

STRUCTURAL TRANSFORMATION AND INTERINDUSTRY LINKAGES DURING MULTIFACETED CRISES: KEY SECTORS OF THE ALGERIAN ECONOMY FROM 2015 TO 2021

***Hadjer HANED:**

LEQAD, ENSSEA, Kolea, Algeria.

Email : Haned.hadjer.enssea@gmail.com ,

Saloua CHAOUICHE :

LEQAD, ENSSEA, Kolea, Algeria

Reçu le: 20/10/2024 Accepté le :27/11/2024 Publication en ligne le: 05/12/2024

ABSTRACT:

In the modern field of economic analysis, structural analysis techniques have emerged as invaluable tools for monitoring and understanding the structure of the economics' sectors dynamic.

This article analyses structural change in the Algerian economy for the period 2015 - 2021, based on a series of input-output tables. For this purpose, we used the powerful Rasmussen's structural decomposition method to inspect the structure of the economy and examined the evolving internal complexity of relationships and interdependencies, using key sector analysis to assess the strength of forward and backward linkages.

The objective was to gain insights into the dynamics of this economy and to evaluate the extent to which it has undergone changes during this critical period witness of a multifaceted crisis. The findings from our analysis provide support for the hypothesis that the structural framework of the economy remained relatively stable over this period. While the broader structure exhibited signs of continuity, our investigation also revealed a modest enhancement in the cross-sector connections within the economy. These results could be used as a strong tool in terms of the relationships and interactions among various sectors, for the country's economic resilience and prospects for diversification. Indeed, over time we would expect economic growth and development to coincide with increasing internal complexity and perhaps durability.

Key words: Structural change, economics' diversification, multifaceted crisis, Rasmussen's method, key sectors.

*Hadjer HANED

I INTRODUCTION

The economic literature has consistently demonstrated that the process of economic development requires significant structural change (Chenery, 1971). The analysis of economic structure can take different forms. Examining the dynamics of key macroeconomic indicators as analytical tools simplifies the observation of economic evolution.

In the field of economic analysis, the structural arrangement of economic activity within sectors is a central element, particularly for economies facing diversification challenges such as Algeria. This introductory remark underlines the crucial importance of delving deeper into the subtleties of sectoral dynamics within these economies. Algeria, like many resource-dependent nations, faces the imperative of diversifying its economic base in order to mitigate the vulnerabilities associated with over-reliance on a single sector. This requires a thorough understanding of the existing sectoral composition and its evolution over time. By examining the sectoral structure of economic activity, policymakers and researchers can gain valuable insights into the underlying drivers of economic growth, identify potential bottlenecks and formulate targeted strategies to foster diversification and sustainable development.

Furthermore, in the context of Algeria's economic landscape, characterized by heavy dependence on hydrocarbon exports, the analysis of sector structure takes on added importance. The diversification of economic activity away from oil and gas extraction presents both challenges and opportunities for the Algerian economy. Understanding the interaction between different sectors, their linkages and their contributions to overall economic output is essential for designing effective policies to promote structural transformation and foster inclusive growth.

The sectoral structure of economic activity serves as a fundamental pillar in the analysis of Algeria's economic landscape, offering valuable insights and guiding policymakers in their quest to navigate the complexities of economic diversification and sustainable development.

Undoubtedly, the techniques of structural decomposition analysis have become a major tool today for tracking the evolution of an economy's sector dynamics. Within the framework of input-output tables, these techniques allow for the analysis of interactions between different production sectors and highlight the key sectors contributing to the development of an economy.

In this context, the aim is to achieve intertemporal comparisons of production structures. In this regard, two methods have particularly excelled in this field and were developed by Rasmussen (Rasmussen, 1957) and (Chenery & Watanabe, 1958).

The Algerian economy provides a very promising research framework for this type of analysis. The nation's economy still heavily depends on the hydrocarbon industry and export

earnings, accounting for 38% of budgetary receipts, 19% of GDP, and 93% of product exports between 2016 and 2021 (World Bank, Spring 2023). In this context, the nation aims to enhance economic diversification, seeking to expand revenue sources and bolster employment opportunities giving the demographic structure.

The resource-dependent character of this economy and its heightened desire for diversification raise two questions: the exploration for pivotal key sectors upon which Algeria can anchor its transition to a more diversified economy. Furthermore, evaluating the impact of this transition on the structure of production process, especially within the recent years amid various crises.

Our research contributes to the ongoing efforts to underscore the necessity of diversification as an assessment of the possible structural changes during 2015, a year significantly affected by the drop in oil prices. In 2019, Algeria experienced massive socio-political turmoil. In 2021, the Algerian economy faced the challenge of meeting several recovery goals amidst the backdrop of the pandemic year 2020; like countries all over the world, the country had to deal with the Covid-19 pandemic.

This study is structured into four sections that will follow this introduction. In the upcoming section, we will provide a brief overview of the Algerian economic context with particular attention to the most promising production sectors in the context of transition. The third part presents the methodology used and applies it to Algerian data to determine the structure of its productive sectors. In the fourth part, we will present the various results obtained and discuss their significance.

II KEY SECTORS OF THE ALGERIAN ECONOMY

As an upper middle-income country, Algeria's economy has long been heavily dependent on revenues from the hydrocarbon sector. This dependence has created vulnerability to fluctuations in world energy prices and has hampered the diversification of the country's economy. Despite attempts to diversify the economy and promote other sectors, this heavy dependence on hydrocarbons has limited the emergence of new industries and hampered the growth of other economic sectors. These circumstances have considerably limited the actions of policies that aim to encourage exports outside the hydrocarbon sector adding to these low levels of competitiveness and productivity.

