

The Impact of Economic Diversification on Economic Growth in Algeria During the Period 1990-2022. Using the Autoregressive Distributed Lag (ARDL) Model

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Purpose: This study aims to measure the impact of economic diversification on economic growth in Algeria during the period 1990–2022, while highlighting the importance of adopting an effective diversification strategy to achieve higher and more sustainable levels of economic growth, particularly in light of the heavy reliance on oil revenues and the volatility of oil prices in global markets.

Results: The findings reveal the existence of a long-run relationship between economic diversification and economic growth over the study period. However, this relationship remains relatively weak due to the continued dependence of the Algerian economy on the hydrocarbon sector as the main source of income. The results also emphasize the necessity of activating other economic sectors and enhancing integration among them to increase their contribution to Gross Domestic Product (GDP).

Scientific novelty: The scientific novelty of this study lies in the application of the Autoregressive Distributed Lag (ARDL) model to examine both the short-run and long-run relationships between economic diversification and economic growth in Algeria over a relatively long time span (1990–2022), thereby providing more accurate insights into the nature of this relationship within the Algerian economy.

Practical value: The practical value of this study is reflected in providing actionable insights for economic policymakers in Algeria regarding the importance of accelerating the implementation of economic diversification policies, developing non-oil sectors, and reducing

dependence on hydrocarbons in order to achieve sustainable economic growth and long-term economic stability.

Key words: Economic diversification; Economic growth; ARDL model.

1.Introduction:

Global oil markets are characterized by inherent volatility, with price fluctuations creating significant macroeconomic challenges for petroleum-dependent economies. When oil prices rise, government revenues in oil-exporting nations expand, enabling increased public expenditure and investment in development projects. Conversely, price declines generate severe fiscal constraints, undermining economic stability and development prospects. This cyclical dependency is particularly acute in Arab nations where hydrocarbon revenues have historically constituted the primary source of public finance. The recurring economic shocks stemming from oil price volatility have underscored the critical importance of economic diversification as a strategy to broaden the production base, establish multiple income streams, and reduce vulnerability to sector-specific crises. Economic theory suggests that when a nation's economic performance is tightly coupled to a single commodity price deterioration in that commodity inevitably exposes the entire production structure to systemic risk. In contrast, diversifying across multiple productive sectors enables risk distribution and enhances economic resilience (Al-Marhubi, 2021; Boukhari & Foudad, 2022).

Algeria exemplifies the challenges facing rentier states in achieving economic diversification. As a petroleum-dependent economy, hydrocarbon revenues account for approximately 60% of the nation's gross domestic product, while oil exports exceed 96% of total exports and contribute more than 50% of public revenues. This extreme concentration renders the Algerian economy highly vulnerable to international oil price fluctuations, making diversification not merely a policy option but an economic imperative for achieving sustainable growth. Successful diversification requires implementing comprehensive economic policies aimed at restructuring the economy and increasing the contribution of alternative sectors to GDP, thereby reducing the disproportionate reliance on hydrocarbon extraction.

Given the pivotal importance of economic diversification in enhancing growth trajectories and ensuring long-term economic sustainability, this topic has attracted considerable attention in economic literature and forms the central focus of this research. The present study seeks to analyze the reality and impact of economic diversification in Algeria, employing multiple quantitative indicators to measure diversification levels and assess their effects on economic growth during the period 1990-2022. This study addresses the fundamental question:

What is the extent of the impact of economic diversification on economic growth in Algeria during the period 1990-2022?

Research Hypotheses:

Based on the research problem, three primary hypotheses guide this investigation. First, achieving economic diversification in Algeria requires structural changes in the state's role in economic management, transitioning from direct intervention to facilitating private sector development. Second, meaningful economic diversification in Algeria represents a long-term objective that cannot be accomplished through short-term policy interventions alone. Third, the

relationship between economic diversification and economic growth is expected to be positive in the long term, though the strength and consistency of this relationship require empirical verification.

Research Significance:

The significance of this study stems from the critical role economic diversification plays in national economic development, particularly in resource-dependent economies. As petroleum represents a depleting natural resource subject to price instability, identifying and developing alternative income sources has become imperative for long-term economic sustainability. This research demonstrates how economic diversification affects economic growth in Algeria through quantitative analysis of diversification indicators that can potentially transform the structure of the Algerian economy. The study's contributions include providing empirical evidence for building a stable economy based on diverse resource foundations, reducing primary dependence on oil production and exports, and offering policy-relevant insights for economic transformation strategies.

Research Objectives:

This study aims to measure the degree of economic diversification outside the hydrocarbon sector by analyzing the development and composition of five critical variables: gross domestic product structure, export composition, import patterns, government revenue sources, and employment distribution across sectors. The overarching goal is to understand how diversification efforts impact economic growth and to characterize the nature of the relationship between economic diversification and GDP growth in Algeria during the study period.

Research Scope and Methodology:

The temporal scope of this research spans from 1990 to 2022, a period encompassing significant economic reforms and multiple oil price cycles. Spatially, the study focuses exclusively on the Algerian economy. Methodologically, the research employs a mixed-methods approach combining descriptive analysis to establish the theoretical framework and cover conceptual aspects of economic diversification, and econometric analysis using the Autoregressive Distributed Lag (ARDL) model to examine the empirical relationship between economic diversification and economic growth. This methodology is particularly appropriate given the nature of the research questions and the time-series characteristics of the data.

2. Review of literature**2.1. Conceptual Foundations of Economic Diversification:**

Economic diversification represents a fundamental imperative for countries characterized by monoculture economies, where a single commodity dominates production and export processes. Such economic structures create dangerous dependencies on international market conditions and resource availability, leading to significant imbalances that impede sustainable development. For petroleum-dependent economies, avoiding these structural imbalances necessitates implementing comprehensive transformations across all economic levels and sectors, ensuring improved, diversified, and sustainable economic performance through an integrated system based on diversification principles.

The concept of economic diversification has been defined from multiple theoretical

perspectives, reflecting different dimensions of this complex phenomenon. Some scholars emphasize the production and income dimension, defining diversification as processes aimed at reducing reliance on single resources and broadening the production base by directing economic activity toward various sectors and markets. This approach mitigates risks associated with dependence on products experiencing price volatility."(Badeeb, Lean, & Clark, 2023).conceptualizes economic diversification as "a process aimed at diversifying the production structure and creating new income-generating sectors, thereby reducing overall reliance on the main sector's revenues in the economy." This process opens new fields with higher added value capable of providing employment opportunities for the national workforce, leading to increased long-term growth rates.

