

# Modeling of Agricultural Production Using Input- Output Analysis Technique A Quantitative Study of the Algerian Economy for the Period 2005-2019

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## **Abstract**

Agricultural development and strategic planning require good reliable and comparable data that can guide appropriate policies and good governance to provide experts and decision makers in countries with effective tools. However, the quantitative measurement of sectors of the Algerian economy is relatively recent when compared with developed countries. Agriculture, fishing and forestry sector can if exploited should promote economic growth and protect national food security.

Agricultural production was not only an engine of economic recovery in many countries but also a vital contributor to job creation, value added and output. The researcher used the input-output analysis method (IOA) and its analytical indicators of the interdependencies between sectors in the Algerian economy. This method is generally used to estimate the effects of positive or negative economic shocks and to analyze the crumbling effects across the economy. Using the PYIO package and drop them on the Algerian input-output tables for the separate years 2005-2010 -2016 and 2019. The main purpose of this paper is to estimate the output impacts of Agriculture, fishing and forestry sector if will be extracted, and identifying key sectors at different levels of time series. To achieve this two purposes, finding on both analytical and empirical grounds from input-output analysis technique and the data available from Algerian input-output tables, the researcher used linkage analysis. To study these measures our empirical study is based on sectoral output and output impacts for 18 Algerian sectors of four different years; The quantitative study showed the potential of the agricultural sector which was classified as a key sector according to HEM, reflecting the potential to be the locomotive of the Algerian economy in the 21st century. In addition, the study concluded that the agricultural sector in terms of wealth formation is in second position, but on the output and income side, the sector still need help, a big push to enable him to take the leading role in development path. It is a promising sector if there is human potential, especially the skilled hand to become a sector of the agriculture industry.

**Keywords:** input-output analysis, linkages analysis, hypothetical extraction method, key sectors, net backward linkage, Algeria.

## **Introduction**

In the input-output analysis literature, there are many attempts to identify quantitative measures to study

linkages, including identifying the key sectors. It is the source of much debate so far. In this research paper; Structural changes in the Algerian economy are analyzed using input-output model derived for the years 2005, 2010, 2016 and 2019. Three alternative approaches to the analysis are presented. The first approach focuses on classical interdependency measures for segment classification. The early work of Chenery and Watanabe (1958), Perroux (1955), Rasmussen (1956), Hirschman (1958), Jones (1976) and many others includes identifying measures of backward and forward linkages between sectors and identifying the key ones for the economic development. The Second one applies net backward linkage to identified pioneer sector was proposed by Dietzenbacher (2005). The third approach focuses on the importance and the role of the sector by hypothetical extraction in its twofold, the original hypothetical extraction method (complete extraction) initially developed by Strassert (1968), and later (incomplete extraction) developed by Dietzenbacher and van der Linden (1997). The basic premise behind this method is to theoretically extract the sector from the input-output system completely and then to study the effect of this hypothetical extraction on other sectors and the deleted sector itself, the incomplete hypothetical extraction method proposed by Dietzenbacher and van der Linden (1997). Using the inverse of the matrix partitioned by the demand-side Leontief model or the supply-side Ghosh model, the effects of backward and forward linkages can be tracked in detail and explained more clearly. These three approaches are compared to examine the degree to which sectors can be accurately classified as key sectors and their importance, in addition, to discover important changes in the economy over the period (2005-2019).

### **Historical background:**

The idea of interdependency or linkages between the productive sectors of an economy emerged from the British economist Albert Hirschman (1958), when he formulated the concept of the effect of linkage and included it in the strategy of unbalanced growth in economic development in the less developed countries, (Even if Perroux preceded him in what is known as the poles of growth).

Hirschman and his supporters believe that this strategy is a better method for the growth process suitable for developing countries. The state should focus on a major sector(s) of society, as a result of the lack of financial resources for investments in development plans. This key sector(s) will attract other sectors to the stage of balanced growth, which will lead to achieving the desired development at all levels. There is much evidence from economic history that supports what they have argued, and that economic growth did not occur in all sectors at a similar time, such as:

- The railroad sector in America in the nineteenth century;
- The food production sector in Denmark;
- The textile sector in Britain;
- The chemical and electronic industries sector in Western Europe in the second half of the twentieth century;
- The electricity sector in Russia in the 1930s and 1940s.

Hirschman believes that productive activities are interconnected and linked, creating pressures (bottlenecks) of surpluses that would generate corrective forces for this imbalance. The process of imbalance in the form of surplus or bottleneck plays a central role in the strategy. The main focus is on bottlenecks, as they have an effective role and provide the conditions for pushing the process of economic and social development forward.

The open demand-driven model of Input-Output Analysis is an economic approach that allows the analysis of linkage between sectors of the economy. It is based on the idea that elements of final demand

affect the production and distribution of goods and services. The open demand-driven model of I-O-A has many uses. What is of interest in this research paper is to study the economic linkages between different sectors and identify the key sectors.

The hypothesis in the development literature according to Hirschman's unbalanced growth strategy is that investment in productive sectors with large sectoral linkages will promote faster economic growth than investment in all economic sectors, especially with the limited resources available to the country. Hirschman identified two types of linkages that promote economic development:

1. The input-provision, derived demand or backward linkage effects, i.e., every nonprimary economic activity will induce attempts to supply through domestic production the inputs needed in that activity.
2. The output-utilization or forward linkage effects, i.e., every activity that does not by its nature cater exclusively to final demands will induce attempts to utilize its outputs as inputs in some new activities. (*Leroy P. Jones, 1976, p.323*)
3. Finally, one should also consider the higher order effects that derive from the expansion of the activities which provide inputs to the "nonprimary" activity that induced the backward linkage. Thus we shall define a third measure of linkage, the total linkage effect). (*Pan A. Yotopoulos & Jeffrey B. Nugent, 1973,p. 158*).

**Mathematical background of input-output analysis:**

An economy can be described by an input-output table, from which an input-output equation can be derived. We have in general; In the full n-sector model, output is of the form:

$$\begin{aligned}
 X_1 &= a_{11} X_1 + a_{12} X_2 + \dots + a_{1j} X_j + \dots + a_{1n} X_n + y_1 \\
 X_2 &= a_{21} X_1 + a_{22} X_2 + \dots + a_{2j} X_j + \dots + a_{2n} X_n + y_2 \\
 &\dots \\
 X_i &= a_{i1} X_1 + a_{i2} X_2 + \dots + a_{ij} X_j + \dots + a_{in} X_n + y_i \quad (1-1) \\
 &\dots \\
 X_n &= a_{n1} X_1 + a_{n2} X_2 + \dots + a_{nj} X_j + \dots + a_{nn} X_n + y_n
 \end{aligned}$$