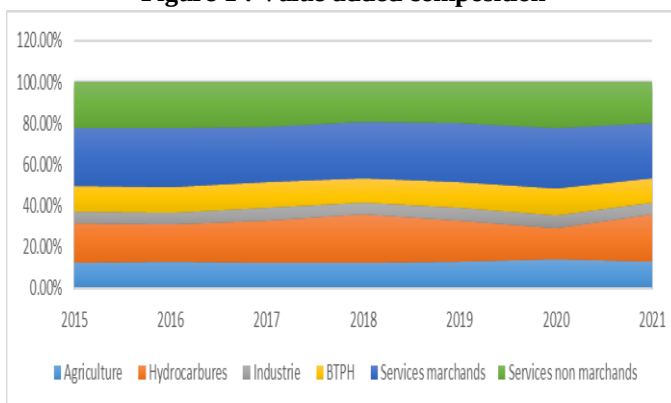
In terms of supporting long-term economic growth, public sector investment has reached its limit. This reality has thrown the long-preferred development paradigm based on large-scale public investment into question, particularly in the context of an economy primarily reliant on oil income.

In response to this critical situation the Algerian government has halted the privatization of state-owned industries and imposed limits on imports and foreign participation in its economy. The government implemented a set of economic measures aimed at bolstering business operations, safeguarding employment, and mitigating the adverse impact on the nation's public and external financial balances.

Current economic issues have highlighted the importance of diversifying the Algerian economy and reducing its reliance on the oil sector. Economic diversification necessitates the development of competitive sectors, the stimulation of innovation, the strengthening of the economic knowledge base and the promotion of digital development.

Several sectors have returned to growth since 2021. However, some have had negative growth rates, such as agriculture and different industries. Hydrocarbons, water, energy, the steel industry and the services sector are among the sectors on the upswing.

Figure 1 : Value added composition



Source: National Office of Statistics (NOS)

The distribution of gross domestic product (GDP) by sector mirrored prior trends; the service sector slightly increased to 45.9%, and agriculture represented 12%. In 2020, the Algerian government prioritized investment in the modernization of industry and agriculture, aiming to diversify economic sectors. The GDP growth in 2019, standing at a mere 0.8%, marked a decrease compared to 2018 (1.4%) and was notably lower than the stable growth observed in previous years, which averaged around 3.7%. The measures taken to curb the spread of Covid-19, coupled with reduced global demand, significantly impacted economic activity.

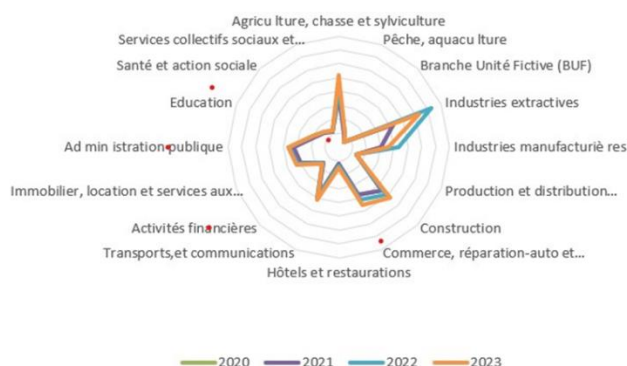
Structural Transformation and Interindustry Linkages During Multifaceted Crises: Key Sectors of the Algerian Economy from 2015 to 2021

For 2020, Algeria's real GDP is forecasted to decline by -5.5%, with an anticipated inflation rate (average consumer prices) change of 3.5%¹.

The lack of statistics and measurement issues in Algeria present significant challenges to economic analysis and policy formulation. Restricted access to reliable and current data compromises one's ability to accurately assess the state of the economy, comprehend its dynamics, and develop effective policy.

Measuring questions exacerbate the issue further because available data may not accurately reflect the complexity of economic activities or may contain errors and inconsistencies. This could lead to distortions in economic indicators and undermine the credibility of analytical results. Furthermore, it is difficult to identify trends, evaluate performance, and make clear decisions in the absence of complete data on the key sectors and variables.

Figure 2. Sectoral Contributions to Algeria's GDP (2020-2023)



Source: National Statistics Office of Algeria (ONS)

Based on the radar map figure 2, we can assess the various sectors' contributions to Algeria's GDP and deduce how important sectors have changed between 2020 and 2023.

A steady pattern throughout the four years suggests that the contribution from the Agriculture, Forestry, and Fisheries sector is still comparatively constant. Algeria's historic backbone has been agriculture, which has neither grown nor shrunk dramatically. Algeria's oil and gas resources make the extractive industries a vital industry. In comparison to previous years, the figure displays a noticeable uptick in 2022 and 2023, which is probably due to both an increase in demand for energy resources and the recovery from the worldwide

