

EVALUATING THE IMPACT OF OIL PRICE VOLATILITY AND RENEWABLE ENERGY ADOPTION ON PAKISTAN'S ECONOMIC GROWTH: A TIME-SERIES ANALYSIS

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Abstract

Due to its importance to the world economy, oil price volatility is still one of the vital sources of economic instability for oil importing developing economies such as Pakistan. Historically, fluctuations in global oil prices have been associated with inflationary pressures, trade imbalances and currency depreciation thus affecting macroeconomic performance. In this paper, the effect of oil price volatility and adoption of renewable energy on Pakistan's economic growth has been investigated from 2008 to 2023 by using time series econometric approach. The study uses Autoregressive Distributed Lag (ARDL) model and incorporates oil price volatility (OVX), renewable energy consumption (RES), exchange rate (EXR), interest rate (IR) and industrial production index (IPI) to uncover their joint impact on GDP growth.

The main results indicate that oil price volatility is negatively associated with economic growth while the effects are positive associated with oil consumption, and they appear with a lag, pointing out the long term disturbances caused by energy price shocks. On the other hand, how the adoption of renewable energy leads to stabilization of the GDP thus, showing that adoption of renewable energy is potent enough to stabilize the economy through oil price shocks. Certainly exchange rate movements will impact macroeconomic trends, but in any case will not affect GDP growth directly whereas interest rates will neither impact macroeconomic trends. The significance of energy diversity, stable exchange rate, and industrial reforms is made clear for the economy of Pakistan to be more resilient.

Keywords: Oil price volatility, renewable energy, economic growth, Pakistan, macroeconomic stability

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Introduction

Oil is to the world economy as what the heart is to the human body: it moves to the rhythm of energy markets. 1980s oil crises, the 2020 price collapse in the midst of COVID may have primed us to that it is inevitable oil prices will oscillate and that may dictate the economic fate of countries. Energy prices volatility can destabilize economies, cause disturbances to trade balances, and unleash an inflationary spiral for countries dependent on oil importations (IEA, 2023). The emergence of a resilient economy through oil prices hinges on oil, which is still the backbone of industrial economies.

In just one decade, oil prices have been extraordinary: Brent crude was above \$140 per barrel in 2008, \$20 in 2020, then rose above \$120 in post-pandemic times, only to settle around \$80 – \$90 in 2023 (World Bank, 2023). Such kind of volatility ruins economic planning, inflation

and currency stability. Instead, renewable energy has continued to evolve and was invested with \$1.7 trillion in 2022 (IRENA, 2023). The reality is that countries are competing to reshape their economic growth trajectories with solar, wind and hydropower.

Economies everywhere suffer the impact of oil price ripples, but it hits hardest at those that are still developing. That's different to the situation in advanced economies where there are buffers to deal with energy import dependency or fiscal constraints, less energy intensity and more advanced economic shock absorbers. With oil importers experiencing severe balance of payment crises during price jumps, inflation and currency depreciation are triggered (The World Bank, 2022). While investments in renewable energy are unequally spread, wealthy countries are ahead of the transition and poor economies are lagging.

Oil dependent developing countries may lose as much as 0.5% of GDP because a 10% increase in oil price volatility can cost that much (ResearchGate, 2022). Nations like India, and China have been extremely aggressive when it comes to promoting renewable energy to lessen the effects of the oil price movements but several developing economies, including Pakistan, still await a dignified decision at a crossroads.

As is the case with many other developing countries, Pakistan is balancing between energy dependence and economic stability. Pakistan is an oil import country and spends billions of dollars a year on fuel import, uses an economy that is highly sensitive to the oil price fluctuation. The State Bank of Pakistan (2023) explains that economic slowdown, inflation surges and currency depreciation have coincided with sharp increases in oil prices in their history. For example, in 2008, Pakistan's GDP growth fell from 6 percent to 1.7 percent and inflation crossed 20 percent, when oil prices spiked in 2008.

Despite being new the country's renewable energy sector has big potential. Solar and wind, however, have significant potential for the remaining share but only add a small fraction of 5-6% in the total energy mix (Pakistan Alternative Energy Development Board, 2023). While government policies have promoted solar and wind energy projects, bureaucracy, financing and infrastructure barriers have been cumbersome.

Now the question is that whether renewable energy adoption can provide Pakistan's economy with defense from oil price volatility? In order to answer this, a time-series econometric analysis was undertaken with the aim of examining how the oil price volatility interacts with the renewable energy adoption in Pakistan to determine its economic growth.

