

Foreign Direct Investment, Public Expenditure, and Real Economic Output in Algeria: An ARDL Analysis, 1990–2023

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Abstract

This study aims to examine the relationship between foreign direct investment, public expenditure, and real economic output in Algeria over the period 1990–2023. Using annual time-series data, the study employs the Autoregressive Distributed Lag (ARDL) approach and its associated Error Correction Model (ARDL-ECM) to examine the short-run and long-run relationships among the variables. The results provide evidence of a long-run equilibrium relationship among real GDP, foreign direct investment, and public expenditure. The findings also indicate a positive and statistically significant relationship between public expenditure and real economic output in both the short run and the long run, whereas the relationship between foreign direct investment and real economic output is not statistically significant over the study period, the error-correction coefficient indicates the presence of a clear adjustment mechanism toward the long-run equilibrium following short-run deviations. Overall, the findings highlight the relevance of public expenditure in explaining variations in real economic output in Algeria, while suggesting that the relationship between foreign direct investment and domestic output may be influenced by the composition of FDI and its degree of integration into domestic productive activity within an economy that remains highly dependent on the hydrocarbon sector.

Keywords: Foreign Direct Investment; Public Expenditure; Real Economic Output; Real GDP; ARDL; Error Correction Model; Algeria.

Introduction

Achieving sustained improvements in economic performance remains a major challenge for developing economies, particularly those characterized by a high degree of dependence on natural resources and exposure to fluctuations in external markets. Economic performance in such economies depends not only on the expansion of real output but also on the ability to diversify the sources of economic activity, mobilize financial and investment resources, enhance productivity,

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and strengthen the productive base against external shocks. Within this context, foreign direct investment and public expenditure occupy an important place in discussions of the factors associated with economic performance, although their relationships with real output may vary according to the structure of the economy, the quality of institutions, the efficiency of resource allocation, and the sectors receiving investment and public spending.

Foreign direct investment is particularly relevant to developing economies because it can provide external financing, contribute to capital formation, facilitate technology and knowledge transfer, and strengthen integration into international production and value chains. However the presence of foreign capital does not necessarily translate into higher domestic output. Its potential contribution depends, among other factors, on the extent to which foreign investments are integrated into the domestic economy, the sectors in which they are concentrated, and their ability to establish linkages with local firms. The potential benefits of FDI may also be influenced by human capital, infrastructure, and the institutional environment. The relationship between FDI and real economic output is thus an empirical issue that needs to be examined in the specific economic and institutional context of each country.

Public expenditure meanwhile represents one of the main instruments through which the state influences economic activity, its role may operate through expenditure on infrastructure, public services, education and training, public investment, and other forms of government spending, public expenditure may support the expansion of real output when it contributes to physical and human capital formation and improves productivity ; its contribution may be more limited when expenditure is characterized by inefficient allocation, or when a large share is directed toward current expenditure with relatively limited productive effects. The relationship between public expenditure and real economic output therefore depends not only on the volume of spending but also on its composition, allocation, and efficiency.

Algeria provides a particularly relevant context for examining these relationships because of the rentier characteristics of its economy, its strong dependence on hydrocarbon revenues, and the economic and fiscal policy transformations it has experienced over the past three decades. These transformations have been accompanied by changes in public expenditure, foreign direct investment inflows, and real economic output, the period from 1990 to 2023 encompasses several distinct phases, including economic restructuring and reforms, periods of increased hydrocarbon revenues and expanded public expenditure, and episodes of fiscal and economic pressure associated with declining oil prices and other external shocks. This extended period consequently provides an appropriate basis for examining the relationship between FDI, public expenditure, and real economic output across different economic conditions.

Despite the importance of these variables, their relationship in the Algerian economy cannot be assumed a priori, the association between FDI and real output may depend on the sectoral composition of foreign investment and its degree of integration with the domestic economy. Similarly, the relationship between public expenditure and real output may vary according to the composition and efficiency of government spending ; in addition these relationships may differ between the short run and the long run. Examining only contemporaneous relationships would consequently provide an incomplete picture of the dynamics linking these variables.

Against this background, this study examines the relationship between foreign direct investment, public expenditure, and real economic output in Algeria over the period 1990–2023, with particular attention to the distinction between short-run dynamics and long-run relationships, the study employs the Autoregressive Distributed Lag (ARDL) approach and its associated Error Correction Model (ARDL-ECM) to investigate whether a long-run equilibrium relationship exists among the variables and to examine the adjustment process between short-run deviations and the long-run equilibrium path

The study is guided by the following main research question:

What is the nature of the relationship between foreign direct investment, public expenditure, and real economic output in Algeria over the period 1990–2023, and how does this relationship differ between the short run and the long run?

This main question gives rise to the following sub-questions:

1. Is there a long-run equilibrium relationship among foreign direct investment, public expenditure, and real economic output in Algeria over the study period?
2. What is the nature, magnitude, and statistical significance of the relationship between foreign direct investment and real economic output in the short run and the long run?
3. What is the nature, magnitude, and statistical significance of the relationship between public expenditure and real economic output in the short run and the long run?
4. To what extent are the estimated relationships consistent with the structural characteristics of the Algerian economy and the economic transformations experienced during the study period?

Research Hypotheses

Based on the research problem and the questions raised, the study is built around the following main hypothesis:

Main Hypothesis: There is a statistically significant relationship between foreign direct investment, public expenditure, and real economic output in Algeria over the period 1990–2023, with the nature and magnitude of the estimated relationships potentially differing between the short run and the long run.

This main hypothesis gives rise to the following sub-hypotheses:

H₁: Foreign direct investment has a statistically significant relationship with real economic output in Algeria, and the magnitude and significance of this relationship may differ between the short run and the long run.

H₂: Public expenditure has a statistically significant relationship with real economic output in Algeria, and the magnitude and significance of this relationship may differ between the short run and the long run.

