INTERNATIONAL JOURNAL OF
SOCIAL SCIENCES BULLETIN
ISSN: (E) 3007-1917 (P) 3007-1909

Volume 4, Issue 3, 2026

ENERGY CONSTRAINTS AND MACROECONOMIC FRAGILITY IN EMERGING ECONOMIES: EVIDENCE FROM PAKISTAN

Muhammad Ghulam Shabeer[1], Usman Ghani[2], Hafiz Muhammad Qasim[*3]

[1,*3]*Assistant Professor, Department of Economics, Akhuwat Institute, Kasur, Pakistan.*
[2]*Department of Economics, Akhuwat Institute, Kasur, Pakistan*

[1]imgshabeer@gmail.com, [*3]hmq.economist@gmail.com

Corresponding Author: *
Muhammad Qasim

DOI: https://doi.org/10.5281/zenodo.22090886

Received	Accepted	Published
01 January 2026	17 March 2026	31 March 2026

ABSTRACT

Pakistan continues to face persistent macroeconomic fragility driven by structural bottlenecks, among which energy constraints remain a critical factor. This study examines the role of energy shortages in shaping inflation dynamics and economic growth in Pakistan. Using annual time series data from 1990 to 2023, the analysis employs the Autoregressive Distributed Lag (ARDL) approach to investigate both short-run and long-run relationships among the variables. The empirical results indicate that energy constraints significantly contribute to rising inflation while exerting a negative and persistent effect on real GDP growth in the long run. The findings suggest that energy shortages transmit macroeconomic instability through higher production costs, supply disruptions, and reduced industrial output, thereby intensifying overall economic fragility. The study concludes that strengthening energy infrastructure, improving supply efficiency, and diversifying the energy mix are essential policy measures to reduce macroeconomic vulnerability and support sustainable growth in Pakistan.

Keywords: *Energy crisis, Inflation, Real GDP, ARDL approach, Pakistan*

INTRODUCTION

In the modern era, the stability and growth of any country's economy heavily depend on sectors that operate on energy. According to a recent report by the United States Energy Information Administration, fluctuations in fuel prices can significantly affect macroeconomic indicators such as inflation and GDP growth. Countries that heavily rely on energy imports are especially vulnerable to economic instability caused by energy price volatility.

Compared to an energy shortfall of 4,000 megawatts in 2004, Pakistan's energy deficit exceeded 6,000 MW in 2011. According to the National Electric Power Regulatory Authority, Pakistan again experienced an energy deficit of approximately 6,000 MW in October 2023. In urban areas, daily power outages ranged from eight to ten hours.

In rural areas, however, load shedding has historically lasted for more than 20 hours per day. Previous studies have shown that Pakistan's energy consumption is directly linked to industrial activities, economic growth, and living standards. Unresolved energy shortages continue to hinder economic expansion.

Pakistan has been facing a persistent energy crisis characterised by continuous power outages, fuel shortages, and rising energy costs. As a result, the crisis negatively affects key indicators of economic stability, including inflation, real GDP, and overall productivity. Furthermore, the energy crisis disrupts daily life, lowers living standards, and increases economic hardship for the population.

This study aims to investigate the impact of the energy crisis on Pakistan's macroeconomic variables. Several macroeconomic indicators play an important role in determining the stability of an economy. However, this research focuses on three fundamental variables: energy crisis, inflation, and real GDP.

By examining these variables, the study seeks to provide insights that may help policymakers design effective strategies to reduce the adverse effects of the energy crisis and improve economic growth and welfare. The findings of this research may contribute to economic planning, policy formulation, and the resolution of Pakistan's energy crisis.

The persistent energy crisis significantly increases inflation (Model 1) and reduces the real GDP growth rate (Model 2) in Pakistan, thereby creating substantial barriers to sustainable economic development.

Most previous studies on Pakistan's energy crisis cover the period from 1991 to 2015. This study extends the analysis by incorporating recent developments in Pakistan's energy sector. In addition, the research includes two important macroeconomic variables, inflation and real GDP, which are critical indicators of economic stability. Furthermore, this study addresses an important gap in the literature by providing an advanced econometric analysis of the impact of the energy crisis on Pakistan's macroeconomic indicators. The findings are expected to assist policymakers, industry leaders, and researchers in developing strategies to reduce the adverse effects of energy shortages and promote sustainable economic growth and stability in Pakistan.

LITERATURE REVIEW

Following the oil crisis of the 1970s, energy economics emerged as an important branch of economics. During the 1970s and 1980s, researchers mainly focused on two areas: the relationship between energy consumption and economic growth, and the impact of energy prices on economic performance.

Kraft and Kraft (1978), along with James D. Hamilton (1983), conducted pioneering studies on the energy crisis. Kraft and Kraft (1978) applied Sims' (1972) methodology to examine the causal relationship between energy consumption and economic growth in the United States during the period 1947 to 1974. Their findings suggested a causal relationship between gross national product and energy consumption.

Hamilton (1983) made a major contribution to the field of energy economics by empirically demonstrating that rising fossil fuel prices reduce output and increase unemployment. He argued that fuel price shocks can push an economy into recession. Furthermore, Hamilton highlighted the role of monetary policy and inflationary expectations in shaping the economic effects of oil shocks. According to his analysis, long-run price levels are largely controlled by monetary authorities, raising important policy questions regarding the appropriate response to oil price shocks.

Harrison and Burbidge (1984) identified oil price fluctuations as a major contributor to economic recessions. Using a seven-variable vector autoregressive (VAR) model with monthly data from 1961 to 1982, they analyzed five OECD countries to observe the effects of oil price shocks on macroeconomic stability. Their findings indicated that oil shocks significantly affected price levels in the United States and Canada. In contrast, oil-intensive industries across OECD countries suffered severe impacts, especially in the United States and the United Kingdom.

