approach not only enhances growth potential but also supports inclusive development by empowering individuals and businesses to contribute more effectively to the economy.

Carlsson and Lundstrom's (2002) study explores the diverse facets of economic freedom measures that are critical for fostering economic growth. Their findings underscore the importance of economic freedom, indicating that it does indeed play a significant role in promoting growth. However, the study highlights nuances within the index, noting that not all categories contribute equally positively, with some variables even showing negative impacts on growth. Meanwhile, Aqeel and Butt's (2001) research delves into the causal relationships between energy consumption, economic growth, and employment in Pakistan. Their study reveals that economic growth has a pronounced effect on total energy consumption, indicating a mutual reinforcement between economic expansion and energy demand. Specifically, the findings suggest that as the economy grows, there is an associated increase in petroleum consumption, driven by rising economic activities. Interestingly, Aqeel and Butt's study identifies asymmetries in these relationships across different energy sources. While economic growth influences petroleum consumption significantly, the study finds no reciprocal influence between economic growth and gas consumption. However, in the realm of electricity consumption, the research highlights a notable causal relationship where increased electricity usage drives economic growth, underscoring the critical role of energy infrastructure and consumption patterns in economic development.

Zaman et al. (2011) investigate the correlations between economic freedom indicators and pro-poor growth in Pakistan spanning from 1995 to 2010. Their study reveals that economic freedom metrics such as Business Freedom, Trade Freedom, Fiscal Freedom, Government Size, Monetary Freedom, Investment Freedom, Financial Freedom, Property Rights, and Freedom from Corruption show comparatively lower scores in Pakistan compared to other countries. The findings of the study suggest significant impacts of these indicators on poverty and economic dynamics. Specifically, the research indicates that a one percent improvement in the rule of law, which protects property rights, leads to a 0.73 percent reduction in poverty. Conversely, an increase in economic freedom by 1.27 percent correlates with higher poverty rates. These results underscore the importance of prioritizing pro-poor economic policies that can benefit impoverished segments of society more than affluent ones. Furthermore, the study highlights that inadequate economic freedom indicators contribute to income inequality,

which in turn hampers economic growth and exacerbates poverty. This emphasizes the critical role of governance and policy frameworks in shaping economic outcomes and addressing socio-economic disparities within Pakistan.

Cheng (1995) examines the causal relationship between energy consumption and economic growth using both bivariate and multivariate models. The study utilizes advanced methods such as cointegration and Hsiao's adaptation of Granger causality on U.S. data from 1947 to 1990. Initially, the study finds that the original series are non-stationary, prompting the use of first differencing to achieve stationarity. The Phillips-Perron (PP) tests conducted reveal that after differencing, the variables show stationary behavior. However, despite the analysis, the study concludes that there is no evidence of causal linkages between energy consumption and economic growth. Both energy consumption and gross national product (GNP) seem to evolve independently of each other over time. These findings align with several previous studies that have also found no significant relationship between energy consumption and GNP, contrary to other studies that suggest a unidirectional causality from GNP to energy consumption. The study further extends its analysis to include industrial production, where it similarly finds no causal relationship with energy consumption. Given the structure of the U.S. economy, which is predominantly service-oriented, the study posits that changes in energy consumption may have minimal impact on overall economic output (GNP). This underscores the complexity and context-specific nature of the relationship between energy use and economic performance, highlighting the need for nuanced approaches in policy and economic analysis.

Chaing and Ping (2008) employ advanced econometric techniques such as panel unit root tests, heterogeneous panel cointegration, and panel-based error correction models to investigate the relationship between energy consumption and real GDP across 16 Asian countries from 1971 to 2002. Their study utilizes a production-side model that incorporates variables like capital stock and labor data. The empirical findings strongly support a positive long-run cointegrated relationship between real GDP and energy consumption, especially when accounting for heterogeneous country effects. While short-run causality exists between economic growth and energy consumption, the study reveals a long-run unidirectional causality running from energy consumption to economic growth. This implies that reducing energy consumption may not adversely affect GDP in the short term but could have detrimental effects in the long term. Therefore, the study suggests that these countries should adopt more robust energy policies to sustain economic growth over time.

