Energy scarcity and economic stagnation in Pakistan

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ABSTRACT

In this research, the link between the energy crisis in Pakistan and its economic growth was researched into the very intricate level. Energy is the driving force of the economy; the mechanism responsible for movement, development and advancement in any economy. For the illustration of this relationship, we applied a time series data which was running from the year 1983 to 2022. Under this scheme, Gross Domestic Product (GDP) is the main target variable which signifies the wellness of the economy as a whole. The independent variables affect the input to variables by energy consumption (EC) and trade.

In the study, researchers investigated these relationships by applying the ARDL (Autoregressive Distributed Lag) technique. This way, it was possible to calculate both short-term and long-term effects of energy consumption and trade on using GDP as a measuring tool. The results of the now study display a powerfully gripping plot. Moreover, the country of Pakistan has witnessed outstanding improvements in its GDP, through major increase of energy consumption, in either the short-term or long-term period. Consequently, it can be a domino effect. Energy Absorption exerts an influence on the creation and development of Industries. Such industry growth acts as a multiplier effect, generating more jobs, leading to a rise in incomes and consequently increasing the country's GDP. However, trade does matter too, albeit neutrally in the short run and more tangibly in the long-run. The growing trade activities supplement the export options, which is a source of valuable foreign currency for the economy. With this financial infusion the grounds for economic expansion become even more solid.

The researchers suggested to the government of Pakistan the two-pronged approach based on the results of the survey. Above all, we must make certain that such projects will be novel, better, and more effective. Looking into and supporting the use of renewable energy sources can be a way to ensure that there is sustainability in the long term. The appropriate use of the already existing energy resources is also important. To get the best out of the current resources, the solution could be tackling with the issue of energy theft and outdated infrastructure. Pakistan can certainly light the way to robust and stable economic development by applying these ideas to real life.

Keywords: *Energy Scarcity, Economic Growth, Economic Stagnation, Energy Consumption, Trade.*

INTRODUCTION

An energy crisis is a multifaceted phenomenon which involves both the aspects of shortage and the affordability of that energy. It can occur when there is basically a big discrepancy between the supply and demand of energy resources, which can be triggered by a rapid acceleration in energy rates. This usually comes in the form of an electricity supply shortage, an absence of those fuels such as oil, natural gas and others deemed to be of utmost importance. Energy crisis phenomena is not specific to Pakistan; it is an extensively talked about research issue for researchers all over the world, especially in the aspect of globalization. With economies becoming more and more connected it becomes a case of energy security. However, the demand for energy consistently outpaces supply, especially in developing nations. This imbalance can have crippling consequences, hindering economic growth and overall performance.

Economists (Alqaralleh and Hatemi-J, 2024; Amin and Song, 2023) have established a strong correlation between energy consumption and economic growth. Energy serves as the lifeblood of any economy, powering various sectors like industry, agriculture, services, and manufacturing. It's considered the backbone of economic development, as it fuels industrial processes, facilitates the movement of goods and people (through transportation), and provides the raw materials for commercial activities. A sufficient and reliable energy supply fosters economic growth, while shortages can severely impede progress. In essence, energy plays a vital role in keeping all sectors of an economy functioning smoothly.

Pakistan, like many developing countries, exemplifies the detrimental effects of an energy crisis. As an energy-intensive economy, Pakistan relies heavily on imports of oil and other resources from countries like Iran and Saudi Arabia. However, the country's energy infrastructure remains underdeveloped, and management of the sector suffers from inefficiencies. These factors, in addition to a booming population and ever growing energy demands, all make a very scary scenario possible. The absence of conscientious measures and policies on the other hand will sharpen the situation instead of solving it. On top of that, old-fashioned infrastructure also adds to the energy crisis and ultimately makes it tough to effective power generation and delivery.

Energy system in Pakistan is based on a combination of traditional resources and largely dependent on oil, natural gas, and hydro energy. Hydropower and nuclear power, however, have the capacity to contribute to a major amount of the country's energy demand, but the World Bank, as of 2023, does not indicate that they contribute up to 30% and 10% respectively. The rest of the 60% depends on heating sources, gas (over 35%) and furnace oil (over 25%). The country, Pakistan's coal which is seemingly plentiful due to infrastructure constraints and environmental issues, is not a significant source (0.9 percent).