¹ <https://www.statista.com/statistics/408037/algeria-gdp-distribution-across-economic-sectors/>

slowdown during the pandemic. Following an interruption during the 2020 pandemic year, the industrial sector appears to be growing steadily. This points to a rebound, maybe fuelled by the Algerian economy's attempts to diversify and lessen its dependency on hydrocarbons. By 2023, there seems to be a discernible downturn in the construction industry, which could be due to a decrease in investment in real estate or infrastructure projects, which could be impacted by changes in governmental spending priorities or financial limitations. The financial sector exhibits some volatility; it peaked in 2021 and then declined in 2023. Changes in the banking system or foreign investment inflows during the post-pandemic recovery phase may be the cause of this. The consistent contributions from public administration and education demonstrate the stability of government spending in these fields. This is common in economies when jobs and services are largely provided by the public sector. Communication and Transportation, Following the COVID-19 pandemic that struck in 2020, these industries appear to be rebounding. The relaxation of constraints and the restart of international trade and communication networks probably helped these industries by 2023. The post-pandemic health and social services industry seems to be stable or even growing, which is indicative of continued government spending on healthcare, particularly in light of the lessons learnt from the health crisis. Particularly in 2022 and 2023, the commerce and hospitality (hotels and restaurants) sector appear to be recovering from the pandemic's effects. This sector's GDP contribution probably improved as domestic consumption and tourism recovered. 2020 has seen a noticeable decline in a number of industries, which is indicative of the slowdown in the world economy. Construction, hotels, and transportation were probably the industries most affected. The notable peaks in the extractive sectors highlight the energy sector's ongoing dominance in Algeria's economy, especially between the years 2022 and 2023 when the world's energy demand spiked. Although some industries, like construction, have found it difficult to recapture their pre-pandemic speed, 2021 shows signs of recovery in several sectors, with additional improvements in 2022 and 2023, especially in manufacturing, transportation, and commerce. In addition to showing the impact of global trends like the pandemic and changes in the energy market, the figure emphasizes the significance of manufacturing and energy to Algeria's GDP.

III METHODOLOGY

The introduction of input-output tables has proven to be a valuable tool for facilitating international and intertemporal comparisons of production structures (Dietzenbacher, 1992). These tables provide a comprehensive framework for understanding how various sectors of an economy are interconnected and how they contribute to overall production. Building on Leontief's input-output model, which posits that output is primarily determined by final demand and that there are no constraints on the volume of production, we can delve into the details presented in the input-output table depicted in Table 1.

Leontief's model (Leontief, 1986) represents a fundamental concept in economics, particularly when examining the flow of goods and services within an economy (demand driven). It helps us grasp the complex web of interactions between different sectors, shedding light on the interdependencies that underlie economic activity, known as upstream interdependencies. The input-output table presented in Table 1 serves as a practical manifestation of this model, providing a structured overview of how each sector's output and input are linked, which is essential for studying the relationships and dynamics of an economy.

Table 1. Input-output table (Dietzenbacher, 1992)

	n production sectors	Final demand	Total
n production sectors	X	y	x
Primary inputs	v'	d	$v'e + d$
Totals	x'	$e'y + d$	

Where X denotes the $n * n$ matrix of interindustry flows, x the columns vector of total outputs, e the column summation vector ($e_i = 1$ for all i). We also know that $x = Ax + y$ where A is the matrix of technical coefficients with each element, $a_{i,j}$ is the amount of input that a sector requires to produce a unit of product. Finally, y is a vector with final demand.

Making basic transformations (Miller & Blair, 2009) we can easily find the basic matrices needed in order to calculate different linkages² :

Technical coefficients	$A = X\hat{x}^{-1}$
Leontief invers	$M = (I - A)^{-1}$
Gosh Matrix	$B = \hat{x}^{-1}X$
Gosh inverse	$G = (I - B)^{-1}$

The Gosh matrix represents a row-view (output) rather than the column-view (input) present in the Leontief model. This supply-driven approach is essential to capture downstream sectorial interdependencies.

In the field of the sectoral structure of the economy, backward and forward linkages are two crucial measures used to analyse the dynamics of an economy. These measures shed light on the relationship between a specific industry and its impact on the economy as a whole. Backward linkage assesses the extent to which a sector serves as a central role in the entire economy. In other words, it gauges how vital a sector is in terms of contributing in the domestic demand that is crucial for the functioning of other sectors. On the other hand, forward linkage examines the degree to which a sector acts as a supplier to other sectors

² A prime denotes transposition where a circumflex is used to denote a diagonal matrix.

within the economy. It essentially measures the extent to which a sector's output feeds into the production processes of other sectors.

To comprehensively capture both the direct and indirect effects³ of these linkages, we have chosen to implement the Rasmussen method to calculate both backward and forward linkages for the Algerian economy. This approach is favoured over the Chenery and Watanabe method, which, unfortunately, is known to be unsuitable for capturing the indirect effects. By employing the Rasmussen method, we can obtain a more accurate and holistic understanding of how different sectors in the Algerian economy are intertwined and influence one another, which is crucial for informed economic analysis and policymaking.

For backward linkages (BL), we determine them by summing the columns of the inverse of Leontief's $e^T M$ matrix. In contrast, we establish forward linkages (FL) by summing the rows of the inverse of the Gosh Be matrix. These computations enable us to understand the flow of inputs and outputs between sectors, which is essential for understanding the economy's structure.

To further assess the significance of these linkages and identify key sectors within the economy, we apply a normalization process. For the backward linkages, we normalize using the formula:

$$BL = \frac{ne^T M}{e^T M e}$$

which results in a row vector with an average value of one. Sectors with "above-average" backward linkages have index values greater than one, and vice versa. This step allows us to pinpoint the sectors that play a pivotal role in the demand of other sector, making them essential for the overall economy dynamic.

Similarly, we normalize forward linkages using the column vector

$$FL = \frac{nGe}{e^T Ge}$$

This normalization process provides a perspective on the sectors that act as major suppliers to other sectors, contributing significantly to the economy's production processes.