In light of the critical energy crisis and economic instability in Pakistan, the objective of this paper is to understand how energy shocks impact the macroeconomic performance. The scope of this study utilizes a time-series econometric approach to examine two key forces impacting the two scenarios, oil price volatility and renewable energy adoption. The questions it tries to answer are as follows.

1. What is the influence of oil price volatility on Pakistan's GDP growth?
2. Does renewable energy adoption help reduce the economic damage resulting from oil price shocks?
3. What are the macroeconomic factors of exchange rates, interest rates, industrial production, etc, and what is their role in this dynamic?

This research is timely and policy relevant: it provides essential insights for Pakistan's economic resilience and fiscal planning as well as speaks to its energy strategy. This will guide policymakers as they weigh up dependence on fossil fuels against sustainable alternatives and

determine how to invest in renewable energy to prevent future oil price shocks from hitting the economy. Providing the empirical evidence for Pakistan to adapt to the changing global energy markets, or face economic stagnation, this study will contribute to shaping informed and forward thinking policies.

Literature review

Economic growth in developing economies, which depend on importing their fuel as fossil gasoline, has made oil price volatility and its relation to economic growth a major subject of economic research. Thus, the body of studies on oil price volatility has continued, and have shown the negative effect of oil price volatility on macroeconomic variables such as inflation, exchange rate, industrial output and the fiscal policy.

Okegbemi (2024) also carried out a study which proved the closeness in the correlation of high inflation rates, volatile exchange rates and declining fiscal stability of Nigeria to oil price fluctuation. The study implied that the economies that depended solely on oil imports and lack energy diversification lost their ability to maintain macroeconomic stability. In the same vein, Akpan et al. (2024) studied the effect of the ups and downs in the oil revenue in Nigeria's economic growth from year 1981 to 2022; showing that oil price crashes result in steep contraction of GDP, which shows the vulnerability of oil dependent economies to market shocks (Okegbemi, 2024; Akpan et al., 2024).

More recently, Mahajan & Sah (2025) studied India and China's economic response to oil price shocks based on large VARs. They reported that oil price changes were immediately coupled with national economic downturns but renewable energy investments contributed to long term national economic resilience. Indeed, Rehman & Ahmad's (2024) study on Pakistan's manufacturing sector, which claimed that oil price uncertainty is damaging industrial output and costs of production (Mahajan & Sah, 2025; Rehman & Ahmad, 2024).

In the meantime, researches about oil export developing economies like Hasanzadeh et al. (2025) reveals higher oil prices, in the first place, trigger short term revenues for oil exporting economies, but in the long term this volatility causes them to have economic instability and financially unmanageable budget deficits. This argument is backed by other scholars who examine the effects of crude oil price shocks on fuel importing developing economies and ascertain that developing economies' economic growth is very weak, unless they invest in renewable energy alternatives (Hasanzadeh et al., 2025; El Kadri & El-Khodary, 2025).

There is an evolving body of literature regarding renewables energy uptake that suggests the ability of higher investments in renewables to diminish the negative consequences of oil price volatility. However, several studies affirm that by moving towards renewable energy, dependence on fossil fuels is reduced, energy markets are stabilized, and long term economic stability is encouraged.

Solar and wind energy expenditures come along with the decrease of macroeconomic fluctuations, the increase of industrial competitiveness and the decrease of industrial competitiveness with respect to oil price shocks, according to Di Sabatino & Ceccaroli (2025). In their paper they assess how much the stabilisation potential of alternative energy sources is sufficient to disturb the energy market which would mitigate the volatility of GDP; a 10th increase in the renewable energy share lowers GDP volatility by 0.8th. For instance, Babu et al. (2025) also argue how GCC nations used renewable energy investments to decrease the economic vulnerability to oil price volatility, supporting the concept that energy diversification represents an important strategy to ensure economic resilience in the region (Di Sabatino and Ceccaroli, 2025; Babu et al., 2025).

When looking at specific studies concerning Pakistan, the country has a huge renewable potential available, but investment and policy implementation have not proved to be adequate. One reason attributed for the underdevelopment of Pakistan's renewable energy sector which holds ample solar and wind resources are financing barriers, bureaucratic inefficiencies. (Rehman and Ahmad 2024). Meidl et al. (2025) confirm it by showing that the developing economies with the weak institutional framework fail to incorporate the big renewable energy projects, hence, become more exposed to oil price shocks (Rehman & Ahmad, 2024; Meidl et al., 2025).