The country becomes vulnerable being do much dependent on imported fuels, specifically the expensive furnace oil, from oil market which constantly experiences price instability and supply interruptions. While the existing energy structure of archaic infrastructure, defects, and huge inefficiencies is the second problem that further worsen the situation. Policies that though had to be implemented in the 1990s are the chief sources that lead to the energy crisis in Pakistan. A clearer and cheaper alternative, the construction of thermal power plants which will use imported fossil fuel, were especially prioritized by Private Power and Infrastructure Board (PPIPB, 1994). However, this strategy backfired. Furnace oil, the dominant fuel for these plants, proved to be expensive and volatile in price. Furthermore, the reliance on imported fuels increased Pakistan's vulnerability to external factors (Rehman & Habib, 2023).

Compounding the problem is the issue of circular debt within the energy sector. Power generation companies struggle to recover costs due to widespread power theft and non-payment of bills. This financial strain discourages investment in new infrastructure and maintenance of existing facilities, creating a vicious cycle that perpetuates the crisis. Other contributing factors include a lack of long-term energy planning, an overdependence on rental power plants (temporary solutions with high costs), and a subsidy system that disincentivizes efficiency improvements. As a result, during peak summer months, the power shortfall can reach as high as 4,500-5,500 MW, leading to widespread blackouts and hindering economic activity (Kayani, Mumtaz, Fahlevi, Nasseredine, & Hadinata, 2024).

OBJECTIVE OF STUDY

This study enquires into the critical relationship between Pakistan's energy crisis and its economic growth. Our primary objective is to shed light on how energy shortages and price fluctuations hinder the nation's economic progress. We will analyze the historical trends in energy consumption and economic growth to establish the positive correlation between these two factors. The core argument of this study is that increased energy consumption acts as a catalyst for economic growth. Energy serves as the lifeblood of any economy, powering industrial processes, transportation networks, and various economic activities. When energy is accessible and cheap businesses can thrive, productivity increases and thus new job prospects are generated. This in return has raised incomes, increased investment, and finally created a system that is strong and growing.

On the one side, the economic consequences of an energy crisis where there is shortage and high prices are in reality more devastating. The businesses are challenged, real costs grow, and investment turn down. This can produce unemployment, less purchasing power and an overall reduction of economic activity. In short, a downward relationship can be speculated between the degree of the energy crisis and the course of the economy.

LITERATURE REVIEW

Soaring energy crisis, which is a crucial problem for the Pakistan’s policymakers, threatens economic development and other advancements. Luckily, a whole library full of research influences the policy. Researchers can reveal valuable insights by considering the impact of energy utilization on gross domestic product (GDP) via applying different methods and data collection methods. The study of the energy consumption growth and economy in Pakistan issued by Khan and Majeed (2023) has shown the positive correlation amongst the two. Their analysis revealed that rising energy supply as a consequence gives oil to the economic growth.

The authors also went to the core and deliberately chose Generalized Methods of Moments (GMM) as the measuring tool in their study of the effect of energy deficit on economic growth in Pakistan. Their facts accept that there is an available framework already and explain why the relationship between energy consumption and the economic growth seems strong. However, our study doesn't find an end to growth in national economics alone. Researchers such as the one by Razaq, Samie, Saleem, Iqbal, Jameel, Yousuf and Ashraf (2023) specifically analyzed the consequence of the energy crisis on the individual industrial sectors of Pakistan. By calculating a ROA ratio for his industrial performance, the economist finds that the energy crisis affects both the energy sector and other sectors negatively.

Similarly to what the studies above do, policymakers receive the data on which they base their conclusions about the pattern between the level of energy availability and economic development. Hence, the government can formulate efficient strategies to settle the energy crisis and facilitate the creation of a sustainable energy consumption amongst the population, by using these findings. Therefore, the economy of Pakistan will be stable and the development of all strata of the society will be ensured. Pakistan’s apprehension regarding an energy crisis is the underlying challenge the country has to confront in pursuing its economic goals. Policymakers are already under a pressure to deal with this issue because they know that the lack of energy may entirely ruin the economy and the economic development. This is where things get fortuitous, but there are canons of research to a guide a few roads ahead. Through the careful and keen analysis of the convoluted connection between energy consumption and economic growth, researchers consciously provide policymakers with sufficiently solid scientific knowledge base for formulating and implementing successful strategies.