Finally, we classify the sectors based on the classification system outlined in (Miller & Blair, 2009), as detailed in Table 2. This comprehensive methodology allows us to understand the

³ For the BL linkage: measuring the impact of final demand changes on output. For the FL linkage: measuring the impact of value-added changes on price.

structure of the Algerian economy and identify sectors of particular importance for further analysis and policy considerations.

Table 2. Classification of sectors (Hirschman, 1958)

		Forward linkage	
		Low (<1)	High (>1)
Backward linkage	Low (<1)	Weak linkages (LL)	Strong forward linkages (SFL)
	High (>1)	Strong backward linkages (SBL)	Key sector (KS)

It is important to emphasize that two indicators, namely Backward Linkage (BL) and Forward Linkage (FL), are normalized and calculated based on an average. They reflect an influence, either upstream or downstream, at a moderate level. This suggests, for example, that a sector with a very high BL index (greater than 1) might have a significant impact on a limited number of sectors only. To address this, we introduce a coefficient of variation (Bekhet, 2010) whose purpose is to assess the extent to which a sector, upstream, has the capacity to uniformly influence all other sectors, and vice versa downstream. These coefficients are calculated based on the IO tables from 2015 to 2021 and according to the following equations:

$$CBL = \frac{\sqrt{\left[\frac{1}{n-1} \sum_{i=1}^n (A_{ij} - \frac{1}{n} \sum_i^n BL_{.j})^2\right]}}{\frac{1}{n} \sum_i^n BL_{.j}}$$

$$CFL = \frac{\sqrt{\left[\frac{1}{n-1} \sum_{i=1}^n (G_{ij} - \frac{1}{n} \sum_i^n FL_{i.})^2\right]}}{\frac{1}{n} \sum_i^n FL_{i.}}$$

IV DATA

This study is based on predicted input-output tables for the Algerian economy in the period 2015–2021. Provided by the National Office of Statistic (ONS)⁴, the methodology states that the 1989 base year table is the sole input-output table that is based on a structural survey. Tables created after 1989 are therefore updated to represent the current state of the economy

⁴ The National Office of Statistics (NOS) officially publishes economic data that they closely align with, ensuring the essential consistency across the various economic accounts. Establishing trustworthy balances between resources and uses is the goal of these assessments, particularly when it comes to the different industries and the goods they produce

as much as is feasible. These tables, which were made in compliance with the Algerian System of Economic Accounts (SCEA) rules, aim to accurately balance resources and uses across nineteen individual market sectors. They now incorporate an updated intermediate consumption matrix to accurately represent the possible economic interrelationships between these sectors. It should be noted that non-market sectors are not included in the input-output matrices in their own right, which could underestimate the importance of certain economic sectors. Non-market services are not taken into account individually, as they are not directly linked to business activities. This means that evaluations based on input-output matrices may underestimate or misinterpret the true influence of these industries on the economy. As such, this constraint must be taken into account when using data to inform investment and economic policy choices.

In order to guarantee uniformity and adherence to the economic analysis technique, sectors 16 hotels, coffee, restaurants and 17 commercial margins (See Annex A) have been combined into a single sector, called Hotels, coffee, restaurants and commerce (16). The goal of this operation is to make sure that the input matrix's row and column counts are balanced as needed.

V RESULTS AND DISCUSSION

Table 1 illustrates the outcomes of the backward linkages analysis conducted for Algeria's 19 sectors. These results have been derived employing Rasmussen's method (1957) and are structured in descending order based on sector rankings.

In 2020, the Oil-field Services and Public Works sector secures the top position in the ranking. Throughout the years under scrutiny, there is a discernible stability observed in the sector rankings. A consistent trend is apparent across all sectors.

Indeed, there is a decrease indicated by the calculated index for the majority of sectors for the years of the study. This reduction can be attributed to the country's stagnation during this period, particularly in a political crisis context. Similar findings persist for the period spanning 2019 to 2020, where the pervasive health crisis significantly impacted the index. Notably, from 2021 onwards, a modest dynamic is observed in specific sectors.

The construction materials sector emerges at the forefront with a variation of +14% observed between 2015 and 2021. This notable increase can be predominantly credited to substantial infrastructure endeavors carried out within the country during this timeframe. These initiatives encompassed the development of a metro line, the construction of roads and new buildings, alongside the inauguration of the GICA group in 2019. This diversification of activities in the sector thus greatly contributes to the construction of a certain heterogeneity of activity, with a more diversified cost structure that leads to this observed increase in the BL index. We can observe that Sectors 13 and 14 exhibited a backward linkage effect below

Structural Transformation and Interindustry Linkages During Multifaceted Crises: Key Sectors of the Algerian Economy from 2015 to 2021

one from 2015 to 2021, signifying minimal reliance on their suppliers. In other words, these sectors are supplied by less diversified inputs than the average. This circumstance is reasonable for sectors where an extensive supplier network is unnecessary, as exemplified by Sector 3 (Hydrocarbons, albeit recording indices close to 1) and Sector 18 (services provided to businesses). However, the rationale behind this observation remains unaccounted for in Sector 1 (agriculture, forestry, fishing) and Sector 14 (various industries).

Sector 16 (Hotels, cafes, restaurants, commerce) consistently maintains the highest position in the ranking over the observed period, resulting from the amalgamation between Sector 16 (Commercial Margin) and Sector 17 (Hotels, cafes, restaurants). It is important to acknowledge that there may be some bias in these results. The respective average weights for the commercial margin in 2015, 2019, and 2021, at 60%, 72.6%, and 72.3%, imply a potential situation where Sector 17 (Hotels, cafes, restaurants) might exhibit a very low BL index, akin to Sectors 1 and 14. These sectors display a tenuous relationship with their suppliers, a characteristic not fully understood but possibly correlated with the highly developed level of informal economy in these particular sectors (Kellou, 2022).

