

## From Crude to Crop: Cultivating Economic Diversity in Algeria through Agricultural Sector

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### Abstract:

This study aims to critically evaluate Algeria's shift towards economic diversification with a special emphasis on the agricultural sector's contribution. Employing Vector Autoregression (VAR) models over the time span from 2000 to 2024, we analyze the interconnected effects of shocks in non-hydrocarbon sectors, government agricultural spending, food imports, and foreign direct investment in agriculture on the diversification process. The methodology integrates a comprehensive set of variables, including GDP from non-oil sectors, agricultural productivity, government expenditures on agriculture, and import-export dynamics and HHI calculated index to provide a multifaceted view of the economic diversification landscape. Results highlight the potential of the agricultural sector as a key driver for reducing oil dependency and suggest recommendations for strengthening sector linkages, optimizing government spending, and enhancing competitiveness.

**Keywords:** Economic diversification, agriculture, Non hydrocarbon sector, Algeria, VAR model.

### 1. Introduction:

Algeria, like many resource-rich countries, has long been both blessed and cursed by its hydrocarbon wealth. For decades, the country's economy has been tightly related to the performance of the global oil market. During periods of high oil prices, revenues surged, allowing for robust government spending and economic growth (Elhannani et al., 2016; Lefèvre, 2017). However, the oil price crashes, particularly in 2014, revealed a fundamental weakness in this dependency. The sharp drop in oil revenues brought Algeria to a financial crossroads, exposing the

fragility of its oil-dependent economy and sparking a renewed conversation about economic diversification (**Benramdane, 2017**).

Algeria's economic dilemma lies a question that many resource-rich countries face: *How can a nation escape the "resource curse"?* For Algeria, the answer increasingly points toward the land through the agricultural sector, which for centuries was the backbone of the nation's economy before oil dominated the scene (**Kadi, 2020**).

The potential of Algeria's agricultural sector is significant. With over 8.4 million hectares of arable land and a climate conducive to diverse crop production, Algeria could feasibly reduce its reliance on food imports, increase domestic productivity, and even become a key player in global agricultural markets (**Laoubi & Yamao, 2012; Nadhira & Ouahiba, 2018**). However, this potential has been largely underutilized, as systemic inefficiencies, poor governance, and historical underinvestment have stunted the sector's growth (**Omari et al., 2012b**). Since the early 2000s, the government has initiated several programs aimed at revitalizing agriculture, including the National Plan for Agricultural Development (NPAD). Despite these efforts, the sector's contribution to national GDP remains modest, and Algeria continues to import a significant portion of its food, making it vulnerable to fluctuations in international food prices (**Baghdad, 2022**).

The challenge, therefore, is not simply to develop agriculture but to integrate it into a broader strategy of economic diversification that can reduce the country's reliance on hydrocarbons. Diversification is not a new goal for Algeria. Since gaining independence in 1962, successive governments have recognized the need to diversify the economy. However, the overwhelming dominance of oil and gas exports—accounting for over 95% of export revenues—has created structural barriers to change (**Bouchentouf & Benabdeli, 2021**). To break free from this cycle, Algeria must not only invest in sectors like agriculture but also address deeper institutional and infrastructural challenges that have long hindered progress (**Achy, 2013**).

This paper investigates the role of agriculture in economic diversification in Algeria. Specifically, it aims to analyze the sector's contribution to non-oil GDP growth and its potential to drive sustainable economic development. One of the key metrics used to evaluate the progress of economic diversification is the **Herfindahl-Hirschman Index (HHI)** (**Djolov, 2013; Rhoades, 1993**), a widely recognized tool for measuring market concentration. The HHI is especially valuable in assessing how dependent an economy is on a particular sector (**Pasipanodya & Knott, 2021**). For Algeria, an economy historically dominated by hydrocarbons, the HHI provides a

quantitative insight into the degree of sectoral concentration and the extent to which diversification efforts are succeeding (Ukav, 2017).

Additionally, this study lies in the recognition that diversification is not merely a policy choice but an economic necessity for Algeria's long-term survival. As global oil demand becomes increasingly uncertain amidst the rise of renewable energy sources and the transition to a low-carbon economy (Khaddir & Khouazem, 2018), Algeria faces mounting pressure to shift its economic base. Agriculture, with its capacity to generate employment, reduce food insecurity, and stimulate growth in related industries, stands out as a critical sector in this transition (Boussedra & Saoudi, 2019).

In addressing these issues, this paper contributes to both the academic literature on economic diversification and the practical policy debate in Algeria (Amine & Fatima, 2016). In addition, this paper fills the gap by applying the Herfindahl-Hirschman Index (HHI) and Vector Autoregression (VAR) models to provide a comprehensive, empirical assessment of the interconnectedness between agriculture and non-oil sectors in Algeria (Ferraz et al., 2021). By doing so, this study not only illuminates the pathways through which agriculture can contribute to economic diversification but also offers specific policy recommendations grounded in data-driven insights, an area where the current literature is lacking.

## 2. Literature review

Economic diversification has long been recognized as a vital strategy for resource-dependent economies seeking to mitigate the risks associated with over-reliance on a single commodity (Esanov, 2012). For countries like Algeria, where hydrocarbons dominate the economic landscape, the concept of diversification has been central to policy discussions for decades. The risks of this dependency have been well-documented in the literature, often referred to as the "resource curse", a phenomenon where natural resource wealth hinders broader economic development, leading to slow growth and increased vulnerability to external shocks (Frankel, 2012; Gylfason & Nganou, 2016). Scholars like (Chigara & Nassira, 2021; Lefèvre, 2017) argue that the Algerian economy has been largely shaped by its hydrocarbon exports, creating structural barriers to diversification despite numerous governmental initiatives. These studies underscore that these efforts, while well-intentioned, have struggled to gain traction due to entrenched institutional inefficiencies and a lack of coordinated implementation.