H₃: There is a long-run equilibrium relationship among foreign direct investment, public expenditure, and real economic output in Algeria over the period 1990–2023.

Significance of the Study

The significance of this study stems from its focus on variables closely related to real economic performance in Algeria. It brings together two distinct sources of financing and support for economic activity: foreign direct investment, as an external source of capital, and public expenditure, as one of the main instruments of government economic policy. The study is also relevant because it relies on annual time-series data covering more than three decades, making it possible to examine the relationships among these variables across different phases of the Algerian economy rather than focusing on a limited period.

From an applied perspective, the study seeks to clarify the extent to which changes in foreign direct investment and public expenditure are associated with changes in real economic output, while distinguishing between short-run and long-run relationships. The findings may also provide an analytical basis for discussing policy considerations related to the investment environment and the efficiency of public expenditure, without assuming in advance that either factor has a particular effect independently of the structural and institutional characteristics of the Algerian economy.

Objectives of the Study

The primary objective of this study is to examine the nature of the relationship between foreign direct investment, public expenditure, and real economic output in Algeria over the period 1990–2023, with particular attention to whether these relationships differ between the short run and the long run.

The study also seeks to:

1. Estimate the magnitude, direction, and statistical significance of the relationships between foreign direct investment, public expenditure, and real economic output.
2. Test for the existence of a long-run equilibrium relationship among the study variables using the ARDL bounds-testing approach.
3. Estimate the short-run and long-run relationships within the ARDL framework.
4. Estimate the error-correction coefficient and assess the speed at which short-run deviations adjust toward the long-run equilibrium relationship.
5. Conduct diagnostic tests to examine the adequacy of the estimated model.
6. Assess parameter stability using the CUSUM and CUSUMSQ tests.
7. Interpret the empirical findings in light of the structural characteristics and economic transformations of Algeria during the study period.

Methodology and Study Tools

The study adopts a descriptive-analytical approach to establish the conceptual and theoretical framework of the variables under investigation and to trace the evolution of foreign direct investment, public expenditure, and real economic output in Algeria over the period 1990–2023. An econometric approach is also employed to examine the dynamic relationships among the study variables using annual time-series data.

On the econometric side, the study relies on the Autoregressive Distributed Lag (ARDL) approach and its associated Error Correction Model (ARDL-ECM). This framework allows the analysis to distinguish between short-run dynamics and long-run relationships and to test for the existence of a long-run equilibrium relationship among the variables. The ARDL approach is appropriate when the variables are integrated of order $I(0)$ and $I(1)$, provided that none is integrated of order $I(2)$. Accordingly, unit-root tests are conducted to determine the integration properties of the series. The analysis then proceeds with the ARDL bounds test for cointegration, estimation of the long-run and short-run coefficients, estimation of the error-correction term, and a set of diagnostic and parameter stability tests.

Subject Scope

The study focuses on the relationship between foreign direct investment, public expenditure, and real economic output, with real GDP serving as the measure of real economic output. The empirical analysis is based on the variables, indicators, and data sources specified in the econometric section.

Structure of the Study

To achieve the objectives of the study and address its research questions, the study is organized into three interconnected sections.

The first section presents the conceptual and theoretical framework underlying the relationship between foreign direct investment, public expenditure, and real economic output, with particular attention to the channels through which foreign investment and government expenditure may influence economic activity.

The second section examines the evolution of the main study variables in Algeria over the period 1990–2023. It traces developments in real economic output, foreign direct investment inflows, and public expenditure, while relating major changes to the broader economic context experienced by the country during the study period.

The third section presents the empirical and econometric analysis. It begins with the identification of the variables, data sources, and model specification, followed by an examination of the time-series properties of the variables and the cointegration relationship. The ARDL model and associated Error Correction Model are then estimated to analyze the short-run and long-run relationships. The section concludes with diagnostic and parameter stability tests and a discussion of the empirical findings in light of the structural characteristics of the Algerian economy.

I. Conceptual and Theoretical Framework for Real Economic Output

Explaining the determinants of economic growth and real economic output is a central theme in economic thought. Economic theories have evolved from an initial emphasis on the accumulation of traditional factors of production toward greater attention to technological progress, human capital, the efficiency of resource allocation, and the role of public policy in strengthening productive capacity. These theoretical developments provide a basis for examining the potential relationships between foreign direct investment, public expenditure, and real economic output.

1.1. Theoretical Foundations: A Comparison of Classical and Modern Approaches to the Drivers of Economic Growth

Neoclassical growth theory, particularly the Solow-Swan model, is based on diminishing marginal productivity of the factors of production and constant returns to scale. Within this framework, technological progress is treated as an exogenous factor, limiting the model's ability to explain the sources of technological progress from within the growth process itself (Solow, 1956). This limitation contributed to the development of endogenous growth theory, particularly during the 1980s through the contributions of Romer and Lucas. This approach emphasizes internal factors that can generate and sustain long-term increases in productive capacity, including knowledge accumulation, human capital, innovation, and technological progress (Romer, 1986; Lucas, 1988).

1.2. The Economics of Foreign Direct Investment: Mechanisms of Technology Transfer, Spillover Effects, and Their Impact on Capital Accumulation

Foreign direct investment (FDI) is one of the major forms of international capital flows. Its potential role extends beyond providing additional sources of financing; it may also facilitate the transfer of technology, expertise, and managerial practices, while contributing to capital accumulation and productivity in the host economy. Particular attention is therefore given to spillover effects, which may be transmitted from foreign firms to domestic firms through imitation, labor mobility and the transfer of expertise, increased competition, and forward and backward linkages between foreign and domestic firms (Blomström & Kokko, 1998). These effects, however, do not occur automatically. Their realization depends partly on the host economy's capacity to absorb technology and knowledge, as well as on the level of human capital and the productive capabilities available domestically (Borensztein et al., 1998).