Kilian (2008) explored the economic effects of energy shocks and examined econometric models suitable for energy crisis analysis. His work identified several influencing factors, including production inputs, consumer demand, investor behavior, and monetary factors.

Wen and Aguiar-Conraria (2007) argued that traditional econometric techniques failed to identify the root causes of recessions in the United States because they ignored interactions among multiple variables. Their findings emphasized the crucial role of oil shocks in causing economic recessions.

Standard exchange rate theory suggests that increases in oil prices lead to currency depreciation in oil-importing countries. Basnet and Upadhyaya (2015) found that higher oil prices led to appreciation in the currencies of oil-exporting countries. Similarly, Chaudhuri and Daniel (1998) identified rising oil prices as a major cause of the United States' recession.

Faisal et al. (2015) suggested that increasing petroleum prices were a major factor behind the depreciation of Pakistan's currency and the acceleration of inflation. Similarly, Huang and Guo (2007), using a structural vector autoregressive model, found that rising oil prices led to a slight appreciation in China's real exchange rate, despite China being an oil-importing country.

Manera and Cologni (2008) investigated the impact of fuel prices on inflation and interest rates in G7 countries using quarterly data from 1980 to 2003 within a cointegrated VAR framework. Their results showed that rising energy prices significantly raise overall prices, prompting monetary authorities to raise interest rates to control inflation, which may also hinder economic development.

Alam et al. (2013) analyzed the effects of global fuel and food prices on Asia Pacific economies using structural vector autoregressive models with quarterly data from 1980 to 2010. Their findings revealed that resource-scarce industrial economies such as Taiwan and South Korea were highly vulnerable to oil price shocks. In contrast, economies with diversified natural resources or strong financial sectors, such as Australia, New Zealand, Hong Kong, and Singapore, were less affected.

Despite the growing international literature, limited research exists regarding the effects of the energy crisis on Pakistan's macroeconomic performance.

The energy crisis in Pakistan has remained a serious concern for policymakers because of its impact on macroeconomic stability. According to Siddiqui et al. (2011), persistent energy shortages reduce industrial output and negatively affect GDP growth. Their study emphasized that energy is an essential input for production, and any disruption in supply generates widespread economic consequences.

Similarly, Khan and Ahmed (2014) highlighted the impact of rising energy prices on inflation, arguing that higher energy costs raise production costs and push inflation upward, thereby slowing economic growth. Ali and Rehman (2015) also argued that disruptions in energy supply create market uncertainty, reduce investor confidence, and weaken economic stability. Several scholars, including Ayyubi et al. (2024), Anwar et al. (2024), Zubair et al. (2024), Ahsan et al. (2024), and Iqbal et al. (2025), have contributed to the literature on energy, inflation, and economic growth.

Furthermore, Sadiq (2016) examined the long-term effects of energy shortages on unemployment and exchange rates and concluded that prolonged energy crises contribute to a cycle of economic instability. Collectively, these studies demonstrate the critical importance of energy in sustaining macroeconomic stability and achieving sustainable economic growth in Pakistan.

METHODOLOGY

Data Sources

This section describes, analyses, and sources the data used in the study. The research examines the impact of the energy crisis on Pakistan's macroeconomic indicators. The energy crisis is measured as the difference between energy demand and energy supply.

The study is based on annual time series data covering the period from 1990 to 2023. Data were collected from various editions of the Pakistan Economic Survey, the International Monetary Fund, and the World Bank. Table 1 shows the description of the variables.

Table 1: Description of the Variables

Variables	Variable Representation	Unit of Measurement	Sources
Energy Crisis	EC	Metric tons of oil equivalent per capita	WDI
Inflation	INF	Percentage	IMF
Real Government Expenditure	RGE	Constant LCU (Million)	WDI
Real Interest Rate	RIR	Percentage	WDI
Total Trade	TTG	Trade (% of GDP)	WDI
Money Supply	M2	Percentage of GDP	WDI
Population	POP	Million	WDI
Real GDP	RGDP	constant	WDI
Foreign Direct Investment	FDI	Constant LCU	WDI

ARDL Approach

The Autoregressive Distributed Lag (ARDL) approach to cointegration was developed by Pesaran et al. (2001). The ARDL model is based on the Autoregressive (AR) and Distributed Lag (DL) frameworks.

In the ARDL model, a time series variable is explained by its current value, past values, and the lagged values of one or more explanatory variables. One major advantage of the ARDL approach is that it distinguishes between dependent and explanatory variables, thereby reducing the problem of endogeneity. In addition, the ARDL framework allows the simultaneous estimation of both long-run and short run relationships through the Error Correction Model (ECM).

The ARDL approach also helps address issues such as autocorrelation and omitted variable bias. According to Pesaran et al. (2001), the ARDL estimators are unbiased, efficient, and consistent in the presence of serial correlation and endogeneity.

Econometric research has used different techniques to analyze the relationship between the energy crisis and macroeconomic variables. Some studies have applied forecasting methods to predict relationships among variables, while others have used various cointegration techniques to estimate long-run relationships. However, these traditional approaches are associated with certain limitations. For instance, the cointegration methods developed by Søren Johansen and Katarina Juselius (1989), as well as the Engle Granger approach proposed by Robert F. Engle and Clive W. J. Granger (1987), are less suitable for small sample sizes and low degrees of freedom. Therefore, this study employs the Bounds Testing approach to cointegration within the ARDL framework developed by Pesaran et al. (2001).

The ARDL approach has several important features

The ARDL model is a dynamic single equation estimation technique.

It estimates both short-run and long-run relationships simultaneously through the Error Correction Model (ECM).

The estimated coefficients are unbiased, consistent, and efficient.

The ARDL approach performs well in small sample studies.

It addresses the problems of serial correlation and endogeneity.

The ARDL model provides more reliable results than the Johansen Juselius cointegration technique when variables are integrated of mixed orders, such as I(0) and I(1).