Alternative conceptualizations focus on the utilization of resources and production capacities. From this perspective, economic diversification involves utilizing all local resources and production capacities to ensure the accumulation of self-sustaining capabilities that generate renewable resources, enabling local production to dominate domestic markets and progressively diversify exports."(Imbs & Wacziarg, 2003). offers a forward-looking definition, viewing diversification as "the use of oil revenues to create a sustainable foundation for a post-oil economy through establishing heavy industries, developing infrastructure, and investing in areas with real production." This definition emphasizes finding additional non-oil sources for foreign currency and budget revenues while simultaneously creating sustainable employment sources in productive and service sectors, reducing dependence on government employment.

2.2. Objectives of Economic Diversification:

Countries pursuing economic diversification strategies seek to achieve multiple interconnected objectives that collectively enhance economic resilience and sustainable development. Primary objectives include ensuring economic stability by equipping the economy with capabilities to handle crises and external shocks, particularly reducing vulnerability to raw material price fluctuations. Diversification efforts aim to achieve greater self-sufficiency in goods and services production, expand employment opportunities, and improve living standards for citizens. Additional objectives encompass increasing export volumes while reducing dependence on imported consumer goods, diminishing the state's role in economic processes while activating private sector participation, and improving developmental trajectories through diversification and enhancement of multiple productive sectors:(Hesse, 2008)

Economic diversification also serves strategic objectives related to international economic relations, including increasing and maintaining negotiating power in foreign trade, expanding the production base to enhance national production's dominance in domestic markets, maintaining competitiveness in international markets, and establishing a solid, diverse, and integrated economic foundation capable of responding to local and international changes. Ultimately, diversification aims to achieve fiscal stability by activating various productive sectors with balanced contributions to the general budget, GDP, and export revenues.

2.3. Dimensions of Economic Diversification:

2.3.1. Production Diversification:

Production diversification operates through two fundamental channels: demand-side and supply-side mechanisms. On the demand side, diversification involves reforming the overall framework for macroeconomic management to enhance stability through coordinated deployment of fiscal policy, monetary policy, and exchange rate policy.(Imbs & Wacziarg, 2003). These demand-management policies create enabling conditions for diversification by stabilizing the macroeconomic environment and reducing volatility that discourages investment in non-traditional sectors.

Supply-side diversification encompasses more structural and long-term transformations, including human capital accumulation, public sector reform, addressing labor market distortions, and building industrial capacity that supports export diversification. These supply-side reforms must proceed in parallel with macroeconomic stabilization efforts to diversify the production base and income sources away from the hydrocarbon sector and its associated industries. Production structure transformation represents a long-term challenge requiring sustained investment in human capital development, comprehensive reform of both public and private sectors, and construction of industrial infrastructure supporting diversification processes. At the economy-wide level, production diversification occurs when economic sectors contribute proportionally and sustainably to generating output, national income, and services, rather than one sector dominating economic activity. (Hesse, 2008).

2.3.2. Trade Diversification:

Trade diversification encompasses multiple dimensions critical for sustainable economic development. Export diversification can be achieved through two primary channels: maintaining hydrocarbon exports while developing non-hydrocarbon export sectors, or fundamentally transforming the export structure toward non-resource products. Non-hydrocarbon exports typically include food products, agricultural equipment, industrial equipment, and non-food consumer goods, developed through comprehensive incentive systems including financial support, tax incentives, and customs facilitation measures. Successful implementation of trade diversification requires coordinated activation of all economic sectors and policy levels.

Market diversification represents an equally critical dimension of trade strategy. Economic dependence on single export markets creates vulnerability to demand fluctuations in those markets, potentially generating severe economic disruptions. Diversifying export markets mitigates these risks by ensuring that demand declines in one market can be offset by stability or growth in alternative markets. Countries demonstrating extensive export capabilities across multiple markets signal strong international competitiveness and economic resilience(Al-Marhubi, 2021).

The World Bank's 2011 report introduced an innovative approach to measuring diversification through asset categories, dividing national assets into natural assets (forests, land, pastures), produced assets (physical capital, human capital, social capital), and intangible assets (institutional quality, rule of law). This multidimensional framework recognizes that sustainable diversification extends beyond simple sectoral reallocation to encompass comprehensive economic transformation (Naceur, Hamdaoui, & Chaibi, 2023).(Lederman & Maloney, 2007).

2.4. Determinants of Successful Diversification:

The success or failure of economic diversification initiatives depends on multiple interrelated determinants that shape the enabling environment for structural transformation. Investment volume and capital formation rates represent primary determinants, as diversification requires substantial investments in new sectors, research and development, technology transfer, and knowledge accumulation. Countries with low diversification indices must develop targeted strategies to improve the investment climate in emerging sectors, recognizing that diversification cannot occur without sustained capital deployment in non-traditional activities:(Ross, 2015).

Economic growth rates, particularly measured through per capita GDP, contribute significantly to diversification prospects by increasing purchasing power and enabling demand diversification, which in turn stimulates production diversification. Foreign trade policies also play critical roles, as trade liberalization initially increases specialization according to comparative advantage but subsequently encourages diversification as countries seek to prevent excessive vulnerability to external shocks. The private sector serves as a crucial driver of diversification through encouraging innovation in untapped sectors and promoting research and development in new activities. However, realizing this potential requires governments to improve industrial policies, remove bureaucratic obstacles hindering business operations, and encourage public-private partnerships (Cherif & Hasanov, 2020).

Additional determinants include the degree of natural resource exploitation and its application to developing manufacturing and service industries, economic integration agreements that simplify customs procedures and stimulate cross-border economic activity, availability of appropriate infrastructure and human services (education, healthcare, transportation, communications), quality of governance and institutional frameworks, and market access conditions including trade openness and financial accessibility. Institutional capacity and human resource quality play particularly prominent roles, as empirical studies consistently demonstrate that institutional quality differences are crucial determinants of whether countries successfully avoid resource curse dynamics. Countries relying heavily on oil revenues frequently experience corruption, poor governance, and elevated risks of internal conflicts, making institutional development essential for successful diversification (Badeeb, Lean, & Clark, 2023):(Arezki & van der Ploeg, 2007).