Historically, several resource-dependent economies have sought to diversify their economic base by developing non-hydrocarbon sectors, with varying degrees of success. Countries like Australia and Norway have achieved development through diversification into new resource products and industries, relying heavily on innovation and knowledge-producing sectors (**Ville & Wicken, 2013**). Successful diversification strategies include investing in human capital, public and intellectual capital, and fostering firm dynamism (**Lashitew et al., 2020**). Similarly, Saudi Arabia and Oman have pursued aggressive economic diversification strategies to reduce their reliance on hydrocarbons. Saudi Arabia, under its Vision 2030 program, has invested heavily in agriculture, particularly in developing food security and reducing its dependency on food imports (**Khashan, 2017**). While Oman has made significant strides in expanding its agricultural output through strategic investments in irrigation and rural development.

One of the most widely used tools for assessing economic diversification is the Herfindahl-Hirschman Index (HHI). Studies applying the HHI in other resource-dependent economies, such as Brazil and Malaysia, have shown that targeted investments in agriculture and other non-oil sectors can significantly reduce economic concentration and foster long-term stability (**Jamalkhanov, 2021; Shadab, 2019**). For Algeria's case, integrating the HHI into the analysis of agricultural development allows for a more nuanced understanding of the sector's potential to contribute to economic diversification. By tracking changes in the HHI over time, policymakers can assess the effectiveness of agricultural investments and make informed decisions about future diversification strategies.

Agriculture, in particular, has been identified as a critical sector for economic diversification, especially in resource-rich countries like Algeria. The sector's ability to generate employment, reduce reliance on food imports, and foster value-added industries positions it as a potential cornerstone for diversification efforts (**Khaddir & Khouazem, 2018**). Numerous studies have emphasized the importance of agriculture in the Algerian context, citing the country's vast arable land and favorable climate as underutilized assets. (**Ammar, 2022**) argues that with targeted investments in modern farming techniques and infrastructure, Algeria's agricultural sector could contribute significantly to non-oil GDP growth and reduce the country's vulnerability to global oil price fluctuations.

Despite widespread recognition of the need for economic diversification in Algeria, most studies have focused on the broader theoretical implications of diversification, with limited attention to the specific role agriculture can play as a driver of structural transformation. Existing literature tends to either address diversification in general terms or highlight agriculture's

challenges without offering a detailed, empirical analysis of its contribution to reducing hydrocarbon dependency. Moreover, while global cases of successful diversification through agriculture have been documented, Algeria-specific studies that quantitatively assess the sector's potential using advanced economic models are notably scarce.

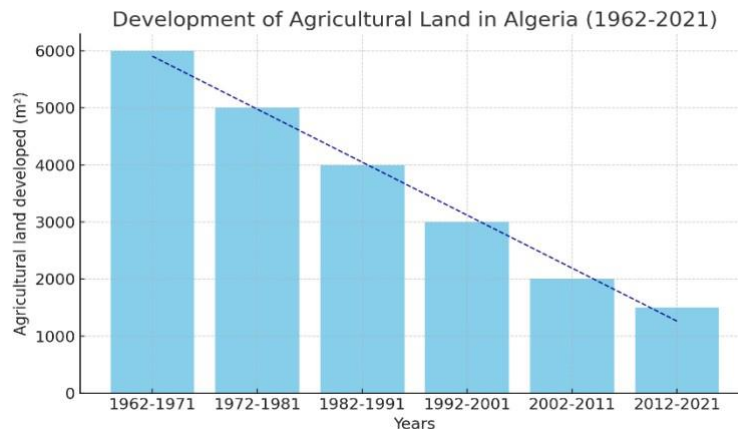
### 3. The agriculture in Algeria: an overview

The agricultural sector in Algeria is at a crossroads, with significant opportunities for growth through modernization and investment. While challenges such as climate variability and import dependency persist, ongoing governmental reforms aim to bolster this vital sector's contribution to the economy and ensure food security for its population. Since the nineties, the sector of agriculture in Algeria has witnessed significant changes (**Laoubi & Yamao, 2012**). One of the pivotal moments in this transformation was the launch of the *National Plan for Agricultural Development* (NPAD) in 2000. This plan aimed to revitalize agriculture through initiatives such as land reclamation, expansion of arable land, and improvements in irrigation systems. The NPAD was designed to ensure food security, enhance productivity, and reduce Algeria's reliance on food imports, which remains a significant concern (**Omari et al., 2012a**).

Despite the positive intentions behind the NPAD, the agricultural sector has faced numerous challenges. Historically, the sector was constrained by inefficient land management policies, where smallholders were often neglected in favor of large state-controlled farms. This created inefficiencies and limited agricultural output. The 1970s "Agricultural Revolution" sought to modernize the sector, but bureaucratic hurdles and resistance from conservative factions hampered progress. These issues were exacerbated in the 1980s when agricultural land ownership was reorganized, leading to instability and further misuse of land for non-agricultural purposes, such as urban development (**Laoubi & Yamao, 2012**).

Today, Algeria has approximately 8.4 million hectares of arable land, but much of this potential remains untapped due to inadequate infrastructure, limited access to modern farming technologies, and governance issues (**Djihad et al., 2021**). Figure 1 illustrates the decline in agricultural land development from 1962 to 2021, with significant reductions in recent decades. Although the government has introduced measures to increase agricultural output, such as modern irrigation techniques, the results have been uneven across different regions.