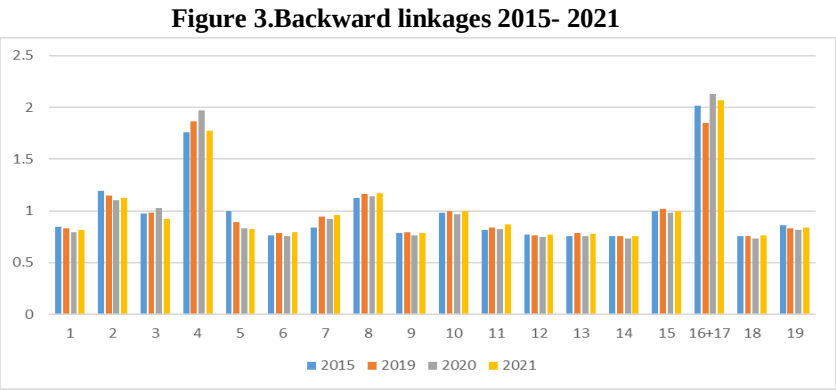
During the period from 2015 to 2021, three sectors demonstrated a backward linkage index surpassing one: Sector 2 (Water and Energy), Sector 4 (Oilfield Services and Public Works), and Sector 8 (Construction and Public Works). Notably, Sector 15 (Transportation and Communication) registered an index greater than one solely in 2019. This occurrence directly stemmed from the implementation of several transportation projects finalized in late 2018 and early 2019, encompassing tram, metro and train initiatives. Additionally, concerted efforts were dedicated to expanding communication infrastructure such as fiber-optics and the establishment of a 4G network.

Table 3. Rasmussen backward linkages indices and sectorial classification 2015, 2020, and 2021

	2015			2019			2020			2021		
	Index	Rank	Classes	Index	Rank	Classes	Index	Rank	Rank	Index	Rank	Classes
Agriculture, Forestry, Fishing	0,84	10	LL	0,83	12	LL	0,80	12	LL	0,82	12	LL
Water and Energy	1,19	3	KS		4	KS	1,11	4	KS	1,13	4	KS
Hydrocarbons	0,97	8	LL	0,98	7	LL	1,03	5	SBL	0,92	8	LL
Oilfield Services and Public Works	1,76	2	KS	1,87	1	KS	1,97	2	KS	1,77	2	KS
Mines and Quarries	0,99	6	SFL	0,89	9	SFL	0,83	9	LL	0,82	11	LL
ISMME	0,77	15	LL	0,79	14	LL	0,76	14	LL	0,79	13	LL

Construction Materials	0,84	11	SFL	0,95	8	SFL	0,92	8	SFL	0,96	7	SFL
BTPH	1,13	4	SBL	1,16	3	SBL	1,14	3	SBL	1,17	3	SBL
Chemistry, Plastics, Rubber	0,78	13	LL	0,79	13	LL	0,76	13	LL	0,79	14	LL
Food and Beverage Industries	0,98	7	LL	0,99 8	6	LL	0,96	7	LL	0,99 6	5	LL
Textiles, Clothing, Hosiery	0,81	12	LL	0,84	10	LL	0,82	10	LL	0,87	9	LL
Leather and Footwear	0,77	14	SFL	0,76	16	SFL	0,75	16	SFL	0,77	16	SFL
Wood, Paper, and Cork	0,76	18	SFL	0,78	15	SFL	0,75	15	SFL	0,78	15	SFL
Various Industries	0,76	16	SFL	0,75	18	LL	0,73	18	LL	0,75	18	LL
Transport and Communications	0,99 5	5	LL	1,02	5	SBL	0,98	6	LL	0,99	6	LL
Hotels, Cafes, Restaurants, Commerce	2,0 2	1	SB L	1,8 5	2	SB L	2,1 3	1	SB L	2,0 7	1	SB L
Services Provided to Businesses	0,7 6	17	LL	0,7 6	17	LL	0,7 3	17	LL	0,7 7	17	LL
Service Provided to Household	0,86	9	LL	0,83	11	LL	0,81	11	LL	0,84	10	LL
Number of	14			13			13			14		
sector BL<1												

Weak linkages (LL); Strong forward linkage (SFL); Strong backward linkages (SBL); Key sector (KS)



Source: established by the authors

Figure 2 provides evidence supporting the consistency observed in the arrangement of backward linkages between 2015 and 2021. Specifically, it highlights a notable improvement in the linkages of three sectors that have notably increased in productivity: Sector 6 (ISMME), Sector 7 (Construction Materials) and Sector 8 (BTPH).

Table 2 showcases the outcomes of forward linkages analysis across the 19 sectors of the Algerian economy. These results have been computed using Rasmussen’s method (1957) and are arranged in descending order based on sector rankings. Notably, the sector Leather and Footwear attains the top rank in both 2015 and 2020, a notable shift from its position of 14th in backward linkages. This shift signifies the sector's potential to serve as a substantial supplier to others. Additionally, the sector Construction and Materials secures the first rank in both 2019 and 2021.

Among the 18 sectors analyzed in this study, only 4 to 7 sectors exhibit a forward linkage effect surpassing one, suggesting that the products from these sectors are disseminated as inputs across the remaining sectors. The decrease in the index of Sector 3 (Hydrocarbons) from 0.80 to 0.71 can be explained by the predominant intention of this sector to allocate a significant portion of its outputs for export purposes.

