Theoretical and Applied Economics
Volume XXXI (2024), No. 4(641), Winter, pp. 323-338

The impact of oil price shocks on economic growth in Algeria

Hafsa DIB
University of Ain Temouchent Belhadj Bouchaib, Algeria
hafsadib94@gmail.com

Abstract. *This research aims to quantify the impact of oil price shocks on Algeria's economic growth by employing the novel Dynamic Auto Regressive Distributed Lag (dynardl) approach in conjunction with the Regularized Least Square Kernel (KRLS) method, utilizing annual data spanning from 1970 to 2022.*

The findings indicate a notable positive influence of oil prices on economic growth, which is similarly observed with government expenditure and population growth. Conversely, the real effective exchange rate and the money supply are found to negatively impact economic growth. Further, the KRLS estimations lend robust support to the outcomes derived from the dynardl model. Analysis of counterfactual oil price shocks on GDP suggests that a positive shock of +10% in oil prices significantly boosts GDP over the long term, whereas a negative shock of -10% conversely results in a long-term decline in GDP.

Keywords: oil price shocks, economic growth, dynamic ARDL, Algeria.

JEL Classification: Q31, O4, C32, Q43, O55.

1. Introduction

The role of crude oil in the global economy is profound, and its price fluctuations present a significant area of concern for economists, notably recognized by Hamilton in 1983. Although much of the literature has focused on the United States, the largest oil importer, there is an increasing emphasis on the unique dynamics within oil-exporting nations. The economic repercussions of oil price shocks vary markedly between oil-exporting and importing countries (Yudong et al., (2013), p. 01).

Increases in oil prices, typically viewed as unfavourable for oil-importing nations, escalate production costs, negatively influencing production outputs and economic growth, while simultaneously shifting profits towards oil-exporting nations. Such price hikes are frequently accompanied by increased economic and financial instability, which can adversely affect investment and spending decisions across all nations, potentially leading to economic downturns (Raouf, (2021)). Conversely, oil-exporting countries benefit from rising oil prices, though the effects of price decreases are quite the opposite. (Berument et al. , (2010))

Oil's abundance in the Middle East and various developing countries means that any price fluctuations lead to significant economic shocks, positive or negative. Despite the potential benefits of high oil prices, their distribution is not uniform across Africa; Nigeria, Algeria, Libya, Angola, and Egypt constitute the top five oil producers, collectively contributing more than 80% of the continent’s output. (African Development Bank, (2007))

These oil-exporting countries heavily depend on oil revenues, which enhance their financial capacity to fund development initiatives. Consequently, oil price volatility critically influences their monetary and fiscal policies. In contrast, a decline in oil prices can precipitate severe budget deficits as governments struggle to adjust their expenditures swiftly (Abdelmoula & Abdelsalam, (2023)). The responses of oil-exporting countries to oil shocks are influenced by their political-economic structures, stages of economic development, levels of economic diversification, and the types of exchange rate regimes they employ. (Sinem Sonmez, (2016))

Algeria's economy is heavily reliant on the hydrocarbons sector; thus, any price fluctuations induce either positive or negative shocks. The revenues generated from this critical sector not only support but also enable the development and implementation of major projects that bolster the Algerian economy. This paper distinguishes itself from previous research by analyzing both the positive and negative impacts of oil price changes on economic growth.

Furthermore, it enhances the literature by employing an innovative autoregressive dynamic (ARDL) simulation, as outlined by Jordan and Phillips (2018), along with the kernel-based regularized least squares (KRLS) method. The subsequent sections of this paper are organized as follows: a review of the literature in Section 2, the model and data presentation in Section 3, estimation results in Section 4, and the conclusion in Section 5.

2. Literature review

The nexus between oil prices and GDP has been a focal point of economic research since the 1980s. (Hamilton, (1983)) was among the pioneers to deduce that spikes in oil prices are typically followed by reductions in GNP growth, a finding that has been corroborated by subsequent studies, such as those by (Hooker, (1996)), who also observed that increases in oil prices adversely affect the gross domestic product.

The dynamics of oil prices and economic growth have been extensively documented by scholars like Golub (1983), Darby (1982), and Hooker (1999), who noted that oil price volatility impacts growth in both importing and exporting nations. Specifically, an increase in oil prices leads to a decrease in GDP for oil-importing countries due to heightened import expenditures and a depreciating exchange rate, whereas a decrease in oil prices causes the exchange rate to appreciate. (Akinsola & Odhiambo, (2020))

Notably, abrupt changes in oil prices, either increases or decreases, can transiently diminish aggregate output as they introduce business investment delays by escalating uncertainty and necessitating costly sectoral resource reallocations. (Guo & Kliesen, (2005)) Recent estimations by the International Energy Agency (IEA) suggest that a $10 increase in oil prices could reduce global GDP by 0.5%, resulting in losses amounting to $225 billion over several years. (Aarón & Nabiyev, (2009))

Moreover, studies indicate that hikes in oil prices negatively impact macroeconomic activities in both oil-importing and exporting countries through various supply-side and demand-side channels, affecting trade, unemployment, investment, interest rates, and inflation. (Reneé van et al., (2019))

Contrarily, (Raouf, (2021)) posits that an increase in oil prices for oil-exporting countries typically enhances net exports and government revenues, thereby boosting the country's growth rate. (Bjornland, (2009)) identifies that although higher oil prices benefit oil-producing countries through positive income and wealth effects, they simultaneously exert a negative trade effect. Specifically, while higher oil prices represent an immediate wealth transfer from oil importers to oil exporters, they also negatively affect oil-exporting countries by diminishing trade volumes. This reduction occurs as oil-importing countries decrease their demand for oil and other goods and services from oil-exporting nations, which can stifle economic stimulation in countries with large export sectors.