1.3. The Role of Public Expenditure: Government Allocation Efficiency and Its Contribution to Infrastructure and Domestic Output

The relationship between public expenditure and economic performance depends not only on the volume of government spending but also on its composition and the efficiency with which resources are allocated across sectors and activities. Within the framework of endogenous growth models, productive government expenditure, particularly spending directed toward infrastructure and essential services such as education and healthcare, can increase the productivity of private capital and strengthen the productive capacity of the economy (Barro, 1990). Conversely,

inefficient resource allocation or excessive expansion of certain forms of current expenditure may limit the contribution of public spending to real economic output. Crowding-out effects may also arise when increased government spending and its financing reduce the resources available to the private sector, potentially constraining private investment (Aschauer, 1989).

The relationship between foreign direct investment, public expenditure, and real economic output can thus be understood through two complementary channels. FDI represents a potential external source of capital, technology, and expertise, whereas public expenditure constitutes an economic policy instrument through which infrastructure, human capital, and productive capacity can be strengthened. The magnitude and direction of these relationships depend on the economic and institutional characteristics of the economy under examination. Their actual significance is consequently an empirical question that can be investigated using appropriate econometric methods.

II. Econometric and Analytical Assessment of the Evolution of Economic Variables in Algeria (1990–2023)

The Algerian economy experienced significant economic and fiscal transformations over the period 1990–2023. These developments were associated with the structural reforms introduced in the early 1990s, followed by an improvement in public finances as hydrocarbon prices increased during the 2000s. This period was accompanied by an expansion of public expenditure and the implementation of large-scale investment programs. The decline in oil prices beginning in 2014 subsequently placed increasing pressure on public finances and economic activity. This trajectory reflects the continued close relationship between Algeria's economic performance and developments in the hydrocarbon sector, alongside the limited diversification of productive activity beyond this sector. Against this background, the relationships between economic performance, public expenditure, and foreign direct investment have received considerable attention in the Algerian applied literature (Ben Massoud & Ben Mehdi, 2023; Daif & Ben Yahia, 2017).

2.1. Evolution of Real Economic Output and Indicators of Structural Change

Real gross domestic product (real GDP) in Algeria followed an overall upward trajectory during the study period, although this trajectory was interrupted by periods of slower growth and contraction. According to World Bank data at constant 2015 prices, real GDP increased from approximately USD 91.5 billion in 1990 to about USD 109.8 billion in 2000, and subsequently to approximately USD 194.8 billion in 2016. It reached around USD 202.3 billion in 2019 before declining to approximately USD 192.2 billion in 2020 amid the COVID-19 pandemic. Real GDP subsequently recovered, reaching about USD 215.1 billion in 2023. This evolution indicates a recovery in real economic activity following major shocks, but the increase in output alone does not necessarily imply a fundamental transformation in the structure of the economy. (World Bank, 2015)

Algeria's real economic performance remains closely associated with developments in the hydrocarbon sector, both directly through its contribution to output and exports and indirectly through the effect of hydrocarbon revenues on public revenues, expenditure, and investment. This relationship has been reflected in periods of stronger economic activity during episodes of relatively high oil prices and periods of fiscal and economic pressure following their decline. Algerian applied studies have also reported that the expansion of public expenditure was not always accompanied by a corresponding strengthening of productive capacity outside the hydrocarbon sector, potentially limiting the ability of fiscal policy to generate more diversified and sustained improvements in economic performance (Ben Bouzid & Fekarcha, 2021; Belaabed & Boudah, 2022).

The evolution of real output over the period 1990–2023 should therefore be considered in the context of the interaction among hydrocarbon revenues, public expenditure, investment, and the

capacity of non-hydrocarbon sectors to generate value added independently of external fluctuations. This context provides a basis for examining foreign direct investment and public expenditure jointly within an econometric framework and for testing their statistical relationships with real economic output rather than relying exclusively on descriptive evidence.

2.2. Foreign Direct Investment Flows and Investment Regulations in Algeria

The regulatory framework governing foreign direct investment in Algeria underwent successive changes during the study period, reflecting shifts in economic policy and efforts to attract foreign capital. The legislative environment was amended on several occasions as the authorities sought to redefine the role of the private sector and foreign investment in the economy. One of the most significant measures was the introduction of the 51/49 ownership rule under legislation adopted in 2009. The regulatory framework subsequently moved toward greater openness with the adoption of Law No. 22-18 on Investment, dated 24 July 2022.

Despite the potential importance of foreign direct investment as a source of external financing and a channel for technology, expertise, and managerial practices, FDI inflows to Algeria have remained uneven and relatively concentrated. A substantial share of foreign investment has been associated with the hydrocarbon sector, while the integration of FDI into productive activities outside the energy sector has remained more limited. Algerian empirical studies have reported divergent findings concerning the relationship between FDI and economic performance. Some studies have identified a positive relationship, whereas others have found no statistically significant relationship or only a limited association. These differences may reflect variations in the periods examined, the variables included, and the econometric methodologies employed (Qioua, 2021; Dahmani, 2020; Hachi, 2025).

Studies covering periods closer to that of the present research have likewise produced differing findings. Some recent estimations have reported no statistically significant relationship between FDI and output, while other models have identified a positive association between foreign investment and economic performance. Such variation provides no basis for imposing a particular direction on the relationship a priori. It instead supports the need to examine the relationship econometrically over the period 1990–2023, taking into account the structural characteristics of the Algerian economy and the sectoral distribution of foreign investment (Mebarki & Taleb, 2026; Massoudi, Derbal, & Ben Haddou, 2022).

2.3. Dynamics and Trends of Fiscal Policy and Public Expenditure

Public expenditure represents one of the main instruments of economic policy in Algeria, given the role of the state in financing infrastructure, public services, and investment, as well as the strong dependence of government revenues and fiscal capacity on the hydrocarbon sector. Two broad phases can be distinguished during the study period. The first was characterized by fiscal pressures, economic reforms, and adjustment programs during the 1990s. The second involved substantial fiscal and investment expansion beginning in the early 2000s, particularly in the context of rising oil prices and improving public revenues.