The restricted level of tourism activity in Algeria provides reasoning for the subdued Forward Linkage (FL) index observed in Sector 16 (Hotels, cafes, restaurants, commerce). Despite endeavors in recent years to enhance this sector —such as the promotion of Saharan tourism and the inauguration of the new international terminal at Houari Boumediene Airport on May 9, 2019—the index exhibits a decline of 7.3% between 2015 and 2021.

However, some sectors, namely Sector 1 (Agriculture, forestry, fishing), Sector 6 (ISMME) and Sector 10 (Food and Beverage Industries), exhibit notably low indices in comparison to

theoretical values (<0.80). In the case of Sector 1, the lack of modernized equipment resulting in the near absence of a processing industry within this sector is highlighted as the primary justification, contributing to the frailty in the sector's relationship with its clientele. Sector 6, although displaying a positive 2015-2021 variation in the Forward Linkage (FL) index (+1.14%), encounters challenges in establishing enduring relationships with its clientele, indicating its current struggle to compete with imported goods. This same observation applies to Sector 10, which, despite multiple investment endeavors and the emergence of several entities (such as Palmary Food, Kazamie, Soummam, etc.), has yet to fully convince the Algerian consumer base. Consequently, consumers continue to prioritize foreign products over local offerings within this sector.

Table 4. Rasmussen forward linkages indices and sectorial classification 2015, 2020 and 2021

	2015			2019			2020			2021		
	Index	Rank	Class	Index	Rank	Class	Index	Rank	Rank	Index	Rank	Class
Agriculture, Forestry, Fishing	0,80	11	LL	0,73	13	LL	0,67	13	LL	0,69	13	LL
Water and Energy	1,24	5	KS	1,11	5	KS	1,13	5	KS	1,15	5	KS
Hydrocarbons	0,80	10	LL	0,76	11	LL	0,77	8	SBL	0,71	12	LL
Oilfield Services and Public Works	1,02	7	KS	1,33	4	KS	1,69	3	KS	1,59	3	KS
Mines and Quarries	1,27	3	SFL	1,04	6	SFL	0,86	7	LL	0,79	9	LL
ISMME	0,67	17	LL	0,67	15	LL	0,67	14	LL	0,68	15	LL
Construction Materials	1,68	2	SFL	2,20	1	SFL	2,16	2	SFL	2,37	1	SFL
BTPH	0,60	18	SBL	0,56	18	SBL	0,53	18	SBL	0,55	18	SBL
Chemistry, Plastics, Rubber	0,84	9	LL	0,82	8	LL	0,76	9	LL	0,79	8	LL
Food and Beverage Industries	0,67	16	LL	0,65	16	LL	0,60	16	LL	0,62	16	LL
Textiles, Clothing, Hosiery	0,85	8	LL	0,81	9	LL	0,74	10	LL	0,80	7	LL
Leather and Footwear	2,26	1	SFL	2,09	2	SFL	2,43	1	SFL	2,22	2	SFL
Wood, Paper, and Cork	1,25	4	SFL	1,40	3	SFL	1,34	4	SFL	1,28	4	SFL
Various Industries	1,09	6	SFL	0,96	7	LL	0,97	6	LL	0,98	6	LL
Transport and Communications	0,69	15	LL	0,63	17	SBL	0,58	17	LL	0,61	17	LL
Hotels, Cafes, Restaurants, Commerce	0,74	14	SBL	0,72	14	SBL	0,65	15	SBL	0,69	14	SBL

**Structural Transformation and Interindustry Linkages During Multifaceted Crises:
Key Sectors of the Algerian Economy from 2015 to 2021**

Services Provided to Businesses	0,75	13	LL	0,75	12	LL	0,74	11	LL	0,72	11	LL
Service Provided to Household	0,77	12	LL	0,77	10	LL	0,71	12	LL	0,76	10	LL
Numb of sector FL<1	11			12			13			13		

Weak linkages (LL); Strong forward linkage (SFL); Strong backward linkages (SBL); Key sector (KS)

Figure 4.Forward linkages 2015- 2021

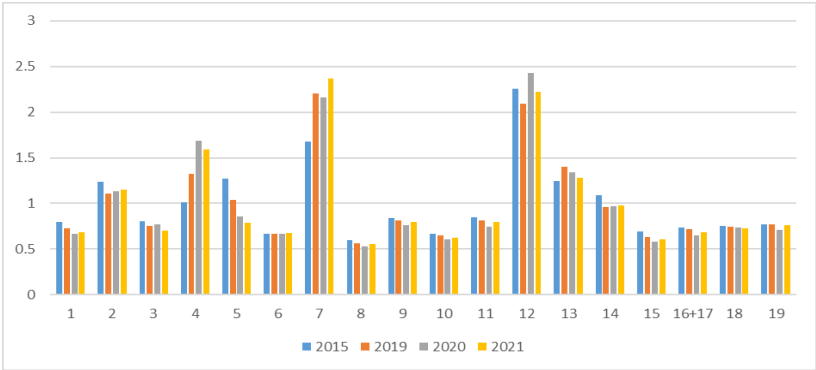


Figure 3 demonstrates notable transformations observed within sectors concerning forward linkages throughout the period from 2015 to 2021. A discernible trend is noticeable wherein the Forward Linkage (FL) index shows a significant decline across multiple sectors. This trend is rooted in the context of the economic crisis has stalled the activity of many businesses, thereby reducing the market diversification of all sectors.