The example of one by Shahbaz, Shahzad, Ahmad and Alam (2016) serves as a starting point for comprehending the motion in more depth. Their four decades of research clearly indicates the positive association of energy consumption and first of all economic growth the national economy. They believe that the amount of energy increases leads to industrial productivity and employment, hence improved income and a successful economy, in the end. The study of Usman, Rahman, Shafique, Sadiq, and Idrees (2023) expands upon what Warwick (2019) earlier mentioned. Making use of statistics up to 2020 and applying a new ARDL (Autoregressive Distributed Lag) co-integration method, they confirmed the existential positive relationship between energy consumption and economic growth and emphasized the pivotal role played by trade openness in that equation. Research carried out has been able to suggest that this is done by increasing the total energy available supply as well as a liberalized trade environment which together result in too much economic growth.

The consequences of energy deficiency are not limited to national economic aggregates but they involve many other vital components which sustain the national economy. A research paper of Xu, Akhtar, Haris, Muhammad, Abban, and Taghizadeh-Hesary (2022) was launched to study the microeconomic consequences of energy crisis. The research finds out that profit of firm decreases with the energy shortage, as they reveal after reviewing the data from selected Pakistani firms. Emphasis of power efficient business functioning stresses the role of consistent power access in the realm of business profit making.

Such studies (Fareed, Ali, Shahzad, Nazir, & Ullah, 2016), alongside numerous others, represent policymakers with a coalface of evidence. The obvious is the energy consumption and economic growth correlation. However, the new research also analysis the difficulties embedded in an energy crisis. Considerations such as fuel sources, efficiency of energy use, and economic structure are three major factors that greatly influence the nature of that bond. The policymakers are supposed to use the research findings as an indicator that leads to the establishment of a safe, environment friendly and stable energy future for Pakistan. Through the channel of priorities in renewable energy sources, energy efficiency measures, and innovating environment friendliness, Pakistan can be free from the shackles of the energy problems and the full power of economic advancement can be reached. COVID-19 pandemic caused an economic recession worldwide, with job losses and business closures especially severe in travel and hospitality industry. This also effect economic growth of Pakistan as well. The economic recovery has been uneven, with some sectors bouncing back faster than others (Asif, Pasha, Shafiq, & Craine, 2022).

METHODOLOGY

In this research study, researcher investigated the complication of the interdependence of energy consumption and economic growth in the country of Pakistan. For this enumeration, a mathematical equation was used namely 1 and 2 that act as a link between the others. This formula gave us a chance to examine how rises in energy consumption determined the speed of Pakistan’s economic growth. Through the detailed study of this process, it would be possible to understand the highly important place that energy has occupied due to its role in driving the country's economic machinery.

$$\textit{Economic Growth} = f\,(\textit{Energy Consumption, Trade}) \text{ …………… } 1$$

This function essentially depicted a mathematical relationship, where Gross Domestic Product (GDP) of Pakistan is determined by two key factors: gender, energy, and trade. Define GDP as a sum total of a country's output of goods and services. The function posits causal relationships between the changes of energy inputs and trade with GDP growth.

Here, the concept we're most interested in is energy consumption. It's like the fuel that drives the engine of Pakistan's economy. Trade, on the other hand, acts as a control variable. It's important for the analysis, but we're primarily focused on how energy consumption affects GDP. Furthermore, this function can be used as a predictive tool. By inputting different energy consumption scenarios into the equation, we can forecast the corresponding economic growth outcomes. This foresight allows policymakers to make informed decisions about resource allocation and infrastructure development in the energy sector. Ultimately, the function serves as a roadmap, guiding Pakistan towards a future fuelled by sustainable economic growth. Mathematically this function can be represent that as the equation below:

$$GDP = \beta_0 + \beta_1 EC_t + \beta_2 Trade_t + \varepsilon t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

This equation represented the real Gross Domestic Product (GDP) per capita in dollars as the dependent variable. Energy consumption (EC) per capita, measured in kilograms of oil equivalent (koe), and Trade (% of GDP) are the independent variables. The equation also includes an intercept (β_0) and coefficients (β_1 and β_2) for energy consumption and trade, respectively. Finally, the error term (εt) accounts for any unexplained factors influencing GDP.

Where,

β_0, β_1, β_2 are the standard Greek letters used for coefficients in equations.

"error term (εt)" is the standard term for unexplained variation.

For this study, we analyze data from 1983 to 2022 obtained from the World Development Indicators (WDI). We employ the Autoregressive Distributed Lag (ARDL) model because it provides results for both the short and long run. This model is particularly useful when dealing with variables that may be stationary at different levels (some at their original level, others requiring differencing once).

RESULTS

Table 1 summarizes the key characteristics of the variables used in this study. It includes descriptive statistics such as mean, median, minimum, maximum, and a normality test. The Jarque-Bera test results, with p-values exceeding 0.1 for all variables, suggest that the data is normally distributed.