ARDL Model Specification

Suppose the econometric model contains the variables X_t with m lags and Y_t with n lags. The Error Correction representation of the ARDL model can be expressed in the following general form:

$$\Delta Y_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i \, \Delta Y_{t-i} + \sum_{j=0}^{n} \beta_j \, \Delta X_{t-j} + \lambda_1 Y_{t-1} + \lambda_2 X_{t-1} + \varepsilon_t \qquad \text{(Eq 1)}$$

UECM Model Specification

The unrestricted error correction model (UECM) based on the research hypothesis is specified as follows:

$$\Delta INF_t = \alpha + \beta_1 INF_{t-1} + \beta_2 EC_{t-1} + \beta_3 M2_{t-1} + \beta_4 RIR_{t-1} + \beta_5 RGE_{t-1} + \beta_6 TTG_{t-1} + \sum_{i=0}^{m} \delta_1 \Delta INF_{t-i} + \sum_{i=0}^{n} \delta_2 \Delta EC_{t-i} + \sum_{i=0}^{o} \delta_3 \Delta M2_{t-i} + \sum_{i=0}^{p} \delta_4 \Delta RIR_{t-i} + \sum_{i=0}^{q} \delta_5 \Delta RGE_{t-i} + \sum_{i=0}^{r} \delta_6 \Delta TGT_{t-i} + \nu_t \quad \text{(Eq 2)}$$

Where:

- Δ represents the difference operator.
- t denotes time series observations.
- β_i represents the long-run coefficients.
- δ_i denotes the short-run coefficients of the model.
- ν_t is the white noise error term.

Bounds Test

Before estimating the long-run coefficients and the Error Correction Model (ECM), it is necessary to confirm the existence of a long-run relationship among the variables. The Wald test or F statistic is estimated using Ordinary Least Squares (OLS) to assess the joint significance of the lagged-level variables.

The null and alternative hypotheses are given as follows:

Null Hypothesis:

$$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0 \quad \text{(Eq 3)}$$

No cointegration exists among the variables.

Alternative Hypothesis:

$$H_1: \beta_i \neq 0 \quad \text{(Eq 4)}$$

Cointegration exists among the variables.

In the Bounds Test, the null hypothesis implies that all long-run coefficients are jointly equal to zero, indicating the absence of cointegration among the variables. Conversely, the alternative hypothesis suggests that if at least one coefficient differs from zero, a long-run relationship exists.

After calculating the F statistic, the result is compared with the critical lower and upper bound values proposed by Pesaran et al. (2001).

- If the F statistic exceeds the upper bound critical value, the null hypothesis is rejected, confirming cointegration.
- If the F statistic falls below the lower bound critical value, the null hypothesis cannot be rejected, indicating no cointegration.
- If the F statistic lies between the lower and upper bounds, the result remains inconclusive.

Once cointegration is confirmed, the long-run and short-run coefficients are estimated through the ARDL framework.

Functional Form for Energy Crisis and Inflation (Model 1)

The impact of energy crises and inflation is studied in Model 1.

Long-run ARDL Equation

$$\Delta INF_t = \sum_{i=0}^{m} \delta_1 \Delta INF_{t-i} + \sum_{i=0}^{n} \delta_2 \Delta EC_{t-i} + \sum_{i=0}^{o} \delta_3 \Delta M2_{t-i} + \sum_{i=0}^{p} \delta_4 \Delta RIR_{t-i} + \sum_{i=0}^{q} \delta_5 \Delta RGE_{t-i} + \sum_{i=0}^{r} \delta_6 \Delta TTG_{t-i} + \Omega ECM_{t-1} + \nu_t \quad \text{(Eq 5)}$$

The parameters of the short run model incorporating the Error Correction Term (ECT) are estimated using the following equation.

Short Run ARDL Equation

$$\Delta INF_t = \sum_{i=0}^{m} \delta_1 \Delta INF_{t-i} + \sum_{i=0}^{n} \delta_2 \Delta EC_{t-i} + \sum_{i=0}^{o} \delta_3 \Delta M2_{t-i} + \sum_{i=0}^{p} \delta_4 \Delta RIR_{t-i} + \sum_{i=0}^{q} \delta_5 \Delta RGE_{t-i} + \sum_{i=0}^{r} \delta_6 \Delta TTG_{t-i} + \Omega ECM_{t-1} + \nu_t \quad \text{(Eq 6)}$$

The short-run coefficients are represented by δ_i. The Error Correction Term (ECM) captures the speed of adjustment from short-run disequilibrium toward long-run equilibrium. A negative and statistically significant ECM coefficient confirms convergence toward equilibrium.

Functional Form for Energy Crisis and Economic Growth (Model 2)

The impact of energy crises and economic growth is studied in Model 2.

Long-run ARDL Equation

$\Delta RGDP_t = \sum_{i=0}^{m} \delta_1 \, \Delta RGDP_{t-i} + \sum_{i=0}^{n} \delta_2 \, \Delta EC_{t-i} + \sum_{i=0}^{o} \delta_3 \, \Delta RGE_{t-i} + \sum_{i=0}^{p} \delta_4 \, \Delta TTG_{t-i} + \sum_{i=0}^{q} \delta_5 \, \Delta FDI_{t-i} + \sum_{i=0}^{r} \delta_6 \, \Delta POP_{t-i} + \Omega ECM_{t-1} + \nu_t$ (Eq 7)

The equation incorporates lagged values of RGDP and explanatory variables to account for delayed economic effects. The Error Correction Mechanism (ECM) measures how quickly the short-run disequilibrium adjusts toward the long-run equilibrium. A negative and significant ECM coefficient confirms the stability of the long-run relationship.

Short Run ARDL Equation

The short-run ARDL equation explains the immediate impact of changes in real GDP (RGDP), energy crisis (EC), government expenditure (RGE), trade openness (TO), foreign direct investment (FDI), and population growth (POP) on current GDP. It also incorporates lagged effects and the Error Correction Mechanism to capture short-term adjustments toward equilibrium.