These can be rearranged to give:

$$\begin{aligned}
 (1 - a_{11}) X_1 - a_{12} X_2 \dots - a_{1j} X_j \dots - a_{1n} X_n &= y_1 \\
 - a_{21} X_1 + (1 - a_{22}) X_2 \dots - a_{2j} X_j \dots - a_{2n} X_n &= y_2 \\
 &\dots \\
 - a_{i1} X_1 - a_{i2} X_2 \dots + (1 - a_{ij}) X_j \dots - a_{in} X_n &= y_i \quad (2-1) \\
 &\dots \\
 - a_{n1} X_1 - a_{n2} X_2 \dots - a_{nj} X_j \dots + (1 - a_{nn}) X_n &= y_n
 \end{aligned}$$

We have n simultaneous equations in n unknowns. Collecting together terms and rearranging we get, the general form:

$$\begin{aligned}
 b_{11} X_1 + b_{12} X_2 \dots + b_{1j} X_j \dots + b_{1n} X_n &= y_1 \\
 b_{21} X_1 + b_{22} X_2 \dots + b_{2j} X_j \dots + b_{2n} X_n &= y_2 \\
 &\dots \\
 b_{i1} X_1 + b_{i2} X_2 \dots + b_{ij} X_j \dots + b_{in} X_n &= y_i \quad (3-1) \\
 &\dots \\
 b_{n1} X_1 + b_{n2} X_2 \dots + b_{nj} X_j \dots + b_{nn} X_n &= y_n
 \end{aligned}$$

It is apparent that the solution of such simultaneous equations is fundamental to input-output analysis, and as so often in Maths, the solution to this problem is made easier and more transparent by finding a neat notation.

The notation we shall use involves rewriting the above equations in the matrix form:

$$\begin{matrix}
 b_{11} & b_{12} & \dots & b_{1j} & \dots & b_{1n} \\
 b_{21} & b_{22} & \dots & b_{2j} & \dots & b_{2n} \\
 \dots & \dots & \dots & \dots & \dots & \dots \\
 & b_{i1} & b_{i2} & \dots & b_{ij} & \dots & b_{in} \\
 \dots & \dots & \dots & \dots & \dots & \dots & \dots \\
 b_{n1} & b_{n2} & \dots & b_{nj} & \dots & b_{nn}
 \end{matrix}
 \begin{pmatrix}
 X_1 & y_1 \\
 X_2 & y_2 \\
 \dots & \dots \\
 X_i & y_i \\
 \dots & \dots \\
 X_n & y_n
 \end{pmatrix}
 =
 \begin{pmatrix}
 y_1 \\
 y_2 \\
 \dots \\
 y_i \\
 \dots \\
 y_n
 \end{pmatrix}
 \quad (4-1)$$

We therefore, now have an equation of the form:

**Matrix \* vector = vector** (5 -1)

This is called a matrix equation. We can convert our single equation back to our original (n) of ordinary equations by using the rule of matrix multiplication. We have introduced this notation, when it boils down to what we had originally! The reason is that allows us to write a whole (n vector) set of simultaneous equations as **one** matrix equation.

The central equation in the model from which all mathematical analysis proceeds is:

**X = (I - A)⁻¹ Y** (6-1)

Where A is given in the national economy X\* the new output necessary to meet the new final demand Y\* determined externally has the following relationship:

-1)7 \* **(X\* = (I - A)⁻¹ Y**

Where I: is the unity matrix, the (I - A)⁻¹ matrix is a fundamental building block of I-O analysis and is known as the Leontief Inverse, after its originator. Now we have a very powerful tool for analysis.

**DATA BASE AND METHODOLOGY**

**1. DATA BASE**

The data used in the study were taken from the Algerian derived input-output tables (IOT) prepared by the Technical Directorate in charge of National Accounting (DTCN the Technical Department in charge of Accounting), which is affiliated to the National Office of Statistics (ONS). The tables include 18 production sectors, and cover the study period from 2005 to 2019, the latest available table. Tables (IOT) are not field Bench-Marck but were derived on the basis of the RAS technique modified for the Bench-Marck Input-Output Table 1989. To assess the importance and position occupied by the agriculture, forestry and fishing sector in the Algerian economy. The researcher applied the linkage analysis and the hypothetical extraction method (HEM) for the analysis of the change in the production structure of the Algerian economy which are based on four input output tables for the years 2005, 2010, 2016 and 2019. These tables were very disaggregated (with 96 sectors) compared to the 2005, 2010, 2016 and 2019 tables published by the National Statistical Office (ONS) only at a disaggregation level for 18 sectors, this is consistent with the purposes of this study.

**2. Methodology**

Following to the historical background of linkages analysis in input-output analysis, two trends appear. The first is a classic one based on the Rasmussen approach, which has become an accepted method for identifying the key sectors of the economy and is therefore one of the most widely used methods in this

type of economic structure analysis.

The researcher relied on measuring the forward and backward linkage with the Rasmussen index measures (Rasmussen 1956) to determine the classification of that sector. It is based on the input or output matrix of Leontief model or Ghosh model respectively in determining forward and backward linkage measures for productive sectors.

The second approach is represented by Strassert and Dietzenbacher, namely the hypothetical extraction method (HEM) originally developed by Strassert (1968) and later developed in Dietzenbacher and Lahr (2013). The original HEM was proposed to measure the importance of an industry (or its linkages) within a national economy (*Erik Dietzenbacher, Bob van Burkena and Yasushi Kondo 25 December 2018*).

Later the incomplete hypothetical extraction method proposed by Dietzenbacher and van der Linden (1997). they believe that determining the total or forward and backward linkage of any sector is done by completely excluding the sector from the input-output system and by deleting the row and/or column from the input or output matrices.

This method refers in understanding the linkages between sectors of the economy and how the complete extraction of one sector can affect others. This method considers both the sector's connections with the rest of the economy and its size to determine its relative importance. The total absolute and relative linkages measure reflects the output loss that would occur if a sector is completely extracted from the economy. This measure can provide insights into the ripple effects and potential vulnerabilities within an economic system and the extent of its effect on the production process with and without it. Both hypothetical extraction method and intersectoral linkage specifications utilize as a methodological foundation the Leontief demand driven model and the Ghoshian supply driven model.

### 3. Linkage analysis

Interdependency among sectors is the essential of modern production; the pattern and measurement of these interdependencies or linkages, indicates a given sector's capacity to stimulate other sectors. Key sectors are those that have the most linkages. Because of these interdependencies and the multiplier effects a strategy for development based on investment in the key sectors should promote generalized economic development. (*Patricio Meller and Manuel Marfán ; 1981 p 266*)

The importance of linkages lies in its enormous impact on governments, industry and institutions. First, information about these linkages is essential for understanding the structure of the economy, which is important in formulating the government's industry policies. Governments can intervene in the sector by imposing it on other sectors, which have high linkages with that sector, and vice versa.