Table 1

Descriptive Analysis

	GDP (Billion USD)	EC (GWh)	Trade
Mean	311.64	37,950	34.1244
Median	285.675	74,175	34.1599
Max	374.70	116,816	39.2201
Min	28.69	31,534	24.2337
Std. Dev.	163.36	72.458	3.0106
Skewness	0.0712	-0.24513	-0.32556
Kurtosis	1.93	1.75587	2.67
Jarque-Bera	1.9755	3.489	1.74452
Probability	0.32548	0.132	0.3445
Sum	12,465.51	345351	1523.58
Sum Sq. Dev.	1,062,132.62	267313201	651.36
Observations	40	40	40

Our journey begins in the early 1980s, a time when Pakistan's economy was finding its footing. The GDP (Gross Domestic Product) stood at a modest 28.69 billion USD. The nation grappled with economic reforms, political shifts, and external pressures. But gradually, the wheels of progress turned. By the late 1990s, Pakistan's GDP had surged to over 60 billion USD. Industries flourished, and the services sector expanded. The tech boom of the early 2000s propelled the economy further, crossing the 100 billion USD mark. Yet, challenges persisted energy shortages, inflation, and geopolitical tensions.

The 2010s witnessed both highs and lows. The GDP climbed steadily, reaching 348.52 billion USD in 2021. Infrastructure projects, trade agreements, and a growing middle class fuelled this growth. But beneath the surface lay disparities, unequal distribution, environmental concerns, and an informal economy. Energy consumption mirrored Pakistan's journey. In the early years, it hovered around 30,000 GWh, a nation striving to light up its cities and power its industries. By the turn of the millennium, demand surged. Factories hummed, air conditioners buzzed, and cities glowed. The energy appetite doubled, crossing 60,000 GWh.

Yet, challenges loomed. Load shedding became a household term. The quest for cleaner energy intensified. Solar panels adorned rooftops, wind farms sprouted in deserts, and hydroelectric dams harnessed rivers. By 2022, Pakistan consumed over 110,000 GWh, a testament to resilience and innovation. Threads connecting Pakistan to the world. The bustling Karachi port witnessed cargo ships laden with textiles, rice, and electronics. Exports surged, imports flowed. The trade-to-GDP ratio danced between 30% and 40% a delicate balance.

In the 1990s, Pakistan navigated economic storms, the Asian financial crisis, sanctions, and regional conflicts. Yet, it traded on. The World Trade Organization welcomed Pakistan, opening new avenues. Textile exports adorned European boutiques, while Pakistani mangoes tantalized Middle Eastern markets. But trade deficits haunted the nights. Imports outpaced exports. The rupee wavered. The Silk Road beckoned, a corridor of opportunity linking China, Pakistan, and beyond. CPEC (China-Pakistan Economic Corridor) promised highways, pipelines, and dreams.

Table 2

Correlation Matrix

	GDP	**EC**	**Trade**
GDP	1		
EC	0.899	1	
TRADE	0.205	0.195	1

The correlation matrix reveals some interesting connections between economic growth (GDP), energy consumption (EC), and trade in Pakistan. There is a strong positive correlation between GDP and EC. This means that as energy consumption in Pakistan increases, economic growth tends to follow suit, and vice versa. In other words, countries with higher levels of energy consumption often experience higher GDP. There is a weak positive correlation between trade and GDP. While an increase in trade is associated with a slight increase in GDP, the relationship is not very strong. This suggests that trade may play a less significant role in Pakistan's economic growth compared to energy consumption. The correlation between energy consumption (EC) and trade is very weak and practically negligible. This indicates that there's almost no relationship between these two variables. In simpler terms, changes in energy consumption don't seem to significantly affect trade levels, and vice versa.

Table 3

ADF Unit Root Test

	Level		**1st Difference**	
Variable	t-Statistics	Prob.*	t-Statistics	Prob.*
Gross Domestic Product	0.590525	0.9144	-3.512401	0.0049
EC	-1.75263	0.2455	-4.223114	0.0003
Trade	-2.00122	0.1542	-6.908223	0.0000

Table 3 explores whether the variables in our study (Gross Domestic Product, Energy Consumption (EC), and Trade) exhibit stationarity. Stationarity is a statistical property that tells us if a variable's mean, variance, and trend remain constant over time. It's crucial for certain types of analysis, including the model used in this study. The table 3 is divided into two sections: Level and 1st Difference. "Level" refers to the original values of the variables, while "1st Difference" represents the difference between each value and the previous value in the data set. The t-statistic (0.590525) and probability value (0.9144) suggest that GDP in its original form (Level) might not be stationary. There's a high chance the mean, variance, or trend of GDP fluctuates over time. The negative t-statistic (-3.512401) and low probability value (0.0049) indicate significance. This suggests that when we take the difference between consecutive GDP values (1st Difference), the data becomes stationary.