$\Delta RGDP_t = \sum_{i=0}^{m} \delta_1 \, \Delta RGDP_{t-i} + \sum_{i=0}^{n} \delta_2 \, \Delta EC_{t-i} + \sum_{i=0}^{o} \delta_3 \, \Delta RGE_{t-i} + \sum_{i=0}^{p} \delta_4 \, \Delta TTG_{t-i} + \sum_{i=0}^{q} \delta_5 \, \Delta FDI_{t-i} + \sum_{i=0}^{r} \delta_6 \, \Delta POP_{t-i} + \Omega ECM_{t-1} + \nu_t$ (Eq 8)

RESULTS AND DISCUSSION

Descriptive Statistics

This section provides a statistical overview of the variables used in the analysis. These measures help in understanding the overall behaviour and distribution of the data. Table 2 shows descriptive statistics.

Table 2: Descriptive Statistics

Statistic	INF	M2	TTG	RGE	EC	RGDP
Mean	40.26847	41.65011	31.97974	4.091046	379.3263	1.45E+13
Median	27.22535	42.53000	32.86458	3.945844	396.6077	1.35E+13
Maximum	141.6985	48.71594	38.49932	18.53185	461.6011	2.95E+13
Minimum	5.006852	28.68950	21.45997	-9.190904	293.1570	4.37E+12
Std. Dev.	37.31521	5.016494	4.107097	5.986486	53.07792	7.59E+12
Skewness	1.306780	-0.731964	-0.833492	0.024605	-0.321628	0.402307
Kurtosis	3.765863	2.916822	3.243146	3.397617	1.677764	1.967179
Jarque Bera	12.67112	3.672918	4.848175	0.274224	3.693564	2.928290
Probability	0.001772	0.159381	0.088559	0.871873	0.157744	0.231276
Observations	41	41	41	41	41	41

Correlation Matrix

Correlation analysis measures the direction and strength of the linear relationship between variables. Table 3 shows Correlation Matrix.

Table 3: Correlation Matrix

Variables	INF	M2	TTG	RGE	EC	RIR
INF	1					
M2	0.389	1				
TTG	-0.177	0.636	1			
RGE	-0.290	-0.216	-0.058	1		
EC	0.770	0.341	-0.092	0.227	1	

RIR	0.945	0.371	-0.170	0.246	0.928	1

Unit Root Test

To obtain reliable and efficient estimates in time series analysis, the variables must be stationary. The Augmented Dickey Fuller (ADF) test is used to examine stationery. The null hypothesis of the ADF test states that the variable is non-stationary, whereas the alternative hypothesis states that the variable is stationary.Table 4 shows unit root test.

Table 4: Augmented Dickey Fuller Test (ADF)

Variables	Level (Intercept)	Level (Intercept & Trend)	First Difference	Order of Integration
INF	-0.743 (0.825)	1.243 (0.999)	-7.305 (0.023)	I(1)
RGDP	0.548 (0.985)	-3.341 (0.079)	-8.700 (0.0000)	I(1)
EC	-1.397 (0.574)	-0.657 (0.969)	-5.220 (0.0001)	I(1)
M2	-2.500 (0.121)	-3.366 (0.0681)	-5.916 (0.0000)	I(1)
RGE	-5.337 (0.0000)	-5.867 (0.0001)	—	I(0)
TTG	-1.083 (0.710)	-4.522 (0.0066)	—	I(0)
RIR	0.673 (0.9903)	-1.504 (0.814)	-5.378 (0.0000)	I(1)
POP	4.421 (1.0000)	-0.590 (0.969)	-6.780 (0.0023)	I(1)
FDI	-2.950 (0.051)	-2.957 (0.159)	—	I(0)

Values in parentheses represent probability values. The null hypothesis of the ADF test states that the series contains a unit root. Variables significant at the level are considered I(0), while variables significant after first differencing are considered I(1).

Model 1: Diagnostic Test

Model 1 represents the impact of energy crises of inflation. In the field of Econometrics, diagnostic tests are a list of statistical tests, which are employed to check whether the model satisfies all assumptions or not. These tests ensure the reliability, validity, efficiency, and consistency of the variables of the regression model. Table 5 shows the results of diagnostic tests.

Table 5: Results of the Diagnostic Test

Tests applied	Null hypotheses	F-statistic	Prob.	Decision
JARQUE-BERA Normality test	Normal distribution	0.153	0.926	Not Rejected
Breusch-Godfrey LM Test	No serial correlation	2.0562	0.17	Not Rejected
Breusch-Pagan-Godfrey	No heteroscedasticity	1.33	0.29	Not Rejected
Ramsey RESET Test	Correctly specified	0.082	0.778	Not Rejected

Diagnostic tests are applied to check the goodness of fit of the model. Firstly, according to the JARQUE-BERA Normality test, our model has a normal distribution between the variables. Secondly, the Breusch-Godfrey Serial Correlation LM Test is applied to check the serial correlation. So there is no serial correlation in the model. Thirdly, this model is also free from heteroscedasticity. Finally, according to the Ramsey RESET Test, our model is correctly specified.

Table 6: Bound Test Results

F-Statistic	99% Confidence Interval I_0	99% Confidence Interval I_1	95% Confidence Interval I_0	95% Confidence Interval I_1

5.56	3.41	4.68	2.62	3.79

Table 6 shows Bound Test Results. The bound test is very necessary for analysing the long-run relation between the variables. Here, the F-statistic has a 5.56 value. The rule of thumb is that the F-statistic must be greater than the upper and lower bound values at a 1% or 5% significance level. So, our estimated mode is significantly correct at a 99% confidence interval. We can say that there is the existence of a long-run relationship between all variables.

Cointegration

This study shows a long-term relationship between the variables by using a partial F-test and the first coefficient diagnostic in the ARDL model. The ARDL model's long-term coefficients now need to be estimated.