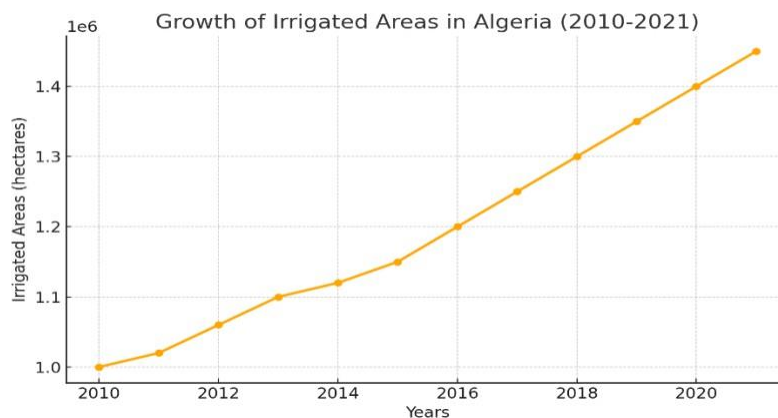
**Figure 01:** the development of agricultural land in Algeria



**Source:** Daoudi 2021

Moreover, Figure 2 shows the expansion of irrigated areas from 2010 to 2021. While there has been steady progress in increasing irrigated land—critical for maintaining crop yields in Algeria’s semi-arid climate—the expansion rate has not kept pace with the demands of the growing population or the sector’s potential. The government has made considerable efforts to boost irrigation, but these initiatives have been constrained by water shortages and inconsistent resource management.

**Figure 02:** Irrigated land expansion

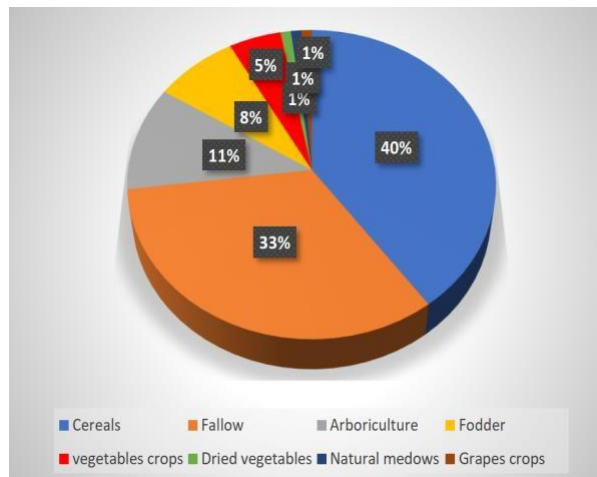


**Source:** by the authors based on (Hoogerwerf, 2023)

In terms of land use, Figure 3 reveals that a significant portion of Algeria’s arable land is dedicated to cereal production, accounting for 40% of the agricultural area, with 33% left as fallow

land. Other important agricultural activities include arboriculture (11%) and fodder production (8%), while vegetable cultivation and other specialized crops occupy a much smaller share of the land. This distribution reflects a heavy emphasis on staple crops like wheat and barley, which are vital for food security but limit the diversification of agricultural output.