Examined from the broader view point, Shachmurove (2025) suggests that historical oil crises have led emerging countries to a more rapid transition toward renewable energy instead. The study determined that countries that choose to invest in renewable energies while emerging have better opportunities of long-term growth stability of GDP than oil dependent economies. Shachmurove (2025) and Ewubare & Akidi (2025) claim that countries in the portfolio of diversified energy have lower exchange rate volatility and higher economic resilience (Shachmurove 2025, Ewubare & Akidi 2025). Much of the literature is concerned with how developing economies negotiate oil price forces and whether renewables investments can act as an economic shield against macroeconomic instability.

In their study, El Kadri & El-Khodary (2025) investigate the economic impact of the sharp rise in oil prices on fuel importers' developing economies; thus, it concludes that such economies witness prolonged recessions. However, they maintain that venturing into renewable energy lessens the vulnerability of the economy to shocks because nations with more renewable energy do not readily lose economic stability. Hasanzadeh et al. (2025) findings support this claim that although high oil prices benefit oil-exporting developing economies, their reliance on petroleum revenues is so overreliant they experience fiscal crises in oil price downturns (El Kadri & El-Khodary, 2025; Hasanzadeh et al., 2025).

The energy landscape of Pakistan is impacted by various policies aimed at diversifying the power mix and making the system more resilient to system shocks. A cornerstone policy is AREP of 2019, which aimed to achieve a 25% share of renewables in 2025 and 30% by 2030, supported by feed-in tariffs, net metering for solar rooftops, and more efficient licensing systems. Complementing AREP is NEECP 2023, which mandates energy efficiency in the industry, transport, and buildings while also introducing minimum efficiency performance standards for appliances and/or equipment. Coupled with the Energy Security Action Plan 2005-2030, which strives to optimize an "all-of-the-above" resource mix that includes hydro, nuclear, coal, and renewables, these policies provide a cohesive path for reducing import dependence and greenhouse-gas emissions and stabilizing the costs of electricity supply.

This study focuses on two theoretical perspectives that complement one another. According to Resource Dependence Theory, organizations experiencing critical resource external dependencies will try to internalize or externalize those resources to minimize risk (Pfeffer & Salancik, 1978).

An example of this is Pakistan's imported oil dependency; the economy is vulnerable to world-market oil price volatility. However, domestic renewable energy expansion can weaken that dependency and improve economic independence. The second perspective is the "shock-absorber" framework, which stems from the oil-shock literature on macroeconomic buffers and their disparate impacts on the transmission of price shocks to output (Kilian, 2009).

Within this view, the renewable energy infrastructure acts as macroeconomic buffers and enables economies to mitigate the negative consequences of oil price volatility on GDP growth.

Supporters of this view regard infrastructure providing alternative energy sources as fiscal stabilizers.

Merging these policy insights with the theoretical frameworks deepens the analysis of the empirical findings, revealing the renewable investment policies targeted towards resource dependence theory are effectively functional as energy-dependent shock absorbers in Pakistan's macroeconomic framework.

Literature Gap

Although there are many works on oil price volatility and renewable energy adoption, the literature exhibits multiple gaps. Most of existing studies focus on either oil price volatility or renewable energy adoption independently without considering the combined effect of oil price volatility and renewable energy adoption on economic stability. Moreover, there are very few studies, making use of econometric models such as ARDL, to understand the long run and short run effects of oil price volatility and renewable energy adoption on GDP growth in the case of Pakistan. Even though Pakistan is experiencing an ongoing energy crisis and economic instability there is very little research related to Pakistan's energy economic relation and the research, if available, usually lack robust policy recommendations. In addition, there is limited emphasis on how macroeconomic factors like exchange rate fluctuations, interest rate, and industrial production index mediate the effect of volatility in oil price on GDP growth. Closing these gaps is necessary for designing forward economic strategies that reinforce Pakistan's ability to withstand shocks to oil prices and make renewable energy a rational alternative as a stabilizer of national economies.

Conceptual Framework and Hypotheses

On the basis of the insights from the literature, this study advances a conceptual framework which combines oil price volatility, renewable energy adoption and macroeconomic stability as the key determinants of GDP growth of Pakistan. These hypotheses will be tested.

H1: Oil price volatility negatively impacts Pakistan's economic growth.

H2: Higher renewable energy adoption mitigates the adverse effects of oil price volatility.

H3: Macroeconomic variables such as exchange rates, interest rates, and industrial production moderate the relationship between oil price volatility and GDP growth.