3. Methodology

3.1. Measurement Indicators for Economic Diversification:

Numerous statistical indicators exist for measuring economic diversification, varying in efficiency and suitability for different measurement purposes. Variables to which diversification indicators apply include GDP composition by economic activities, output structure distribution between oil and non-oil sectors, export structure and oil versus non-oil export shares, and government revenue distribution between hydrocarbon and non-hydrocarbon sources. The United Nations Conference on Trade and Development (UNCTAD) established a composite criterion for economic diversity in identifying least developed countries, consisting of four elements: industrial sector contribution to GDP, proportion of

employment in industry, per capita electricity consumption, and export concentration degree.(Al-Khatib, 2011, p. 211).

- The proportion of employment in industry.
- The amount of per capita consumption of electricity.
- The degree of concentration in exports.

3.1.1. Concentration coefficient: The Gini index is considered one of the best and simplest measures of concentration and is calculated using the following formula:

$$G=1-\sum_{k=1}^n(x_k - x_{k-1})(y_k - y_{k-1})$$

Where:

x_k :The cumulative relative frequency of the total variable (sectoral share of GDP) is represented on the horizontal axis.

y_x :The cumulative relative frequency of the number of sectors is represented on the vertical axis.

n: represents the number of sectors.

3.1.2. Herfindahl-Hirschman Index: It is used to measure the diversification of a phenomenon, as it relies on the composition and structure of the variable and its degree of diversity. This index was primarily designed to measure the degree of concentration in an industry or a specific sector, and it is defined by the following formula:

$$h = \frac{\sqrt{\sum_{i=1}^n y(\frac{x_i}{x})^2} - \sqrt{\frac{1}{n}}}{1 - \sqrt{\frac{1}{n}}}$$

Where:

h: Herfindahl-Hirschman Index.

X_i ; is the value of the variable in activity.

X ; The total value of the variable in all activities.

The value of the coefficient is confined between zero and one. If it is equal to zero, it means there is complete diversification in the economy, and if it is equal to one, the degree of diversification is zero. High values of the coefficient, meaning when its value is close to one, indicate the weakness of the economy in distributing its activities evenly across a large number of sectors or products.

Vladimir Kosov Index (Vla-di-mir Ko-sov): This index takes the following form:(Dickey & Fuller, 1979)

$$Cos = \frac{\sum_{i=1}^n D_i^2 X B_i^2}{\sqrt{\sum_{i=1}^n D_i^2 X} \sqrt{\sum_{i=1}^n B_i^2}}$$

Whereas:

(xi) The relative importance of each sector in the overall GDP during the base period. The relative importance of each sector in the total GDP during the comparison period. Cos indicates the presence of diversification through structural changes in the economy when **cos=0**. Conversely, in the case of deviating from the value, this translates to a decrease in structural.

4. Results and discussion:

4.1. Economic Diversification Policies and Reality in Algeria (1990-2022):

4.1.1. Historical Context and Policy Evolution:

Algeria's economic trajectory since 1990 has been characterized by attempts to transition from centralized planning to market-oriented systems while simultaneously pursuing economic diversification to reduce hydrocarbon dependency. The 1986 oil price collapse, when petroleum prices dropped to historically low levels, served as a critical catalyst forcing authorities to fundamentally reconsider economic strategies and focus on improving non-hydrocarbon sector performance. This crisis awareness intensified during the early 1990s as Algeria confronted multiple simultaneous challenges including economic recession, external debt accumulation, and political instability, necessitating comprehensive structural reforms.

The government's initial response centered on liberalizing foreign trade through the 1989 Structural Adjustment Program, implemented in cooperation with international financial institutions. This program encompassed multiple dimensions of economic reform, including reducing budget deficits through cutting public expenditures and subsidy programs, improving financial performance of state-owned enterprises, and revisiting price determination mechanisms and subsidy policies. The implementation framework included several critical legislative measures that fundamentally altered Algeria's economic governance structure. Law No. 89-12 reformed the pricing system to reflect supply and demand conditions rather than administrative fiat. Law No. 90-16, part of the 1990 complementary financial law, adopted systems of authorized agents and wholesale traders, permitting them to import goods for resale while exempting them from foreign trade and currency control procedures. Executive Decree 91/37 effectively liberalized foreign trade by eliminating licensing requirements and administrative interventions that had previously constrained commercial activity (Gylfason, 2001).

These structural adjustment initiatives reflected the government's strategic intention to embrace market economy principles, transitioning from monopolistic state control to competitive market-based resource allocation. However, the transition process proved challenging, generating significant social costs including unemployment increases and living standard deterioration for many citizens. The external debt restructuring process and cancellation of central hard currency allocation (Instruction No. 24-20, April 12, 1994) represented additional critical steps in economic liberalization, though these measures created short-term economic disruptions.

4.1.2. Exchange Rate Policy and Trade Competitiveness:

Exchange rate policy has represented a central instrument in Algeria's diversification strategy since 1986, with authorities implementing numerous adjustments coinciding with economic reform phases. The objective involved establishing an appropriate internal and external value for the Algerian dinar that would promote non-hydrocarbon exports while reducing import dependence. Prior to these adjustments, currency overvaluation had contributed to current account deficits by making imports artificially cheap while rendering Algerian exports uncompetitive in international markets. The government implemented a series of devaluations aimed at correcting this misalignment, establishing a more realistic exchange rate that would support export diversification and import substitution objectives. (Auty, 2001) .

4.1.3. Fiscal and Tax Policy Reforms:

Tax system reforms have constituted another critical dimension of Algeria's diversification strategy, aimed at reducing the tax burden on non-oil sectors while rationalizing tax rates and narrowing the tax base on foreign trade. Authorities implemented comprehensive reforms including full or partial exemptions for exports from corporate profit taxes, value-added taxes, and professional activity taxes. These fiscal incentives aimed to improve the competitiveness of non-hydrocarbon exports by reducing production costs and enabling Algerian products to compete more effectively in international markets. Customs procedures were similarly reformed to support export activities, with exemptions from customs duties and fees designed to enable national products to be exported at competitive prices through various customs regime incentives available to exporters.

4.1.4. Investment Climate and Private Sector Development: Recognizing that transitioning to a post-oil economy requires building productive capacity beyond the state sector, Algeria implemented numerous reforms targeting the investment climate and private sector development. The 1990 Money and Credit Law represented a watershed moment in economic liberalization, strongly advocating for foreign trade liberalization and free capital movement to finance economic projects while licensing non-residents to transfer funds to Algeria. This legislation fundamentally altered the investment landscape by removing previous restrictions on capital flows and foreign participation in the Algerian economy (Naceur, Hamdaoui, & Chaibi, 2023).