**Figure 03:** Distribution of the useful agricultural area in Algeria

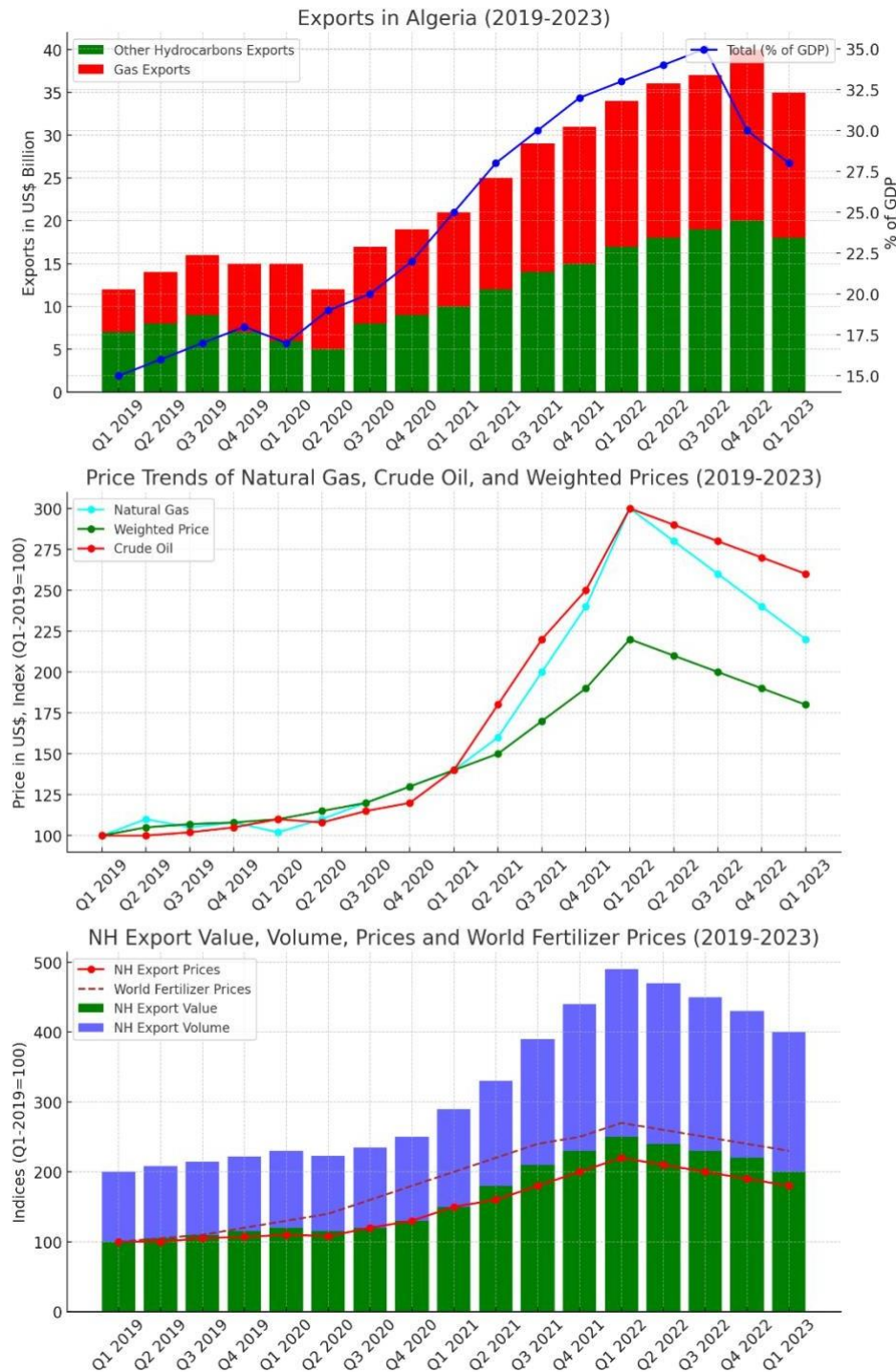


**Source:** (Hoogerwerf, 2023)

### 3.2. Stages and Strategies of Economic Diversification in Algeria.

Algeria has adopted numerous phases and policies with the aim of diversifying its economy, relying on several key pillars: diversification of exports, diversification of financial revenues, and diversification of the goods and services production base. These strategies are essential to reducing the country's heavy reliance on hydrocarbons, a central issue that has made the economy vulnerable to fluctuations in global oil prices. As shown in Figure 04, while there has been a noticeable increase in export revenues in recent years, these gains are largely driven by hydrocarbon exports. Non-hydrocarbon exports, though growing, remain limited in comparison. This highlights a key challenge in Algeria's diversification efforts: the need to expand and strengthen non-hydrocarbon exports to mitigate the risks associated with global oil price volatility. By broadening its export base to include more agricultural products, manufactured goods, and services, Algeria could stabilize its revenues and reduce its susceptibility to external economic shocks, moving closer to a more balanced and resilient economy.

**Figure 04: Algerian Export Trends (2019-2023): Hydrocarbon, Non-Hydrocarbon, and Price Dynamics**



**Source:** BOA and WB estimates

To promote further diversification, policy implications may include the need for investment in other sectors, enhancement of non-hydrocarbon export capabilities, and development of markets for a broader range of Algerian products. This could involve strengthening the agricultural sector,

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investing in renewable energy, and encouraging high-value-added manufacturing, all of which could contribute to a more balanced and resilient economic structure.

The challenge of diversifying Algeria's economy is not new. Over the decades, the country has adopted various strategies to reduce its reliance on hydrocarbons and promote growth in other sectors. These efforts have evolved through distinct phases, each characterized by specific policies and objectives aimed at fostering a more balanced economic structure. From post-independence industrialization efforts to more recent initiatives like the National Plan for Agricultural Development, Algeria's diversification strategies have sought to leverage key sectors such as agriculture, manufacturing, and services. Understanding these stages provides valuable insight into how Algeria's economic policy has been shaped over time, as well as the successes and obstacles encountered along the way.

#### **First: The Post-Independence Phase:**

After the independence, Algeria adopted a developmental strategy aimed at fostering growth in both the agricultural and industrial sectors. This strategy initially focused on promoting industrialization by developing manufacturing industries, leveraging its abundant energy resources, particularly oil and natural gas, Algeria expanded into related sectors such as petrochemicals, including cement and iron production (Haouas & Lin, 2023). Throughout the 1970s, many factories were established as part of large-scale economic projects. However, over time, the economy gradually shifted towards a rentier economy<sup>5</sup>, heavily dependent on oil and gas revenues. This reliance exposed the national economy to significant vulnerabilities, particularly due to fluctuations in global oil and gas prices, which had a detrimental impact on economic stability.

#### **Second: The Growth Consolidation Program 2010-2014 in Algeria:**

In response to the ongoing challenges of economic instability and the need for diversification, Algeria launched the Growth Consolidation Program (GCP) for the period 2010-2014. This ambitious initiative aimed to stimulate economic growth, improve infrastructure, and address long-standing structural deficiencies in various sectors (Touil et al., 2018). Table (01) summarizes the key components of this program as part of Algeria's efforts to diversify and revitalize its economy.

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<sup>5</sup> relying solely on a single source for its economy, which is oil that constitutes a large percentage of the Algerian economy.

**Table 01:** the growth consolidation program (GCP) 2010-2014

Program Component	Details
<b>Total Budget</b>	\$286 billion
<b>Division</b>	- <b>First Part:</b> Launching new projects, \$156 billion - <b>Second Part:</b> Completing major ongoing projects (railways, roads, water projects), \$130 billion
<b>Objectives</b>	- Improve human development - Continue developing basic infrastructure and improving public service - Support industrial development - Encourage job creation - Develop the knowledge economy
<b>Human Development Initiatives</b>	- Completion of 2 million housing units - Establishment of approximately 5000 national promotion facilities - Completion of more than 1500 basic facilities aimed at youth and sports - Connection of one million homes to the natural gas network and provision of electricity to 220,000 rural homes - Improvement of drinking water supply

**Source:** by the authors

While the Growth Consolidation Program represented a significant financial commitment to diversification and infrastructure development, its outcomes were mixed. Although it contributed to notable improvements in infrastructure, such as the completion of housing units and the expansion of the natural gas network, the broader goal of reducing Algeria’s dependency on hydrocarbons remained unmet.

**Thirdly : the Economic Diversification Program in Algeria (2015-2019):**

Building on the momentum of the Growth Consolidation Program, Algeria introduced the Economic Diversification Program (EDP) for the period 2015-2019. This program was specifically designed to reduce the country's heavy dependence on hydrocarbon revenues by stimulating growth in other sectors such as **agriculture, manufacturing, tourism, and renewable energy (Imen & Reguia, 2023)**. The EDP aimed to lay the groundwork for a more resilient and sustainable economy, capable of withstanding external shocks like fluctuating oil prices. Table 02 encapsulates the strategic focus areas of the EDP highlighting the sectors targeted for development and the broad strokes of the investments and initiatives undertaken to achieve sustainable economic growth and diversification.