Methods

Using a time series econometric approach this study tries to address the issue of influence of oil prices volatility and renewable energy population on Pakistan's economic growth from year 2008 to year 2023. The World Development Indicators (WDI) of the World Bank and the Oil Volatility Index (OVX) on Investing.com are the sources of the dataset. The chosen period of economic fluctuations following energy market dynamics can be analyzed in a complete manner due to OVX's availability from 2007 onwards. The stationarity test, differencing of variables and the application of Autoregressive Distributed Lag (ARDL) model appropriate for mixed order integration in the time series data are included in the methodological framework. Model equation is as under:-

$$\text{GDPGrowth}_t = \alpha + \sum_{i=1}^p \beta_i \text{GDPGrowth}_{t-i} + \sum_{i=0}^q \gamma_i \text{OVX}_{t-i} + \sum_{i=0}^q \delta_i \text{RES}_{t-i} + \sum_{i=0}^q \lambda_i \text{EXR}_{t-i} + \sum_{i=0}^q \theta_i \text{IR}_{t-i} + \sum_{i=0}^q \phi_i \text{IPI}_{t-i} + \varepsilon_t$$

In this study, GDP Growth (annual %) is considered as the dependent variable, in other words, as a marker of the overall economic performance. The other key independent variables include Oil Price Volatility (OVX) which is measured by fluctuations in global oil prices and Renewable Energy Consumption (as a percentage of total final energy consumption) which measures the extent of renewable energy integration in the Pakistan's energy mix. Moreover, macroeconomic factors playing an important role in the economic growth have been controlled by adopting control variables such as Exchange Rate (USD/PKR), Lending Interest Rate (%), and Manufacturing Value Added (as % of GDP) (Table 1).

Table 1

Variables, Measurement Units, and Data Sources for the ARDL Model

Variable Name	Category	Abbreviation	Unit of Measurement	Data Source
Gross Domestic Product Growth	Dependent	GDPGrowth	Annual %	World Development Indicators (WDI)
Oil Price Volatility Index	Independent	OVX	Index Value	Investing.com
Renewable Energy Consumption		RES	% of Total Final Energy Consumption	World Development Indicators (WDI)
Official Exchange Rate	Control	EXR	Local Currency per USD (Period Average)	World Development Indicators (WDI)
Lending Interest Rate		IR	%	World Development Indicators (WDI)
Manufacturing Value Added		IPI	% of GDP	World Development Indicators (WDI)

First, stationarity was tested using the Augmented Dickey-Fuller (ADF) test. Stationarity is an essential property in time series econometrics, since we may obtain false regression results or even false conclusions from statistical inference if our data is non stationary. The ADF test results further show that GDP growth is stationary at level ($p < 0.05$) while other variables are non-stationary. To deal with this issue, we followed the suggestion of Moftakhari (2024) and Bello (2024) that first difference should be introduced to a nonstationary variable until stochastic trend is removed and variables really relate to each other. Yet some of the macroeconomic indicators, like the exchange rate and interest rate, still appear to be non stationary even in their first difference; thereby requiring the process of second differencing. Additionally, Zhang (2024) also reinforces the need for differencing based on the fact that overlooking it will result in confusing statistical relationships that are induced by common trends and not real economic relationships.

Thus, diagnostic tests on regression were carried out after stationarity is ensured. To check the existence of multicollinearity among the independent variables, the Variance Inflation Factor (VIF) Test was applied. Breusch Pagan test of heteroscedasticity verified that there is no change in residual variance ($p > 0.05$) and so model is homoscedastic. Also, the results of the Shapiro-Wilk normality test reveal that residuals follow a normal distribution, which is an assumption for regression analysis. According to the Durbin-Watson test for serial correlation; a value

above this test but with ARDL such variation is ignored. Furthermore, Ramsey RESET test was used to verify the misspecification of a model, and the result shows no omitted variables bias.

According to the mixed integration order of these variables, Autoregressive Distributed Lag (ARDL) approach is the preferred econometric model. Pesaran, Shin and Smith (2001) introduced the ARDL bounds testing procedure which is especially suitable for time series data where some variables are stationary at level ($I(0)$) and the others are stationary at first difference ($I(1)$). Unlike Johansen cointegration test which requires all the variables to be of same order of integration, ARDL allows one to estimate the short run and long run relationship of the variables simultaneously. Moreover, Mushtakhi and Samadpoor (2024) justify the selection of ARDL based on the fact that it involves heterogeneous lag structure capability and reliable long term estimates despite a small sample size. Similarly, Mbaleki (2024) also underlines that the ARDL modeling technique can accommodate the structural break that may most likely feature both the energy and economic sectors of Pakistan.