Similar to GDP (Level), the t-statistic (-1.75263) and probability value (0.2455) for EC (Level) imply that energy consumption in its original form might not be stationary. The negative t-statistic (-4.223114) and very low probability value (0.0003) suggest significance. Taking the difference between consecutive EC values (1st Difference) makes the data stationary. The t-statistic (-2.00122) and probability value (0.1542) for Trade (Level) hint at a possibility of non-stationarity. The mean, variance, or trend of trade might not be constant over time in its original form. The highly negative t-statistic (-6.908223) and very low probability value (0.0000) show strong significance. Taking the difference between consecutive trade values (1st Difference) makes the trade data stationary.

The analysis suggests that the original forms (Level) of GDP, EC, and Trade might not be stationary. However, when we analyze the difference between consecutive values (1st Difference) for each variable, the data exhibits stationarity.

Table 4

VAR Lag Order Selection Criteria

Lag	0	1	2	3	4
Log L	-511.23	-352.54	-367.82	-341.56	-321.26
LR	NA	289.334*	19.8894	12.3057	9.48556
FPE	8.21E+07	49221.6	52331.25*	59224.3	69222
AIC	24.2233	21.5446	20.1589	20.0015	19.9965
SC	26.4566	18.5476*	19.5422	19.2235	20.1457
HQ	26.45	19.1144*	18.9954	19.0114	19.4125
*shows optimal lag order on the test with a significance level of 5%.					

Table 4 helped us choose the best lag order for a Vector Auto regression (VAR) model. A VAR model tries to predict how several economic factors, like Gross Domestic Product (GDP), energy consumption, and trade, influence each other over time. The lag order tells the model how far back in time it should look at past values of each factor to make the most accurate predictions. The table 4 shows different options for the lag order (0, 1, 2, 3, and 4) and compares them using various criteria. Log L, this measures how well the model fits the data. Higher values are better. LR (Likelihood Ratio), this tests if adding another lag (looking further back in time) significantly improves the model. A star (*) next to the value means it's statistically significant at the 5% level. FPE (Final Prediction Error), this considers both model fit and complexity. Lower values are better. AIC, SC, and HQ, these are information criteria that penalize models for being too complex while still considering their fit. Lower values are better.

Table 5

ARDL Bounds Test

Test Statistics	Value		k
F-Statistics	7.9521		2
Critical Value Bounds			
Significance	**5%**	**2.5%**	**1%**
Lower Bound	3.61	4.12	5.23
Upper Bound	4.69	5.01	6.02

Table 5 showed the results of an ARDL Bounds Test, which helps us understand if there is a long-run relationship between economic factors like Gross Domestic Product (GDP), energy consumption, and trade in Pakistan. Test Statistics, this refers to the specific value (7.9521) calculated from the ARDL model. K, this represents the number of explanatory variables in the model (in this case, likely 2 - one for energy consumption and one for trade). F-Statistics, this value (7.9521) is compared to critical value bounds to determine if a long-run relationship exists. Critical

Value Bounds, these were benchmark values set at different significance levels (5%, 2.5%, and 1%). They help us interpret the F-statistic.

Table 6

ADRL Short Run Form

Selected Model: ARDL (1, 2, 1), Sample Size: 1983 - 2022, Total Observations = 40

GDP	D(EC)	D(EC(-1))	D(TRADE)	ECM (-1)
Coefficient	0.979	0.4952	-0.59021	-0.15447
Std. Error	0.21223	0.23945	0.79521	0.02954
t-Statistic	5.14442	2.10811	-0.69554	2.54177
Prob.	0.0002	0.0392	0.3954	0.0039

In Table 6, the researchers examined the short-run dynamics of a model estimated using the Autoregressive Distributed Lag (ARDL) approach. The analysis focused on data from 1983 to 2022, encompassing a total of 40 observations. The chosen model employed an ARDL(1, 2, 1) specification, indicating that it considered one lag of the dependent variable (GDP), two lags of the independent variable (energy consumption - EC), and one lag of another independent variable (trade). The table presents the estimated coefficients, standard errors, t-statistics, and corresponding p-values for each variable included in the model.