**Table 02:** the economic diversification program (EDP)

Sector/Initiative	Description
<b>Food Industry Development</b>	Enhancing agricultural production and exploring new export markets for value-added products.
<b>Energy Sector Enhancement</b>	Intensifying oil and gas efforts with 14 new pipelines to In Amenas and In Salah, and launching 6 new refineries to increase fuel storage capacity.
<b>Tourism Sector Expansion</b>	Establishing 15 new tourist resorts to leverage Algeria's natural beauty and attract tourism.
<b>Craft Industry Support</b>	Organizing and supporting artisans directly and indirectly to preserve cultural heritage.
<b>Regulatory Framework Enhancement</b>	Developing a comprehensive framework for investment protection and modern infrastructure management.
<b>Infrastructure Development</b>	Completing 663 km of roads in the highlands, establishing a new 2000 km line connecting the south to the highlands, expanding railway lines, and developing Tramway and Metro lines.
<b>Maritime Sector Improvements</b>	Taking over 'Jen Jen' port, starting 4 new marine stations including a deep-water port in the capital, and enhancing ports with new ships.
<b>Aviation Sector Enhancement</b>	Adding 16 new planes to the national airline, constructing new stations in Algiers and Oran, and rehabilitating old airports.
<b>ICT Advancements</b>	Enhancing ICT capabilities, including the rollout of third and fourth-generation telecommunications services across all administrative regions.

**Source:** by the authors

Despite these efforts, the EDP faced numerous challenges. Progress in diversifying exports and reducing the dominance of hydrocarbons in the economy was slower than anticipated.

#### **4. Data and methodology:**

##### **4.1. The impact of agriculture on economic diversification through the lens of Vector autoregressive model**

This study employs a **Vector Autoregression (VAR) model** and the **Herfindahl-Hirschman Index (HHI)** to assess the impact of agriculture on Algeria's economic diversification. By using these two quantitative approaches, we aim to capture the dynamics between the agricultural sector and non-hydrocarbon economic growth.

Vector Autoregression (VAR) models are powerful tools for analyzing multivariate time series data in macroeconomics and finance (Fomby et al., 2013). VAR models simultaneously capture the development of multiple variables over time, allowing for the examination of their interdependencies (Korstanje, 2021). These models are particularly useful for studying complex systems where variables may influence each other's growth (Harivigneshwar C J et al., 2019).

To carry out this analysis, this study adopts yearly data spanning from 2000 to 2022, The key variables analyzed include the agriculture sector's contribution to GDP (excluding oil revenues), food import levels, government expenditures on agriculture, and total agricultural production. These variables allow us to explore how agriculture interacts with broader economic diversification efforts and contributes to the reduction of Algeria's dependency on hydrocarbons.

**Table 03:** variables' description

Variable	Measure
<b>HHI</b>	Economic Diversification Index calculated by summing the squared percentage shares of each sector's contribution to GDP.
<b>GDP (Excluding Oil)</b>	Total Gross Domestic Product excluding revenues from the oil sector.
<b>Import-Food</b>	Total value of food imports.
<b>Exp</b>	Government expenditures on agriculture sector.
<b>Prod-Agri</b>	Total agricultural production.

**Source:** by the author

Following (Ciccarelli & Rebucci, 2003) and (Tsagkanos et al., 2022), let the VAR model:

$$Y_t = \alpha + X_t\beta + \varepsilon_t \dots (1)$$

Where

- $Y_t$  is a  $n \times 1$  vector of endogenous variables namely, the digital attributes within Islamic banking.
- $\varepsilon_t$  is a  $n \times 1$  vector of error terms that explains the random disturbances, identically and normally distributed with variance - covariance matrix  $\Sigma$ ,  $\varepsilon_t \sim \text{IIN}(0, \Sigma)$ .
- $X_t$  is a matrix  $n \times nk$  and represents the set of independent variables.
- $\beta$  is  $nk \times 1$  and represents the coefficients that assess the relationship between variables.

$$\begin{aligned}
 \text{GDP NOIL } t &= \alpha_1 + \sum_{i=1}^p \beta_{11,i} \text{GDP\_NOIL}_{t-i} + \sum_{i=1}^p \beta_{12,i} \text{Prod Agri}_{t-i} + \sum_{i=1}^p \beta_{13,i} \text{Exp}_{t-i} + \sum_{i=1}^p \beta_{14,i} \text{Import Food}_{t-i} + \epsilon_{1,t} \\
 \text{Prod Agri } &= \alpha_2 + \sum_{i=1}^p \beta_{21,i} \text{GDP NOIL}_{t-i} + \sum_{i=1}^p \beta_{22,i} \text{Prod Agri}_{t-i} + \sum_{i=1}^p \beta_{22,i} \text{Exp}_{t-i} + \sum_{i=1}^p \beta_{24,i} \text{Import Food}_{t-i} + \epsilon_{2,t} \\
 \text{Exp } &= \alpha_3 + \sum_{i=1}^p \beta_{31,i} \text{GDP NOIL}_{t-i} + \sum_{i=1}^p \beta_{32,i} \text{Prod Agri}_{t-i} + \sum_{i=1}^p \beta_{33,i} \text{Exp}_{t-i} + \sum_{i=1}^p \beta_{34,i} \text{Import Food}_{t-i} + \epsilon_{3,t} \\
 \text{Import Food } &= \alpha_4 + \sum_{i=1}^p \beta_{41,i} \text{GDP NOIL}_{t-i} + \sum_{i=1}^p \beta_{42,i} \text{Prod Agri}_{t-i} + \sum_{i=1}^p \beta_{43,i} \text{Exp}_{t-i} + \sum_{i=1}^p \beta_{44,i} \text{Import Food}_{t-i} + \epsilon_{4,t}
 \end{aligned}$$

Where:

- $t$  represents the time period.
- $p$  is the number of lags selected for the model.
- $\alpha_1, \alpha_2, \alpha_3, \alpha_4$  are constants (intercepts).
- $\beta_{ij,i}$  are the coefficients representing the relationships between the lagged values of the variables.
- $\epsilon_{1,t}, \epsilon_{2,t}, \epsilon_{3,t}, \epsilon_{4,t}$  are the error terms (innovations).