The results of the long-run estimated coefficients of the study model are displayed in the following table:

Estimated results of Model 1

Table 7: ARDL (3, 2, 4, 2, 4, 3) Long-run Results (Model 1)

Regressors	Coefficient	Standard Error	T-Ratio	Probability
M2	3.234719	1.539181	2.101584	0.0557
TTg	4.356342	1.804943	-2.413562	0.0313
RGE	5.012647	2.498802	2.006020	0.0661
EC	0.766565	0.368055	-2.082744	0.0576
RIR	-0.434142	0.162053	2.679017	0.0189
C	-72.320741	78.497147	-0.921317	0.3737

Table 7 shows ARDL long run Results. The results show the analyses of the long-run relationship between one dependent variable followed by five independent variables. Where EC is positively related to INF, it indicates that when there is a rise in EC, it will result in a rise in inflation. Furthermore, the second explanatory variable M2 has a positive impact on inflation, it means a rise in the amount of money supply in the economy, which will increase the percentage of inflation. Additionally, there is a trade off between inflation and interest rate, central banks will increase the interest for control inflation, this relationship depicts that interest rate and inflation are negatively related to each other.

Moreover, T and RGE have a positive impact on inflation. If a developing economy whose imports are greater than exports, it will discourage domestic production and encourage the demand for foreign products. Ultimately, this will result in a rise in overall prices in the country. Similarly, when the increase its expenditure, investing in its infrastructure, education, and health. These factors help in increasing overall output and employment levels. As a result, people will earn more and they increase the demand for goods and services, which causes an increase in the rate of inflation.

Table 8: ARDL (3, 2, 4, 2, 4, 3) Short Run Results (Model 1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(INF(-1))	0.310125	0.171756	1.805611	0.0942
D(INF(-2))	0.381826	0.250153	1.526368	0.1509
D(M2)	-0.110699	0.097326	-1.137402	0.2759
D(M2(-1))	-0.333089	0.117974	-2.823418	0.0144
D(T)	0.227371	0.108672	2.092277	0.0566
D(TTG(-1))	0.283865	0.146079	1.943224	0.0740
D(TTG(-2))	-0.002561	0.079950	-0.032037	0.9749

D(TTG(-3))	0.169729	0.073929	2.295848	0.0390
D(RGE)	0.115702	0.070271	1.646508	0.1236
D(RGE(-1))	-0.133377	0.055948	-2.383953	0.0331
D(EC)	-0.053627	0.047264	-1.134625	0.2770
D(EC(-1))	0.121113	0.055939	2.165102	0.0496
D(EC(-2))	0.000652	0.055101	0.011837	0.9907
D(EC(-3))	-0.064081	0.033320	-1.923194	0.0766
D(RI)	-0.023523	0.019172	-1.226960	0.2416
D(RI(-1))	-0.039777	0.020843	-1.908455	0.0787

Cointeq = INF - (3.2347*M2* -4.3563T + 5.0126*RGE* -0.7666EC + 0.4341*RI -72.3207)

Dependent Variable is INF. Table 8 shows the result for the short-run relationship between the variables. Where EC indicates the dependent variables, and D shows the first difference in the model. In the short run, inflation is positively related to INF on its first and second lag. Moreover, here estimated parameters like M2, RGE, T, and RI harm inflation in the short run. Figure 1 shows histogram.

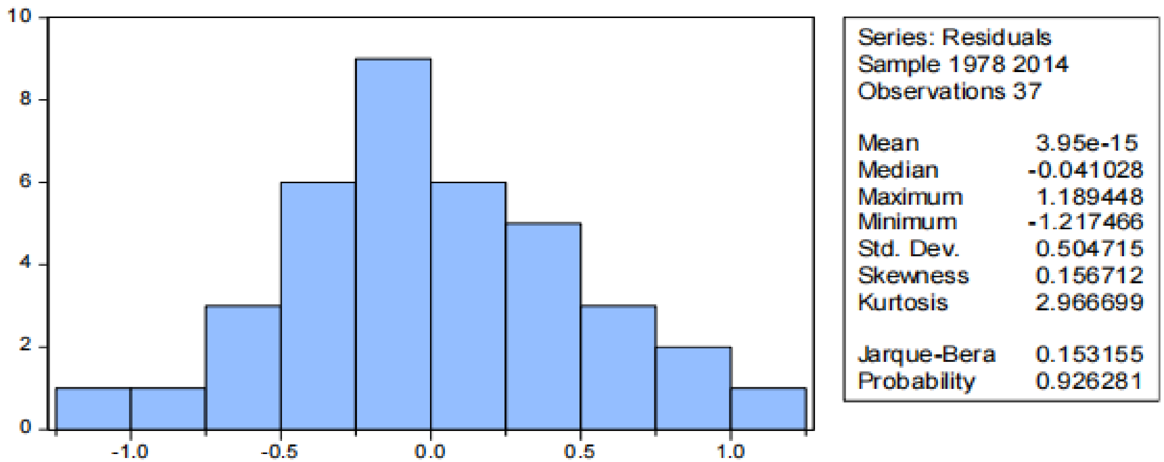

Figure 1: Histogram

Model 2: Energy Crisis and Economic Growth

In this extended analysis, the focus shifts to examining the relationship between the energy crisis and economic growth in Pakistan. Economic growth, typically measured by the increase in GDP, is a vital indicator of a nation's overall economic health. Energy serves as a backbone for industrial productivity, infrastructure development, and technological advancement, making it a critical input for sustained economic progress. This study aims to quantify how the energy crisis impacts economic growth by incorporating data-driven insights. Using an econometric approach, this section will assess whether energy shortages significantly deter GDP growth, shedding light on the broader implications of energy policies and management. The findings will help policymakers understand the critical link between energy stability and economic expansion, enabling more informed decisions for Pakistan's development agenda.