(Akinlo & Apanisile, (2015)) analyzed the effects of oil price volatility on economic growth in 20 sub-Saharan African countries from 1986 to 2012. Their study, employing panel data, reveals that oil price volatility has a significant positive impact on the economic growth of oil-exporting countries, but an insignificant positive impact on non-oil-producing countries.

Further elaborating on regional dynamics (Abdelmoula & Abdelsalam, (2023)) investigate the profound impacts of crude oil price fluctuations and volatility on economic growth within the Middle East and North Africa (MENA) region, focusing on the asymmetric and dynamic relationships between oil prices and economic growth. Their analysis, differentiated by oil-exporting and oil-importing countries within MENA, employs a panel quantile regression approach. They discover that the effects of oil price changes and volatility are diametrically opposed for oil-exporting versus oil-importing nations: positive impacts from oil price changes but negative from volatility for the former, and negative impacts from oil price changes but positive from volatility for the latter. Moreover, they explore how institutional quality modulates the effects of oil price fluctuations on economic growth, finding that stronger institutional frameworks tend to mitigate the adverse impacts of oil price changes on economic growth.

(Berument et al., (2010)) analyzed the effects of oil price shocks on the economic outputs of selected Middle East and North Africa (MENA) countries, categorizing them as either net exporters or importers. Their findings indicate that oil price increases significantly enhance the economic outputs of Algeria, Iran, Iraq, Kuwait, Libya, Oman, Qatar, Syria, and the United Arab Emirates. However, the impacts on Bahrain, Djibouti, Egypt, Jordan, Morocco, and Tunisia were not statistically significant.

In another study, (Ftiti et al., (2016)) investigated the dynamics between oil prices and economic growth in specific OPEC countries (United Arab Emirates, Kuwait, Saudi Arabia, and Venezuela) over the period from September 3, 2000, to December 3, 2010. Utilizing the cointegration procedure developed by Engle and Granger (1987), they found that oil price shocks during global business cycle fluctuations or financial turmoil significantly influence the relationship between oil prices and economic growth in these countries. They noted that medium-term effects are largely driven by demand-side oil price shocks, such as those from a housing market boom, Chinese economic growth, or the global financial crisis, which led to a significantly higher correlation. Conversely, short-term effects were predominantly caused by precautionary demand-side shocks, such as the second Iraq war or terrorist attacks, which resulted in a lower coherence.

3. Model and data

In this study, we utilize time series data from 1970 to 2022 to explore the impact of oil price shocks on the economic growth of Algeria. The data analysis is based on the following model equation:

$$\mathrm{LnGDP_t} = \alpha_0 + \alpha_1 \mathrm{LnOILP_t} + \alpha_2 \mathrm{LnGOV_t} + \alpha_3 \mathrm{LnREER_t} + \alpha_4 \mathrm{LnM2_t} + \alpha_5 \mathrm{LnPOP_t} + \varepsilon_t \ldots\ldots \quad (1)$$

Where the variable (GDP) denotes the Gross Domestic Product, (OILP) Oil Prices, (GOV) Government Spending, (REER) Real Effective Exchange Rate, (M2) Money Supply, and (POP) denotes the Total Population. α_0 is the constant, $\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5$ are parameters to estimate, ε_t is an error term. t represent time. All variables are in natural logarithm. Table 1 shows the descriptive statistics for the study variables.

Table 1. *Descriptive statistics for study variables*

Variable	Mean	Std. dev.	Min	Max
Ln GDP	14.16668	2.205459	10.08629	17.12059
Ln OILP	3.228852	1.028519	0.1823216	4.695468
Ln GOV	13.048558	2.30805	8.678632	15.96837
Ln REER	5.140988	0.5597096	4.526131	6.097556
Ln M2	27.49824	2.278374	23.29397	30.76457
Ln POP	17.12536	0.3314333	16.48724	17.63331

Sources: STATA program outputs.

The Autoregressive Distributed Lag (ARDL) model is utilized to investigate the dynamic relationships between oil price shocks and economic growth. The ARDL approach is specified as follows:

$$\Delta \mathrm{LnGDP}_t = \alpha_0 + \sum_{i=1}^{p} \beta_0 \Delta \mathrm{LnGDP}_{t-1} + \sum_{j=0}^{q1} \beta_1 \Delta \mathrm{LnOILP}_{t-j} + \sum_{j=0}^{q2} \beta_2 \Delta \mathrm{LnGOV}_{t-j} + \sum_{j=0}^{q3} \beta_3 \Delta \mathrm{LnREER}_{t-j} + \sum_{j=0}^{q4} \beta_4 \Delta \mathrm{LnM2}_{t-j} + \sum_{j=0}^{q5} \beta_5 \Delta \mathrm{LnPOP}_{t-j} + \theta_0 \mathrm{LnGDP}_{t-1} + \theta_1 \mathrm{LnOILP}_{t-1} + \theta_2 \mathrm{LnGOV}_{t-1} + \theta_3 \mathrm{LnREER}_{t-1} + \theta_4 \mathrm{LnM2}_{t-1} + \theta_5 \mathrm{LnPOP}_{t-1} + e_t \ldots\ldots \quad (2)$$

Where #Δ difference operator, α_0 is the constant, $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4,$ and β_5 are the short term coefficients, $\theta_0, \theta_1, \theta_2, \theta_3, \theta_4,$ and θ_5 are the long term coefficients, $p, q_1, q_2, q_3, q_4, q_5$ is the optimal lag length, Ln GDP, Ln OILP, Ln GOV, Ln REER, Ln M2, Ln POP are the defined variables previously.