#### 4.2. HHI Index for Economic Diversification (HHI)

Herfindahl-Hirshman index is the most widely used indicator of economic diversification. This index was used by US courts in 1982 to measure market concentration for antitrust. The index is also used extensively in foreign trade to measure the concentration of industries or a branch of a sector or measure the concentration of foreign trade markets used in global development systems and TRAINS and WITS indicators. The HHI is computed as the sum of the squares of each sector of production's shares in total output (or sometimes as the square root of the sum of squares) (UNCTAD, 2012).

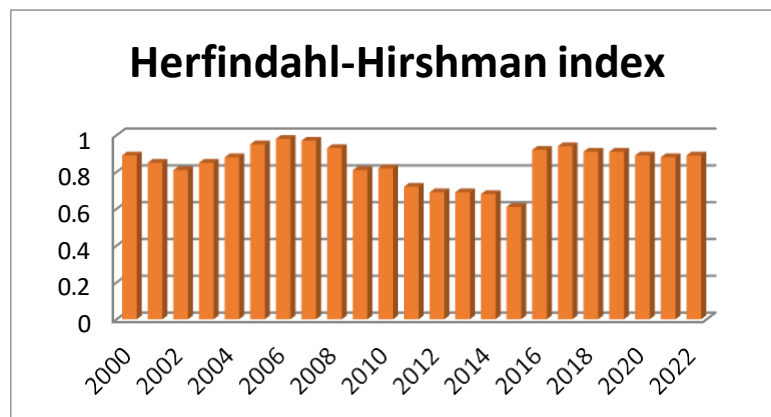
$$\text{HHI} = \frac{\sqrt{\sum_{i=0}^n \left(\frac{x_i}{\bar{x}}\right)^2} - \sqrt{\frac{1}{N}}}{1 - \sqrt{\frac{1}{N}}} \dots (1)$$

where :

- $N$ : Number of activities, and the value of this index ranges between 0 and 1. If its value is zero, this means there is diversification, and if its value is 1, this means concentration in one sector.
- $X$ : Total exports
- $X_i$ : Export sectors, which include: foodstuffs, energy, raw materials, semi-manufactured goods, agricultural equipment, industrial equipment, and consumer goods. The following figures illustrate the development of the study variables.

By applying equation 02, we obtain the index values in the figure ... , we observe that the index values are close to one, indicating a lack of economic diversification policy. Additionally, there is a noticeable decline in the index values during the period 2011-2015, resulting from the drop in oil prices affected by the fallout of the global financial and economic crisis and economic recession, which contributed to the decrease in oil exports as a total of exports.

**Figure 05:** HHI for Algeria



**Source:** by the author

## 5. Results and discussion:

### 5.1. Augmented Dickey Fuller Unit root test:

In order to evaluate the stationary characteristics of the variables, this study employed the Augmented Dickey-Fuller (ADF) test, results are summarized in table 04.

Table 04: ADF results

variables	With constant			With constant & trend			Without constant & trend		
	Level	1 <sup>st</sup> diff	Decision	Level	1 <sup>st</sup> diff	Decision	Level	1 <sup>st</sup> diff	Decision
<b>HHH</b>	0.4109	0.0033	I (1)	0.9504	0.0159	I (1)	0.7629	0.0002	I (1)
<b>IMPORT_FOOD</b>	0.4924	0.020	I (1)	0.9677	0.0005	I (1)	0.6808	0.0001	I (1)
<b>E-NOIL</b>	0.2417	0.0042	I (1)	0.9758	0.0056	I (1)	0.9885	0.0007	I (1)
<b>EXP01</b>	0.1552	0.0009	I (1)	0.5695	0.0055	I (1)	0.2040	0.0001	I (1)
<b>Pro-agri</b>	0.0070	0.3757	I (0)	0.0229	0.0068	I (0)	0.0007	0.0792	I (0)

Results indicates non-stationarity at levels across all models. However, upon first differencing, these variables achieve stationarity.

**5.2. Johansen cointegration test:**

The Johansen cointegration test expands on the augmented Dickey-Fuller test by assessing the linear interplay of multiple variables (Dwyer, 2015) using both the trace and maximum eigenvalue methods to determine the highest rank of cointegration. As shown in Table (3), the variables do not display cointegration, implying that they lack a sustained, long-term association.

**Table (3):** Johansen cointegration results

Johansen test			
Hypothesized	Eigenvalue	Trace statistics	Probabilities
<u>None</u>	0.763723	30.29773	0.0621
<u>At most one</u>	0.7031670	25.50628	0.1327
<u>At most two</u>	0.495886	14.38403	0.1517
<u>At most three</u>	0.332872	8.500236	0.1449

**Source:** data processing

**5.3. Lag order selection :**

Lag length denotes the number of past periods used as predictors in the vector autoregressive model (Ozcicek & Douglas Mcmillin, 1999). Several criteria, such as the Akaike Information Criterion (AIC), Schwarz Bayesian Criterion (BIC), and the Hannan-Quinn Criterion (HQ), help determine the optimal lag.

**Table 04:** lag order selection results:

Lag	LogL	LR	FPE	AIC	SC	HQ
0	9.488743	NA	4.58e-07	-0.408068	-0.160103	-0.349655
1	93.08388	121.5929*	2.39e-09*	-5.734898*	-4.247113*	-5.384421*