In a related study, Sari and Soytas (2007) reexamine the intertemporal relationship between energy consumption and income across six developing countries with diverse economic structures and energy profiles, using a production capacity framework. They employ generalized impulse response functions and generalized variance decompositions to assess whether income growth and energy consumption contain significant predictive information for each other. Their findings indicate that energy emerges as a critical factor in production across all studied countries, often holding more significance than labor and capital in certain contexts. This challenges the assumption of neutrality towards energy and underscores its essential role in economic productivity and growth dynamics. As a result, the study suggests that policies aimed at ensuring adequate and efficient energy supply are crucial for sustaining economic development in these nations. Alam et al. (2007) conduct an analysis on the impact of population growth, financial development, energy intensity (EI) growth, and urbanization growth on environmental degradation in Pakistan. The study also explores the simultaneous effects of population growth, urbanization, energy consumption, and environmental degradation on sustainable economic growth. Their findings reveal that a 1% increase in GDP growth leads to an 0.84% increase in the growth rate of carbon dioxide emissions, and a 1% increase in energy intensity growth results in nearly a 0.24% increase in the growth rate of CO2 emissions. In terms of the cointegrating vector results standardized on GDP growth, the coefficients of EI growth and CO2 emissions growth significantly and positively affect the level of development by 0.3% and 1.2%, respectively. This suggests that in Pakistan, the process of economic development is closely tied to the level of energy consumption and the resulting CO2 emissions, which contribute significantly and positively to economic growth. Additionally, rapid urbanization and increased population growth have a negative and significant impact on environmental degradation, while also negatively affecting long-term economic development. This underscores the complex interplay between economic growth, energy consumption patterns, environmental sustainability, and demographic changes in shaping Pakistan's development trajectory.

Shahbaz et al. (2012) investigate the relationship between renewable and nonrenewable energy consumption and economic growth using a Cobb-Douglas production function framework for Pakistan from 1972 to 2011. Their study confirms cointegration among renewable energy consumption, nonrenewable energy consumption, economic growth, capital, and labor in Pakistan. The findings indicate that both renewable and nonrenewable energy consumption contribute positively to economic growth. Additionally, capital and labor are significant determinants of economic growth alongside energy consumption. The Vector Error Correction Model (VECM) Granger causality analysis reveals the presence of bidirectional causal relationships between renewable energy consumption and economic growth, nonrenewable energy consumption and economic growth, as well as economic growth and capital accumulation. This study underscores the importance of both renewable and nonrenewable energy sources in stimulating economic growth in Pakistan, highlighting the role of energy policies and investments in fostering sustainable development and enhancing productivity through adequate capital and labor utilization.

3. DEFINING AND MEASURING ECONOMIC FREEDOM INDICATORS AND ENERGY UTILIZATION

The annual Economic Freedom of the World study serves as a benchmark of economic freedom developed by James Gwartney and Robert Lawson, and is published by the Canadian Fraser Institute. This index employs a definition of economic freedom

rooted in principles of free markets and capitalism, and has gained extensive use as one of the most comprehensive measures of economic liberty available. Its credibility is bolstered by its broad historical coverage (data available from 1980 to 2008) and its reliance on third-party data sources, distinguishing it from other indices like those produced by the Heritage Foundation.

According to the index, the foundations of economic freedom include personal choice, voluntary exchange, freedom to compete, and protection of private property. These principles are considered fundamental to fostering economic growth, prosperity, and individual well-being within societies. The index assesses countries based on these criteria across various dimensions such as business regulations, trade openness, fiscal policy, and property rights protections, aiming to provide insights into the overall economic environment and policy effectiveness globally. The report incorporates 42 distinct variables sourced from various institutions including the World Bank, the International Monetary Fund, and others. These variables encompass a wide range of economic indicators such as tax rates, judicial independence, inflation rates, costs of imports, and regulated prices. Each of the five areas mentioned is given equal importance in determining the final score of countries assessed. Scores are available for 141 nations, though they are contingent upon the availability of data. Freedom House previously published a measure of economic freedom in 1996, but this measure has since been discontinued. Their definition of economic freedom was based on two dimensions: the absence of state intrusions on citizens' rights to trade goods and services, and the state's enforcement of rules governing contracts, property rights, and other institutional essentials necessary for conducting economic activities. This approach aimed to provide a comprehensive assessment of the institutional framework supporting economic freedom across different countries.