Secondly, linkages are one of the most important factors to gain competitive advantage for the industry. The more the standard indices of the sector's forward and backward linkages are greater than 1, the more important the sector becomes, meaning that it provides its output to other sectors, including the sector itself, at a level that exceeds the general average of the economy, and uses the outputs of other sectors in a greater volume as inputs to its production process, which means a group it has a large number of sectoral linkage, and it affects and is affected by the rest of the components of the national economy. On the contrary, if the index is less than 1, this indicates a lack of linkages of the sector and a lack of importance in economic activity. Joint analysis of these two indicators makes it possible to determine how the sector is woven into the economic structure of the country and how important it is.

Linkage analysis for LDCs is probably the most common use to which their input-output tables have been put. (*Victor.B.Tomas. 1982 p 196*).

Since the linkage concept is based on industrial interdependence, an input-output table is a natural place

to look for linkage indicators. Hirschman himself originally used the Chenery and Watanabe (C & W) industrial classification based on the shares of direct intermediate sales and inputs in total output ( *Leroy P. Jones. May, 1976, p 324*).

Input-output (I-O) analysis has found an important application in the economics of development through the hypothesis of linkages. Albert Hirschman has been instrumental in defining operationally the linkage effects and also in providing the causal linkage between linkages and economic development. His significant contribution has claimed the respect of academicians and planners alike. (*Pan A. Yotopoulos Jeffrey B. Nugent ;1973. P157*).

**3.1 Watanabe. T & Chenery. B.H (1958):**

The idea of measuring linkages between productive activities in an economy goes back to them. They studied the economies of four developed countries - the United States of America - Japan - Italy and Norway, and developed quantitative coefficients to measure the degree of direct interdependency between sectors. This is considered the first attempt to measure forward and backward linkages. They proposed the sum of the column of the direct coefficients matrix (A) as a measure of the backward linkage, and in the same way the measure of the forward linkage is calculated as the sum of the row of the direct coefficients matrix (A) .

$$(8 - 1) \quad BL_j = \sum_{i=1}^n a_{ij} \quad FL_i = \sum_{j=1}^n a_{ij}$$

**3.2 (Rasmussen. P.N,1956)** considered a sector to be a key sector if and only if the effect of growth in this sector is greater than the average effect of growth for all other sectors on the national economy. Therefore, Rasmussen relied on measuring the forward and backward linkages on the Leontief Inverse (I-A)<sup>-1</sup>.

$$(9 - 1) \quad BL_j = \sum_{i=1}^n (I - A)^{-1} = \sum_{i=1}^n l_{ij}$$

The forward linkage measure is the row sum of the same matrix (I-A)<sup>-1</sup>. With the following mathematical formula:

$$(10 - 1) \quad FL_i = \sum_{j=1}^n (I - A)^{-1} = \sum_{j=1}^n l_{ij}$$

For cross-sector comparisons, Rasmussen used standard backward linkage indices, as well as standard forward linkage indices, and called them “**Sensitivity of dispersion.**” The aim was to measure the average of the sector to the average of the entire economy as a whole. It was therefore called the method of average of averages or Index Linkage. Rasmussen coined the term “**power of dispersion**” for backward linkage, which describes the relative expansion in which final demand for a sector’s products increases. The development of this index of sector dispersion as a way to identify key sectors earned Rasmussen great fame and reputation. .

backward linkage index

$$(11 - 1) \quad BL_j = \frac{\frac{1}{n} \sum_{i=1}^n L_{ij}}{\frac{1}{n^2} \sum_{j=1}^n \sum_{i=1}^n L_{ij}} = nL_{ij} / \sum_{j=1}^n \sum_{i=1}^n L_{ij}$$

Rasmussen also presented another measure called "Sensitivity of dispersion" as a measure of forward linkage, which expresses the increase in the production of a sector that occurred as a result of a unitary increase in the final demand for all sectors, and these changes are called "Permissive effect."

forward linkage index and its mathematical formula:

Forward linkage index



$$(12 - 1) \quad FL_i = \frac{\frac{1}{n} \sum_{j=1}^n L_i}{\frac{1}{n^2} \sum_{j=1}^n \sum_{i=1}^n L_{ij}} = nL_i / \sum_{j=1}^n \sum_{i=1}^n L_{ij}$$

where  $L_i = \sum_{j=1}^n L_{ij}$

The user’s statement discusses two key indices related to economic sectors:

1. The **index of the power of dispersion** for a sector represents the total production required across all sectors to support a unit of consumption of this sector’s production.
2. The **index of the sensitivity of dispersion** for a sector represents the total production required across all sectors to accommodate an increase in a unit of this sector’s primary input.

These indices measure the linkages and sensitivities among different productive sectors. They help in understanding how changes in one sector can impact others.

**3.3 Hazari. R. B (1970)** based on Hirschman's criticism of the method of Chenery and Watanabe, he formulated linkage coefficients for direct and indirect effects using the Leontief multiplier matrix  $B = (I - A)^{-1}$  to infer the key sectors in the Indian economy in two ways, the first taking weighting and the other without weighting.

**3.4 Jones L. (1976)** criticized the method of calculating forward linkage coefficients that depended on the matrix of input coefficients by Leontief A. Accordingly, he proposed a new method of calculating forward linkage coefficients with economic significance based on the matrix of output coefficients of Ghosh, what is known as the supply-side input-output model. To differentiate it from the supply-side input-output model. For the demand side of Leontief  $\sum_{i=1}^n l_{i,j}$

$$(13 - 1) \quad FL_i = \frac{\frac{1}{n} \vec{l}_i}{\frac{1}{n^2} \sum_{j=1}^n \sum_{i=1}^n \vec{l}_i} = \frac{n \vec{l}_i}{\sum_{i=1}^n \sum_{j=1}^n \vec{l}_{ij}}$$

#### 4. Net Backward Linkage

Another linkage measure was proposed by Dietzenbacher (2005); (*Miller, R.E & Blair, P.D. op. cit. pp 558-559*).

net multiplier formulation:

$$(14 - 1) \quad (i' L \hat{f}_c)_j = \frac{\sum_{i=1}^n L \hat{f}_c}{\sum_{j=1}^n L \hat{f}_c} = \frac{i' L \hat{f}_c}{L \hat{f}_c} = \frac{i' L \hat{f}_c}{x_j}$$

Where:

$i' L \hat{f}_c$  :  $j^{\text{th}}$  column sum

$L \hat{f}_c$  :  $j^{\text{th}}$  row sum

$(i' L \hat{f}_c)_j$  : Net Backward Linkage of sector j.

In words: the output generated in all industries by  $f_j$  divided by the output generated in j by all final demands. This suggests a kind of “net” backward linkage or net key sector measure. In particular, if  $(i' L \hat{f}_c)_j > 1$  then economy-wide output generated by final demand in j is larger than the amount of j’s output that is generated by all the other industries’ final demands. So industry j can be said to be more important for the others than the others are for industry j, and j would thus be identified as a key sector by this measure.

#### 5. Hypothetical Extraction method (HEM) Strassert 1968\*

The original hypothetical extraction method (HEM) was initially developed by Strassert (1968) and later developed further in Dietzenbacher and Lahr (2013). The basic hypothesis behind this method is to

theoretically exclude a sector from economic activity, and then study the impact of this hypothetical extraction on the rest of sectors and on the deleted sector itself. It measures the importance of the sector excluded from the input-output system, and expresses the total linkage.