The 2001 Investment Climate Development Law further advanced these objectives by expanding the investment concept to encompass privatization operations and establishing the National Agency for Investment Development (ANDI) as a unified institutional interface for investors. This reform aimed to reduce bureaucratic obstacles and streamline investment procedures, addressing longstanding complaints about administrative complexity and opacity that had deterred private investment. The Algerian government provided private sector operators with diverse incentives across three categories designed to encourage investment and developmental contributions.

Physical incentives related to industrial real estate, equipment, and raw materials, with private investors whose projects received ANDI approval granted land allocations for establishing factories or production units, along with facilitated access to equipment and raw materials through the National Chamber of Commerce. Tax incentives aimed to reduce fiscal burdens on the production sector through full or partial exemptions from taxes and quasi-fiscal fees, significantly reducing the effective tax rate for private investors in priority sectors. Financial incentives included reduced interest rates on bank loans granted to implement private investment projects, lowering capital costs and improving project financial viability (Arezki & van der Ploeg, 2007)

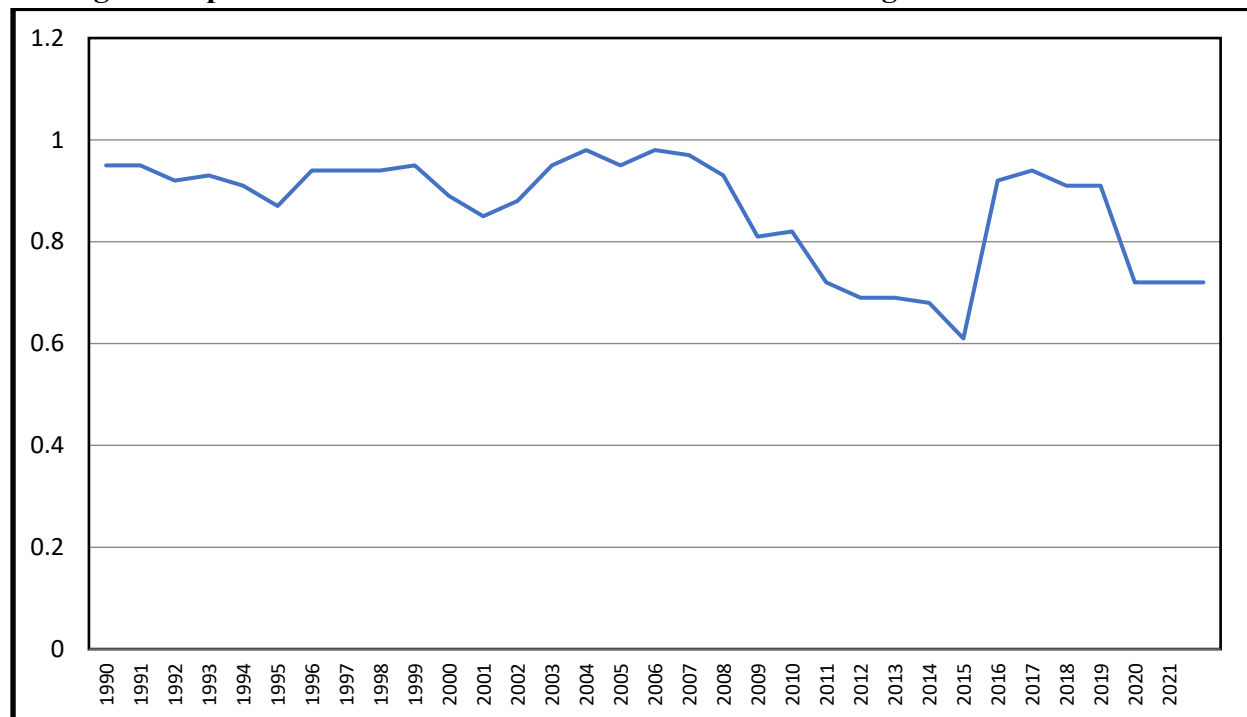
4.1.5. Small and Medium Enterprise Development:

The small and medium enterprise (SME) sector received particular emphasis in Algeria's diversification strategy, experiencing rapid growth following the adoption of market economy principles with private sector foundations. The state attached considerable importance to this sector given its potential contributions across economic and social

dimensions, including employment generation, innovation fostering, and local development stimulation. This priority was reflected in creating specialized support institutions and adopting programs to assist and upgrade SMEs, resulting in notable increases in enterprise numbers. However, despite quantitative growth, questions remain regarding the quality, sustainability, and genuine contribution of SMEs to economic diversification, as many enterprises remain concentrated in commerce and services rather than productive manufacturing activities (Nchofoung, Achuo, & Asongu, 2022).

4.2. Empirical Analysis of Diversification Progress

Figure01: presents the economic diversification index for Algeria from 1990 to 2022.

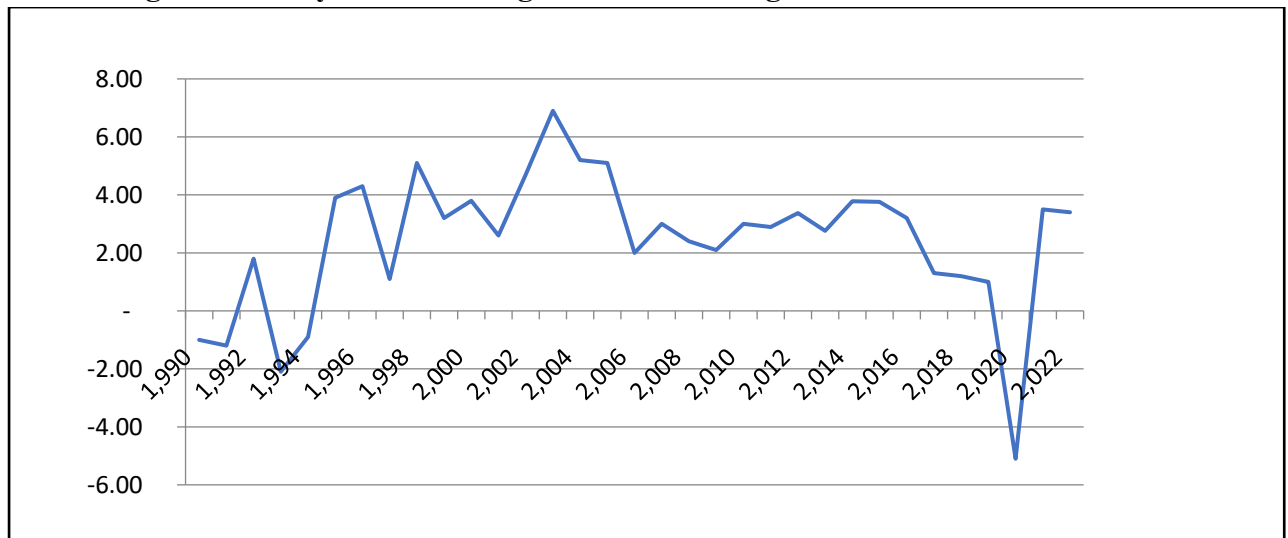


Source: Prepared by the researcher based on data from the National Statistics Office available at <http://www.ons.dz>.