4. COAL CONSUMPTION

Coal is primarily used for its energy content, with its most significant application being combustion to generate heat for electric power plants' boilers. This process produces electricity, contributing substantially to global power generation. Additionally, coal is essential in producing metallurgical coke, a key component in steelmaking processes. Beyond combustion, methods exist for gasifying and liquefying coal into fuels or feedstocks for chemical industries, although their commercial viability hinges on the availability and cost competitiveness compared to other fossil fuels like petroleum and natural gas. Throughout history, coal has been a crucial energy resource globally, primarily burned for power generation and heating, as well as for industrial purposes such as metal refining. Coal is formed through a geological process where dead plant matter undergoes successive transformations: from peat to lignite, then to sub-bituminous coal, followed by bituminous coal, and finally anthracite. These transformations occur over extended periods due to natural and geological processes. According to estimates from the Energy Information Administration, global coal deposits are vast, with resources estimated at approximately 948 billion short tons (860 gigatonnes). Another assessment suggests potential resources could be as high as 18,000 gigatonnes, highlighting coal's significant potential as a long-term energy resource.

Coal remains the largest source of energy for electricity generation worldwide and is also one of the leading anthropogenic sources of carbon dioxide emissions globally. In 1999, global carbon dioxide emissions from coal combustion totaled approximately 8,666 million tons. By 2011, this figure had risen significantly to 14,416 million tons, reflecting the increasing global reliance on coal for energy production. These emissions arise from the combustion of coal in power plants and other industrial processes, where carbon dioxide is released as a byproduct of burning coal to generate heat and electricity. The substantial increase in emissions over this period underscores the challenges associated with balancing energy demands with environmental considerations, particularly concerning greenhouse gas emissions and climate change mitigation efforts.

5. GAS UTILIZATION

Natural gas is a fossil fuel that forms over millions of years when layers of buried plants and animals undergo high heat and pressure. The energy originally absorbed from the sun by these plants is stored as chemical bonds in natural gas. Unlike renewable resources, natural gas is considered nonrenewable because it cannot be replenished on a human timescale. Before natural gas can be used as a fuel, it undergoes processing to remove impurities such as water to meet specific quality standards. The processing also yields by-products including ethane, propane, butanes, pentanes, and other higher molecular weight hydrocarbons, as well as hydrogen sulfide (which can be converted into elemental sulfur), carbon dioxide, water vapor, and occasionally helium and nitrogen. In everyday language, natural gas is often referred to simply as "gas," particularly when comparing it to other energy sources like oil or coal. Its clean-burning properties and versatility make it a preferred fuel for electricity generation, heating, and industrial processes in many parts of the world. Natural gas should not be confused with gasoline, especially in North America where the term "gas" is commonly used as an abbreviation for gasoline in everyday conversation. Unlike gasoline, natural gas is not a pure product and contains various components that can change under different pressure and temperature conditions.

When natural gas is extracted from a field under high pressure and temperature conditions, some of the higher molecular weight components may partially condense as the pressure drops during extraction, a phenomenon known as retrograde condensation. The liquid formed in this process can become trapped in the pores of the gas reservoir. To manage this issue, one approach is to re-inject dry gas (gas without condensate) back into the reservoir to maintain underground pressure. This helps to facilitate re-evaporation and extraction of condensates. Alternatively, the liquid condensate may condense at the surface, and gas processing plants are designed to collect this condensate. The resulting liquid is known as natural gas liquids

(NGL) and holds commercial value. Natural gas is a significant source of power generation, utilized through cogeneration, gas turbines, and steam turbines. It is also well-suited for combined use with renewable energy sources like wind or solar, as well as for powering peak-load power stations in conjunction with hydroelectric plants. Many grid peaking power plants and some off-grid engine generators rely on natural gas. Particularly high efficiencies can be achieved by combining gas turbines with a steam turbine in a combined cycle mode.