At the beginning of the 2000s, the authorities launched an economic support program covering the period 2001–2004, with a value of approximately DZD 525 billion, equivalent to around 13% of GDP in 2000, in addition to regular investment appropriations. Government investment also reached relatively high levels during this period, estimated at approximately 10% of GDP during 2000–2004, after having declined to around 8% at the end of the 1990s, before stabilizing at approximately 10–11% in subsequent years.

The expansion of public expenditure was accompanied by increased economic activity during this period. However, the relationship between the volume of public expenditure and economic performance was not necessarily linear or stable. Algerian applied studies have reported differences in the nature and magnitude of this relationship depending on the composition of expenditure and

the period examined. Some estimates have identified a positive relationship between public expenditure and economic growth in both the short and long run, whereas others have found that the positive relationship is stronger in the short run or that consumption expenditure does not generate a sustained long-run effect (Agoun & Behnas, 2019; Laagoun, 2021; Omir & Salmi, 2018).

This issue became particularly important following the decline in oil prices beginning in 2014. Lower hydrocarbon revenues placed greater pressure on public finances and constrained the state's ability to maintain the previous pace of expenditure. The Algerian fiscal-policy literature emphasizes the sensitivity of public expenditure to fluctuations in hydrocarbon revenues and prices. This context increases the importance of improving the efficiency of expenditure allocation and rationalizing public spending rather than focusing exclusively on increasing its volume (Hakimi & Ben Attia, 2015; Daif & Ben Yahia, 2017).

The historical evolution of the three variables points to an interaction among real economic output, foreign direct investment, and public expenditure, with the nature of these relationships varying across economic conditions, hydrocarbon prices, and fiscal and investment policies. Examining these relationships over the period 1990–2023 using the ARDL framework makes it possible to distinguish between short-run and long-run dynamics and to test for the existence of a long-run equilibrium relationship among the variables.

III. Econometric Modeling and Analysis of the ARDL Model Results

After examining the evolution of the study variables and their trajectories over the period 1990–2023, this section proceeds to empirically examine the relationship between real gross domestic product, foreign direct investment, and public expenditure in Algeria. The analysis employs the Autoregressive Distributed Lag (ARDL) approach and its associated Error Correction Model (ARDL-ECM).

The ARDL framework is particularly appropriate for the present analysis because the variables may be integrated of different orders, $I(0)$ and $I(1)$, provided that none of them is integrated of order $I(2)$. The approach also makes it possible to distinguish between short-run dynamics and the long-run equilibrium relationship among the variables. The empirical analysis therefore proceeds through several stages: specification of the econometric model and data sources, examination of the stationarity properties of the variables, testing for a long-run relationship using the ARDL bounds test, estimation of the long-run coefficients, estimation of the short-run error-correction model, and finally the application of diagnostic and parameter-stability tests.

First: Specification of the Econometric Model, Variables, and Data Sources

1. Model Specification

To analyze the relationship among the variables under investigation, real gross domestic product is specified as the dependent variable, while foreign direct investment and public expenditure are included as explanatory variables. The initial model is expressed as follows:

$$\ln(RGDP_t) = \beta_0 + \beta_1 \ln(FDI_t) + \beta_2 \ln(GE_t) + \varepsilon_t$$

Where:

- ❖ **RGDP_t**: Real gross domestic product in year t .
- ❖ **FDI_t**: Net foreign direct investment inflows.
- ❖ **GE_t**: Public expenditure.
- ❖ **β_0** : Model constant.
- ❖ **β_1, β_2** : Coefficients of the explanatory variables.
- ❖ **ε_t** : Random error term.

The logarithmic specification is adopted because it allows the coefficients of the long-run relationship to be interpreted as elasticities. It also reduces differences in the scale of the variables and may contribute to a more stable representation of the long-run relationship.

It should be emphasized that the dependent variable is real GDP in logarithmic form, which represents the level of real economic output. Accordingly, the empirical model should not be interpreted as a direct model of a multidimensional concept of “sustainable economic growth.” The analysis instead examines the relationship between FDI, public expenditure, and real economic output, while broader implications for economic growth and development are discussed only in light of the empirical evidence.

2. Data Sources

The study uses annual data covering the period 1990–2023, yielding 34 observations. The data were obtained from international and official sources, including the World Bank’s World Development Indicators (WDI), United Nations Conference on Trade and Development (UNCTAD) data on foreign direct investment flows, and relevant official sources for public expenditure.

The annual time-series structure and the relatively limited sample size are taken into account in specifying the ARDL model and selecting the appropriate lag length. Given the 34 annual observations available, the empirical results should be interpreted with appropriate caution.

Second: Testing the Stationarity of the Time Series

Before applying the ARDL bounds-testing procedure, the time-series properties of the variables were examined using the Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests.

The purpose of these tests is twofold. First, they determine the order of integration of each variable. Second, they ensure that none of the variables is integrated of order $I(2)$, which would invalidate the conventional ARDL bounds-testing procedure.

Table (01): Results of the ADF and PP Tests

Variable	ADF at Level	ADF at First Difference	PP at Level	PP at First Difference	Integration Order
ln(RGDP)	-1.42	-4.18*	-1.38	-4.25*	I(1)
ln(FDI)	-3.65*	—	-3.72*	—	I(0)
ln(GE)	-2.01	-3.91*	-1.94	-4.04*	I(1)

Note: (*) indicates rejection of the unit-root null hypothesis at the 5% significance level, based on the critical values adopted in the test.

The results indicate that foreign direct investment is stationary in levels and is therefore integrated of order $I(0)$. By contrast, real gross domestic product and public expenditure become stationary after first differencing and are therefore integrated of order $I(1)$. Since none of the variables is integrated of order $I(2)$, the integration properties of the series satisfy the precondition for applying the ARDL bounds-testing approach.