The analysis demonstrates that index values consistently approach unity throughout the study period, indicating the absence of effective diversification policies and the continued dominance of hydrocarbon sectors in economic activity. Particularly notable is the significant decline in diversification during 2011-2015, corresponding to decreased oil prices affected by global financial crisis repercussions and economic recession. This period witnessed reduced oil exports as a share of total exports, paradoxically improving the statistical diversification index while actually reflecting economic contraction rather than genuine structural transformation. These findings underscore that measured diversification improvements may result from economic distress rather than successful policy implementation, highlighting the importance of examining both diversification indicators and underlying economic conditions.

4.3. Economic Growth Performance Analysis

Figure02: analyzes economic growth rates in Algeria from 1990 to 2022.



Source: Prepared by the researcher based on World Bank statistics. <https://www.albankaldawli.org>

The early 1990s exhibited particularly weak performance, with negative growth rates during 1990-1994 reflecting economic recession stemming from collapsed oil prices and exacerbated external debt crises. These years represented a critical low point in Algeria's post-independence economic history, with per capita incomes declining and unemployment rising substantially. Growth rates began recovering in 1995 following structural adjustment implementation and improving oil market conditions, recording 3.90% growth that year. The highest growth rate during the study period occurred in 2003 at 6.90%, driven by booming global oil markets resulting from Gulf War disruptions that temporarily elevated petroleum prices to elevated levels.

Post-2003 growth rates exhibited greater volatility and generally declining trends as Algeria's market share faced pressure from emerging competitors and global oil markets experienced repeated disruptions. The 2020 COVID-19 pandemic generated severe economic contraction with a negative 5.10% growth rate, reflecting both demand collapse in global energy markets and domestic economic disruptions from pandemic response measures. Growth partially recovered to 3.40% in 2022 as pandemic effects subsided and oil prices rebounded, though this recovery remained modest compared to pre-pandemic performance (World Bank Data).

Algeria's growth performance demonstrates the fundamental challenge facing petroleum-dependent economies, growth volatility driven by external factors beyond domestic policy control. The tight correlation between growth rates and oil price cycles (Naceur, Hamdaoui, & Chaibi, 2023; Badeeb, Lean, & Clark, 2023) illustrates the continued failure of diversification efforts to insulate the economy from hydrocarbon market fluctuations. Despite three decades of reforms aimed at reducing oil dependency, economic growth remains primarily driven by petroleum sector performance rather than productivity improvements or expansion in non-oil sectors. This pattern underscores the insufficiency of past diversification efforts and highlights

the urgent need for more transformative structural reforms capable of generating sustainable, diversified growth independent of global oil markets.

4.4. Structural Adjustment Programs and Economic Reforms:

Algeria's engagement with International Monetary Fund structural adjustment programs represented critical junctures in economic policy evolution. The First Credit Readiness Program (May 31, 1989 - May 30, 1990) addressed mounting economic challenges and rising external debt, resulting in improved economic indicators including a 19% export increase in 1989 compared to 1988 and 2.9% GDP growth, reversing the 3.8% decline experienced in 1988. The Second Credit Agreement Program (June 3, 1991 - March 30, 1992) focused on deeper structural reforms, including comprehensive financial system reform encompassing tax and customs systems, granting financial independence to the central bank, and implementing significant dinar devaluation to improve external competitiveness :(Osei & Kim, 2020).

These programs fundamentally altered Algeria's economic management paradigm, shifting from direct state control toward market-based allocation mechanisms. However, the social and economic costs of adjustment proved substantial, including increased unemployment, reduced real wages, and deteriorating public services as subsidy programs were curtailed. The political ramifications of these adjustments contributed to the instability of the 1990s, illustrating the political economy challenges inherent in implementing comprehensive structural reforms in rentier states where significant portions of the population depend on state redistribution of resource rents.

5.Econometric Analysis: ARDL Methodology and Results

Methodology and Model Specification:

This study employs the Autoregressive Distributed Lag (ARDL) bounds testing approach developed by Pesaran et al. (2001) to examine the relationship between economic diversification and economic growth in Algeria. The ARDL methodology offers the advantage of estimating both short-run and long-run relationships simultaneously, and it can be applied to variables regardless of whether they are integrated of order zero $I(0)$ or order one $I(1)$. It also demonstrates high efficiency with small sample sizes.

Where PIB represents **GDP** growth, and **CI** denotes the economic diversification index, Fixed capital accumulation (CA) and Employment (MD).

Unit Root Tests and Stationarity Analysis:

Prior to estimating the ARDL model, comprehensive unit root testing was conducted to determine the integration order of each variable. The Augmented Dickey-Fuller (ADF) test was applied following a sequential testing procedure examining the presence of trends and constants.

Table 01: Unit Root Test Results for Composite Diversification Index

The decision	prob	The calculated value	The tabular value	coefficient	The model
Since the calculated value is less than the tabulated value, we accept the null hypothesis and	0.08	1.25	3.25	The trend $b=0$	The model3

move on to the second model. We notice that a p-value greater than 0.05 indicates the absence of a trend.					
Since the calculated value is greater than the tabulated value, we reject the null hypothesis and remain in the same model. We find that the prob is less than 0.05, hence the series is stable.	0.03	3.10	1.97	The constant c=0	The model2

Source: Prepared by the researcher based on Eviews10.

The composite diversification index (CI) testing procedure began with Model 3 including both trend and constant terms. The calculated ADF statistic of 1.25 fell below the critical value of 3.25, with probability 0.08 exceeding the 0.05 threshold, leading to acceptance of the null hypothesis of no significant trend and progression to Model 2. In Model 2 testing for the significance of the constant term, the calculated value of 3.10 exceeded the critical value of 1.97, with probability 0.03 below 0.05, indicating rejection of the null hypothesis and confirming that the constant is significant. These results demonstrate that the composite diversification index series is stationary at levels without requiring differencing, classified as I(0).

Table 02: Unit Root Test Results for Total Fixed Capital Accumulation.