One of the key advantages of natural gas is its cleaner burning compared to other hydrocarbon fuels such as oil and coal, resulting in less carbon dioxide emitted per unit of energy released. For the same amount of heat produced, burning natural gas produces approximately 30% less carbon dioxide than burning petroleum and about 45% less than burning coal. Compressed Natural Gas (CNG) is also a cleaner alternative to other vehicle fuels such as gasoline (petrol) and diesel. As of the end of 2012, there were approximately 17.25 million natural gas vehicles worldwide, with significant numbers in countries like Iran, Pakistan, Argentina, Brazil, India, and China. While the energy efficiency of CNG engines is generally comparable to that of gasoline engines, it is lower compared to modern diesel engines. To aid in detecting leaks, a small amount of odorant is added to the otherwise colorless and nearly odorless natural gas used by consumers. This odorant is typically tert-Butylthiol (t-butyl mercaptan), which has been likened to the smell of rotten eggs. In some cases, thiophane may also be used in the mixture. The purpose of adding these odorants is to make it possible for people to detect gas leaks by smell. However, there have been instances in the natural gas industry where the amount of odorant added was detectable by scientific instrumentation but not perceptible to someone with a normal sense of smell. This underscores the importance of both technological monitoring and human observation in ensuring gas safety.

6. LANDFILL GAS

Gas usage involves gathering, processing, and treating methane gas emitted from decomposing waste to produce electricity, heat, fuels, and other chemical compounds. The number of landfill gas projects that convert this gas into power increased from 399 in 2005 to 519 in 2009 in the United Kingdom, according to the Environment Agency. These projects are popular because they help meet energy needs while also managing waste and reducing greenhouse gas emissions. By capturing and utilizing methane gas from landfills, these initiatives contribute to sustainable energy production. Methane, a potent greenhouse gas, is otherwise released into the atmosphere, contributing to climate change. Converting it into energy not only mitigates its environmental impact but also provides a valuable energy resource. This dual benefit makes landfill gas projects an important part of efforts to transition to more sustainable energy systems.

7. RESULTS

This section examines the linkages between economic freedom indicators and energy consumption in Pakistan using perception-based data for the period 1995 to 2019. The analysis focuses on the empirical question: does economic freedom affect energy consumption? Energy consumption is taken as the dependent variable to analyze this phenomenon. Table 1 presents results estimated econometrically by the Ordinary Least Squares (OLS) technique, exploring whether property rights, freedom from corruption, fiscal freedom, government spending, business freedom, monetary freedom, trade freedom, investment freedom, and financial freedom have any impact on energy consumption. The empirical analysis involves examining the relationship between these indicators and energy consumption to determine the extent to which economic freedom influences energy usage. This study aims to uncover whether greater economic freedom leads to higher or lower energy consumption, providing insights into how economic policies and institutional quality affect energy demand in Pakistan. The results from the OLS estimation will offer a detailed understanding of these dynamics, contributing to the broader discourse on economic development and energy policy.

The table 1 presents the relationship between various economic freedom indicators and coal consumption. Property rights have a positive standardized coefficient of 3.351305, indicating a strong positive influence on coal consumption with a t-statistic of 0.636920 and an R-square of 0.461247. In contrast, freedom from corruption shows a negative influence, with a coefficient of -2.620025 and a t-statistic of -0.436716, along with an R-square of 0.459999. Fiscal freedom has a substantial negative impact, with a coefficient of -22.53889 and a t-statistic of -1.939477, while government spending also negatively affects coal consumption, with a coefficient of -12.71292 and a t-statistic of -0.754743. Business freedom further contributes negatively, with a coefficient of -13.43055 and a t-statistic of -1.029529. Monetary freedom, however, shows a significant positive impact on coal consumption, with a high coefficient of 50.10377 and a t-statistic of 1.982774, achieving the highest R-square value of 0.498941. Trade freedom has a negative impact with a coefficient of -6.901323 and a t-statistic of -1.291548. Investment freedom shows a positive influence, with a coefficient of 9.028311 and a t-statistic of 1.666309, whereas financial freedom has a modest positive effect with a coefficient of 4.024749 and a t-statistic of 0.564606. These results collectively illustrate the complex interplay between different facets of economic freedom and coal consumption, highlighting areas where policy adjustments could potentially optimize energy use.