\* Miller and Blair point out that the origin and earliest discussions of the HE hypothetical extraction approach, as far as we know, were first mentioned in an article (in French) by Paelinck, de Caebel and Degueudre, 1965, or in an article (in German) by Strassert in 1968. First discussion in English as far as we know, was in the works of Schultz in 1976 and 1977.

The starting point is the basic equilibrium equation of the Leontief model, which is also known as the demand-side model. We need this note later.

As we mentioned previously, the goal of the hypothetical extraction method is to measure the amount of total change (decrease) in the gross output of an economy consisting of  $n$  sectors if a specific sector ( $j$ ) is excluded from this economy and  $(n-1)$  sector remains. This is modeled in an input-output context with two distinctive methods:

### 5.1: the complete hypothetical extraction method

**HE** methods define a series of less known key sector measures. The central idea of the classical HE method is that the hypothetical elimination of a complete industry allows one to estimate its contribution to the economy-wide total output (*Umed Temurshoev ; Jan Oosterhaven , 2014 , p. 288*). The complete extraction of a sector  $j$  from the system is done mathematically by deleting the row and column of that sector from the matrix of input coefficients  $\mathbf{A}$ , or replacing it with zeros in the column and line of sector  $j$  to be extracted. This approach was initially developed by Strassert.(1968)

- **The total absolute linkage** (Delete the row and column for sector  $j$ )

This is known as the total effect (total linkage). We extract column and row  $j$  from the (technical) input coefficient matrix  $\mathbf{A}$ . Using  $(\tilde{\mathbf{A}}(j))$  for the  $(n - 1) \times (n - 1)$  matrix without the  $j^{\text{th}}$  sector excluded, and  $\tilde{\mathbf{f}}(j)$  for the reduced final demand vector, the output in “reduced” economy it is calculated as follows:

$$(15 - 1) \quad \tilde{\mathbf{x}}(j) = [\mathbf{I} - \tilde{\mathbf{A}}(j)]^{-1} \tilde{\mathbf{f}}(j).$$

Instead of completely eliminating row and column  $j$  in the coefficient matrix ( $\mathbf{A}$ ) and element  $j$  in the final demand  $\mathbf{Y}$ , they can simply be replaced with zeros.

In the complete model ( $n$  sectors), the result is with the famous relation:

$$(16 - 1) \quad \mathbf{X} = (\mathbf{I} - \mathbf{A})^{-1} \mathbf{f}$$

After obtaining the output before and after the extraction of sector  $j$ , we calculate the difference between the actual output before extraction and the reduced output after the hypothetical extraction of sector  $j$ , so we obtain a total measure of the economic loss due to sector  $j$  excluded from the production system, and it is in the following formula:

$$i' \tilde{\mathbf{x}}(j) - (17 - 1) \quad \text{TL}_j = i' \mathbf{x}$$

indicates the total absolute effect of completely extracting sector  $j$ . Its reason is due to the fact that the extracted sector  $j$  no longer depends on the production sectors to obtain its inputs. So it is considered one of the absolute aggregate measures of the loss to the economy (a decrease in the value of the gross output) if sector  $j$  is excluded – (delete both the column and the row. Or to be replaced by zeros) .

The normalization is through division by total gross output ( $i' \mathbf{x}$ ) and multiplication by 100 produces an estimate of the percentage decrease in total economic activity (Miller, R.E & Blair, P.D. 2009, p. 563).

$$(18 - 1) \quad \overline{\text{TL}}_j = 100[(i' \mathbf{x} - i' \tilde{\mathbf{x}}(j)) / i' \mathbf{x}]$$

### 5.2 the non-complete hypothetical extraction method of dietzenbacher and Van der Linden (1997)

Both dietzenbacher and Van der Linden noted that this approach suffers from some limitations as it does



not take into account the linkages in detail from the backward and forward linkages between the sectors. A major difficulty with the original Strassert method is that it does not distinguish the total linkages into backward and forward linkages (*Erik dietzenbacher & Van der linden, 1997, P236*).

To overcome these limitations, they proposed not to extract the sector completely, but to cut off its requirements (inputs) from other sectors, thus cutting off its backward linkage and its input needs from the rest of the sectors and importing them from outside the economy in question, and thus we have tracked its backward linkage and its impact on the economy. Hence, the backward linkages are reflected in the difference between the output generated before and after extracting the needs of the sector from within the system, expressed by comparing the actual gross output (before) with the new gross output (after) in the hypothetical case.

The method of non-complete hypothetical extraction is based on a more developed one that takes into account the linkages between sectors. This method involves calculating the total background and forward effects in dealing with the extraction of sector J on the rest of the economy.

- **The total backward impact Linkage** (Delete column j) :

This is known as the total absolute backward impact of sector j. It is translated by the following mathematical formula:

$$(19 - 1) \quad B_t = i'x - (i' \tilde{x}_{(c_j)})$$

- **The total forward absolute linkage** (Deleting row i):

We exclude row i from the output coefficient matrix (Ghosh distribution matrix) **B**. Using **B**<sup>-1</sup> for the matrix with rank (n - 1) × (n - 1) without sector i extracted. The matrix **B**<sup>-1</sup> is defined as a matrix of output coefficients (supply-side model) with sector i extracted (its row of matrix B), and (v<sup>-i</sup>)' is a row vector of the primary inputs after sector i is excluded.

This is what is known as the total forward absolute linkage. It is translated into the following mathematical formula:

$$(20 - 1) \quad F_t = x'i - (\tilde{x}'_{(r_j)})i$$

Using the inverse of the partitioned matrix we can compute the backward linkage and forward linkage of the extraction method as outlined in Dietzenbacher et al. (1993). The importance of a sector or region is presented in terms of the backward and forward linkages between a system with and without the extracted element. Further, the backward linkage is computed in terms of the Leontief inverse while the forward linkage is obtained using the Ghoshian system.

The economy is partitioned into two sets: one set consists of the sectors that are to be extracted from the economy while the other encompasses all the remaining sectors of the economy.