In ARDL model specification GDP growth is considered as dependent variable and independent variables include oil price volatility, renewable energy consumption, exchange rate, interest rate as well as manufacturing value added. Short run dynamics and the long run equilibrium relationships are captured by the regression equation. Following this to test whether the presence of cointegration among the variables, ARDL bounds test was applied which compares the F-statistic obtained with the critical values to decide whether a long run relationship exists among the variables of interest. If the F-statistic is greater than the upper bound critical value, the null hypothesis of no cointegration is rejected, implying GDP growth and the other explanatory variables are (stably) associated in the long run. The significance of the coefficients is interpreted to give the final interpretation of the results, more emphasis being placed on the contribution of oil price volatility and renewable energy in facilitating the growth of Pakistan's GDP.

Such a methodological framework guarantees a rigorous empirical analysis of Pakistan's experiences pertaining to the relationship between oil price volatility, renewable energy adoption and economic growth. Stationarity testing, differencing techniques, the use of macroeconomic control variables, and the estimation using the ARDL adds a sense of reliance to the way findings are arrived at, and also improves the robustness of the model. This is a suitable application of the ARDL approach using recent literature, given its ability to provide comprehensive short run and long run economic dynamics insight into policy options of investing in renewable energy as a means of mitigating the adverse shock induced by oil price shocks.

Results and Discussion

Robustness Checks and Model Diagnostics

A series of robustness tests was conducted prior to estimating the ARDL model to make sure the validity and reliability of the regression results. The stationarity tests, tests of multicollinearity, tests for heteroscedasticity, the normality checks, autocorrelation tests and the model specification checks were the tests of the tests.

Augmented Dickey-Fuller (ADF) test was utilized to check stationarity of all variables in the data set. There is a fundamental assumption in time series econometrics, which is nonstationary data that can give spurious regressions which can lead to deceptive inferring (Gujarati & Porter, 2009). The GDP growth was stationary at level $I(0)$ and was suitable for regression analysis without transformation as the results indicated. However, oil price volatility (OVX), renewable energy share (RES) and industrial production index (IPI) were found to be non-stationary at level but became stationary at first difference implying the order of integration of $I(1)$ s

respectively. On the other hand, exchange rate (EXR) and interest rate (IR) were non stationary after being first differenced and became stationary after being second differenced confirming the integration order of I(2) (Table 2). However, the order of integration among the variables is mixed which justify the use of the Autoregressive Distributed Lag (ARDL) model that enables the inclusion of I(0) and I(1) variables (Pesaran et al., 2001).

Table 2

ADF Stationarity Tests for Variables Used in the ARDL Model

Variable	ADF Test at Level	ADF Test at First Difference	ADF Test at Second Difference	
GDP Growth (GDPGrowth)	-3.089 (p = 0.0274)	-	-	Level (I(0))
Oil Price Volatility (OVX)	-2.680 (p = 0.0775)	-3.089 (p = 0.0274)	-	First Difference (I(1))
Renewable Energy Share (RES)	-1.401 (p = 0.5816)	-4.453 (p = 0.0002)	-	First Difference (I(1))
Exchange Rate (EXR)	2.371 (p = 0.9990)	-0.788 (p = 0.8226)	-5.579 (p = 0.0000)	Second Difference (I(2))
Interest Rate (IR)	-1.502 (p = 0.5326)	-2.101 (p = 0.2439)	-3.983 (p = 0.0015)	Second Difference (I(2))
Industrial Production Index (IPI)	-1.731 (p = 0.4153)	-2.850 (p = 0.0515)	-	First Difference (I(1))

The Variance Inflation Factor (VIF) test was done to check for multicollinearity among the independent variables. The mean VIF value is 3.04 which implies that in the model multicollinearity was not a problem (Table 3) (Hair et al., 2010). Yet, highest value of VIF (4.28) that is less than 10 was calculated for D2_IR which indicates no multicollinearity with the other explanatory variable. This confirms that the model is not problematic with respect to collinearity, since values above 10 are usually taken to indicate severe multicollinearity (Kutner et al., 2005).

Then, it was tested that if residuals variance is constant (Breusch–Pagan test for heteroscedasticity). When it was tested, it had a p value of 0.6708 and so it cannot be rejected, the null hypothesis that the variances are homoscedastic (Table 3). This implies that the residual variance is constant across observations thus the homoscedasticity assumption is satisfied (White, 1980).