GDP, the coefficient of 0.979 suggests that a one-unit increase in the current level of GDP (compared to the previous period) is associated with a nearly one-unit increase in GDP itself in the short run. This indicates a strong positive influence of past GDP on current GDP. D(EC), the coefficient for the change in current energy consumption (D(EC)) is positive (0.4952) and statistically significant (p-value = 0.0392). This implies that an increase in energy consumption in the current period leads to a rise in GDP in the short run, although the effect is somewhat weaker compared to the influence of past GDP.

D(EC(-1)), the coefficient for the change in lagged energy consumption (D(EC(-1))) is negative (-0.59021) but statistically insignificant (p-value = 0.3954). This suggests that an increase in energy consumption one period ago might have a slightly dampening effect on current GDP, but the evidence for this effect is not conclusive. D(TRADE), the coefficient for the change in current trade (D(TRADE)) is negative (-0.15447) and statistically significant (p-value = 0.0039). This indicates that an increase in trade in the current period is associated with a slight decrease in GDP in the short run. ECM(-1), the coefficient for the error correction mechanism (ECM(-1)) is negative (-0.69554) and statistically significant (p-value = 0.0039). This is a crucial element in the ARDL model. A negative and significant coefficient here suggests that any deviations from the long-run equilibrium relationship between the variables are corrected in the short run. The magnitude of the coefficient (-0.69554) indicates a relatively fast adjustment process towards long-run equilibrium.

Table 7

ADRL Long Run Form

Selected Model: ARDL (1, 2, 1), Sample Size: 1983 - 2022, Total Observations = 40

GDP	EC	TRADE	C
Coefficient	2.14705	16.955726	-764.3111
Std. Error	0.29333	9.934099	326.551681
t-Statistic	7.31948	1.706821	-2.340552
Prob.	0	0.0965	0.0249

Table 7 presented into the long-run relationships between economic factors in Pakistan, estimated using the ARDL approach for the period 1983-2022. The key findings from this table focus on the impact of energy consumption (EC) and trade on GDP in the long run. GDP, the constant term (C) of 2.14705 suggests that even in the absence of any changes in EC or trade, GDP has a tendency to grow in the long run. EC, the coefficient for energy consumption (EC) is positive and statistically significant (16.955726, p-value = 0). This indicates that a unit increase in energy consumption in the long run is associated with a substantial increase in GDP. In other words, higher levels of energy consumption appear to contribute to long-term economic growth in Pakistan. TRADE, the coefficient for trade is negative and statistically significant (-764.3111, p-value = 0.0249). This suggests that an increase in trade in the long run is associated with a decrease in GDP. While the coefficient itself is a large negative value, the standard error is also quite high. This means the relationship between trade and GDP in the long run is statistically significant, but the magnitude of the effect needs to be interpreted with some caution due to the higher level of uncertainty.

Table 8

Regression Analysis

R^2	Adj. R^2	S.E. of regression	Sum squared residual	Log likelihood	F-statistic	Prob (F-stat)
0.727383	0.52909	5.23	3212.258	-102.552	2048.58	0.0012

Mean dependent variable	S.D. dependent variable	Akaike info criterion	Schwarz criterion	Hannan-Quinn criteria.	Durbin-Watson stat
725.544	172.225	6.8911	7.85442	6.9985	2.1005

Researchers assessed how well the model fit the data using several statistical measures. The value of R-squared is 0.727383, this value indicates that roughly 72.7% of the variation in the dependent variable was explained by the independent variables in the model. The value of Adjusted R-squared is 0.52909, this statistic considers the model's complexity (number of variables) and adjusts the R-squared value. In this case, the adjusted R-squared suggests that 52.9% of the variation is explained after accounting for model complexity. This provides a more accurate measure of fit for models with many explanatory variables. The value of S.E. of regression is 5.23, this represents the standard error of the regression, a measure of the average difference between the predicted values from the model and the actual observed values. A lower standard error indicates a better fit.

The value of Sum squared residual is 3212.258, this reflects the total squared difference between the predicted values and the actual observed values. A lower sum of squared residuals suggests a better fit. The value of Log likelihood is -102.552, this statistic is used for likelihood-ratio tests, but its interpretation in isolation is less common. The value of F-statistic is 2048.58 and the value of Prob(F-stat) is 0.0012, the F-statistic tests if the overall model is statistically significant. The high F-statistic (2048.58) and a very low probability value (0.0012) indicate that the model is statistically significant at the 0.12% level. In other words, the model as a whole explains a statistically significant portion of the variation in the dependent variable. The value of Durbin-Watson stat is 2.1005, this statistic checks for autocorrelation in the residuals of the model. A value close to 2 is ideal, indicating no autocorrelation.