Undoubtedly, assessing a sector's prowess and its capacity to drive economic vitality based solely on one index (BL, FL) might lack comprehensive representation. However, by concurrently examining both indices, only two sectors consistently surface as pivotal sectors (KS) throughout the four-year study period: Sector 2 (Water and Energy) and Sector 4 (Oilfield Services and Public Works). This observation mirrors the rentier nature characterizing the Algerian economy.

One additional sector aligns closely with the two aforementioned sectors, exhibiting Backward Linkage (BL) indices nearly reaching unity, specifically Sector 7 (Construction Materials). Notably, with variations of approximately 14.05% for the BL index and 41% for the FL index between 2015 and 2021, this sector stands as the sole entity within the economy classified as in progress.

In line with Hirschman's classification of sector groups pivotal for favourable economic development (Hirschman, 1958), the second cluster comprises sectors categorized as SBL

(BL > 1, FL < 1). Currently, only Sector 8 (Construction and Public Works, BTPH) falls within this classification. However, Sector 10 (Food and Beverage Industries) and Sector 15 (Transportation and Communication) closely approach unity in their indices (and exceed unity in certain years), potentially positioning them to be included in this category.

Given that the calculated indices (BL, FL) are based on averages, meaning a moderate level of backward or forward linkage, we compute their respective coefficients of variation (CBL, CFL) to gauge the uniformity of a sector's influence on others. Table 3 displays the outcomes of these coefficient calculations. Given the nature of dispersion coefficients, the specific order of magnitude is not of primary significance. The aim of these calculations is to identify sectors with strong influence, resulting in very low coefficients. It is essential to emphasize that while the calculation of this index does not alter established sector rankings, it does offer a more comprehensive perspective on the role of a sector and its impact on the wider economy.

Table 1. Coefficient of variation CBL CFL, 2015-2021

	2015		2019		2020		2021	
	CBL	CFL	CBL	CFL	CBL	CFL	CBL	CFL
Agriculture, Forestry, Fishing	4,256	4,254	4,260	4,244	4,261	4,236	4,269	4,240
Water and Energy	4,278	4,207	4,283	4,195	4,267	4,169	4,276	4,198
Hydrocarbons	4,255	4,225	4,268	4,200	4,259	4,182	4,267	4,196
Oilfield Services and Public Works	4,293	4,223	4,277	4,219	4,261	4,208	4,267	4,219
Mines and Quarries	4,326	4,292	4,326	4,285	4,323	4,277	4,326	4,282
ISMME	4,292	4,188	4,296	4,180	4,288	4,187	4,296	4,181
Construction Materials	4,284	4,271	4,302	4,261	4,293	4,257	4,295	4,263
BTPH	4,306	3,918	4,309	3,720	4,307	3,688	4,309	3,697
Chemistry, Plastics, Rubber	4,283	4,280	4,289	4,276	4,286	4,269	4,290	4,273
Food and Beverage Industries	4,295	4,264	4,277	4,246	4,256	4,238	4,274	4,239
Textiles, Clothing, Hosiery	4,307	4,279	4,304	4,267	4,300	4,256	4,301	4,257
Leather and Footwear	4,297	4,291	4,303	4,283	4,298	4,277	4,303	4,280
Wood, Paper, and Cork	4,287	4,290	4,294	4,280	4,294	4,273	4,305	4,278
Various Industries	4,308	4,294	4,309	4,288	4,293	4,283	4,302	4,287
Transport and Communications	4,253	4,187	4,270	4,189	4,271	4,188	4,270	4,197
Hotels, Cafes, Restaurants, Commerce	4,319	4,205	4,321	4,210	4,324	4,199	4,324	4,204
Services Provided to Businesses	4,323	4,284	4,320	4,273	4,317	4,265	4,323	4,269
Service Provided to Household	4,327	4,258	4,320	4,249	4,317	4,237	4,319	4,243

Source: established by the authors.

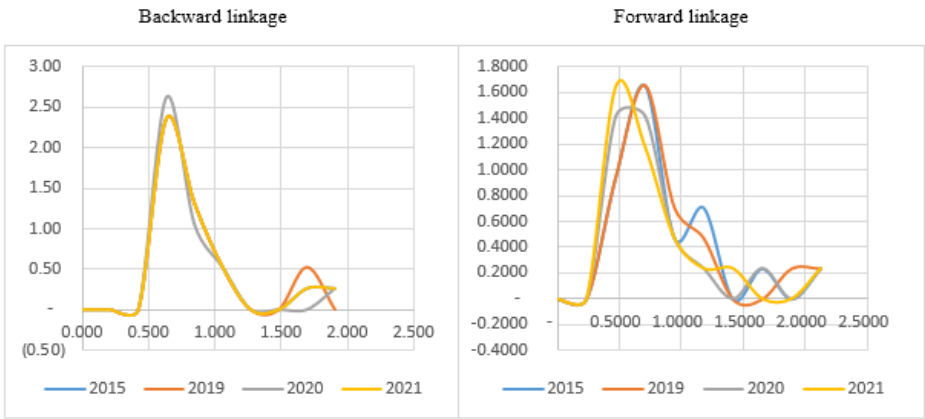
It is apparent that Sector 8 (Construction and Public Works) consistently demonstrates a low CFL index across the four years, signifying extensive dissemination of its outputs throughout the broader economy and a robust relationship established with its clientele. Sectors classified within the key sector group (KS), specifically Sector 2 and 4, typically display reasonably moderate CBL and CFL indices, consistently ranking among the seven smallest indices during most years of the study. Likewise, Sector 10 and 15 also indicate relatively small CBL and CFL indices, consistently ranking among the ten smallest indices during the majority of the study years.