Diagnostic Test for Model 2

The diagnostic tests performed on the regression model assessing the relationship between the energy crisis and economic growth demonstrate that the model adheres to key statistical assumptions, ensuring its reliability and validity for interpretation. Table 9 shows the results of the diagnostic test for economic growth model.

Table 9: Results of the Diagnostic Test for Model 2

Tests applied	Null hypotheses	F-stat	Prob.	Decision
JB Normality test	Normal distribution	0.388	0.823	Not Rejected
Breusch-Godfrey LM Test	No serial correlation	1.169	0.364	Not Rejected
Breusch-Pagan-Godfrey	No heteroscedasticity	1.506	0.262	Not Rejected
Ramsey RESET Test	Correctly specified	3171	0.988	Not Rejected

The JARQUE-BERA normality test checks whether the residuals (errors) of the model follow a normal distribution, which is essential for reliable hypothesis testing and inference. In this case, the null hypothesis that the residuals are normally distributed is not rejected, as the p-value is 0.823, significantly greater than the common threshold of 0.05. This indicates that the model's residuals are symmetrically distributed around zero, validating the assumption of normality.

The Breusch-Godfrey serial correlation LM test evaluates whether the residuals are serially correlated, meaning whether they are related to one another across time or observations. The null hypothesis that there is no serial correlation is not rejected, as evidenced by the p-value of 0.364, which is greater than 0.05. This result confirms that the residuals are independent, supporting the model's reliability for estimating the relationship between the energy crisis and economic growth.

The Breusch-Pagan-Godfrey test for heteroscedasticity assesses whether the residuals have constant variance, a key assumption of regression models. The null hypothesis of homoscedasticity (no heteroscedasticity) is not rejected, with a p-value of 0.262. This indicates that the variance of the residuals is consistent across observations, ensuring the efficiency and reliability of the model’s coefficient estimates.

Finally, the Ramsey RESET test examines whether the model is correctly specified, meaning it captures the correct functional form and includes all relevant variables. The null hypothesis that the model is correctly specified is not rejected, as the p-value is 0.988, far above the 0.05 threshold. This result implies that the model adequately captures the relationship between the energy crisis and economic growth, without missing key variables or nonlinear effects.

Table 10: Bound Test Results (Model 2)

F-Statistic	99% Confidence Interval I_0	99% Confidence Interval I_1	95% Confidence Interval I_0	95% Confidence Interval I_1
5	3.41	4.68	2.62	3.79

The bound test results, which are shown in Table 10, provides evidence regarding the existence of a long-run relationship (cointegration) between the energy crisis and economic growth in the ARDL model. The calculated F-statistic for the test is 5, which is compared against the critical bounds at different confidence levels to assess the presence of cointegration.

At the 99% confidence level, the lower critical bound (I_0) is 3.41, and the upper critical bound (I_1) is 4.68. Since the F-statistic of 5 is greater than the upper bound value (4.68), the null hypothesis of no cointegration is rejected at this level. This strongly suggests that a long-run relationship exists between the variables in the model.

At the 95% confidence level, the lower critical bound (I_0) is 2.62, and the upper critical bound (I_1) is 3.79. Here again, the F-statistic exceeds the upper bound value (3.79), further supporting the rejection of the null hypothesis and reinforcing the conclusion that the variables are cointegrated.

ARDL Long-run Results (Model 2)

The estimated ARDL model explores the relationship between key variables and real GDP (RGDP) to assess long-term dynamics. The results indicate varied levels of significance and impact among the predictors. Table 11 shows the ARDL long run results.

Table 11: ARDL Long Run Results (1, 1, 1, 2, 1, 2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EC	-0.00344	0.000000	0.148175	0.8855
LRGE	0.035155	0.000097	362.069201	0.0000
TTG	-0.0086	0.000065	1.326662	0.2173
FDI	0.0004	0.000005	0.916189	0.3835
POP	0.0987	0.000001	0.534311	0.6061
C	0.6578	0.001119	587.155782	0.0000

Dependent Variable: RGDP. The energy crisis (EC) has a coefficient of -0.00344, suggesting a small negative relationship with RGDP. However, the high p-value of 0.8855 indicates that this relationship is statistically insignificant. This result may be attributed to the possibility that energy shortages alone do not have an immediate or strong direct effect on GDP, as the economy may temporarily adapt to energy constraints through alternative energy sources or efficiency measures. Additionally, the indirect effects of energy crises, such as reduced industrial output or inflationary pressures, may take longer to materialize, making the short-term direct impact less pronounced in this model.

The government final consumption expenditure (LGFCE), with a coefficient of 0.035155 and a highly significant p-value of 0.0000, shows a strong and positive impact on RGDP. This finding is logical, as government spending stimulates economic activity by creating demand for goods and services, fostering employment, and driving investments in infrastructure. Increased public expenditure often acts as a catalyst for economic growth, especially in developing economies like Pakistan, where government intervention plays a crucial role in addressing structural deficiencies and boosting aggregate demand.

For trade openness (TTG), the coefficient is -0.0086, showing a weak negative effect on RGDP. However, with a p-value of 0.2173, this effect is statistically insignificant. This may be because the benefits of trade openness, such as increased market access and foreign exchange earnings, might be offset by challenges like trade deficits or dependency on imports, which can weaken local production. Additionally, the insignificant result could indicate that trade policies or global economic conditions during the study period may not have significantly influenced GDP growth in Pakistan.

The coefficient for foreign direct investment (FDI) is 0.0004, reflecting a negligible positive effect on RGDP. However, the p-value of 0.3835 suggests statistical insignificance. A possible reason for this could be that FDI inflows, though beneficial, may not be large or consistent enough to significantly impact GDP in the short term. Moreover, the sectors receiving FDI may not be the ones driving overall economic growth, limiting its immediate influence on the broader economy.