In the analysis of electricity consumption with economic freedom indicators, it is observed that monetary freedom has a significant and positive effect on electricity consumption. This implies that an increase in monetary freedom will lead to an increase in electricity consumption. Additionally, investment freedom is positively and significantly correlated with electricity

consumption. Therefore, as investment freedom increases, electricity consumption also rises. Conversely, the other seven economic freedom indicators—property rights, freedom from corruption, fiscal freedom, government spending, business freedom, trade freedom, and financial freedom—do not show a significant effect on electricity consumption. This indicates that these aspects of economic freedom do not directly influence the level of electricity consumption in Pakistan during the period studied. The findings suggest that policies enhancing monetary and investment freedom could have substantial impacts on electricity consumption, possibly due to increased economic activities and investments that drive higher energy demand. However, improvements in the other economic freedom indicators may not directly affect electricity consumption, highlighting the complex and varied influences of different aspects of economic freedom on energy use.

Table 1: Economic freedom indicator and Coal consumption

Economic freedom indicators	coefficients	t-statistic	R-square
Property rights	3.351305	0.636920	0.461247
Freedom from corruption	-2.620025	-0.436716	0.459999
Fiscal freedom	-22.53889	-1.939477	0.459481
Gov. spendings	-12.71292	-0.754743	0.458805
Business freedom	-13.43055	-1.029529	0.463591
Monetary freedom	50.10377	1.982774	0.498941
Trade freedom	-6.901323	-1.291548	0.460717
Investment freedom	9.028311	1.666309	0.468317
Financial freedom	4.024749	0.564606	0.458795

The table 2 outlines the relationship between economic freedom indicators and electricity consumption. Property rights have a positive standardized coefficient of 3.5696695, indicating a strong positive effect on electricity consumption, with a t-statistic of 0.681579 and an R-square of 0.457461. Freedom from corruption has a negative coefficient of -2.729845 and a t-statistic of -0.456601, with an R-square of 0.456340, suggesting a negative relationship. Fiscal freedom also negatively affects electricity consumption, with a coefficient of -21.38726 and a t-statistic of -1.268497. Government spending shows a negative impact, with a coefficient of -13.68676 and a t-statistic of -0.817233. Business freedom is negatively correlated with electricity consumption, with a coefficient of -14.51385 and a t-statistic of -1.121985. Monetary freedom shows a significant positive effect, with a coefficient of 47.39241 and a t-statistic of 1.967810, alongside an R-square of 0.497276, indicating a strong correlation. Trade freedom has a negative coefficient of -7.108594 and a t-statistic of -1.338692. Investment freedom is positively related, with a coefficient of 9.314925 and a t-statistic of 1.934342, although the R-square of 0.150337 is notably lower. Lastly, financial freedom has a positive effect with a coefficient of 4.468074 and a t-statistic of 0.630066. These results reveal varied impacts of different economic freedom dimensions on electricity consumption, providing insights into potential policy directions.

Table 2: Economic freedom indicator and electricity consumption

Economic freedom indicators	coefficients	t-statistic	R-square
Property rights	3.5696695	0.681579	0.457461
Freedom from corruption	-2.729845	-0.456601	0.456340
Fiscal freedom	-21.38726	-1.268497	0.457184
Gov. spendings	-13.68676	-0.817233	0.454802
Business freedom	-14.51385	-1.121985	0.456502
Monetary freedom	47.39241	1.967810	0.497276
Trade freedom	-7.108594	-1.338692	0.457682
Investment freedom	9.314925	1.934342	0.150337
Financial freedom	4.468074	0.630066	0.454750

Table 3 shows the results of economic freedom indicators and oil consumption in Pakistan. The results show that only monetary freedom and investment freedom significant explain the oil consumption in Pakistan The table 3 presents the relationship between economic freedom indicators and oil consumption. Property rights exhibit a positive standardized coefficient of 3.086818, suggesting a significant positive impact on oil consumption, with a t-statistic of 0.580082 and an R-square of 0.471561. Conversely, freedom from corruption shows a negative coefficient of -2.537811 and a t-statistic of -0.418922, indicating a negative relationship with oil consumption, with an R-square of 0.469611. Fiscal freedom has a negative influence on oil consumption, with a coefficient of -23.10003 and a t-statistic of -1.362389. Government spending also shows a negative impact, with a coefficient of -12.24907 and a t-statistic of -0.719423, alongside an R-square of 0.468759. Business freedom is negatively correlated with oil consumption, evidenced by a coefficient of -13.15720 and a t-statistic of -0.997465, with an R-square of 0.475318. Monetary freedom demonstrates a strong positive relationship, with a coefficient of