It is evident that sectors assumed to hold strategic positions, such as Sector 9 (Chemicals, Plastics, Rubber) and Sector 14 (Various Industries), exhibit FL and BL indices below unity. Additionally, these sectors display CFL and CBL indices among the highest in the economy, underscoring the minimal role they fulfill within the economic framework.

A *Kernel Rasmussen’s linkages*

To enhance the evaluation of the Algerian economic structure's evolution from 2015 to 2021, we undertake a refinement process of the previously examined data (normalized BL and FL indices) by computing a Kernel Density. The outcomes of these computations are depicted in Figure 3, where the left side illustrates the results for backward linkages and the right side displays the results for forward linkages.

Figure 1. Kernel Rasmussen’s linkages



Concerning the Backward Linkage analysis (depicted on the left side of Figure 1), a notable observation lies in the consistent overlap of the four curves representing the years 2015 to 2021. This consistency indicates a lack of variance in dispersion, suggesting a sustained absence of structural change within the Algerian economy. This prolonged adherence to the

same economic pattern since 2015 raises questions regarding potential innovation deficits within the economy. Conversely, a subtle level of dynamism emerges in the dispersion curve of the FL index (illustrated on the right side of Figure 1), albeit with certain points of curve overlap. This slight dynamism could suggest some degree of production dynamism within the economy.

The onset of the COVID-19 pandemic, the reduction in seasonal precipitation attributed to climate change and the economic decline triggered by the steep decline in oil prices (Brent crude oil plummeted by over 65% from July 2014 to February 2016) constitute the three primary crises confronting the nation. This economic upheaval notably commenced with the abrupt decline in oil prices, occurring concurrently with periods of political instability.

These challenges will weigh heavily on the country's food security, public health, financial stability and social cohesion. This underlying trend could have a significant impact on the country, disrupting the delicate balance of an economy dependent on oil and hydrocarbon revenues to meet the diverse needs of an expanding and increasingly consumptive population.

Encouragingly, there was a 2.3% year-over-year increase in GDP in the initial quarter of 2021, signifying the country's economic rebound. Moreover, in 2022, the non-hydrocarbon economic activity gained momentum, driven by a resurgence in agricultural output and consistent growth in private consumption. The decline in oil prices was counterbalanced by the ascent in natural gas export prices, ensuring elevated export revenues, rapid accumulation of foreign exchange reserves and a reduced budget deficit.

Sectors such as building, public works, and hydraulic engineering (BTPH, inclusive of oil services and public works), alongside non-market services, reported growth rates of 3.3%, 4.0% and 2.5%, respectively, significantly contributing to the overall economic dynamic.

VI CONCLUSION

Analyzing an economy's core sectors requires using a variety of approaches, each of which provides a different perspective. It's critical to embrace the various views offered by several studies rather than focusing only on the benefits of a single technique. Achieving perfect uniformity among approaches would be impractical. The field of influence technique and the Rasmussen/Hirschman indices made it easier to analyze the internal structure of the economy without taking into account the productivity levels of specific industries. On the other hand, pure linkage indices took into account the productive structure while taking different levels of production into account for different sectors. The indicators used have been normalized and averaged to reflect upstream or downstream influences at a moderate level.

An analysis of structural changes in Algerian industry from 2015 to 2021 revealed empirical evidence indicating a decline in intersectoral demand within the industry. Algeria's industry

has experienced a decline in intersectoral demand from 2015 to 2022, with the Oil-field Services and Public Works sector remaining the top sector. However, a modest recovery was observed in specific sectors, with the construction materials sector moving by 14.05%. Sectors 13 and 14 showed a backward linkage effect below one, indicating minimal reliance on suppliers. Sector 16 maintained the highest position, but there may be bias in these results. The Algerian economy's forward linkages analysis shows a consistent pattern between 2015 and 2021, with three sectors showing significant productivity improvements. However, only 4 to 7 sectors have a forward linkage effect, suggesting products are disseminated as inputs across the remaining sectors. Despite these challenges, Algeria experienced a 2.3% GDP increase in Q1 2021, with a resurgence in non-hydrocarbon economic activity in 2022.

Algeria's economy has remained consistent since 2015, with a slight dynamism in the FL index. Despite facing crises like COVID-19, climate change, and oil price decline, Algeria experienced a 2.3% GDP increase in Q1 2021, with a resurgence in non-hydrocarbon economic activity in 2022. Sectors like building, public works, and hydraulic engineering contributed to overall economic growth.

VII BIBLIOGRAPHY

- Bekhet, H. (2010). Ranking sectors changes of the Malaysian economy: I-O approach. *International Business Research*, 3(1), 107-130.
- Chenery, H., & Watanabe, T. (1958). International comparisons of the structure of production. *Econometrica*, 487-521.
- Dietzenbacher, E. (1992). The measurement of interindustry linkages key sectors in the Netherlands. *Economic Modelling*, 419-437.
- Hirschman, A. (1958). *Strategy of economic development*. Yale university press.
- Kellou, M. (2022). Secteurs stratégiques en Algérie : Approche Hirschmanienne et croissance déséquilibrée. *Revue Recherches et études en Développement*, 9(2), 344-356.
- Leontief, W. (1986). *Input-output economics*. Oxford University Press.
- Miller, R., & Blair, P. D. (2009). *Input-output analysis foundations and extensions*. (2, Ed.) Cambridge University Press.
- Rasmussen, P. (1957). *Studies in Inter-Sectoral Relations*.
- World Bank. (Spring 2023). *Rapport de suivi de la situation économique*.