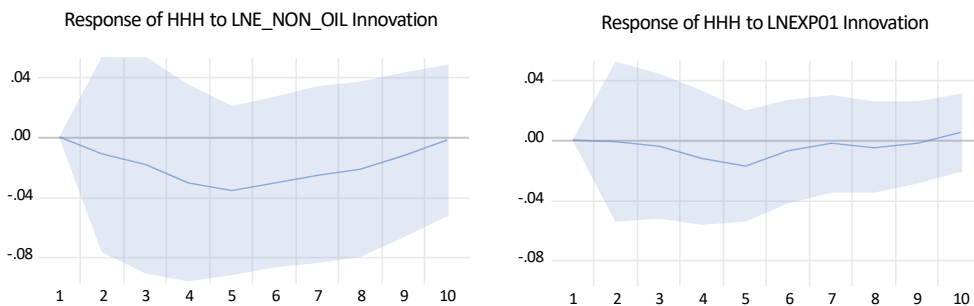
Source: data processing

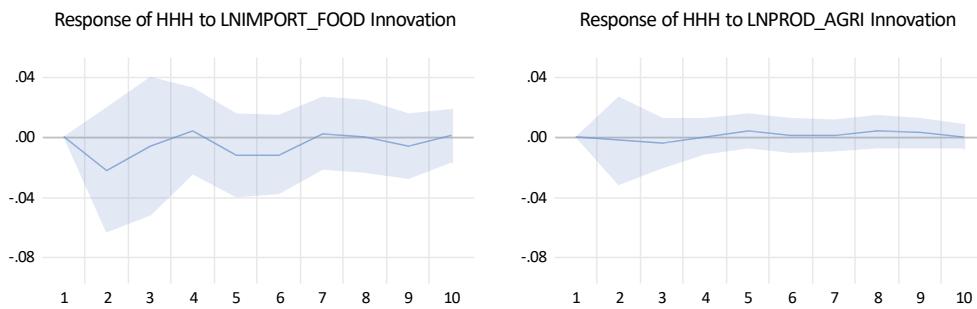
Results in table 04 indicates a lag order of 1 suggesting that in the Vector Autoregression (VAR) model, only one previous period (or lag) of the time series data is used as a predictor for the current period.

**5.4. Impulse response functions:**

The Impulse Response Function describes how a variable responds over time to a one-time shock or "impulse" in another variable while holding all other shocks constant. In the context of a VAR model, where multiple interrelated time series variables are considered, the IRF provides insights into the dynamic interplay among these variables.

**Figure 06 :** the response of HHH economic diversification





**Source:** Data processing

### The response of HHI (economic diversification)

- **Response to Non-Oil GDP (LNE\_NON\_OIL Innovation):**

This graph shows the response of Algeria's economic diversification index to shocks in the non-oil GDP. The fluctuations around zero indicate that the non-oil sectors may not have a clear or immediate impact on diversification efforts. In the Algerian context, this could imply that even as the country attempts to reduce its dependence on oil by investing in other sectors like agriculture, manufacturing, or services, the fruits of these efforts may take time to materialize in terms of contributing significantly to the diversification index.

- **Response to Agricultural Expenditures (LNEXP01 Innovation):**

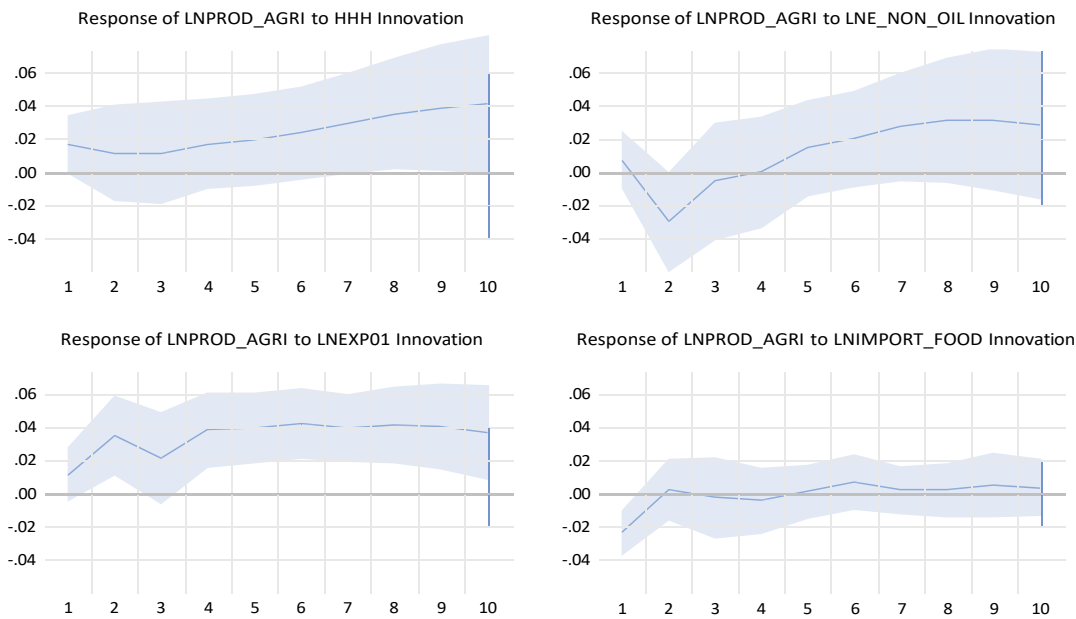
The response to shocks in government agricultural expenditures shows that such spending does not have a definitive impact on diversification. This is particularly relevant for Algeria, where government initiatives and spending have historically aimed to boost the agricultural sector as part of the diversification strategy. The varied response suggests that while government spending is essential, its effectiveness may be contingent on other factors, such as the efficiency of spending, structural reforms, and the development of complementary industries.

- **Response to Food Imports (LNIMPORT\_FOOD Innovation):**

The negative trend in response to food import shocks suggests that increased imports may hinder economic diversification efforts, possibly by impacting domestic agricultural production negatively. For Algeria, which aims to diversify its economy, reliance on food imports could be counterproductive. This response indicates the need for policies that support domestic agriculture and reduce food import dependency to strengthen economic diversification.

- **Response to Agricultural FDI (LNFDI\_AGR Innovation):**

The response to shocks in agricultural FDI is uncertain, as indicated by the fluctuations within the confidence intervals. In Algeria's case, this suggests that while attracting FDI into agriculture is part of the diversification strategy, its impact on the diversification index is not straightforward. It could mean that the quality, rather than the quantity of FDI, matters more, or that other conditions, such as political stability, infrastructure, and the regulatory environment, are also crucial for FDI to effectively contribute to diversification.