The output difference between the full and the extracted system can be estimated from the following equation (Dietzenbacher et al. 1993):

$$x - \bar{x} = \begin{pmatrix} x^1 & - & \bar{x}^1 \\ x^R & - & \bar{x}^R \end{pmatrix} = \left\{ \begin{pmatrix} L^{11} & L^{1R} \\ L^{R1} & L^{RR} \end{pmatrix} - \begin{pmatrix} (I - A^{11})^{-1} & 0 \\ 0 & (I - A^{RR})^{-1} \end{pmatrix} \right\} \begin{pmatrix} f^1 \\ f^R \end{pmatrix}$$

where **x** denotes output, **L** is the Leontief inverse matrix, **A** is the input requirement matrix, **f** is the final demand vector, superscript '1' and 'R' denotes the extracted region or sector and the rest of the system, respectively. The above measure pertains to the backward linkage of the impact. In terms of the forward linkage, the difference is as follows

$$(x - \bar{x})' = (v^{1'} \quad v^{R'}) \left\{ \begin{pmatrix} G^{11} & G^{1R} \\ G^{R1} & G^{RR} \end{pmatrix}^{-1} \begin{pmatrix} (I - B^{11})^{-1} & 0 \\ 0 & (I - B^{RR})^{-1} \end{pmatrix} \right\}$$

where v denotes the primary input vector, G is the Ghoshian inverse, B is the output allocation matrix, and the rest is as previously defined (Suahasil Nazara, Dong Guo, Geoffrey J.D. Hewings & Chokri Dridi. October 2003. P24).

To enhance the readability of the backward and forward linkage indicators obtained from the non-complete hypothetical extraction method, we can use standard backward linkage index, as well as standard forward linkage index, as Rasmussen did with backward and forward linkages, and called them power of dispersion and “Sensitivity of dispersion.” The aim is to measure the average of the output effect of extracted sector to the average of the entire economy as a whole (average of averages). And we call them standard backward and forward Linkages Indices. The development of this index of extracted sector is a way to give us an indicator to identify key sectors in the studied economy if we want to extract any sector from the input-output system. both indices will be normalized using an average of 1, in the manner outlined below:

$$\text{backward linkage index (21 - 1)} \quad BL^{index}_{(j)} = \frac{nb_j}{\sum_{i=1}^n b_j} = \frac{\frac{1}{n}b_j}{\frac{1}{n^2}\sum_{j=1}^n b_j}$$

forward linkage index and its mathematical formula:

Forward linkage index

$$(22 - 1) \quad FL_i = \frac{\frac{1}{n}b_i}{\frac{1}{n^2}\sum_{i=1}^n b_i} = \frac{nb_i}{\sum_{i=1}^n b_i} \text{ where } b_i = \sum_{j=1}^n b_{ij}$$

We attempt to identify key sectors from their backward and forward linkage index, which usually calculate both (in normalized form Rasmussen, 1956) and then select those sectors with a high value (index greater than one) on both measures.

Often, sectors are classified over a four-way classification such as be displayed in a 2 × 2 in the below table no 1.

table no. 01:

Classification of productive sectors according to the sector’s backward and forward linkage indices

|                        |        | Index forward linkage   |  |
|------------------------|--------|---|--|
|                        |        | FLi<1   | FLi>1  |
| Index backward linkage | BLj<1  | <b>Independent or island sector</b><br><b>weak sector</b> last priority         | <b>"Strategic sector"</b><br>dependent on interindustry demand<br>third priority |
|                        | BLj >1 | <b>"Driver sector"</b><br>dependent on interindustry supply;<br>Second priority | <b>"Key sector"</b><br>First priority  |

Reference: the ICT role in the world economy: an input-output analysis Elvio Mattioli, Giuseppe Ricciardo Lamonica.

## 6. Application to the Case of Algerian economy for period: 2005-2019

### 6.1 An overview of the Agriculture, forestry and fishing sector

Agriculture is an important factor in the Algerian economy, as the agricultural sector employs 11% of the

active workforce. Since 2005, agriculture has become one of the government's priorities to diversify the economy, which is still dominated by the fuel sector. The main crops are cereals, afforestation, vegetable crops, including potatoes, and fodder. Livestock occupies an important place, especially sheep farming and poultry farming. In 2014, agricultural production in Algeria reached \$35 billion, meeting the country's needs by 72%. According to the Bank of Algeria report, the gross domestic product increased during the year 2015 by 3.8%, i.e. at the same pace as in 2014, a high level exceeding the distinguished level of 2013. This growth was driven by the sectors of agriculture, industry, construction, public works and irrigation, as well as marketed services. But Algeria still imports milk and grains at a cost of about \$4 billion, which prevents the agricultural sector from achieving self-sufficiency, at least in the short term.

The economic contribution made by the agricultural sector to the national economy is estimated. For example, in 2015, the added value, in terms of volume, of the agricultural sector increased by 6.4%, advancing by 3.9 percentage points, to reach 1936,4 billion DZD (equivalent to 19,274.546.828.2 billion USD and 16,54229758879 billion € at exchange rates for the year 2015) and represents 15.6% of the value added to the real economy. With a contribution of 17.5% to the gross domestic product, and 23.6% to the value added to the real economy, the agricultural sector is considered in the second place in terms of wealth creation. (bank of Algeria, 2016, p. 22; In 2019, this sector of activity contributed nearly 40% to GDP growth and 17.1% to non-hydrocarbon growth. With 2529.1 billion dinars of flow of produced wealth, (equivalent to 21,188.733.970.8 billion USD at exchange rates for the year 2019) agriculture generates the equivalent of 16.0% of the added value of the real sphere, 12.4% of GDP and employs 1.083 million people, or 9.6% of the employed population. (bank of Algeria, 2020. P. 19).

All the methods which as sketched above of the sake to the classification and identifying key sectors has been applied to the input-output tables of the Algerian economy for the years 2005 – 2010 - 2016 and 2019. This table is constructed from derived input-output tables (see ONS, 2021). The sectoral classification is as follows:

**table no. 02 The sectoral classification of the Algerian economy**

| <b>Coded NSA</b> | <b>NSA titles</b>  | <b>Coded NSA</b> | <b>NSA titles</b>               |
|------------------|--|------------------|---------------------------------|
| 01               | Agriculture, forestry, fishing                                   | 10               | Agro-food industries            |
| 02               | Water and Energy   | 11               | Textiles, clothing, hosiery     |
| 03               | Hydrocarbons   | 12               | Leathers and Shoes              |
| 04               | Services and works. public. Oil tankers                          | 13               | Wood, Paper and cork            |
| 05               | Mines and quarries   | 14               | Various industries              |
| 06               | steel, mechanical, electrical and electronic industries » ISMMEE | 15               | Transport and communications    |
| 07               | Building Materials   | 16               | Hotels Cafes Restaurants        |
| 08               | building and public works and hydraulics (BTPH))                 | 17               | Services provided to businesses |
| 09               | Chemistry, Plastics, Rubber                                      | 18               | Services provided to households |

On the other hand, the PB is evaluated at the production price excluding VAT invoiced and imports in Freight Insurance Cost (CAF) excluding customs duties and excluding VAT. We will also note that the

transition from production price to acquisition price will require the addition of commercial margins. The ERE in current value is therefore written as follows:

$$PB + \text{Imports} + \text{VAT} + \text{Duty and taxes on imports} + \text{Trade margins} = CI + CF + \text{GFCF} + \text{Variation in Stocks} + \text{Exports}$$

( *la Direction Technique chargée de la comptabilité nationale Direction des publications et de la Diffusion. Avril 2018*).