Finally, population growth (POP) has a coefficient of 0.0987, indicating a positive relationship with RGDP. However, its p-value of 0.6061 denotes statistical insignificance. While population growth can contribute to a larger labour force and consumer base, the lack of significance might result from insufficient investments in education, health, and infrastructure, which are necessary to harness the economic potential of a growing population. Without these supporting factors, population growth alone may not translate into meaningful economic development.

Short-run Results (Model 2)

The short-run dynamics of the relationship between the energy crisis (EC), government final consumption expenditure (LGFCE), trade openness (TTG), foreign direct investment (FDI), and population growth (POP) with real GDP (RGDP) are examined in the selected ARDL model. The results reveal the immediate effects of these variables, along with the adjustment speed toward the long-run equilibrium. Table 12 shows short run ARDL results for Model 2.

Table 12: ARDL(1, 1, 1, 2, 1, 2) Short Run Results (Model 2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(EC)	0.000001	0.000000	1.699522	0.1234
D(LGFCE)	0.035265	0.000088	398.591561	0.0000
D(TTG)	0.000148	0.000068	2.175195	0.0576
D(TTG(-1))	0.000089	0.000041	2.202200	0.0551
D(FDI)	0.000015	0.000008	1.845736	0.0980
D(POP)	-0.000077	0.000058	-1.317302	0.2203
D(POP(-1))	0.000145	0.000079	1.846041	0.0980
CointEq(-1)	-1.436988	0.308949	-4.651219	0.0012

Dependent Variable: RGDP. The coefficient of D(EC) is 0.000001, indicating a negligible positive short-run impact of the energy crisis on RGDP. However, the p-value of 0.1234 suggests this effect is statistically insignificant. This result can be justified as the immediate impact of energy crises may not directly affect GDP, as businesses and households often adjust in the short term through alternative energy sources, cost-cutting measures, or reduced production. The broader economic consequences of energy crises, such as reduced industrial output or inflation, typically take longer to materialise, explaining the lack of short-run significance.

The variable D(LGFCE) has a coefficient of 0.035265 with a highly significant p-value of 0.0000, demonstrating a robust positive short-run relationship between government final consumption expenditure and GDP. Increased government spending stimulates demand for goods and services, which drives production and economic activity in the short run. This finding aligns with economic theory, where public expenditure acts as a catalyst for growth, particularly in developing economies like Pakistan, where government intervention plays a pivotal role in boosting demand and addressing structural economic issues.

For trade openness (TTG), the coefficients are 0.000148 and 0.000089 for the current and lagged values, respectively. Both coefficients are positive, with p-values of 0.0576 and 0.0551, indicating near-significant short-run effects at the 5% level. This suggests that greater trade openness has a modest positive impact on GDP, likely by increasing export revenues and facilitating the flow of goods, capital, and technology. However, the relatively small coefficients and near-significance may reflect challenges such as trade deficits or reliance on imports, which can dilute the immediate benefits of openness in a developing economy.

The coefficient of D(FDI) is 0.000015, with a p-value of 0.0980, indicating a marginally significant positive effect on GDP in the short run. This suggests that foreign investment contributes to economic activity, likely by bringing capital, technology, and expertise, which can enhance production and employment. However, the effect's marginal significance could be due to limitations in the scale of FDI or its concentration in sectors with limited short-term GDP impact.

Population growth (D(POP)) shows mixed effects, with a current value coefficient of -0.000077 and a lagged value coefficient of 0.000145. Both have p-values of 0.2203 and 0.0980, respectively, indicating statistical insignificance. This suggests that population growth alone does not directly influence GDP in the short term. The negative coefficient for the current period could reflect the economic strain of a growing population, such as increased unemployment or resource constraints, while the positive lagged effect might indicate delayed benefits from an expanding labor force and consumer base.

The error correction term (ECT) has a coefficient of -1.436988, which is highly significant with a p-value of 0.0012. The negative sign and magnitude indicate a strong adjustment speed toward long-run equilibrium, with approximately 143.7% of the disequilibrium corrected each period. This rapid adjustment suggests that while short-term fluctuations in the variables may occur, the system quickly returns to a stable long-run relationship. The significance of the ECT highlights the importance of the long-term dynamics in the model and confirms its stability.

5. CONCLUSION AND POLICY IMPLICATIONS

Conclusion

Thus, the purpose of this research is to establish the effect of the energy crisis in Pakistan on major economic shocks. After the start of the 21st century, Pakistan witnessed high inflation rates which essentially led to cases of hyperinflation and at the same time Pakistan has been undergoing an energy problem or shortage in the provision of energy. Through data from 1990 to 2023 analyzed by the ARDL technique, this paper examines the effect energy deficits have on the inflation rate. The study supports the hypothesis that energy deficits considered a serious long-term structural issue, have a considerable impact on inflation and the pace of economic development. From the obtained results, it is quite clear that when energy deficits are severe, they cause an incline in inflation levels. This inflationary pressure must be followed by the fact that production costs have since escalated because of energy scarcity, which in turn means that prices of products and services are scaled up accordingly. This upswing in costs has resulted in corresponding upswings in prices thus worsening the conditions of instability. Lack of energy hampers production in industries and brings down the overall efficiency causing stunted economic development. Such disruptions, therefore, slow down the development of the nation's economy and its capacity to grow. The quantitative impacts on the inflation rate in terms of energy deficits in the short run are also substantial. Short-term energy scarcity causes a rise in the rate of inflation thereby tightening expenditure on activities in the economy. This will underscore the immediacy of energy-related problems and the 'real-time' effect these have on the economy.

Policy Implications

Thus, the fundamental spheres that require a huge investment are exclusively associated with energy. Increasing the capacity, developing and enhancing the infrastructure of production and transmitting the energy might assist in minimising the gap and increasing the dependability. This ranges from a review on energy mix to enable the energy sector to diversify its portfolio by improving the generation and distribution of energy through traditional electricity, water and the utilisation and promotion of solar energy and any other natural resource as an effective source of energy.