**Response of agricultural production:**

- **Economic Diversification and Agricultural Production (Response to HHH Innovation):**

The impulse response function indicates a neutral to slightly negative initial impact of economic diversification on agricultural production, which is not uncommon for an economy like Algeria's that is attempting to reduce its dependence on hydrocarbon sectors. The neutral response could be because diversification efforts often involve long-term structural changes, such as developing infrastructure, improving education and workforce skills, and fostering new industries, which don't translate into immediate gains in agricultural productivity. It might also suggest that while diversification is a goal, the measures taken have not yet significantly affected or targeted the agricultural sector.

- **Non-Oil GDP and Agricultural Production (Response to LNE\_NON\_OIL Innovation):**

The improvement in agricultural production in response to a shock in non-oil GDP starting from the fifth period could reflect the gradual benefits of economic stability and growth outside the hydrocarbon sector. As the non-oil sectors expand, they may provide increased opportunities for agricultural markets, such as through improved supply chains, better access to technology, and increased domestic demand. This positive trend aligns with the notion that a diversified economy can create a more favorable environment for all sectors, including agriculture.

- **Government Expenditures on Agriculture and Agricultural Production (Response to LNEXP01 Innovation):**

The negative response to government expenditures on agriculture is somewhat counterintuitive, as one would expect increased spending to enhance agricultural output. However, in the Algerian context, this might indicate inefficiencies or misallocation of resources. It could also be reflective of broader challenges within the Algerian agricultural sector, such as issues with land rights, water usage, and distribution channels, which may be hindering the effective translation of government spending into increased production. This calls for a review of how funds are allocated and used within the sector.

- **Food Imports and Agricultural Production (Response to LNIMPORT\_FOOD Innovation):**

The negative response of agricultural production to a shock in food imports could suggest that Algeria is relying on imports to meet its food demands rather than bolstering domestic production. This could be due to competitive pricing of imports, preference for imported goods, or a lack of competitiveness in domestic agriculture. The non-significant impact, however, suggests that the relationship isn't strong, and there could be other factors at play that determine how imports affect domestic production.

## **6. Discussion and policy implication:**

The positive long-term response of agricultural production to non-oil GDP growth indicates that the sector has the potential to contribute significantly to economic diversification. However, the initial negative response suggests a lag in realizing this potential, which may be due to existing structural inefficiencies or a delay in the effects of economic policies aimed at promoting diversification.

Conversely, the negative response of agricultural production to government expenditures on agriculture and food imports, despite not being statistically significant, raises concerns about the current effectiveness of public spending in the sector and the competitiveness of domestic agriculture against foreign imports.

### **Policy Implications:**

- **Strengthening Sector Linkages:** Policies should focus on strengthening the linkages between the agricultural sector and other non-oil sectors of the economy. For instance,

encouraging the processing of agricultural products within the country can add value, create jobs, and stimulate economic growth beyond the primary agricultural sector.

- **Improving Efficiency of Government Spending:** The IRFs indicate that current government spending in agriculture may not be yielding the desired increase in productivity. A detailed audit of agricultural spending could identify inefficiencies and redirect funds to more productive uses, such as research and development, extension services, or infrastructure improvements that directly benefit farmers.
- **Enhancing Competitiveness:** To counter the negative impact of food imports, policies could aim to enhance the competitiveness of the agricultural sector. This could involve improving access to modern farming techniques, offering subsidies or tax incentives for the adoption of new technologies, or implementing standards that favor domestic production.
- **Long-term Investment in Diversification:** The delayed positive response to economic diversification efforts suggests that these policies need time to develop. Long-term, consistent investment in diversification strategies is essential. Algeria might consider establishing special economic zones, fostering entrepreneurship, and investing in education and vocational training to support this.
- **Market Development and Export Orientation:** Developing internal markets for agricultural products and orienting the sector towards exports can also contribute to diversification. Policies could focus on quality standards and certifications that open international markets to Algerian agricultural products.
- **Risk Management:** The agricultural sector is subject to various risks, including climate variability and market fluctuations. The government could implement risk management strategies, such as crop insurance schemes and stabilization funds, to protect farmers and ensure sectoral stability.
- **Institutional Support:** Strengthening institutional support for agriculture, including regulatory reforms, land rights clarification, and improvement of rural financial services, can help unlock the sector's potential.

finally, Algeria's efforts to move away from a rentier economy and to diversify its economic base should include a strong focus on the agricultural sector. By addressing the

inefficiencies in public spending, enhancing competitiveness, and fostering a supportive environment for agricultural development, the sector can become a cornerstone of a more diversified and resilient Algerian economy.

### **Conclusion:**

In conclusion, the journey of Algeria's economy from a heavy reliance on hydrocarbons towards a more diversified and resilient structure is both challenging and replete with opportunities. This paper has explored the intricate dynamics of the agricultural sector's potential to act as a linchpin in this transformative process. Through a careful analysis using the Vector Autoregression (VAR) model and impulse response functions, we have observed the nuanced impact of various economic factors on Algeria's diversification efforts.

The findings highlight that while the non-oil sectors, government agricultural expenditures, food imports, and agricultural FDI have complex and varying impacts on economic diversification, they are integral components of the broader economic fabric that must be weaved with strategic intent and prudence. The evidence points to the necessity of reinforcing sector linkages, enhancing the efficiency of government spending, boosting competitiveness, committing to long-term investment, and developing robust markets for Algerian products.

As Algeria continues to navigate the post-2014 economic landscape, the insights gained herein underscore the importance of adopting a multi-pronged approach that prioritizes sustainable agricultural development, encourages innovation, and cultivates a conducive environment for both domestic and international investment. The policy implications drawn from this research serve as a roadmap for diversification that, if followed with rigor and adaptability, can lead Algeria to not just weather the storms of economic uncertainty but to thrive in the global economic arena.

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