Dynamic autoregressive distributed lag simulations model:

(Jordan & Philips, (2018)) contend that the ARDL model encompasses a complex lag structure, which integrates not only lags but also contemporaneous values, first differences, and lagged first differences of the independent variable within the model's specifications. They observe that while interpreting both short- and long-term effects may seem straightforward in an ARDL (1,1) model, the complexity increases significantly as the model's specification expands, complicating the interpretation and comprehension of the effects of changes in the independent variables over short and long durations.

To address these challenges, (Jordan & Philips, (2018)) introduced the dynardl model, a robust program engineered for the dynamic simulation and visualization of various autoregressive distributed lag models. Essentially, dynardl is a sophisticated command tool that estimates, simulates, stores, and automatically generates plots of substantively interesting predictions derived from ARDL models. Furthermore, according to (Jordan & Philips, (2018)) the dynardl simulation equation is articulated as follows:

$$\Delta \mathrm{LnGDP}_t = \alpha_0 + \theta_0 \mathrm{LnGDP}_{t-1} + \beta_1 \Delta \mathrm{LnOILP}_t + \theta_1 \mathrm{LnOILP}_{t-1} + \beta_2 \mathrm{LnGOV}_t + \theta_2 \mathrm{LnGOV}_{t-1} + \beta_3 \Delta \mathrm{LnREER}_t + \theta_3 \mathrm{LnREER}_{t-1} + \beta_4 \Delta \mathrm{LnM2}_t + \theta_4 \mathrm{LnM2}_{t-1} + \theta_5 \mathrm{LnPOP}_{t-1} + e_t \ldots\ldots \quad (3)$$

Where α_0 represents the constant, θ represents the long-term, β represents the short-term, e_t the error term.

Kernel-based regularized least squares (KRLS)

The fundamental methodology of KRLS has been a staple in the machine learning domain since the 1990s, historically recognized under various designations such as regularized least squares (Rifkin & Lippert, (2007)) and regularization networks (Evgeniou et al., (2000)).

(Hainmueller & Hazlett, (2014)) are credited with providing the inaugural comprehensive delineation of the KRLS methodology and establishing its statistical properties through simulations and empirical data analysis.

Additionally, (Ferwerda et al., (2017), p. 03) regard KRLS as a machine learning method adept at addressing regression and classification dilemmas without depending on the assumptions of linearity or additivity. This model serves as a versatile tool, positioning itself as an intermediary solution between the more traditional generalized linear models (GLMs) that many researchers utilize and the broader spectrum of machine learning techniques. (Hainmueller & Hazlett, (2014), pp. p143-144)

4. Estimation model and results

Unit root test

Prior to estimating the model, it is imperative to assess the stationarity of the variables under consideration to confirm the suitability of applying the dynamic ARDL approach. Specifically, the dependent variable should be integrated at the first difference and must not be of an order higher than one. For this analysis, key unit root tests employed include the Augmented Dickey-Fuller (1981) test and the Phillips-Perron (1988) test.

Table 2. *Unit root tests*

	Level		First difference	
	ADF	PP	ADF	PP
Ln GDP	-2.728 (0.0694)	-2.577 (0.0979)	-5.218 (0.0000)	-5.245 (0.0000)
Ln OILP	-2.899 (0.0455)	-2.945 (0.0404)	-6.545 (0.0000)	-6.523 (0.0000)
Ln GOV	-2.752 (0.0655)	-2.506 (0.1141)	-5.221 (0.0000)	-5.235 (0.0000)
Ln REER	-0.823 (0.8122)	-0.955 (0.7693)	-5.001 (0.0000)	-4.942 (0.0000)
Ln M2	-3.166 (0.0220)	-2.922 (0.0428)	-5.376 (0.0000)	-5.479 (0.0000)
Ln POP	-8.283 (0.0000)	-4.333 (0.0004)	-0.717 (0.8423)	-0.979 (0.7607)

Sources: STATA program outputs.

The results from **Table 2** indicate that all the variables are integrated of order I (1), except for Ln OILP, Ln POP, and Ln M2, which are found to be stationary at level I (0). Consequently, the dynamic ARDL model is appropriate for examining the impacts of oil price shocks on economic growth.

ARDL estimation

Given that no variable is integrated of the second order, we proceed with cointegration analysis utilizing the bounds test. Initial steps include determining the optimal lag length for the ARDL model based on the Akaike Information Criterion (AIC), Schwarz Bayesian Information Criterion (SBIC), and Hannan-Quinn Criterion (HQIC).

Table 3. *Criteria for lag length*

Lag	AIC	HQIC	SBIC
0	-0.334928	-0.24808	-0.107654
1	-18.8034	-18.1955	-17.2125
2	-22.3793*	-21.2503*	-19.4248

Sources: STATA program outputs.

Based on the criteria detailed in **Table 3**, an optimal lag length of 2 is indicated, marked by asterisks. With the optimal lag established and all variables confirmed stationary at the first difference or at level, we apply the bounds test proposed by Pesaran et al., (2001). This critical test computes the F-statistic to verify the existence of a long-term relationship among the studied variables, reinforcing the foundation for dynamic ARDL model application.

Table 4. *Result of the Bounds test*

F= 43.326							
10%		5%		1%		P-value	
I (0)	I (1)	I (0)	I (1)	I (0)	I (1)	I (0)	I (1)
1.947	3.153	2.353	3.696	3.300	4.937	0.000	0.000

Sources: STATA program outputs.

From **Table 4**, we observe that the F-statistic values are greater than the critical values at the upper bounds for significance levels of 10%, 5%, and 1%. This suggests a long-term equilibrium relationship between the studied variables.

Figure 1 illustrates the plot of the estimated parameters in both the long-run and short-run, following the determination of the optimal lag length based on the lowest values from the Akaike and Schwarz criteria, within the context of the general ARDL model. It has been demonstrated that the best model configuration is ARDL (1,1,0,1,0,0). **Table 5** presents these estimation results.