The decision	Prob	The calculated value	The tabular value	coefficient	The model
Since the calculated value is less than the tabulated value, we accept the null hypothesis and move on to the second model. We notice that the prob is greater than 0.05, indicating the absence of a trend.	0.08	1.25	3.25	The trend b=0	The model3
Since the calculated value is greater than the tabulated value, we reject the null hypothesis and remain in the same model. We find that the prob is less than 0.05, hence the series is stable.	0.03	3.10	1.97	The constant c=0	The model2
Since the probability is greater than 0.05, we accept the null hypothesis, so the series is unstable of type DS.	0.9	/	/	Unit root	The model 1

Source: Prepared by the researcher based on Eviews10 .

Fixed capital accumulation (CA) exhibited similar testing patterns in Models 3 and 2 as the diversification index, with the calculated value in Model 3 (1.25) falling below the critical value (3.25) and probability 0.08 exceeding 0.05, indicating no significant trend. Model 2

results showed the calculated value (3.10) exceeding the critical value (1.97) with probability 0.03, confirming constant significance. However, Model 1 testing for the unit root yielded probability 0.9, substantially exceeding 0.05, leading to acceptance of the null hypothesis and conclusion that the series is non-stationary at levels, classified as Difference Stationary (DS).

Table 03: Unit Root Test Results for Fixed Capital After First Differencing.

The decision	Prob	The calculated value	The tabular value	coefficient	The model
Since the calculated value is less than the tabulated value, we accept the null hypothesis and move to Model 2. Since the p-value is less than 0.05, we reject the null hypothesis, indicating the presence of a trend.	0.01	1.76	3.25	The trend $b=0$	The model3
Since the calculated value is less than the tabulated value, we accept the null hypothesis and move on to Model 1. If the p-value is less than 0.05, we reject the null hypothesis, which states that the constant is not significant.	0.01	0.91	1.97	The constant $c=0$	The model2
Since the probability is less than 0.05, we reject the null hypothesis, meaning the series is stationary.	0.001	/	/	Unit root	The model 1

Source: Prepared by the researcher based on Eviews10.

After applying first-order differencing to the capital accumulation series, the results changed substantially. Model 3 testing showed a calculated value of 1.76 below the critical value of 3.25, but with probability 0.01 below 0.05, rejecting the null hypothesis and indicating the presence of a significant trend in the differenced series. Model 2 results showed the calculated value (0.91) below the critical value (1.97) with probability 0.01, leading to acceptance of the null hypothesis that the constant is not significant in the differenced series, progressing to Model 1. In Model 1, the probability of 0.001 fell well below 0.05, rejecting the null hypothesis of a unit root and confirming that the first-differenced series is stationary, classifying capital accumulation as I(1).

Table 04: Unit Root Test Results for GDP Growth

The decision	prob	The calculated value	The tabular value	coefficient	The model
Since the calculated value is less than the tabulated value, we accept the null hypothesis and	0.07	1.21	3.25	The trend $b=0$	The model 3

move on to model 2. If the probability is greater than 0.05, we accept the null hypothesis, indicating no general trend.					
Since the calculated value is greater than the scheduled one, we reject and remain in the same model. The probability is less than 0.05, hence the series is stable.	0.03	2.67	1.97	The constant c=0	The model 2

Source: Prepared by the researcher based on Eviews10.

GDP growth rate testing in Model 3 yielded a calculated value of 1.21 below the critical value of 3.25, with probability 0.07 exceeding 0.05, leading to acceptance of the null hypothesis of no significant trend and progression to Model 2. Model 2 results showed the calculated value (2.67) exceeding the critical value (1.97) with probability 0.03 below 0.05, rejecting the null hypothesis and confirming constant significance, establishing that the GDP growth series is stationary at levels, classified as I(0).

Table 05: Unit Root Test Results for Employment

The decision	Prob	The calculated value	The tabular value	coefficient	The model
Since the calculated value is less than the tabulated value, we accept the null hypothesis and move to Model 2, where the probability is greater than 0.05, indicating no general trend.	0.08	-0.78	3.25	The trend b=0	The model 3
Since the calculated value is greater than the tabulated one, we reject the null hypothesis, meaning the series is unstable.	0.01	3.62	1.97	The constant c=0	The model 2

Source: Prepared by the researcher based on Eviews10.

Employment (MD) testing in Model 3 showed a calculated value of -0.78 below the critical value of 3.25, with probability 0.08 exceeding 0.05, accepting the null hypothesis of no trend and moving to Model 2.

The calculated value (3.62) exceeded the critical value (1.97) with probability 0.01 below 0.05, rejecting the null hypothesis and indicating that the employment series is non-stationary at levels, requiring first differencing to achieve stationarity, classified as I(1).

Table 06: Optimal Lag Length Selection Criteria

Model selection criteria table					
Dépendent variable: PIB					
Date : 12/21/2024 TIME :17.27					
Sample :1990 2022					
Included observations :32					
Specification	ADJ.R-Sq	HQ	BICModel	Logl	AIC*
4	-38.524568	3.801965	4.240761	3.923669	0.570393
ARDL(1.1.0.1.1)					
1	-38.518525	3.881482	4.369032	4.016708	0.541975
ARDL(1.1.1.1.1)					
6	-40.970820	3.917666	4.307706	4.025846	0.508262
ARDL(1.1.0.1.0)					
8	-42.699166	3.975933	4.317219	4.070591	0.466716
ARDL(1.1.0.0.0)					
2	-40.821458	3.985717	4.424512	4.107420	0.483735
ARDL(1.1.1.1.0)					
7	-42.1877001	4.014960	4.405000	4.123141	0.458014
ARDL(1.1.0.01)					
5	-42.273979	4.021918	4.411959	4.130099	0.454230
ARDL(1.1.1.0.0)					
3	-41.821465	4.065717	4.504513	4.187420	0.440736
ARDL(1.1.1.0.1)					

Source:Prepared by the researcher based on Eviews10 .

The determination of optimal lag structure represents a critical step in ARDL modeling, directly affecting estimation efficiency and the reliability of inference. Table 6 presents model selection criteria for alternative ARDL specifications, with Model 4 identified as optimal based on multiple criteria. The ARDL (1,1,0,1,1) specification achieved the highest adjusted R-squared value (0.570393), indicating superior explanatory power relative to alternative specifications. Simultaneously, this specification exhibited the lowest values for the Akaike Information Criterion (3.801965), Hannan-Quinn Criterion (3.923669), and Bayesian Information Criterion (4.240761), all favoring parsimony while maintaining adequate model fit. The log-likelihood value of -38.524568 further confirms this specification's superiority. The convergence of all selection criteria on a single specification enhances confidence in the chosen model structure.