The Shapiro-Wilk normality test was conducted to test if the residuals are normal with the p-value of 0.87437 (Table 3). As this value is above the conventional 0.05 threshold, it confirms that the residuals follow a normal distribution, which is a desirable property in regression models (Doornik & Hansen, 2008).

An application of the Durbin–Watson test to the residuals was done to investigate for a possible first order autocorrelation in the residuals. Durbin-Watson statistic came out to be 2.157 which indicates that there is not strong evidence of serial correlation (Table 3). Moreover, the Breusch-Godfrey LM test for serial correlation was carried out with p= 0.1108 which is greater than 0.05

(duh). The results of these displays suggest there is no serial correlation problem that exists in the model; that is, the residuals are independent which is an assumption in the time series regressions (Greene, 2012).

Table 3

Diagnostic Tests for ARDL Model Validity and Assumptions

Test Name	Results	Status
Variance Inflation Factor (VIF) Test	Mean VIF = 3.04 (No multicollinearity issue)	Passed
Breusch-Pagan Heteroskedasticity Test	p = 0.6708 (No heteroscedasticity detected)	Passed
Shapiro-Wilk Normality Test	p = 0.87437 (Residuals follow normal distribution)	Passed
Durbin-Watson Test for Autocorrelation	Durbin-Watson = 2.157 (No severe autocorrelation)	Passed
Breusch-Godfrey LM Test for Serial Correlation	p = 0.1108 (No serial correlation detected)	Passed
Ramsey RESET Test for Model Specification	p = 0.6088 (No omitted variable bias)	Passed

Note: Breusch-Pagan tests for heteroskedasticity, Shapiro-Wilk for normality of residuals, Durbin-Watson and Breusch-Godfrey for autocorrelation, and Ramsey RESET for functional form.

The Ramsey RESET test was implemented to check if the model was properly specified. p value of the test came to the value of 0.6088, which is larger than 0.05, hence there were no omitted variable biases in the model (Table 3). With the R-squared value of 0.9929, the adjusted R-squared value of 0.9788, both imply that there is approximately 99% variation explained in the GDP growth, thus concluding that the model is fit. Besides this, the F-statistic with significance probability equals 0.0005 (70.13) further proves that the model is highly significant.

Table 4

ARDL Estimation Results: Short-Run and Long-Run Effects on GDP Growth

Variable	Coefficient	Std. Error	t-Statistic	P-Value	95% Conf. Interval
GDPGrowth (L1)	-0.587549	0.0710509	-8.27	0.001	(-0.7848179, -0.39028)
D_OVX	0.0123863	0.009257	1.34	0.252	(-0.0133154, 0.0380879)
D_OVX (L1)	-0.0499921	0.0096537	-5.18	0.007	(-0.0767952, -0.0231891)
D_RES	0.6494255	0.1061399	6.12	0.004	(0.3547338, 0.9441172)
D2_EXR	0.1132494	0.0150039	7.55	0.002	(0.0715918, 0.1549069)
D2_IR	0.0309056	0.1039435	0.3	0.781	(-0.2576879, 0.319499)
D_IPI	-1.47479	0.2516851	-5.86	0.004	(-2.173579, -0.7759998)
D_IPI (L1)	-3.675186	0.1960487	-18.75	0	(-4.219504, -3.130867)
Constant	5.890309	0.2686237	21.93	0	(5.14449, 6.636128)

Note: This table presents the estimated coefficients from the ARDL model assessing GDP growth as the outcome variable. GDP growth (annual percentage change) serves as the dependent variable. The primary explanatory variables analyzed in the model include oil price volatility (OVX) and renewable energy share (RES), while macroeconomic factors such as exchange rate (EXR), interest rate (IR), and industrial production index (IPI) have been incorporated as control variables to account for broader economic influences.

ARDL Model Estimation and Interpretation

The ARDL model was then estimated after the model validation was done for robustness checking. The results show the impact of oil price volatility and renewable energy adoption on Pakistan's economic growth with estimated coefficients, their significance levels as well as confidence intervals

Short-Run and Long-Run Effects

The coefficient of L1, the lagged GDP growth variable, is found to be significantly negative (-0.5875) at 5 percent level ($p = 0.001$) (Table 4). It suggests that the economic growth is highly persistent. Firstly, previous year's growth is significant in forecasting the current year's GDP growth (a regular observation in macroeconomic models, (Barro & Sala-i-Martin, 2004).