The ARDL results revealed a significant positive impact of oil prices on GDP in both the short and long term. Specifically, the coefficient for oil price is significantly positive at the 5% level. The short-term impact was estimated at 0.1980, indicating that the elasticity of oil price to GDP is estimated at 19.80%. Meanwhile, the long-term coefficient was 0.2904, signifying a robust positive long-term impact of oil prices on GDP.

There is a pronounced positive impact of government spending on GDP in both time frames. Government spending was significantly positive at the 5% level in both the short and long term, where the impacts were estimated at 0.2160 and 0.9320, respectively. This suggests that the elasticity of government spending to GDP is 21.60% in the short term and 93.20% in the long term.

Conversely, the real effective exchange rate has a significantly negative impact on GDP at the 5% level for both the short and long term. The impacts are estimated at -0.4610 in the short-term and -0.6659 in the long term, indicating an inverse relationship between the real effective exchange rate and economic growth. This results in a GDP decrease of 46.10% in the short run and 66.59% in the long run.

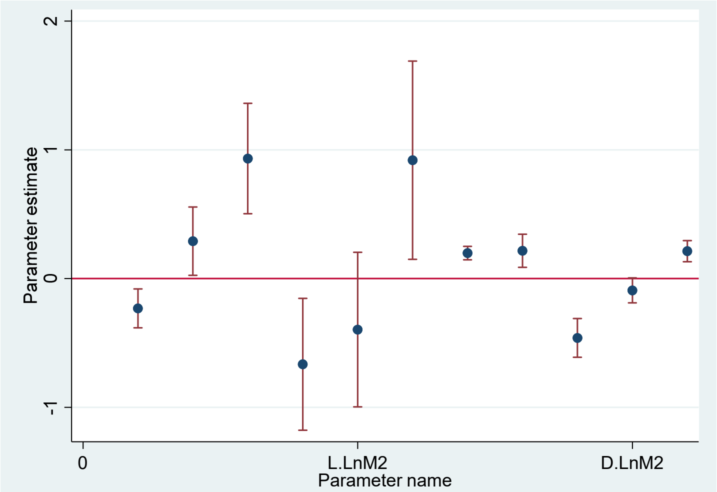
The effect of money supply on GDP is negative and insignificant at the 5% significance level for both the short and long term. The effects are estimated at -0.9180 in the short term and -0.3963 in the long term, suggesting that the elasticity of the money supply to GDP is -91.80% in the short term and -39.63% in the long term.

Finally, the total population displayed a significantly positive effect on GDP at the 5% level for both the short and long term, with impacts estimated at 0.2130 and 0.9196 respectively. This indicates that the elasticity of population to GDP is 21.30% in the short term and 91.96% in the long term.

The results of the error correction model are particularly revealing, with the error correction term ($\mathrm{ECM}_{t-1} = -0.2316$) which is statistically significant at the 5% level. This underscores the existence of a long-run equilibrium relationship among the variables of the estimated model, indicating that approximately 23.16% of deviations from equilibrium are corrected each period in the long run.

Furthermore, the coefficient of determination, $\mathrm{R}^2 = 0.9210$, suggesting a strong explanatory power of the model. This implies that 92.10% of the variability in Gross Domestic Product (GDP) is accounted for by the independent variables included in the model, with the remaining 7.90% attributable to factors outside the model's scope.

Figure 1. *Parameter estimates of the ARDL model*



Notes: black (●) is the estimate in a log-log model, the red line is the reference line, and the red spike indicates the lower 95% and upper 95% confidence intervals.
Sources: STATA program outputs.

Table 5. *Estimation results of the ARDL model*

ARDL (1,1,0,1,0,0) Number of Ob = 52 Root MSE = 0.0527

R-squared = 0.9210 Adj R-squared = 0.9066

	EQN	Variable	Coefficient	Std. Err	T	P>|t|	[95%Conf.Interval]	
	ECT	ECT_{t-1}	-0.2316	0.7516	-3.08	0.004	-0.3831	-0.0801
Lang run								
	Long run	Ln OILP	0.2904	0.1315	2.21	0.032	0.2540	0.5555
		Ln GOV	0.9320	0.2127	4.38	0.000	0.5039	1.3612
		Ln REER	-0.6659	0.2541	-2.62	0.012	-1.1781	-0.1537
		Ln M2	-0.3963	0.2976	-1.33	0.190	-0.9963	0.2035
		Ln POP	0.9196	0.3819	2.41	0.020	0.1498	1.6894
Short run								
	Short run	ΔLn OILP	0.1980	0.2607	7.59	0.000	0.1451	0.2505
		ΔLn GOV	0.2160	0.6365	3.39	0.001	0.8772	0.3442
		ΔLnREER	-0.4610	0.7458	-6.18	0.000	-0.6113	-0.3107
		ΔLn M2	-0.9180	0.4829	-1.90	0.064	-0.1891	0.0055
		ΔLn POP	0.2130	0.0404	5.26	0.000	0.1314	0.2945

Sources: STATA program outputs.

To ensure the reliability of the ARDL model (1,1,0,1,0,0), diagnostics tests were conducted. The Breusch-Godfrey LM test for autocorrelation, considering up to four lag periods as detailed in **Table 6,** supports the null hypothesis of no serial correlation at the 5% significance level, affirming the model's freedom from autocorrelation issues.

Table 6. *Breusch-Godfrey LM test for autocorrelation*

Lags (p)	F	Df	Prob>F
1	0.559	(1, 43)	0.4589
2	0.297	(2, 42)	0.7446
3	1.195	(3, 41)	0.3234
4	0.944	(4, 40)	0.4484
H0: no serial correlation			

Sources: STATA program outputs.