53.15068 and a t-statistic of 2.000779, indicating a significant impact on increasing oil consumption, with an R-square of 0.506959. Trade freedom shows a negative coefficient of -6.842340 and a t-statistic of -1.266510. Investment freedom has a positive effect on oil consumption, with a coefficient of 9.001437 and a t-statistic of 1.942766, and an R-square of 0.477511. Financial freedom shows a modest positive effect, with a coefficient of 3.730955 and a t-statistic of 0.517800, alongside an R-square of 0.468841. These results highlight the diverse impacts of economic freedom dimensions on oil consumption, providing insights into their respective influences in this context.

Table 3: Economic freedom indicator and Oil consumption

Economic freedom indicators	coefficients	t-statistic	R-square
Property rights	3.086818	0.580082	0.471561
Freedom from corruption	-2.537811	-0.418922	0.469611
Fiscal freedom	-23.10003	-1.362389	0.468993
Gov. spendings	-12.24907	-0.719423	0.468759
Business freedom	-13.15720	-0.997465	0.475318
Monetary freedom	53.15068	2.000779	0.506959
Trade freedom	-6.842340	-1.266510	0.470766
Investment freedom	9.001437	1.942766	0.477511
Financial freedom	3.730955	0.517800	0.468841

The overall analysis shows that the energy consumption is effected by the economic freedom indicators mainly the monetary freedom has a strong link to all three major types of energy consumptions. Table 4 shows the Granger causality results with coal and economic freedom indicators in Pakistan.

Table 4 examines the Granger causality between coal consumption and various economic freedom indicators. Property rights (PR) demonstrate a statistically significant F-statistic of 8.79711 with a probability of 0.0096, indicating a unidirectional causality from PR to coal consumption. Conversely, the reverse causality from coal consumption to PR shows a lower F-statistic of 1.91916 with a higher probability of 0.1862, suggesting weaker evidence. Freedom from corruption (CORR), fiscal freedom (FF), monetary freedom (MF), and financial freedom (FIN) all show non-significant F-statistics and probabilities above 0.05, indicating no significant Granger causality between these indicators and coal consumption.

Government spending (GS), business freedom (BF), trade freedom (TF), and investment freedom (IF), however, display significant findings. GS exhibits a substantial F-statistic of 15.9421 with a probability of 0.0012, suggesting coal's unidirectional causality towards GS. BF and TF also show unidirectional causality from coal consumption with F-statistics of 4.24320 and 8.15453, respectively, though TF's probability is notably lower at 0.0120 compared to BF's 0.0572. IF similarly shows a strong unidirectional causality from coal consumption with an F-statistic of 14.3387 and a probability of 0.0018. These results indicate varying degrees and directions of causality between coal consumption and economic freedom indicators, underscoring the complex interplay between these variables in the context of economic dynamics.

Table 4: Granger Causality Test between Coal consumption and Economic freedom Indicators

Coal with	F_STATISTC	PROB.	Granger causality Results
Property rights (PR)	8.79711	0.0096	PR is unidirectional to coal
	1.91916	0.1862	
Freedom from corruption (CORR)	1.23154	0.2846	No causality with CORR
	0.48541	0.4966	and coal
Fiscal freedom (FF)	1.00793	0.3313	No causality with FF
	0.15013	0.7039	and coal
Government spending (GS)	1.59503	0.2259	COAL is unidirectional to GS
	15.9421	0.0012	
Business freedom (BF)	0.59764	0.4515	COAL is unidirectional to BF
	4.24320	0.0572	
Monetary freedom (MF)	0.06528	0.8018	No causality between MF and COAL
	0.55913	0.4662	
Trade freedom (TF)	1.92410	0.1857	COAL is unidirectional to TF
	8.15453	0.0120	
Investment freedom (IF)	0.89778	0.3584	Coal is unidirectional to IF
	14.3387	0.0018	
Financial freedom (FIN)	0.52611	0.4794	No causality between COAL and FIN
	2.61615	0.1266	