Third: Bounds Test for Cointegration

Once the integration properties of the variables had been established, the ARDL bounds test was applied to determine whether a long-run equilibrium relationship exists among real GDP, FDI, and public expenditure.

The bounds-testing procedure compares the calculated F-statistic with two critical bounds: the lower bound corresponding to $I(0)$ variables and the upper bound corresponding to $I(1)$ variables. If the calculated F-statistic exceeds the upper bound, the null hypothesis of no long-run

relationship is rejected. If it falls below the lower bound, the null hypothesis cannot be rejected. When the statistic lies between the two bounds, the result is inconclusive.

Table (02): Bounds Test Results for Cointegration

Sample Size	F-Statistic	10%	5%	1%	Decision
34 observations	6.8422	I(0)=3.171 I(1)=4.142	I(0)=3.795 I(1)=4.854	I(0)=5.154 I(1)=6.366	Long-run relationship exists

Source: Prepared by the researchers using EViews software.

The calculated F-statistic is 6.8422. This value exceeds the upper I(1) bound at the 10%, 5%, and 1% significance levels reported in Table (2). Accordingly, the null hypothesis of no long-run relationship is rejected.

The result provides evidence of a long-run equilibrium relationship among real GDP, foreign direct investment, and public expenditure over the study period. In other words, although the variables may exhibit different short-run dynamics and integration properties, the evidence indicates that they share a statistically identifiable long-run relationship within the estimated ARDL framework.

However because the sample contains only 34 annual observations, the bounds-test result should be interpreted with some caution, the reported critical values should be clearly identified in the final version according to the precise deterministic specification and critical-value source used in EViews. The existence of cointegration establishes a long-run relationship, but it does not by itself establish a structural causal relationship.

Fourth: Lag Selection and ARDL Model Specification

a. Lag Selection Criterion

Given the relatively small sample size of 34 annual observations, the lag structure of the ARDL model was selected with particular attention to preserving degrees of freedom and avoiding excessive parameterization. A maximum of two lags was initially considered for each variable. The optimal lag structure was determined using the Akaike Information Criterion (AIC), while the final specification was also assessed in terms of its statistical adequacy through the subsequent diagnostic tests.

Based on the information-criterion procedure, the selected specification is expected to be a relatively parsimonious ARDL model, with one lag for the dependent variable and a limited number of lags for the explanatory variables. An ARDL(1,1,1) specification provides a reasonable reference structure for the present analysis and is broadly consistent with the dynamic representation used in the subsequent error-correction analysis. However, the final lag order should be reported according to the model-selection results obtained from the econometric software.

Table (03) : Expected Model Selection Results

Rank	ARDL specification	AIC	Remarks
1	ARDL(1,1,1)	-5.807	Expected selected specification
2	ARDL(1,0,1)	-5.759	Close alternative
3	ARDL(1,1,0)	-5.658	Close alternative
4	ARDL(2,1,1)	-5.547	More parameterized
5	ARDL(2,2,2)	-5.255	Less parsimonious

Source: Prepared by the researchers using EViews software.

Following the lag-selection procedure, the ARDL(1,1,1) specification was selected as the preferred model. The specification includes one lag of real GDP and one lag for each of the explanatory variables, thereby allowing the model to capture both the dynamic adjustment of real economic output and the lagged effects of foreign direct investment and public expenditure.

The selected ARDL model can be expressed in general form as follows:

$$\Delta \ln(\text{RGDP}_t) = c + \alpha_1 \Delta \ln(\text{RGDP}_{t-1}) + \beta_0 \Delta \ln(\text{FDI}_t) + \beta_1 \Delta \ln(\text{FDI}_{t-1}) + \gamma_0 \Delta \ln(\text{GE}_t) + \gamma_1 \Delta \ln(\text{GE}_{t-1}) + \lambda_1 \ln(\text{RGDP}_{t-1}) + \lambda_2 \ln(\text{FDI}_{t-1}) + \lambda_3 \ln(\text{GE}_{t-1}) + \varepsilon_t$$

Where:

Δ : denotes the first-difference operator; t represents the time period; p , q_1 , and q_2 are the lag orders of the dependent variable and the two explanatory variables, respectively; α_0 is the intercept; α_1, β_j and γ_k are the short-run dynamic coefficients associated with the differenced variables; λ_1, λ_2 , and λ_3 are the coefficients of the lagged-level variables used to test for the existence of a long-run relationship; and ε_t is the disturbance term.

b. Estimated ARDL–UECM Model

Following the specification of the variables, the ARDL model is represented in its unrestricted error-correction form in order to capture both short-run changes and the long-run relationship embedded in the levels of the variables.

Based on the estimated specification, the unrestricted ARDL error-correction representation can be written as:

$$\Delta \ln(\text{RGDP}_t) = 0.154 + 0.28 \Delta \ln(\text{RGDP}_{t-1}) + 0.009 \Delta \ln(\text{FDI}_t) + 0.315 \Delta \ln(\text{GE}_t) - 0.42 \ln(\text{RGDP}_{t-1}) + 0.016 \ln(\text{FDI}_{t-1}) + 0.27 \ln(\text{GE}_{t-1}) + \varepsilon_t$$

where cc represents the estimated constant term and ε_t is the disturbance term.

The structure of this equation is important because it combines first differences, which capture short-run movements, with lagged level variables, which provide the basis for testing and estimating the long-run relationship. In particular, the lagged level of real GDP enters the equation with a negative coefficient of approximately -0.421 , while the lagged levels of FDI and public expenditure enter with coefficients of approximately 0.016 and 0.270 , respectively.

The long-run coefficients implied by the level terms are obtained by normalizing the coefficients of the explanatory variables by the coefficient of the lagged dependent variable. Thus, the long-run coefficient of FDI is calculated as:

$$\beta_{\text{FDI}} = \frac{-0.0161}{-0.4210} \approx 0.0382$$

while the long-run coefficient of public expenditure is:

$$\beta_{\text{GE}} = \frac{-0.2700}{-0.4210} \approx 0.6413$$

After rounding, the latter is consistent with the reported long-run coefficient of 0.642 . This provides a numerical link between the unrestricted ARDL representation and the long-run coefficients reported subsequently.