Further tests for heteroskedasticity were performed using Cameron & Trivedi's decomposition of IM test. The results, as shown in Table 7, indicate that the null hypothesis of homoskedasticity stands firm at the 5% significance level, confirming that the residuals are homoscedastic, thus stable across the model's predictions.

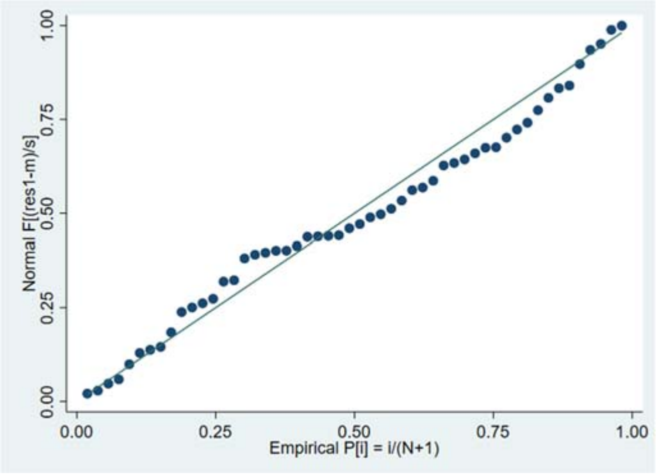
Table 7. *Cameron & Trivedi's decomposition of IM-test*

Source	Chi2	Df	P
Heteroskedasticity	47.98	44	0.3146
Skewness	9.43	8	0.3076
Kurtosis	0.91	1	0.3403
Total	58.32	53	0.2863

Sources: STATA program outputs.

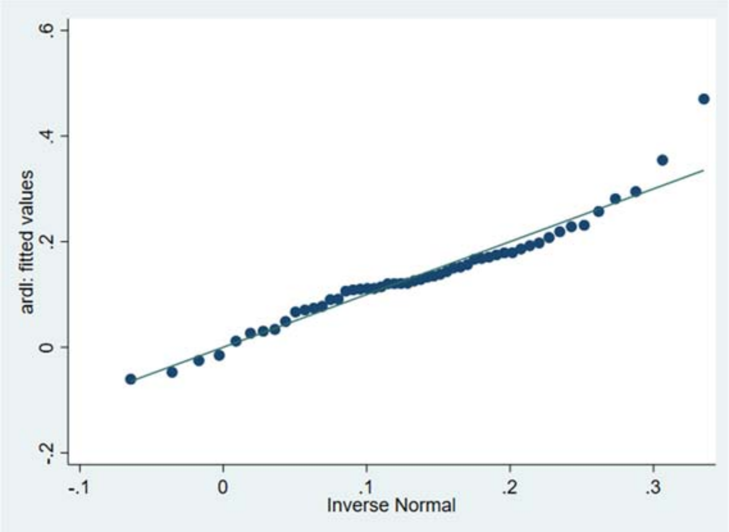
The assessment of residual distribution was meticulously carried out through plots against the standard normal distribution. **Figure 2** reveals that the residuals are normally distributed, which is further corroborated by **Figure 3** showing the alignment of residual quantities with those of the normal distribution. Thus, these findings (**Figures 2 & 3**) conclusively suggest that the residuals in the estimated model adhere closely to a normal distribution.

Figure 2. *Standardized normal distribution*



Sources: STATA program outputs.

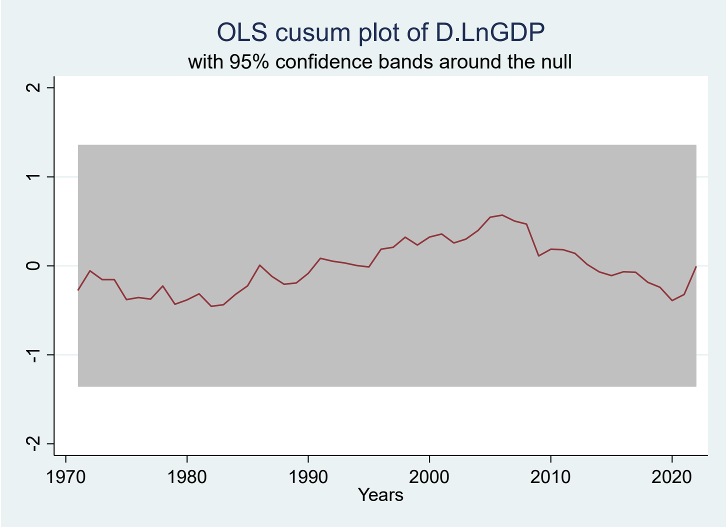
Figure 3. *Quantiles of residuals against quantiles of normal distribution*



Sources: STATA program outputs.

To ascertain the stability of the estimated model over the period of study, the cumulative sum (CUSUM) test was employed. Figure 4 displays the results, clearly indicating that the CUSUM plot remains within the 95% confidence interval, affirming the stability of the model's parameters over time.

Figure 4. *Cumulative sum test using OLS CUSUM plot for parameter stability*



Sources: STATA program outputs.

Results **of dynamic autoregressive distributed lag simulations (dynardl)**

The Dynamic ARDL simulation technique was utilized to explore the impact of oil shocks on various macroeconomic variables, analyzing both short-term and long-term effects on economic growth. Table 8 provides the outcomes from these dynardl simulations, and **Figure 5** visually represents the parameter estimates.