Oil price volatility (D_OVX) is estimated in the short run with a coefficient of 0.0124 that is statistically insignificant ($p=0.252$) (Table 4), therefore implying that short/term fluctuations of oil prices do not immediately affect GDP growth. Nevertheless, the lagged value for oil price volatility (D_OVX L1) is -0.0499 and significant at $p = 0.007$ (Table 4), indicating that the effect of oil volatility is lagged and negative; i.e., previous oil price shocks can affect economic growth later on (Hamilton, 2009).

Renewable Energy Adoption and Economic Growth

The p value for the coefficient of renewable energy consumption (D_RES) is 0.004 and it is found to be highly significant with a value of 0.6494 (Table 4). We find that this finding is consistent with previous empirical findings that show that energy diversification is associated with macroeconomic stability (Sadorsky, 2009) as this finding shows that increasing share of renewable energy has positive contribution to economic growth. The result of this holds that Pakistan's investment in renewable energy can prevent some of the negative effects on oil price fluctuations—it is in line with studies that show that moving to sustainable energy sources has economic benefits (Apergis & Payne, 2012).

Exchange Rate and Interest Rate Effects

The coefficient (b2) for the second difference of the exchange rate (D2_EXR) is 0.1132 ($p = 0.002$) (Table 4). Thus, fluctuations of the exchange rate play an important role in growth in the level of GDP, and depreciation of currencies might have a positive influence on the growth of economy due to an increase in exports. This is in line with the results of developing economies where a weaker currency spurs export oriented growth (Edwards, 1989).

Interestingly, the interest rate variable (D2_IR) comes out statistically insignificant ($p = 0.781$), thus suggesting that short run direct impact of changes in lending rates on GDP growth is not evident in this particular model. This finding is consistent with the work that has shown that the effect of interest rates on economic growth is usually an indirect one, which depends on other financial conditions (Bernanke and Blinder, 1992).

Industrial Production and Economic Growth

The coefficient for industrial production (D_IPI) turned out to be negative and statistically significant ($p = 0.004$), which means that there is a negative impact of industrial activity on GDP growth (coef = -1.4748). This somewhat counterintuitive result may be due to some structural inefficiencies in Pakistan's industrial sector as changes in output of manufactures may not be necessarily translated into sustained economic growth. Nevertheless, lagged value (D_IPI L1) is -.000 (-3.6752, $p = 0.000$) (Table 4), affirming that overall industrial break can cause its consequences persist on GDP for long period of time. This research coincides with others in the developing economies where it is pointed out that the unpredictability of the manufacturing sector can cripple the entire economy (Rodrik, 2009).

Source tables on ARDL estimation results show that the oil price volatility influences, and in turn, is influenced by the renewable energy adoption and economic growth. Short term changes in oil price do not affect GDP, but oil price shocks work with a lag and have negative effect on GDP. Furthermore, these findings provide support for the hypothesis that renewable energy adoption improves economic stability, and also has a positive, strong and significant impact on GDP growth. Economic performance is a function of exchange rate fluctuations, and interest rates seem nearly to have a direct effect. GDP growth has a negative association to industrial production, suggesting that the manufacturing sector could undergo structural inefficiencies. Therefore, these findings emphasize the need of energy diversification in Pakistan to facilitate sustainable growth, along with macroeconomic stability.

Conclusion

This research aims to analyze the impact of oil price fluctuations and the adoption of renewable energy on the economic growth of Pakistan, also considering the mediating impacts of exchange rates, interest rates, and industrial production. Using an ARDL framework and annual data from 2008 to 2023, this work offers conclusive answers to the challenges posed in the introduction.

The findings show that the effect of oil price volatility does not directly impact GDP growth in the short run—its negative consequences are cumulative. Specifically, a one-unit increase in lagged oil volatility leads to a 0.05 percentage-point reduction in growth. On the other hand, the adoption of renewable energy proves to be an effective stabilizer; a one-percentage-point increase in the share of renewables results in a 0.65 percentage-point increase in growth in the short run. Of the control variables, exchange rate shifts have a positive impact on growth—likely because they improve export affordability—while lending rate changes have no direct impact. Shocks to industrial production continue to carry a strongly negative impact on output, highlighting the persistence of structural inefficiencies in the manufacturing sector.

Though the ARDL approach captures short- and long-run dynamics, systematic annual data may hide the spatial and sectoral differences in energy responses over time. Future work should focus on disentangling renewable technologies, utilizing observations with higher temporal resolution, and analyzing the impact of specific policy tools on the energy and economic growth nexus, including feed-in tariffs, carbon pricing, and green financing initiatives.