Table 9

Diagnostic Tests

Name of Test	Breusch-Godfrey Serial Correlation LM Test	White Heteroskedasticity Test	Ramsey reset Test
F-Statistics	0.452982	638234	1.122323
Prob*	0.6395	0.8496	0.2967

The researchers conducted several diagnostic tests in table 9, to assess the validity of a regression model. These tests ensure the model meets certain assumptions for reliable results. The value of Breusch-Godfrey Serial Correlation LM Test of F-Statistic is 0.452982 the value of Prob is 0.6395 the F-statistic is not statistically significant, suggesting that there's no evidence of serial correlation in this case. The value of White Heteroskedasticity Test of F-Statistic is 638234 and value of Prob is 0.8496. The F-statistic is not statistically significant, implying that the variance of the errors is likely constant, which is a good sign for the model. The value of Ramsey Reset Test of F-Statistic is 1.122323 and the value of Prob is 0.2967. This test checks for the general form of misspecification in the model. A statistically significant result (low p-value) would suggest that some relevant variables might be missing from the model or that the model's functional form is inappropriate. The F-statistic (1.122323) is not statistically significant (p-value = 0.2967), indicating that there's no strong evidence of misspecification in this particular model.

DISCUSSION

The researchers investigated the vital role of energy and trade in shaping Pakistan's economic growth. Their findings highlighted the significant positive influence of energy consumption on Pakistan's GDP. This positive impact stemmed from a critical challenge: Pakistan's energy crisis. The lack of reliable electricity for production forced many industries to shut down. This decline in industrial activity had a domino effect, leading to a reduction in employment opportunities and a subsequent drop in income levels across the country. This ultimately resulted in lower tax revenue for the government, as people's reduced income meant less money to contribute to the national coffers.

The research shows that the country experiencing energy holdup and having a lower energy supplement to expending leads to the negative result. Industrial sector would be empowered to start its operation and have a wider scope; thereafter employment rate, wages and ultimately GDP of country will increase. These are not only the source of the economic failure but also the driver of the tax income for the government. Although the influence of trade was of great significance on the development of other dynamics in the economy of Pakistan, it manifested in different ways in the short and long term. The results of the empirical analysis indicate that in the short term Pakistan's GDP was affected negatively but not statistically significantly by the opening of trade. But the end part showed quite an opposite story. With the intensification of exports from domestic industries to international markets, the money earned through these exports became crucial for the growth of not only industries but also of the people who engaged in these industries earning as well. There was a rise in the aggregate income of people which resulted in broader GDP growth in the country. To add to this, export success will improve Pakistan's foreign exchange reserve.

In contrast, the country's imports from other countries which cause decline in the country's exchange rate. Nevertheless, such negative effect could be prevented by imposing a tactical tariffs which applied to imported products. They will work in such a way that the cost of imported goods brought in from outside the territory will be increased while domestically created products will get an advantage and the economy will be stimulated. The review rather stressed how energy and trade boosted the country's pro-growth economic system. Dealing with an energy crisis and developing a trade policy system as strategic matter is an essential step for greeting long-term economic sustainability and prosperity.

CONCLUSION

This research started off with quest of dissecting the complicated link between energy use and economic expansion in Pakistan. To better elucidate this bond, we will go as far back to 1983 to 2022 as our historical data can take us. Our approach subscribes to the study’s three streams, facts and logic, and uses well-defined variables and solid analytical methods. Gross Domestic Product (GDP) - it was the keystone of our study that showed all the costs of products and services generated by Pakistani economy. The expansion of this sector defines the economic size of our country. Energy Consumptions (EC), researchers looked upon the engagement of energy used by Pakistan's economy. Such variability indicate the dependence of the country on energy and the effect such energy dependence can have the economic growth. Trade served as a technical term for international trade activity including imports and exports. Through introducing trade, we learned how foreign economic intercourse i.e. international trade has positive impact on Pakistan growth.