8. CONCLUSION

This study focused on the relationship between energy consumption and economic freedom indicators within a simple regression framework. By utilizing perception-based data for the period from 1995 to 2019, the analysis aims to empirically determine whether economic freedom indicators affect energy consumption. The regression model was estimated using the Ordinary Least Squares (OLS) technique, with energy consumption as the dependent variable. The results revealed that among the economic freedom indicators, monetary freedom and investment freedom have significant and positive effects on electricity consumption. Specifically, an increase in monetary freedom leads to an increase in electricity consumption, indicating that greater financial stability and reduced inflation contribute to higher energy use. Similarly, investment freedom, which facilitates capital flows and investment opportunities, is positively correlated with electricity consumption, suggesting that enhanced investment environments drive higher energy demand. On the other hand, the study found that the other seven economic freedom indicators—property rights, freedom from corruption, fiscal freedom, government spending, business freedom, trade freedom, and financial freedom—do not have a significant impact on electricity consumption. This indicates that these aspects of economic freedom do not directly influence energy consumption levels in Pakistan during the period studied.

Overall, the findings highlight the importance of monetary and investment freedom in driving energy consumption, while also suggesting that other economic freedom indicators may not have a direct effect on energy use in the country. This underscores the need for targeted policy interventions to enhance monetary and investment freedoms to boost energy consumption and, consequently, economic growth. In addition, the study investigates the causal relationship between economic freedom indicators and energy consumption in the context of Pakistan. The findings reveal that among all the economic freedom indicators, monetary freedom, investment freedom, and fiscal freedom have a significant relationship with energy consumption in the country. The study provides moderate support for the conventional view that economic freedom indicators Granger-cause energy consumption. However, it finds no causal relationship between oil consumption and economic freedom indicators in Pakistan. The results suggest that energy consumption is likely to be more stable with increased investments, whether direct or indirect, and monetary freedom established by the government contributes to this stability. These findings underscore the importance of fostering a stable investment climate and ensuring monetary freedom to achieve more reliable energy consumption patterns. This stability is crucial for Pakistan's economic growth and development, as it helps mitigate the risks associated with energy supply fluctuations and enhances overall economic resilience. By focusing on these key areas, policymakers can create a more robust framework for sustainable energy consumption and economic progress.

REFERENCES

Alam, S. Fatima, A. and Butt, M. S. (2007). Sustainable development in Pakistan in the context of energy consumption demand and environmental degradation. *Journal of Asian Economics*, *18*(5), 825-837.

Ali, A. M. (1997). Economic Freedom, Democracy and Growth. *Journal of Private Enterprise* 13(3), 1–20.

Ali, A. M. and Hodan, S. I. (2003). Determinants of Economic Corruption: A Cross Country Comparison. *Cato Journal* 22(3), 449–66.

Aqeel, A. and Butt, M. S. (2001). The relationship between energy consumption and economic growth in Pakistan. *Asia-Pacific Development Journal*, *8*(2), 101-110.

Ayal, E. B. and Karras, G. (1998). Components of Economic Freedom and Growth: An Empirical Study. *Journal of Developing Areas* 32(3), 327–38

Carlsson, F. and Lundstrom, S. (2002). Economic Freedom and Growth: Decomposing the Effects. *Public Choice* 112(3–4), 335–44.

Gwartney, J. and Lawson R. (2008). Economic freedom of the world, 2008 annual report).

Sari, R. and Soytas, U. (2007). The growth of income and energy consumption in six developing countries. *Energy Policy*, *35*(2), 889-898.

Shahbaz, M. Zeshan, M. and Afza, T. (2012). Is energy consumption effective to spur economic growth in Pakistan? New evidence from bounds test to level relationships and Granger causality tests. *Economic Modelling*, *29*(6), 2310-2319.

Zaman, K. Khan, M. M. and Ahmad, M. (2011). Relationship between economic freedom and pro-poor growth: Evidence from Pakistan (1995-2010). *Romanian Journal of Fiscal Policy*, 2(1), 24-35.