Table 8. *Estimates of dynamic simulated ARDL model*

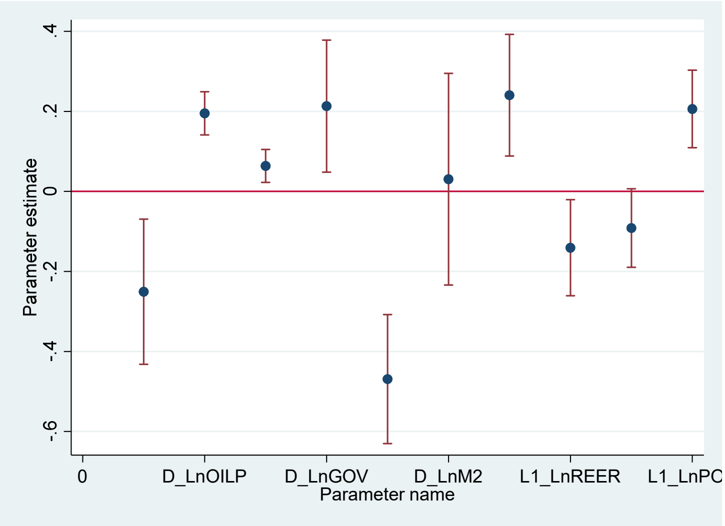
R-squared = 0.9230 Adj R-squared = 0.9046

Prob >F = 0.0000 Simulations = 5000

Variables	Coefficient	Std. Err	t-statistic	Probability	[95% Confidence interval]	
Ln OILP	0.0635	0.0204	3.11	0.003	0.0223	0.1048
ΔLn OILP	0.1950	0.0267	7.30	0.000	0.1411	0.2489
Ln GOV	0.2403	0.0752	3.19	0.003	0.0885	0.3922
ΔLn GOV	0.2131	0.0817	2.61	0.013	0.0481	0.378
Ln REER	-0.1409	0.0594	-2.37	0.022	-0.2609	-0.0208
ΔLnREER	-0.4689	0.0798	-5.87	0.000	-0.6301	-0.3077
Ln M2	-0.0916	0.0486	-1.88	0.067	-0.1897	0.0065
ΔLn M2	0.0304	0.1310	0.23	0.817	-0.2339	0.2949
Ln POP	0.2059	0.0479	4.29	0.000	0.1091	0.3027
ECT_{t-1}	-0.2509	0.0899	-2.79	0.008	-0.4322	-0.0693

Sources: STATA program outputs.

Figure 5. *Parameter estimates for the dynamic ARDL simulation*



Notes: black (●) is the estimate in a log-log model, the red line is the reference line, and the red spike indicates the lower 95% and upper 95% confidence intervals.
Sources: STATA program outputs.

The outcomes from the dynamic ARDL simulations, as delineated in **Table 8**, indicate that oil prices have a significant and positive effect on economic growth over the long term, evidenced by a P-value of 0.003, which is below the 0.05 threshold, confirming statistical significance at the 5% level. This analysis reveals that a 1% increase in oil prices corresponds to a 6.35% increase in GDP in Algeria.

Moreover, in the short term, the impact of oil prices remains robustly positive, with a P-value of 0.000, suggesting that a 1% increase in oil prices results in a 19.50% boost in GDP. These results align well with economic theories and the practical realities in Algeria, where oil is a critical component of the national revenue, underscoring that hikes in oil prices are beneficial for the country's economic growth rates.

Regarding government spending, it also exhibits a significantly positive effect on GDP, consistent over both short and long terms with P-values of 0.013, indicating that a 1% increase in government expenditure leads to GDP increases of 24.03% in the long term and 21.31% in the short term. This relationship highlights the pivotal role of government spending in stimulating economic growth in Algeria.

The coefficients for the real effective exchange rate are negative and statistically significant at the 5% level in both the long and short terms, pointing to an inverse relationship with GDP. Specifically, a 1% rise in the real effective exchange rate is associated with a 14.09% decrease in GDP in the long term and a more pronounced 46.89% decrease in the short term. This result suggests that a devaluation of the exchange rate exerts a contractionary effect on GDP, impacting economic activities negatively.

For the money supply, the coefficient is negatively insignificant at the 5% significance level (P-value = 0.067) in the long term, indicating a 9.16% decrease in GDP with a 1% increase in money supply, a finding that diverges from traditional economic expectations.

Conversely, in the short term, the effect of money supply on GDP is insignificantly positive (P-value = 0.817), implying a 3.04% increase in GDP with a 1% hike in the money supply. This could reflect the initial positive impacts of Algeria's substantial monetary issuance to fund development programs, though this effect appears to wane over time, eventually reversing into a negative influence in the long run.

Finally, the total population parameter shows a positive and significant impact at the 5% level (P-value = 0.000) in the long term, with a 1% increase in population contributing to a 20.59% rise in GDP. This finding validates that population growth, contrary to being a hindrance, actually supports economic expansion in Algeria.

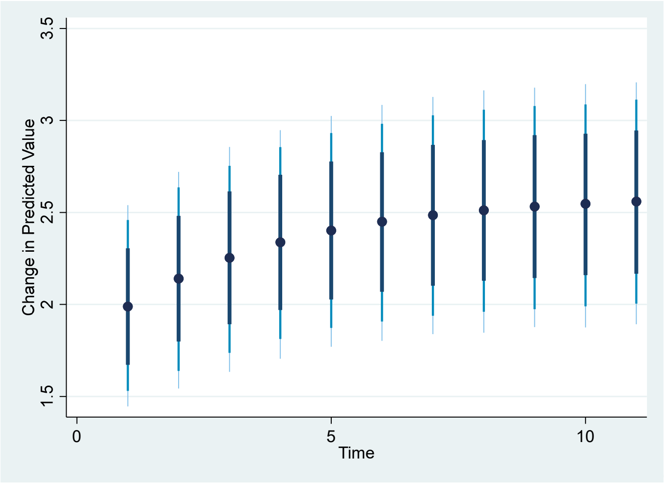
The negative and statistically significant value of the error correction term (ECT_{t-1}) = -0.2509) at the 5% level underscores the presence of a long-term equilibrium relationship between the variables in the estimated model. This finding highlights that deviations from the equilibrium, particularly shocks in oil prices, impact GDP significantly.