There is a need to diversify energy sources in civil society. The government should encourage the search and use of natural resources that can sustainably provide power like solar, wind or hydroelectric power. Renewable energy, in turn, is cheap and offers an unlimited source of power not only will this help in green energy, but also help to save from expensive fuel imports from international markets due to fluctuations in prices.

There are options to relieve the demands: more public awareness on the energy crisis, and increasing energy conservation efforts amongst the public. It is also necessary to build relationships with communities to support changes in people's behaviour towards energy and resource conservation.

REFERENCES

Aguiar-Conraria, L., & Wen, Y. (2007). Understanding the large negative impact of oil shocks. *Journal of Money, Credit and Banking, 39*(4), 925–944.

Ahsan, H., Iqbal, Z., & Shabeer, M. (2024). Developing an inclusive growth index: socio-economic determinants and macroeconomic perspectives for Pakistan. *Journal of Contemporary Macroeconomic Issues*, *5*, 107-125.

Ali, F., & Rehman, Z. (2015). Energy supply disruptions and macroeconomic instability in Pakistan. *Energy Policy Journal, 30*(4), 289–305.

Alom, F., Ward, B. D., & Hu, B. (2013). Macroeconomic effects of world oil and food price shocks in Asia and Pacific economies: Application of SVAR models. *OPEC Energy Review, 37*(3), 327–372.

Amano, R., & Van Norden, S. (1998). Oil prices and the rise and fall of the US real exchange rate. *Journal of International Money and Finance, 17*(2), 299–316.

Anwar, A., Ayyubi, M. S., Riaz, F., & Shabeer, M. G. (2024). Regional disparities in food security: An empirical analysis of Pakistan's provinces and regions. *The Journal of Research Review*, *1*(4), 502-511.

Ayyubi, M. S., Ahsan, H., Anwar, A., Khan, A. E., & Shabeer, M. G. (2024). The nexus between growth and unemployment rate in Pakistan: does Okun's law exist. *International Journal of Contemporary Issues in Social Sciences*, *3*(2), 2124-2152.

Basnet, H. C., & Upadhyaya, K. P. (2015). Impact of oil price shocks on output, inflation and the real exchange rate: Evidence from selected ASEAN countries. *Applied Economics, 47*(29), 3078–3091.

Burbidge, J., & Harrison, A. (1984). Testing for the effects of oil price rises using vector autoregressions. *International Economic Review, 25*(2), 459–484.

Chaudhry, M. O., Faridi, M. Z., & Riaz, S. (2015). Energy crisis and macroeconomic stability in Pakistan. *Pakistan Journal of Social Sciences, 35*(1), 425–436.

Chaudhuri, K., & Daniel, B. (1998). Long-run equilibrium, real exchange rates and oil prices. *Economics Letters, 58*(2), 231–238.

Cologni, A., & Manera, M. (2008). Oil prices, inflation and interest rates in a structural cointegrated VAR model for the G-7 countries. *Energy Economics, 30*(3), 856–888.

Eltony, M., & Al-Awadi, M. (2001). Oil price fluctuations and their impact on the macroeconomic variables of Kuwait: A case study using a VAR model. *International Journal of Energy Research, 25*(11), 939–959.

Hamilton, J. D. (2005). Oil and the macroeconomy. *The Journal of Political Economy, 91*(2), 228–248.

Huang, Y., & Guo, F. (2007). The role of oil price shocks on China's real exchange rate. *China Economic Review, 18*(4), 403–416.

Iqbal, Z., Rashid, M., Anwar, A., & Shabeer, M. G. (2025). An analysis of the role of artificial intelligence in shaping unemployment trends in OECD countries. *International Journal of Social Sciences Bulletin*, *3*(7), 643-657.

Jamali, M., Shah, A., Soomro, H., Shafiq, K., & Shaikh, F. (2011). Oil price shocks: A comparative study on the impacts in purchasing power in Pakistan. *Modern Applied Science, 5*(2), 192–203.

Khan, N. A., & El Dessouky, H. (2009). Prospect of biodiesel in Pakistan. *Renewable and Sustainable Energy Reviews, 13*(6–7), 1576–1583.

Khan, R., & Ahmed, N. (2014). Energy prices and their effect on inflation: Evidence from Pakistan. *Pakistan Economic Review, 22*(3), 45–60.

Kilian, L. (2008). The economic effects of energy price shocks. *Journal of Economic Literature, 46*(4), 871–909.

Kraft, J., & Kraft, A. (1978). On the relationship between energy and GNP. *The Journal of Energy and Development, 3*(2), 401–403.

Kucukali, S., & Baris, K. (2010). Turkey's short-term gross annual electricity demand forecast using a fuzzy logic approach. *Energy Policy, 38*(5), 2438–2445.

Malik, K., Ajmal, H., & Zahid, M. U. (2017). Oil price shock and its impact on the macroeconomic variables of Pakistan: A structural vector autoregressive approach. *International Journal of Energy Economics and Policy, 7*(5), 83–92.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics, 16*(3), 289–326.

Sadiq, H. (2016). Long-term effects of energy crises on macroeconomic variables in developing countries. *International Journal of Energy Economics, 12*(1), 75–88.

Shair, G., Ali, A., & Siraj, W. (2015). Crude oil prices and Pakistani rupee-US dollar exchange rate: An analysis of preliminary evidence. *European Journal of Business and Management, 7*(7), 442–447.

Siddiqui, A., Khan, M., & Ali, S. (2011). The impact of energy shortages on industrial output in Pakistan. *Journal of Economic Studies, 18*(2), 120–134.

Siddiqui, R. (2004). Energy and economic growth in Pakistan. *The Pakistan Development Review, 43*(2), 175–200.

Zubair, R., Zafar, Q., Rasul, F., & Shabeer, M. G. (2024). Navigating the digital marketplace: Examining the influence of social media advertising on purchase intentions through the lens of performance expectancy theory. *Journal of Education and Social Studies*, *5*(2), 330-344.