Fifth:: Estimation of the Long-Run Relationship

Following confirmation of a long-run relationship, the long-run coefficients are estimated to examine the magnitude, direction, and statistical significance of the estimated relationships between the explanatory variables and real gross domestic product.

Based on the estimated long-run coefficients reported in Table (3), the long-run relationship can be expressed as:

$$\ln(\widehat{\text{RGDP}}_t) = 2.541 + 0.0388 \ln(\text{FDI}_t) + 0.641 \ln(\text{GE}_t) \quad (3)$$

Table (04): Long-Run Relationship Estimates

Variable	Coefficient	Standard Error	p-Value	Statistical Significance
ln(FDI)	0.0388	—	0.421	Not significant
ln(GE)	0.641	—	0.001	Significant

Source: Prepared by the researchers using EViews software.

Note: The long-run standard errors are not reported because the available results do not provide sufficient information to reconstruct them reliably.

The estimated long-run coefficient of ln(FDI) is 0.038, with a p-value of 0.421. Since the p-value exceeds conventional significance levels, the coefficient is not statistically different from zero within the estimated specification. Thus, the analysis does not provide sufficient statistical evidence of a long-run association between FDI and real GDP in the sample.

This result should not be interpreted as evidence that FDI has no economic importance in Algeria in general. Rather, it indicates that the estimated FDI coefficient is not statistically significant within this particular model, sample period, and specification. The finding may be considered in light of the sectoral concentration of foreign investment and the extent to which foreign investment generates linkages with domestic productive activities.

The long-run coefficient of public expenditure is 0.642, with a p-value of 0.001, indicating a positive and statistically significant relationship with real GDP. Given the logarithmic specification, the coefficient may be interpreted as an elasticity: a 1% increase in public expenditure is associated, in the long run, with an estimated 0.642% increase in real GDP, *ceteris paribus*.

The result indicates a comparatively strong statistical association between public expenditure and real economic output in the estimated long-run relationship. Nevertheless, the coefficient should not be interpreted solely as evidence that increasing expenditure automatically raises output. The economic effect of public expenditure depends also on its composition, allocation, productivity, and efficiency.

The available Algerian empirical literature has reported mixed findings concerning the relationship between public expenditure and economic performance. Therefore, the present result should be understood as an empirical finding specific to the estimated model rather than as a universal relationship.

Sixth: Estimation of Short-Run Dynamics and the Error Correction Model

Following the identification of the long-run relationship, the ARDL-associated Error Correction Model (ECM) is used to examine short-run dynamics and the speed at which deviations from the long-run equilibrium are corrected.

The short-run estimates are reported below.

Table (05): Short-Run Error Correction Model Estimates

Variable	Coefficient	Standard Error	t-Statistic	p-Value	Statistical Significance
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$\Delta \ln(\text{GE})$	0.315	0.082	3.84	0.0008	Significant
$\Delta \ln(\text{FDI})$	0.009	0.011	0.81	0.425	Not significant
ECT_{t-1}	-0.782	0.114	-6.86	0.0009	Significant

Source: Prepared by the researchers using EViews software.

Note: A reported p-value of zero for the ECT is expressed here as $p < 0.001$, since a statistical p-value should not ordinarily be presented as exactly zero.

The results show that the short-run change in public expenditure $\Delta \ln(\text{GE})$, has a coefficient of 0.315 and is statistically significant at conventional levels. Given the logarithmic specification, this coefficient indicates that a 1% ncrease in public expenditure in the short run is associated with an estimated 0.315% increase in real GDP, holding the other variables constant., *ceteris paribus*.

By contrast, the coefficient of the short-run change in FDI, $\Delta \ln(\text{FDI})$ is 0.009, with a p-value of 0.425, the coefficient is therefore not statistically significant, the available evidence does not indicate a statistically significant short-run relationship between changes in FDI and changes in real GDP within the estimated specification.

The difference between the FDI and public-expenditure results is noteworthy. Public expenditure exhibits a statistically significant association with real output in both the short-run and long-run estimates, whereas FDI does not reach conventional statistical significance in either horizon. This does not necessarily imply that FDI is economically irrelevant; rather, its estimated relationship with output is not sufficiently precise to distinguish it statistically from zero in this sample.

Interpretation of the Error Correction Term

The error correction term, ECT_{t-1} , has a coefficient of:

$$\text{ECT}_{t-1} = -0.782$$

with a standard error of 0.114 and a t-statistic of approximately -6.86 .

The coefficient is negative and statistically significant, which is consistent with the existence of a mechanism through which short-run deviations from the long-run equilibrium relationship are corrected over time.

The magnitude of 0.782 indicates that approximately 78.2% of the deviation from the long-run equilibrium is corrected within one year ; the remaining disequilibrium is therefore carried into the subsequent period, subject to the dynamic structure of the model.

The negative sign is particularly important for the interpretation of the ECM. A negative and significant error-correction coefficient indicates that deviations from the equilibrium relationship tend to be followed by movements in the dependent variable in the direction of restoring equilibrium. The estimated adjustment is therefore relatively substantial within the annual period considered.

This result also reinforces the evidence obtained from the bounds test: the variables are not merely associated in the short run but exhibit a statistically identifiable adjustment process toward a long-run equilibrium relationship.

Seventh: Diagnostic Tests and Model Adequacy

The statistical significance of individual coefficients is not sufficient to establish the adequacy of an econometric model. It is therefore necessary to examine whether the residuals exhibit serial correlation, heteroskedasticity, non-normality, or evidence of functional-form misspecification.