## 6.2 Results obtained from the traditional Rasmussen-Hirschman linkage approach

With the help of four selected derived I-O tables for the years 2005-2010-2016 and 2019 the study ends with some important results.

**The key sectors** identified using the traditional Rasmussen-Hirschman linkage method were the coded sectors (2-7-10 in year 2005), (2-4-11 in year 2010), (2-4-15-3 in year 2016) and (2-10-15 in last year 2019). Three sectors for the years (2005- 2010 – 2016 and 2019. which were Water and energy sector the permanent sector, agro-food industries sector only in 2005 and 2019 but in 2010 and 2016 appeared as driving sector.

(4) Services and works public Oil tankers sector appeared in 2010 and 2016 as a key sector, but in 2005 and 2019 was a driving sector. Transport and communications sector appeared as a key sector in 2016 and 2019, but it was in 2005 and 2010 driving sector.

The three sectors (7) Building Materials, (11) textiles, clothing, hosiery sector and (3) Hydrocarbons appeared as a key sector once in 2005, 2010 and 2016 respectively.

These findings are detailed in Table N° 3. where indices linkages above 1 are highlighted in light green cells, and coded key sectors are in yellow cells. indices linkages ( $<1$ ) are marked in salmon pink cells which were weak sectors. The salient note is, the Water and energy sector consistently appeared as a key sector in all the periods studied, while the agriculture, forestry and fishing sector appeared as a strategic sector in the whole period of study. While (8) Building and public works and hydraulics (BTPH) sector stood out as a driving sector with a backward linkage i.e.  $BL_1 >1$  (in 2005-2010-2016 and 2019), but the rest of the sectors showed a a weak forward backward linkages i.e.  $FL <1$  and  $BL <1$  (weak sectors).

**Strategic Sectors ( $FL_1 >1$ )** we had one sector (1) Agriculture, forestry and fishing which consistently appeared in all years as strategic sector. Agriculture is considered a strategic sector with the inputs it provides to many other economic sectors, especially sector (10 )Agro-food industries, therefore, we will notice that strong linkage between them in the previous analysis using the hypothetical extraction method. Sector (3) Hydrocarbons as a strategic sector in 2005, 2010 and in year 2019, it was key sector in 2016. This is clear because it is considered almost the only source of hard currency in an economy whose dominant nature is oil rents, and it receives great attention from the government in formulating economic policy in the country.

On the other hand, driving sectors ( $BL_1 >1$ ), we had each year three sectors except in 2005 we had four sectors. The dominant driving sector in this category in the whole period was (8) Building and public works and hydraulics (BTPH) sector, in addition to others like (4) Services and works public Oil tankers sector , (11) Textiles, clothing, hosiery sector and (15) Transport and communications sector. In 2010 sectors coded (8-10-15) Building and public works and hydraulics (BTPH) sector, (10) Agro-food industries, (15) Transport and communications sector. In 2016 Mines and quarries sector , Building and public works and hydraulics (BTPH) sector and (10) Agro-food industries, finally in 2019 we had the set of three sectors (Services and works public Oil tankers – Building and public works and hydraulics (BTPH) sector – Building material). The rest of sectors were weak.

**Table no 3 Linkages analysis based on the traditional Rasmussen-Hirschman linkage approach for the years 2005,2010,2016 and 2019**