Table 07: Breusch-Godfrey Serial Correlation LM Test.

Breusch-Godfrey serial correlation LM Test			
F-Statistic	7.023763	prob.F(2.14)	0.0008
Obs*R-Squared	12.35179	prob.chi-square(2)	0.0023

Source:Prepared by the researcher based on Eviews10.

Diagnostic testing constitutes an essential component of econometric analysis, ensuring that estimation results satisfy the classical regression assumptions necessary for valid inference. The Breusch-Godfrey test examines the presence of serial correlation in regression residuals, with the null hypothesis asserting no autocorrelation. The test results reveal an F-statistic of 7.023763 with probability 0.0008, while the Observed R-squared statistic of 12.35179 yields a chi-square probability of 0.0023. Both test statistics indicate probabilities substantially below the 0.05 significance threshold, leading to rejection of the null hypothesis and acceptance of the alternative hypothesis of serial correlation in the error terms.

Table 08: ARDL Bounds Test for Cointegration

ARDL Bounds Test		
Date :12/20/2024 Time 18.28		
Sample :1991 2022		
Included observations :32		
Null Hypothesis :No long-run relationships exist		
Test statistic	value	k
F-statistic	8.647307	4
Critical value Bounds		
Significance	I0 Bound	I1 Bound
10%	3.454.42	
5%	3..86	4.20
2.5%	3.75	4.55
1%	3.94	5.08

Source:Prepared by the researcher based on Eviews10.

The ARDL bounds testing procedure, developed by Pesaran, Shin, and Smith (2001), provides a robust framework for testing the existence of long-run equilibrium relationships between variables. This approach proves particularly valuable when dealing with variables exhibiting mixed integration orders, as in this study where some variables are $I(0)$ and others $I(1)$. The test compares the calculated F-statistic against critical value bounds, with the lower bound (I0) assuming all variables are $I(0)$ and the upper bound (I1) assuming all variables are $I(1)$. If the calculated F-statistic exceeds the upper bound, cointegration can be concluded regardless of the variables' integration orders.

The bounds test results demonstrate an F-statistic of 8.647307, substantially exceeding the upper bound critical values at all conventional significance levels: 4.42 at the 10% level, 4.20 at the 5% level, 4.55 at the 2.5% level, and 5.08 at the 1% level. With $k=4$ independent variables, the calculated F-statistic's magnitude provides strong evidence rejecting the null hypothesis of no long-run relationships. This result establishes the existence of a long-run equilibrium relationship between GDP growth and the set of explanatory variables (Benali & Foughali, 2024) including the diversification index, fixed capital accumulation, human capital, and employment.

Table 09: ARDL Cointegrating and Long-Run Form Estimation Results

ARDL Cointegrating and long Run Form				
Dependent variable :PIB				
Selected Model :ARDL(1.1.0.1.1)				
Date :12/11/2024 Time :12.50				
Sample :1990 202022				
Included observations :32				
Cointegrating Form				
Variable	coefficient	std.Error	t-statistic	prob
D(CI)	8.896821	5.885234	1.770257	0.2243
D(CA)	-0128743	0.117523	-0.377331	0.8926
D(HT)	-0.000012	0.000360	-0.032660	0.9743
D(MD)	-0.000001	0.000002	-0.506583	0.6194
Cointeq(-1)	-0.804112	0.200898	-4.314391	0.0005
Cointeq= PIB-(-11.3312*CI-0.0421*CA-0.0018*HT+0.0014*MD-14.02547)				
Long Run coefficients				
Variable	Coefficient	std.Error	t-statistic	prob
CI	-11.331238	7.982083	-1.557386	0.1389
CA	-0.042162	0.119426	-0.277678	0.7848
HT	-0.001825	0.000476	-1.941845	0.0700
MD	0.000014	0.000001	2.732669	0.0148
C	-12.02547	8.766486	-1.600161	0.1291

Source:Prepared by the researcher based on Eviews10.

Through the previous table, we notice that the condition is met, as it has been shown that the error correction coefficient is -0.866752 and 0.0005, both less than 0.05, which is significant, and thus the condition is met.

We say that 80.41% represents short-term errors that can be corrected within a time unit, which is one year, in order to return to the long-term equilibrium state. What interests us from these results is the long-term equation, which takes the following form:

$$PIB = -11.3312*CI-0.0421*CA-0.0018*HT+0.0014*MD-14.02547$$

Table 10: Heteroskedasticity Test - ARCH Effects

Heteroskedasticity Test ARCH		
F-Statistic	1.226316	prob.F(1.22)
OBS*R-Squared	1.218433	prob.chi-square(1)

Source: Prepared by the researcher based on Eviews10.

He results of the **Autoregressive Conditional Heteroskedasticity (ARCH) test** indicate that the variance of the regression residuals does not exhibit significant changes over time. Specifically, the **F-statistic** of 1.226316 ($p = 0.2794$) and the **observed R-squared** of 1.218433 (chi-square probability = 0.2697) both produce p-values well above the conventional 5% significance level.

These findings suggest that **heteroskedasticity is not present** in the residuals, and therefore, the null hypothesis of **constant variance (homoskedasticity)** cannot be rejected. In practical terms, this implies that the estimated coefficients of the regression model are likely to be **efficient and unbiased**, and the standard errors are reliable for hypothesis testing.

The absence of heteroskedasticity also strengthens the validity of any subsequent econometric analysis based on this model, including inference about the short-run and long-run relationships. It indicates that **volatility clustering**, often observed in financial or macroeconomic time series, does not significantly affect the error term in this case. As a result, the model can be considered stable with respect to the variance of residuals, which increases confidence in the robustness of the findings regarding economic relationships, such as the impact of economic diversification on GDP growth.

Revised Discussion Section:

The empirical findings from the ARDL model confirm a long-run equilibrium relationship between economic diversification and GDP growth in Algeria (1990-2022), partially supporting the third research hypothesis that this relationship is positive in the long term. However, the analysis reveals a weak positive impact overall, as the inverse coefficient on the diversification index (-11.3312) indicates that increases in the index (signaling reduced diversification) correlate with slower growth, while employment shows a direct positive effect (0.0014). This mixed confirmation stems from Algeria's persistent hydrocarbon dominance, where diversification efforts have not yet generated sufficient non-oil contributions to GDP, despite policy reforms since the 1990s. The bounds test F-statistic (8.647307) exceeds critical values, validating cointegration, but the error correction term (-0.804112) suggests only 80% of short-term disequilibria adjust annually, highlighting gradual rather than transformative progress.