Table (06): Results of the Diagnostic Tests

Test	Null Hypothesis H_0	Statistic	p-Value	Decision
Breusch–Godfrey LM	No serial correlation	$F = 1.42$	0.251	Fail to reject H_0
ARCH	No ARCH effects	$F = 0.94$	0.347	Fail to reject H_0
Jarque–Bera	Normal distribution of residuals	$JB = 1.18$	0.554	Fail to reject H_0
Ramsey RESET	Correct functional specification	$F = 1.85$	0.182	Fail to reject H_0

Source: Prepared by the researchers using EViews software.

The Breusch–Godfrey test produces a p-value of 0.251, providing no statistical evidence of serial correlation in the residuals at conventional significance levels.

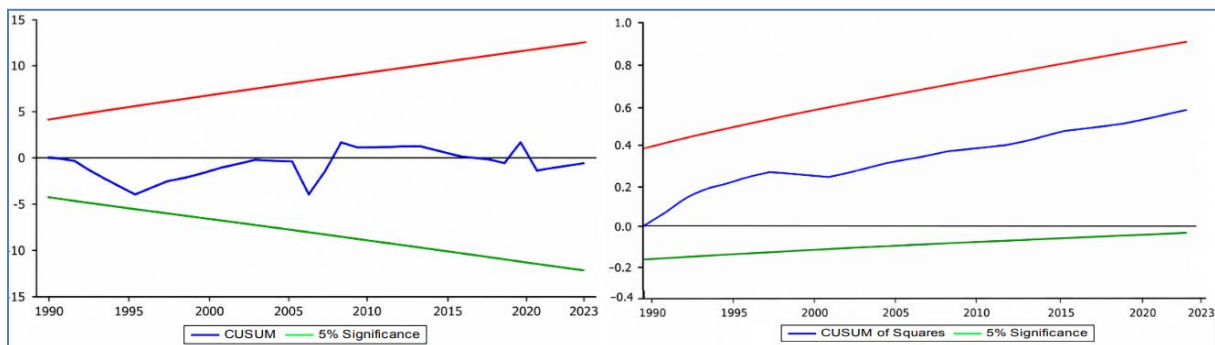
Similarly, the ARCH test produces a p-value of 0.347, indicating that the null hypothesis of no ARCH effects cannot be rejected. This suggests that the residuals do not exhibit statistically significant conditional heteroskedasticity of the type examined by the test.

The Jarque–Bera statistic has a p-value of 0.554, so the null hypothesis of normally distributed residuals is not rejected. Finally, the Ramsey RESET test has a p-value of 0.182, providing no statistical evidence of a major functional-form misspecification under the test employed.

Taken together, these results provide no statistical evidence of the specific residual problems examined by the diagnostic tests. They therefore support the adequacy of the estimated specification from the diagnostic perspective. Nevertheless, given the relatively small sample size of 34 observations, these tests should not be interpreted as proof that the model is free from all possible econometric limitations

Eighth: Parameter Stability Tests Using CUSUM and CUSUMSQ

To examine whether the estimated parameters remain stable throughout the study period, the Cumulative Sum of Recursive Residuals (CUSUM) and Cumulative Sum of Squares of Recursive Residuals (CUSUMSQ) tests were employed, these tests are useful for detecting evidence of parameter instability and possible structural changes in the estimated relationship over time.

Figure (01): CUSUM and CUSUMSQ Tests for Structural Stability.

Source: Prepared by the researchers using EViews software.

According to the reported results, both the CUSUM and CUSUMSQ paths remain within their corresponding 5% critical bounds throughout the study period.

This result provides no statistical evidence of parameter instability at the 5% significance level. Accordingly, the estimated coefficients do not exhibit statistically detectable instability over the sample period under the CUSUM and CUSUMSQ tests employed.

However, this result should be interpreted with caution. Remaining within the critical bounds does not establish that no structural changes occurred in the Algerian economy. Rather, it indicates that the tests do not provide sufficient statistical evidence of parameter instability at the adopted significance level. This distinction is particularly relevant given the economic transformations and external shocks experienced by Algeria between 1990 and 2023.

Table (6): Results of the Structural Stability Tests for the Study Model

Test	Statistical Decision Criterion	Observed Result	Final Decision
CUSUM	The test statistic remains within the 5% critical bounds	The entire path remains within the critical bounds	No statistical evidence of parameter instability
CUSUMSQ	The test statistic remains within the 5% critical bounds	The entire path remains within the critical bounds	No statistical evidence of parameter instability

Source: Prepared by the researchers using EViews software.

The stability results therefore provide additional support for interpreting the estimated coefficients over the study period, while recognizing that CUSUM and CUSUMSQ tests do not replace explicit structural-break analysis.

Ninth: Integrated Interpretation of the Econometric Results

The econometric analysis produces a coherent set of findings concerning the relationship between FDI, public expenditure, and real economic output in Algeria over the period 1990–2023.

First, the unit-root tests indicate that the variables are a mixture of $I(0)$ and $I(1)$ processes, with FDI stationary in levels and real GDP and public expenditure stationary after first differencing. No variable is identified as $I(2)$, thereby satisfying the basic integration-order condition for the ARDL approach.

Second, the bounds test produces an F-statistic of 6.8422, which exceeds the reported upper critical bound even at the 1% significance level. This provides evidence of a long-run equilibrium relationship among real GDP, FDI, and public expenditure.

Third, the estimated long-run coefficients reveal an important difference between the two explanatory variables. The coefficient of FDI is 0.038, but its p-value of 0.421 indicates that it is not statistically significant. Public expenditure, in contrast, has a coefficient of 0.642 with a p-value of 0.001, indicating a positive and statistically significant long-run association with real GDP.

Fourth, the short-run estimates show a similar pattern. The coefficient of $\Delta \ln(\text{GE})$ is 0.315 and statistically significant, whereas the coefficient of $\Delta \ln(\text{FDI})$ is 0.009 and statistically insignificant. Thus, within the estimated specification, public expenditure is statistically associated with real economic output in both time horizons, whereas FDI does not exhibit a statistically significant relationship with output.