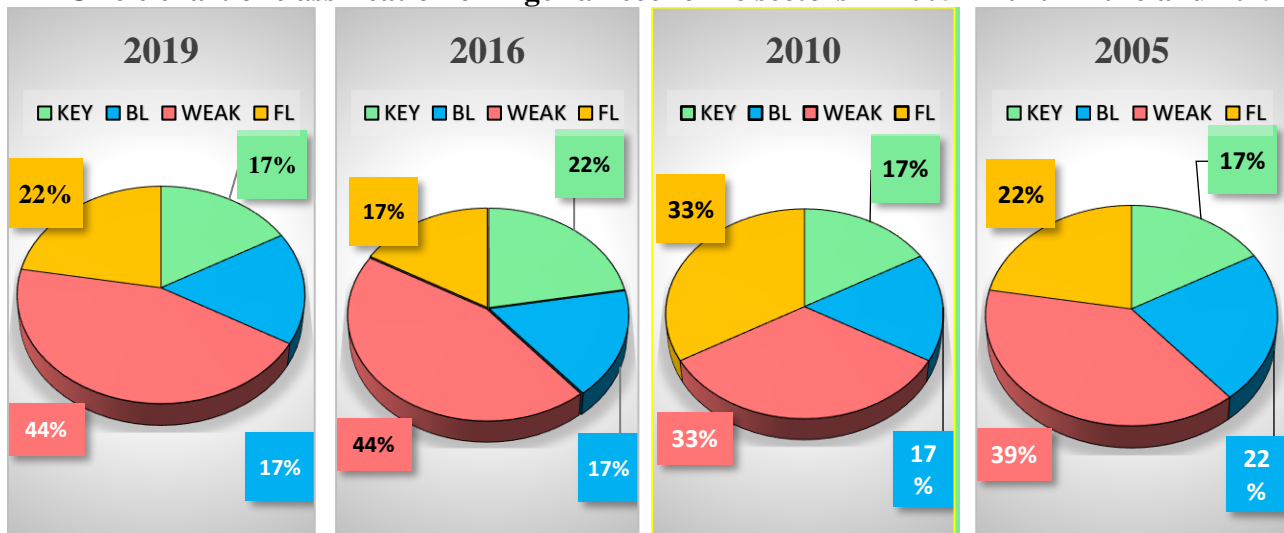
| YE<br>R    | 2005      |           |          | 2010      |           |          | 2016      |           |          | 2019      |           |          |
|------------|-----------|-----------|----------|-----------|-----------|----------|-----------|-----------|----------|-----------|-----------|----------|
| secto<br>r | FL        | BL        | RAN<br>K | FL        | BL        | Rank     | FL        | BL        | Rank     | FL        | BL        | Rank     |
| 1          | 1,35<br>2 | 0,90<br>0 | FL       | 1,21<br>4 | 0,90<br>3 | FL       | 1,23<br>7 | 0,87<br>2 | FL       | 1,29<br>3 | 0,89<br>2 | FL       |
| 2          | 1,16<br>0 | 1,09<br>9 | KEY      | 1,16<br>3 | 1,22<br>8 | KEY      | 1,09<br>8 | 1,22<br>2 | KEY      | 1,12<br>6 | 1,22<br>4 | KEY      |
| 3          | 1,16<br>2 | 0,96<br>2 | FL       | 1,23<br>6 | 0,92<br>4 | FL       | 1,47<br>8 | 1,03<br>9 | KEY      | 1,02<br>6 | 0,99<br>6 | FL       |
| 4          | 0,97<br>5 | 1,34<br>5 | BL       | 1,15<br>1 | 1,62<br>4 | KEY      | 1,24<br>5 | 1,96<br>1 | KEY      | 0,98<br>0 | 1,65<br>5 | BL       |
| 5          | 0,82<br>0 | 0,93<br>8 | Wea<br>k | 0,81<br>1 | 0,94<br>8 | Wea<br>k | 0,78<br>9 | 1,06<br>9 | BL       | 0,84<br>8 | 0,97<br>8 | Wea<br>k |
| 6          | 1,15<br>2 | 0,83<br>5 | FL       | 1,02<br>0 | 0,82<br>7 | FL       | 0,99<br>2 | 0,81<br>0 | Wea<br>k | 0,95<br>8 | 0,83<br>8 | Wea<br>k |
| 7          | 1,00<br>3 | 1,01<br>3 | KEY      | 1,11<br>2 | 0,94<br>0 | FL       | 0,95<br>9 | 0,92<br>7 | Wea<br>k | 0,92<br>4 | 1,01<br>4 | BL       |
| 8          | 0,96<br>2 | 1,16<br>7 | BL       | 0,93<br>6 | 1,16<br>9 | BL       | 0,92<br>6 | 1,19<br>7 | BL       | 0,97<br>1 | 1,25<br>5 | BL       |
| 9          | 1,17<br>7 | 0,88<br>3 | FL       | 1,09<br>9 | 0,85<br>9 | FL       | 1,02<br>7 | 0,83<br>1 | FL       | 0,82<br>3 | 0,87<br>0 | Wea<br>k |
| 10         | 1,21<br>2 | 1,17<br>9 | KEY      | 0,99<br>4 | 1,12<br>6 | BL       | 0,98<br>7 | 1,03<br>8 | BL       | 1,20<br>4 | 1,05<br>5 | KEY      |
| 11         | 0,86<br>2 | 1,03<br>5 | BL       | 1,00<br>9 | 1,00<br>7 | KEY      | 0,91<br>2 | 0,86<br>4 | Wea<br>k | 0,80<br>4 | 0,87<br>9 | Wea<br>k |
| 12         | 0,93<br>4 | 0,98<br>5 | Wea<br>k | 1,10<br>4 | 0,91<br>8 | FL       | 0,98<br>1 | 0,80<br>2 | Wea<br>k | 0,87<br>9 | 0,81<br>8 | Wea<br>k |
| 13         | 0,95<br>8 | 0,91<br>7 | Wea<br>k | 0,99<br>2 | 0,84<br>5 | Wea<br>k | 1,09<br>8 | 0,80<br>6 | FL       | 0,82<br>3 | 0,82<br>6 | Wea<br>k |
| 14         | 0,81<br>3 | 0,85<br>9 | Wea<br>k | 0,80<br>4 | 0,79<br>2 | Wea<br>k | 0,80<br>1 | 0,78<br>9 | Wea<br>k | 1,20<br>4 | 0,94<br>6 | FL       |
| 15         | 0,93<br>4 | 1,16<br>0 | BL       | 0,88<br>7 | 1,22<br>9 | BL       | 1,03<br>5 | 1,18<br>7 | KEY      | 1,27<br>5 | 1,18<br>3 | KEY      |
| 16         | 0,87<br>4 | 0,97<br>1 | Wea<br>k | 0,85<br>5 | 0,94<br>9 | Wea<br>k | 0,80<br>4 | 0,90<br>2 | Wea<br>k | 0,82<br>3 | 0,89<br>5 | Wea<br>k |
| 17         | 0,83<br>7 | 0,83<br>2 | Wea<br>k | 0,82<br>4 | 0,79<br>5 | Wea<br>k | 0,83<br>8 | 0,78<br>7 | Wea<br>k | 0,97<br>5 | 0,79<br>7 | Wea<br>k |
| 18         | 0,81<br>0 | 0,91<br>9 | Wea<br>k | 0,78<br>9 | 0,91<br>7 | Wea<br>k | 0,79<br>2 | 0,89<br>5 | Wea<br>k | 1,06<br>6 | 0,87<br>9 | FL       |

Reference: Prepared by the researcher based on the four input-output tables of the PYIO for the period studied

|              |           |                   |                         |                       |                    |
|--------------|-----------|-------------------|-------------------------|-----------------------|--------------------|
| <b>RANK</b>  | <b>BY</b> | <b>KEY SECTOR</b> | <b>STRATEGIC SECTOR</b> | <b>DRIVING SECTOR</b> | <b>WEAK SECTOR</b> |
| <b>COLOR</b> |           |                   |                         |                       |                    |

Figure 01

Circle chart of classification of Algerian economic sectors in 2005 – 2010 – 2016 and 2019



Reference: Prepared by the researcher based on the four input-output tables for the period studied

### 6.3 Results obtained from the net Backward linkage

Another linkage measure was proposed by Dietzenbacher (2005) in his interpretation of the content of the Oosterhaven and Stelder net multiplier formulation (miller & blair, 2009). Sectors are classified by their values as mentioned in the below table no 04

Table no 04 Classification of sectors according to Net Backward linkages indices for the years of 2005 -2010 -2016 -and 2019 the Algerian economy for 4 IOTs

| year | 2005   | 2005   | 2010   | 2010   | 2016   | 2016   | 2019   | 2019   |
|------|--------|--------|--------|--------|--------|--------|--------|--------|
| RANK | NET BL | sector | NET BL | SECTOR | NET BL | SECTOR | NET BL | SECTOR |
| KEY  | 1,4314 | 8      | 1,5470 | 8      | 1,5526 | 8      | 1,628  | 8      |
| KEY  | 1,3574 | 15     | 1,4026 | 15     | 1,3710 | 15     | 1,388  | 15     |
| KEY  | 1,2124 | 10     | 1,1629 | 10     | 1,1626 | 4      | 1,193  | 10     |
| KEY  | 1,1869 | 11     | 1,1379 | 4      | 1,1520 | 10     | 0,929  | 3      |
| KEY  | 1,0123 | 3      | 1,1237 | 3      | 0,9416 | 3      | 0,882  | 6      |
| NON  | 0,9175 | 14     | 0,9222 | 6      | 0,9094 | 16     | 0,881  | 16     |
| NON  | 0,9166 | 6      | 0,881  | 18     | 0,9049 | 6      | 0,850  | 1      |
| NON  | 0,8346 | 16     | 0,8558 | 14     | 0,8168 | 1      | 0,793  | 2      |
| NON  | 0,7900 | 18     | 0,8500 | 17     | 0,7992 | 18     | 0,774  | 11     |
| NON  | 0,7665 | 12     | 0,7846 | 1      | 0,7973 | 2      | 0,757  | 18     |
| NON  | 0,7639 | 1      | 0,7621 | 16     | 0,7807 | 17     | 0,756  | 17     |



|                |               |    |               |    |               |    |               |    |
|----------------|---------------|----|---------------|----|---------------|----|---------------|----|
| NON            | 0,7003        | 4  | 0,6512        | 9  | 0,7422        | 11 | 0,682         | 9  |
| NON            | 0,6428        | 17 | 0,6088        | 2  | 0,7087        | 9  | 0,597         | 4  |
| NON            | 0,5991        | 13 | 0,6007        | 11 | 0,4434        | 14 | 0,538         | 14 |
| NON            | 0,5977        | 2  | 0,4474        | 5  | -0,0358       | 13 | 0,353         | 5  |
| NON            | 0,5387        | 9  | 0,1174        | 13 | -0,0608       | 5  | -0,156        | 13 |
| NON            | 0,5234        | 5  | -0,9419       | 7  | -0,4325       | 12 | -0,620        | 12 |
| NON            | -0,3435       | 7  | -1,1838       | 12 | -1,2845       | 7  | -2,605        | 7  |
| <b>Average</b> | <b>0,8027</b> |    | <b>0,6516</b> |    | <b>0,6260</b> |    | <b>0,5345</b> |    |