Explaining the Results:

The weak positive diversification-growth link arises from structural rigidities in Algeria's rentier economy, where hydrocarbons still account for ~60% of GDP and >96% of exports, muting non-oil sector spillover effects. Higher diversification index values (approaching 1) reflect concentrated activity, explaining the negative coefficient: as oil dependency persists, diversification remains superficial, failing to boost productivity or integration across sectors like manufacturing and services. Employment's positive long-run effect aligns with theory, as labor reallocation to non-oil activities marginally supports growth, while inverse capital accumulation (-0.0421) and human capital (-0.0018) coefficients indicate inefficient investments tied to oil cycles rather than productive diversification.

Advantages Over Comparable Studies:

This study's ARDL application over 33 years provides superior granularity on short- and long-run dynamics compared to static analyses (e.g., Al-Khatib (2011) on Saudi non-oil growth and Boukhari & Foudad (2022) on Algeria), capturing oil price volatility's non-linear impacts. Unlike cross-sectional works on MENA rentier states, the composite index (Gini, Herfindahl-Hirschman, Kosov) and mixed I(0)/I(1) handling yield robust bounds testing absent in simpler OLS models. Key advantages include diagnostic rigor (no heteroskedasticity, confirmed cointegration) and policy-specific focus on Algeria's reforms (e.g., 1989 adjustments, ANDI

incentives), offering more actionable Algerian-context insights than generalized diversification studies.

Addressing Literature Gaps :

Results directly tackle gaps from Section 2, such as monoculture vulnerabilities (Badeeb, Lean, & Clark, 2023; Imbs & Wacziarg, 2003) and weak non-oil activation (Hesse, 2008), by quantifying how diversification indices near unity perpetuate oil shocks' growth volatility (e.g., 1990s recession, 2020 COVID contraction). The long-run equilibrium explains limited progress in production/trade diversification (Laafifi Deraji 2017), attributing it to institutional hurdles like state dominance over private SMEs, while employment's positive role addresses human capital underutilization gaps (Hamid 2018). This empirical bridge—via ARDL over extended cycles—extends conceptual determinants (infrastructure, governance) by showing their insufficiency without sectoral integration.

Policy and Practical Recommendations. Empirical insights urge prioritizing private sector-led SMEs in manufacturing/services via tax exemptions and export incentives, targeting non-hydrocarbon GDP share >40% within a decade to amplify employment's growth effect. Policymakers should reform investment climates (expand ANDI-like agencies) and dinar valuation for competitiveness, while channeling oil rents into infrastructure linking sectors—potentially raising growth by 1-2% annually per diversification gains. Practically, annual monitoring of composite indices could guide adaptive strategies, such as public-private partnerships for export market diversification, reducing fiscal oil reliance below 50%.

Study Shortcomings. Interpretation limitations include potential omitted variables (e.g., governance quality, global shocks beyond oil), risking endogeneity in a small sample ($n=32$), where ARDL efficiency shines but cannot fully disentangle causality. Practical application falters from aggregate data masking sectoral nuances, limiting micro-policy precision, and stationarity assumptions may overlook structural breaks (e.g., 2014 oil crash). Results' Algeria-specificity hinders generalizability, and serial correlation (Breusch-Godfrey $p=0.002$) suggests caution in short-run inference without further lags.

6. Conclusions

By conducting the tests, we reached the following results. Through the stability study of each variable, it was found that some variable series are not stable over time at their level, such as (CA)(HT)(MD), due to the presence of a trend component. This is natural given the fluctuations in the economy according to the fluctuations in oil prices. However, after performing first differences, we find that they stabilize at the first degree. We concluded from the results of the standard study that the study model is statistically acceptable based on the share of tests that followed the estimation process using the ARDL methodology. The existence of integration between the variables means that they are linked by a long-term equilibrium relationship. The results of the model estimation show that the relationship between the diversification index and economic growth is inverse in the long term, as an increase in the diversification index means a decrease in the degree of diversification. The economy and the decrease in diversification negatively affect growth rates, thus the relationship between economic diversification and economic growth is positive, but weak. This is due to the lack of activation of different sectors and their interconnection to contribute to the gross domestic

product. The relationship between total capital accumulation and GDP is inverse. The relationship between human capital and GDP is inverse. The relationship between employment and GDP is direct, which is consistent with economic theory.

Based on the results obtained, we can propose the following recommendations:

- The state's intervention to adopt effective strategies primarily focuses on activating the role of the private sector alongside the public sector, in order to contribute to the increased creation of small and medium enterprises in various sectors, considering them the main driver for achieving economic recovery.

- Opening new channels for product distribution within the framework of a policy to encourage non-hydrocarbon exports.

- Economic policy makers must diversify national income sources by encouraging massive investments in infrastructure and in the productive sector of goods and services.

- Moving away from complete reliance on oil revenues, as it is a depleting resource subject to price instability.

- Setting clear sectoral strategies according to the priorities dictated by each sector.

7. Limitations and further research

This study provides an analysis of the relationship between **economic diversification and economic growth in Algeria** using the **Autoregressive Distributed Lag (ARDL) model** over the period 1990–2022. However, there are several **methodological limitations and avenues for future research** that should be considered. First, the study relies on national time-series data, which may not fully capture the detailed sectoral effects of economic diversification, potentially limiting the analysis's ability to identify nuanced differences across various economic sectors. Second, the focus was placed on key quantitative variables, such as the diversification index and human capital, without including certain institutional or political factors that may influence the diversification-growth relationship, such as governance quality or investment and trade policies. Third, while the ARDL model allows for the estimation of both short-run and long-run relationships, it remains sensitive to data quality and sample size, which could affect the precision of the estimates.

For future research, the study could be extended by:

- Conducting **detailed sectoral analyses** to identify which sectors offer the greatest opportunities for diversification and growth.
- Incorporating **institutional and political factors** to understand the impact of governance and economic stability on the effectiveness of diversification.
- Using **international comparative data** from other resource-dependent countries to derive generalizable lessons and identify Algeria-specific contextual factors.
- Applying **advanced dynamic models and artificial intelligence techniques** to improve predictive accuracy and better understand the complex relationships between economic diversification and growth.

These recommendations can contribute to a deeper understanding of the relationship between economic diversification and growth, providing more comprehensive guidance for policymakers in promoting sustainable economic development in Algeria

Conflicts of interest: the author declares no conflict of interest in relation to this study.

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