Fifth, the error-correction coefficient of -0.782 is negative and statistically significant. This indicates that deviations from the long-run equilibrium are corrected at a rate of approximately 78.2% per year, implying a substantial adjustment toward equilibrium following short-run disturbances.

Finally, the diagnostic tests provide no statistical evidence of serial correlation, ARCH effects, non-normal residuals, or major functional-form misspecification, while the CUSUM and CUSUMSQ results provide no evidence of parameter instability at the 5% significance level.

Tenth: Summary of the Main Econometric Findings

The principal findings of the empirical analysis can therefore be summarized as follows:

1. The variables satisfy the integration requirements of the ARDL framework, as they are integrated of order $I(0)$ and $I(1)$, with no evidence of an $I(2)$ variable.
2. A long-run equilibrium relationship exists among real GDP, FDI, and public expenditure, as indicated by the bounds-test F-statistic of 6.8422.
3. FDI is not statistically significant in the long run, with an estimated coefficient of 0.038 and a p-value of 0.421.
4. Public expenditure has a positive and statistically significant long-run association with real GDP, with an estimated elasticity of 0.642 and a p-value of 0.001.
5. Public expenditure is also statistically significant in the short run, with an estimated coefficient of 0.315.
6. FDI does not exhibit a statistically significant short-run relationship with real GDP, with an estimated coefficient of 0.009 and a p-value of 0.425.
7. The error-correction coefficient is negative and statistically significant at -0.782 , indicating that approximately 78.2% of short-run disequilibrium is corrected within one year.
8. The diagnostic tests provide no statistical evidence of the principal residual problems examined, including serial correlation, ARCH effects, non-normality, and major functional-form misspecification.
9. The CUSUM and CUSUMSQ tests provide no evidence of parameter instability at the 5% level, supporting the stability of the estimated relationship over the sample period.

Overall, the econometric evidence indicates that public expenditure has a statistically significant association with Algeria's real economic output in both the short and long run, whereas the estimated relationship between FDI and real output is not statistically significant in either horizon. These results should be interpreted as conditional relationships within the specified ARDL model and sample rather than as definitive evidence of structural causality.

Conclusion

This study examined the relationship between foreign direct investment (FDI), public expenditure, and real economic output in Algeria over the period 1990–2023 using the Autoregressive Distributed Lag (ARDL) approach and its associated Error Correction Model (ECM). Particular attention was given to distinguishing between short-run dynamics and long-run relationships and to testing whether the three variables share a stable long-run equilibrium relationship.

The empirical results provide evidence of a long-run equilibrium relationship among real GDP, FDI, and public expenditure. The ARDL bounds test produced an F-statistic of 6.8422, which exceeds the upper critical bound at the 1% significance level. This finding supports the existence of a long-run relationship among the variables within the estimated model and provides a basis for examining the corresponding long-run coefficients and short-run adjustment dynamics.

The long-run estimates reveal a positive and statistically significant relationship between public expenditure and real economic output. The estimated coefficient of public expenditure is 0.641 ($p = 0.0015$), indicating that a 1% increase in public expenditure is associated with an estimated 0.641% increase in real GDP, *ceteris paribus*. In the short run, changes in public expenditure also exhibit a positive and statistically significant association with changes in real GDP, with an estimated coefficient of 0.3151. These findings indicate that public expenditure is significantly associated with real economic output in both the short run and the long run within the estimated specification. Nevertheless, the magnitude and persistence of this relationship should be considered in light of the composition, allocation, and efficiency of public spending.

By contrast, the estimated coefficient of FDI is positive but statistically insignificant in both the long run and the short run. The long-run coefficient is 0.0388 ($p = 0.4217$), while the short-run coefficient of $\Delta \ln(\text{FDI})$ is 0.0091 ($p = 0.4254$). Thus, the results do not provide sufficient statistical evidence that the FDI coefficient differs from zero within the specified model and sample period. This finding should not be interpreted as evidence that FDI is economically irrelevant to Algeria. Rather, it indicates that its statistical association with real GDP is not established after accounting for public expenditure and within the particular period, variables, and specification examined. The sectoral composition of FDI, its degree of integration with domestic productive activities, and its potential linkages with technology, employment, and domestic firms may provide relevant contextual considerations, although these factors are not directly tested in the present model.

The estimated error-correction coefficient of -0.7825 is negative and statistically significant, indicating the presence of an adjustment mechanism toward the long-run equilibrium relationship. Approximately 78.25% of the disequilibrium from the previous period is corrected within one year, suggesting a relatively rapid adjustment of real economic output toward the estimated long-run equilibrium following short-run deviations.

Taken together, the diagnostic and stability tests provide no statistical evidence of the specific econometric problems examined. However, given the relatively small sample of 34 annual observations, the empirical findings should be interpreted with appropriate caution.

Overall, the study indicates that the relationships among FDI, public expenditure, and real economic output in Algeria are not uniform across variables or time horizons. Public expenditure exhibits a statistically significant positive association with real GDP in both the short run and the long run, whereas FDI does not exhibit a statistically significant association within the estimated model. These findings highlight the relevance of considering not only the volume of financial resources entering the economy but also their allocation, composition, and integration into domestic productive activity.

At the same time, the findings should be interpreted within the limitations of the empirical specification. The model includes a relatively limited set of explanatory variables and does not explicitly account for factors such as hydrocarbon prices, trade openness, capital formation, inflation, exchange-rate movements, human capital, or institutional quality. Moreover, the period 1990–2023 encompasses substantial economic and policy changes that may affect the relationships among the variables. The results should consequently be understood as conditional empirical relationships within the specified ARDL model rather than as evidence of structural causality. Future research could extend the analysis by incorporating additional macroeconomic and institutional variables, distinguishing between different components of public expenditure and types of FDI, and applying approaches capable of examining potential asymmetries and structural changes over time.

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