Such deviations are swiftly adjusted, with approximately 25.09% of short-term discrepancies being corrected annually, moving towards the long-term equilibrium path. This dynamic underline the strong explanatory power of the independent variables within the model, evidenced by a high R-squared value of 0.9230.

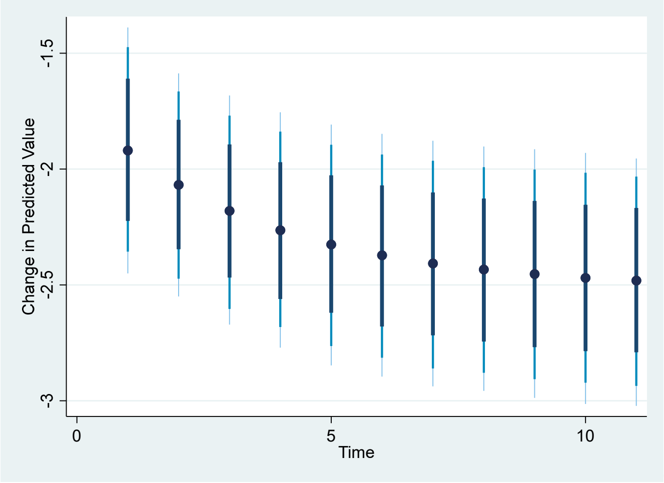
The statistical significance of the model is further confirmed by the P-value associated with the F-statistic, which indicates a robust significance at the 5% level. This attests to the overall significance of the estimated model in capturing the dynamics between the studied variables.

An additional analysis involves estimating the impact of counter-shocks in oil prices on GDP through dynamic ARDL simulations, setting the number of simulations at 5000. This approach allows us to explore the GDP's response to both positive and negative alterations of 10% in oil price shocks.

Figure 6. *Representation of the counter-shock of oil prices on GDP using a dynamic ARDL simulations*



(A)



(B)

Notes: The graphs show the ±10% change in the oil price shock and its impact on GDP, the black dot (•) shows the average prediction value while the dark blue and light blue lines show the confidence intervals at 75, 90, and 95% respectively.

Sources: STATA program outputs.

These visualizations (Figure 6A and 6B) succinctly encapsulate the impulse response functions, affirming the prolonged influence of oil price fluctuations on Algeria's GDP. The differential responses observed in the scenarios of positive and negative shocks provide crucial insights into the asymmetric impact of oil price volatility on economic growth, highlighting the critical nature of oil prices as a driving force in Algeria's economic landscape.

Result of Kernel-based regularized least squares

To examine the causal relationship between oil price shocks and GDP, we utilized the Kernel-based Regularized Least Squares (KRLS) method. This approach allowed us to estimate the pointwise derivatives, offering insights into the pointwise marginal effects of the variables on GDP.

Table 9 encapsulates these estimates, including the average pointwise derivatives from the KRLS estimator and the estimates at the 25th, 50th, and 75th quartiles of the distribution of these effects. The model demonstrates a robust fit with an R-squared value of 0.9981, indicating that 99.81% of the variation in GDP is explained by the dependent variables. The P-values for each parameter are statistically significant at the 5% level, confirming their causal impacts, with the exception of the real effective exchange rate.

The average marginal effects estimated are as follows: oil prices at 0.1472, government spending at 0.1639, the real effective exchange rate at -0.0070, money supply at 1.1814, and total population at 1.7753. The KRLS method also allows for an examination of heterogeneity in effects by analyzing the marginal distribution of pointwise derivatives, revealing that the marginal effects of these variables show minimal variation in the first quartile but increase in the second and third quartiles. Notably, the real effective exchange rate displays a differing sign.

Table 9. *Pointwise derivatives using KRLS*

Lambda = 0.1248 Sigma = 5 $R^2 = 0.9981$

Tolerance = 0.053 Eff. df = 10.82 Looloss = 0.4544

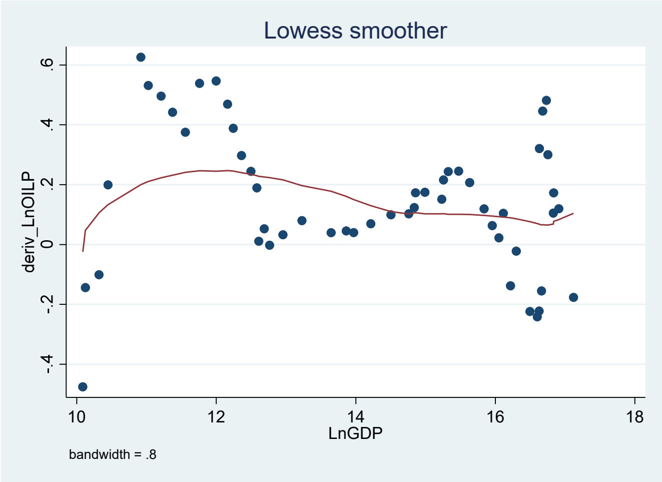
Ln GDP	Avg.	SE	T	P>|t|	P25	P50	P75
Ln OILP	0.147215	0.030252	4.866	0.000	0.032633	0.119659	0.29741
Ln GOV	0.163973	0.013314	12.316	0.000	0.077823	0.165754	0.254394
LnREER	-0.00708	0.062155	-0.114	0.910	-0.16653	0.016548	0.143767
Ln M2	0.181446	0.01056	17.183	0.000	0.088393	0.200151	0.264606
Ln POP	1.77539	0.77691	22.852	0.000	0.964301	2.17775	2.5285

Notes: Where Avg. is the average marginal effect, SE is the standard error, P-25, P-50, and P-75 represent 25th, 50th, and 75th percentile.