This study also underscores Pakistan's unique energy-growth sustainability relationship by quantifying renewable energy's dampening effect on oil-price volatility and identifying critical macroeconomic mediators. Such understanding enables the formulation of more precise policy measures that blend enhanced renewable energy investment, managed exchange rates, and industrial policy realignment to strengthen a low-carbon sustainable economy and enduring resilient growth.

Policy Implications

Reducing Economic Vulnerability to Oil Price Volatility

The findings suggest that positive oil price volatility impacts negatively and with a lag on GDP growth, bolstering the need for policies to decrease Pakistan's dependence on imported fossil fuels. As the country is dependent on oil imports, strategic energy diversification is required to limit the economic consequences of external price shocks. Policymakers should invest in these alternative energy sources such as solar, wind, and hydropower since they guarantee long term stability, which reduces the dependence on the unstable global energy markets (Omri & Kahouli, 2014).

Promoting Renewable Energy as a Growth Driver

Additionally, renewable energy consumption has a strong positive impact on economic growth indicating that the need for increased renewable energy capacity in Pakistan is also high. This is consistent with global trends where countries spending money on clean energy technologies are better able to weather macroeconomic shocks and are less vulnerable to fossil fuel price shocks (Sadorsky, 2009). Incentives to private sector investment in renewable energy, subsidies for solar and wind projects as well as regulatory frameworks that encourage the adoption of clean energy should be implemented as part of policy measures. Additionally, as the economic benefits will be realized through higher shares of renewable energy, strengthening the national energy grid infrastructure will be critical.

Exchange Rate Management for Economic Stability

Results present that the exchange rate is of great importance for the economic performance and indicates that exchange rate fluctuations impinge GDP growth via the trade or the investment channel. Policies should be designed to stabilize currency movements so as to reduce excessive exchange rate volatility. To that end, foreign reserve quality may have to be improved, targeted monetary policies may have to be put in place and export competitiveness has to be improved (Edwards, 1989; Bahmani Oskooee & Kara, 2003). To avoid currency fluctuation having a negative effect on the growth of the economy, a balanced exchange rate policy should be observed.

Reforming Industrial Policy for Sustainable Growth

The industrial production in Pakistan has the negative impact on the economic growth that reflects over the structural inefficiencies in the manufacturing sector. And this finding matches research on developing economies where inefficient industrial policies undermine economic growth (Rodrik, 2009; Szirmai, 2012). Modernizing industrial infrastructure, improving technology access and creating conducive value-added manufacturing would be beneficial. Innovation, entrepreneurship and skill development programs should also be encouraged by industrial policies and should enhance productivity that will make manufacturing sector a positive contributor to economic performance.

Optimizing Monetary Policy for Economic Growth

It is found that interest rates do not have a statistically significant impact on growth, which implies that traditional monetary policy tools are likely ineffective at moving short run real economic outcomes. Nevertheless, interest rates have an indirect influence on investment, credit growth, as well as inflation expectations (Bernanke and Blinder 1992, Mishkin 1996). Economic stabilization should be a more comprehensive task for policymakers in stabilizing

the economy, a task beyond interest rate adjustments but including interest rate adjustments along with fiscal policy, trade policy, and investment incentives for sustainable growth.

Limitations and Future Research Directions

Although this work has some value, there are some drawbacks. The small sample size may constrain the use of results due to the availability of data from 2008 until 2023. In such future research, the time horizon could be expanded further on the dataset, or quarterly or monthly data could be used for more granular trends in the economy. Moreover, such analyses at a more granular sectorial level would enable one to get better insights on how different industries react to changes in the price of oil and in renewable energy penetration.

Future analysis could further examine the moderating role by fiscal policy of energy price shocks effects, for example, government subsidies, tax incentives, or energy pricing policy. Cross country comparisons are another important area for future research since it would allow us to see whether the observed relationships exist along similar oil importing developing economies. The use of additional financial sector variables like foreign direct investment (FDI), stock market performance and credit growth can also help deepen the scope of this research in terms of providing an enhanced understanding of macroeconomic effects of energy price volatility.

Final Remarks

The results from this study are complementary to the increasing research on the macroeconomic consequences of oil price volatility and the relationship between renewable energy and macroeconomic stability. The results indicate that energy diversified, managed exchange rates, and industrial policy reforms serve as suitable policies for sustaining economic growth. However, in a country that is yet struggling with energy and economic challenges, a strategic and a well-coordinated policy approach is necessary for minimizing the external vulnerabilities and enhancing the long run economic resilience of the country.

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