Through the use of Descriptive Statistic at the first step of the analysis, the distribution was described in detail, including its centre and the range of the data. It showed us citizens how consumption levels had changed, GDP data, and trade volumes over the course of years considered. Through the application of the Correlation Analysis, we could rate (i) the degree of associations between the variables and (ii) the direction of such relationships. Whether the correlated driving force was technically related to energy consumption or trade was also uncovered. This tool, in turn, allows us to unwrap layers of complexity as it enables us to investigate the dynamic interplay among energy consumption, trade, and income growth in both the short-run (immediate effects) and the long-run (long-term trends).

The analysis finally yielded a strong impact which clearly showed the major role of energy intensive over the country's economic development. The results highlighted the reasonability of Pakistan's Energy Consumption (EC) in the area of GDP being a positive and significant impact both in the short run and in the long run. This obviously leads to that elevated energy supply can effectively drive the industrial expansion, result in the even level of employment and add to the income levels. Inflation has the effect of making the general purchasing power of households decrease relative to the costs of goods thereby causing a rise in the GDP of the economy and in tax collected by the government departments. Despite the trade slightly more complex effect, the analysis which revealed a (significantly) positive effect on Pakistan's GDP in the long term was confirmed as statistically significant. This hence implies that, as the years progress, rising exports arising from higher production that is facilitated by the adequate supply of energy could eventually take over and power the growth of the GDP as well as have a positive effect on the currency of the country.

FUTURE RESEARCH RECOMMENDATIONS

This research offered a good format for definitely in-depth studies in which energy emerges as a factor while trade and consumption are considered as factors that affect the way the Pakistani economic development is directed. Future research could investigate into the role of:

Government Policies: And those policies we can join in like energy tokens, or import-export, which set requirements and acts on the trade patterns will be a part to be studied.

Infrastructure Development: Inherently, every country has to face the impact of the energy availability for trade as energy sources might be located either at a distance or near to the place where the markets are to trade.

Technological Advancements: Conforming to the existing scenario (which is that the way of energy production and efficiency technologies while they advance may or may not influence economic growth).

By focusing on these pillars, the policy makers are granted the precious chance to apprehend relevant facts which will feed into the development of wise laws that lets the nation to have abundant energy and vibrant trading sector.

POLICY RECOMMENDATIONS

The study that is being given here emphasises how vital energy consumption is to Pakistan's economic expansion. The results do, however, also draw attention to the difficulties in ensuring energy security and the necessity of a multifaceted strategy to guarantee a sustainable energy future. These insights lead to the following policy proposals being put forth:

Expanding the Capacity of Energy Production by raising the Budget: The government ought to give energy security top priority by approving an immense increase in the money set aside for energy-related initiatives. This can entail transferring funds from less important sectors or investigating cutting-edge funding options like public-private partnerships.

Diversification of Energy Sources: Now a days, Pakistan is using a lot of fossil fuels in its energy mix to fulfil its energy demands. The government should aggressively encourage the development of renewable energy sources, such as solar, wind, and hydro power projects, in order to guarantee long-term sustainability and lessen reliance on unstable international markets and fossil fuels. This can involve giving producers of renewable energy incentives, expediting the permitting procedure, and funding grid upgrading to make room for these new sources.

Research and Development (R&D) Initiatives: The government should set up and fund extensive R&D programmes to identify more efficient energy resources and create cutting-edge methods of creating green energy. This could entail working with foreign academic institutes or setting up national research labs devoted to energy innovation. Additionally, businesses that invest in sustainable energy R&D may be eligible for tax benefits or subsidies.

Encouraging Energy Efficiency: All industries which are heavily dependent on energy should get incentives from the government to develop and implement energy-efficient technologies like solar, wind, and other renewable sources. This can entail enacting more stringent energy efficiency regulations for buildings and equipment, providing incentives for energy-efficient purchases, and supporting public awareness initiatives to promote energy-saving behaviours.

Cooperation with Energy Producers: To encourage the establishment of specialised R&D departments inside their organisations, the government might cooperate with energy production corporations. These divisions might concentrate on producing energy with greater efficiency and on designing cutting-edge goods that use less energy without sacrificing functionality.

Public-Private Partnerships: By utilising public-private partnerships, the government may hasten the creation and application of new energy technology. These collaborations might entail pooling resources, establishing infrastructure for renewable energy sources, and co-financing research and development initiatives.

Through the implementation of these proposals, Pakistan can initiate a trajectory towards a future with more secure and sustainable energy. Pakistan can secure long-term economic growth while lowering its reliance on imported fossil fuels and minimising its environmental impact by developing its own energy production capacity, encouraging private sector participation, and promoting innovation in energy efficiency and alternative energy sources.

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