Sources: STATA program outputs.

To further understand the long-run effects of oil price shocks on GDP, we analyze the pointwise derivative of oil price shocks against GDP, capturing the marginal effects. Figure 7 illustrates this relationship. It shows that a positive shock in oil prices leads to an increase in GDP, whereas a negative shock results in a decrease. This visual representation underscores the sensitivity of GDP to fluctuations in oil prices, providing a clear demonstration of the significant impact of oil price volatility on economic performance.

Figure 7. *Representation of the pointwise marginal effect of oil prices on GDP*



Sources: STATA program outputs.

5. Conclusion

In this paper, we explored the impact of oil price shocks on economic growth in Algeria during the period 1790-2022, focusing on the long-term effects using innovative estimation techniques such as Kernel-based Regularized Least Squares (KRLS) and Dynamic ARDL Simulations (dynardl). The findings from both ARDL and dynamic ARDL models reveal a cointegrating relationship among the study variables. The results confirm that increases in oil prices positively influence economic growth, while decreases in oil prices have the opposite effect.

References

Aarón, G. and Nabiyev, S., 2009 (January). Oil Price Fluctuations and its effect on GDP Growth. *JÖnkÖping international business school.*

Abdelmoula, M. and Abdelsalam, M., 2023. Oil price fluctuations and economic growth: the case of MENA countries. *Review of Economics and Political Science, Vol. 8* (No. 5), pp. 353-379. <doi:http://dx.doi.org/10.1108/REPS-12-2019-0162>

African Development Bank, 2007 (December). The Impact of High Oil Prices on African Economies. *Economic Research Working Paper Series* (No 93).

Akinsola , M. and Odhiambo, N., 2020. Oil price and economic growth of oil-importing countries: a review of international literature. (pp. 129-151, Ed.) *Applied Econometrics and International Development, 20*(1).

Akinlo, T. and Apanisile, O., 2015. The Impact of Volatility of Oil Price on the Economic Growth in Sub-Saharan Africa. *British Journal of Economics, Management & Trade, 5*(3), pp: 338-349. <doi:DOI: 10.9734/BJEMT/2015/12921>

Berument, H., Ceylan, N. and Dogan, N., 2010. The impact of oil price shocks on the economic growth of selected MENA Countries. *Berument M. Hakan, Nildag Basak Ceylan & Nukhet Dogan. The Energy Journal*. <doi:DOI: 10.5547/ISSN0195-6574-EJ-Vol31-No1-7>

Bjornland, H., 2009. May. Oil price shocks and stock market booms in an oil exporting country. *Journal of Political Economy,* Vol. 56 (No. 2). <doi:https://doi.org/10.1111/j.1467-9485. 2009.00482.x>

Evgeniou, T., Pontil, M. and Poggio, T., 2000. Regularization Networks and Support Vector Machines. *Advances in Computational Mathematics,* Vol. 13, pp: 1-50. <doi:10.1023/a: 1018946025316>

Ferwerda, J., Hainmueller, J. and Hazlett, C., 2017 (July). Kernel-Based Regularized Least Squares in R (KRLS) and Stata (krls). *Journal of Statistical Software,* Volume 79 (Issue 3). <doi:http://dx.doi.org/10.18637/jss.v079.i03>

Ftiti, Z., Guesmi, K., Teulon, F. and Chouachi, S., 2016 (January/February). Relationship between crude oil prices and economic growth in selected OPEC Countries. *The Journal of Applied Business Research,* Volume 32 (Number 1).

Guo, H. and Kliesen, K., 2005 (November/December). Oil Price Volatility and U.S. Macroeconomic Activity. *Federal Reserve Bank of St. Louis Review,* Vol. 87 (No. 6), Pp. 669-683.

Hamilton, J., 1983. (Apr). Oil and the Macroeconomy since World War II. *The Journal of Political Economy,* Vol. 91 (No. 2), pp. 228-248.

Hainmueller, J. and Hazlett, C., 2014. Kernel Regularized Least Squares: Reducing Misspecification Bias with a Flexible and Interpretable Machine Learning Approach. *Political Analysis,* Vol. 22, pp: 143-168. <doi:10.1093/pan/mpt019>

Hooker, M., 1996. What happened to the oil price-macroeconomy relationship? *Journal of Monetary Economics, (38)*, pp. 195-213. <doi:https://doi.org/10.1016/S0304-3932(96)01281-0>

Jordan, S. and Philips, A., 2018 (December 7). Cointegration Testing and Dynamic Simulations of Autoregressive Distributed Lag Models. *The Stata Journal Promoting communications on statistics and Stata*. <doi:DOI: 10.1177/1536867X1801800409>

Reneé van, E., Difeto, M., Rangan, G. and Wohar, M., 2019. Oil Price Volatility and Economic Growth: Evidence from Advanced OECD Countries using over One Century of Data. *Applied Energy*, pp: 612-621. <doi:https://doi.org/10.1016/j.apenergy.2018.10.049>

Rifkin, R. and Lippert, R., 2007 (May 1). Notes on Regularized Least Squares. *Computer Science and Artificial Intelligence Laboratory Technical Report.*

Raouf, E., 2021. Oil Prices Shocks and Government Expenditure. *International Journal of Energy Economics and Policy, (11)*((5)), pp. 78-84. <doi:DOI: https://doi.org/10.32479/ijeep.11172>

Sinem Sonmez., 2016 (May). The Macroeconomic Response to Oil Price Shocks from 1970-2013.

Yudong, W., Chongfeng, W. and Li, Y., 2013. Oil price shocks and stock market activities: Evidence from oil-importing and oil-exporting countries. *Journal of Comparative Economics, 41*, pp. 1220-1239. <doi:http://dx.doi.org/10.1016/j.jce.2012.12.004>