Reference: Prepared by the researcher based on the four input-output tables for the period studied

The table no 4 shows the results of the application of net backward linkage or net key sector measure, we can classify sectors into **key** or **non-key**, but the salient observation in terms of net backward linkage values is that some values for some years of four sectors were negative, therefore the researcher proposed three categories, which are:

The first category those sectors with indices greater than one (>1), given that the measure has been normalized;

The second category has indices ranging between zero and less than one;

The third category those with negative indices (less than zero).

The first category: reflects the key sectors given that the net backward linkage indicator is greater than one, and it contains a range between (3 – 4 and 5) key sectors that are divided into subcategories as follows:

1. key sectors during the four years of study (2005 - 2010 - 2016 and 2019), which are three sectors (8) building and public works and hydraulics sector (BTPH), (10) Agro-food industries sector and (15) Transport and communications sector.
2. key sectors during the two years of study, which are: (4) Services and works public and Oil tankers sector for the years (2010 and 2016), and (3) Hydrocarbons sector, for the years (2005 and 2010).
3. key sectors for one year, namely (11) Textiles, clothing, hosiery sector for the year 2005 only.

The second category of sectors less than one is, of course, not key sectors, and unfortunately, with the exception of the three sectors (14- 6 and 16), all of them were less than the average index (0.8027) for the year 2005. In year 2016 we had ten sectors except sector (14) all were above the average (0,626).

The third category where sectors had negative values of their net backward linkages. This is due to the final demand for these sectors, which was negative (one of its components was negative for many sectors, which was the stocks variation), therefore will affect the total output of the sector. Note that compared to the other backward linkages, the net backward linkage of industry i can be negative in the rare case when the final demand of industry i is negative (*Temurshoev, U.; Oosterhaven, J. 2013. p9*). However, also in that case this interpretation is still valid. According to the formula the net backward linkage, Eq .(14-1); we find that the numerator is the column sum for sector  $j^{th}$  which has its final demand negative, so the column sum for this sector will be negative, and the indicator will inevitably be negative. We had each year a few sectors such as one sector in 2005, (7) Building Materials consistently appeared in the other years.

As a result, since the sectors (8-15-10-11-3 and 4) - building and public works and hydraulics (BTPH), Transport and Communications, Agro-food industries, Textiles, clothing, hosiery; Hydrocarbons and Services and works public Oil tankers,) had indices greater than one, the economy-wide output generated by final demand in one of these sectors is greater than the amount of j's output that is generated by all the other industries' final demands. Therefore we can assume that these sectors (building and public works

and hydraulics (BTPH), Transport and Communications, Agro-food industries, Textiles, clothing, hosiery; Hydrocarbons and Services and works public Oil tankers) are more important for the others than the others are for these sectors, therefore these sectors would thus be identified as a key sectors by this index in the Algerian economy for the years, 2005 -2010 – 2016 and specially in year 2019.

**6-3** Results obtained from the Strassert (1968) hypothetical extraction method Results obtained from the Strassert (1968) hypothetical extraction method.

**Table no: 05 Classification of the Strassert (1968) Hypothetical Extraction Results, ALG 2005-2010-2016-2019, Data. If Sector 01 is extracted Total Linkage**

| YE<br>AR       | 2005                             |  | Year 2010                        |  | 2016                             |  | 2019                             |  |
|----------------|----------------------------------|--|----------------------------------|--|----------------------------------|--|----------------------------------|--|
| SE<br>CT<br>OR | ABSOL<br>UTE<br>linkage<br>$T_j$ | NORMA<br>LIZED<br>linkage<br>$\bar{T}_j$ | ABSOL<br>UTE<br>linkage<br>$T_j$ | NORMA<br>LIZED<br>linkage<br>$\bar{T}_j$ | ABSOL<br>UTE<br>linkage<br>$T_j$ | NORMA<br>LIZED<br>linkage<br>$\bar{T}_j$ | ABSOL<br>UTE<br>linkage<br>$T_j$ | NORMA<br>LIZED<br>linkage<br>$\bar{T}_j$ |
| 2              | 4506,75<br>9                     | 0,42%                                    | 7783,174<br>238                  | 0,45%                                    | 14501,6<br>7                     | 0,41%                                    | 84532,2<br>7                     | 2,06%                                    |
| 3              | 2784,19<br>9                     | 0,26%                                    | 7309,466<br>248                  | 0,42%                                    | 13048,6<br>4                     | 0,37%                                    | 1349280                          | 32,91%                                   |
| 4              | 47,840                           | 0,00%                                    | 134,9554<br>611                  | 0,01%                                    | 458,18                           | 0,01%                                    | -<br>20031,7<br>4                | -0,49%                                   |
| 5              | 218,149                          | 0,02%                                    | 397,8935<br>302                  | 0,02%                                    | 1155,07                          | 0,03%                                    | -<br>13058,3<br>2                | -0,32%                                   |
| <b>6</b>       | 13711,8<br>54                    | 1,27%                                    | 33373,51<br>4                    | 1,93%                                    | 78049,6<br>1                     | 2,19%                                    | 668783,<br>3                     | 16,31%                                   |
| 7              | 773,402                          | 0,07%                                    | 1898,558<br>82                   | 0,11%                                    | 1355,05                          | 0,04%                                    | 1088096                          | 26,54%                                   |
| 8              | 637,520                          | 0,06%                                    | 1157,354<br>035                  | 0,07%                                    | 4188,58                          | 0,12%                                    | -<br>218825,<br>7                | -5,34%                                   |
| <b>9</b>       | 27299,8<br>35                    | 2,53%                                    | 29161,46<br>677                  | 1,69%                                    | 100785,<br>49                    | 2,83%                                    | 503742,<br>7                     | 12,29%                                   |
| <b>10</b>      | 30595,0<br>31                    | 2,83%                                    | 57588,04<br>286                  | 3,33%                                    | 113713,<br>64                    | 3,20%                                    | -<br>56247,1<br>8                | -1,37%                                   |
| 11             | 807,958                          | 0,08%                                    | 1708,688<br>88                   | 0,10%                                    | 7513,53                          | 0,21%                                    | 69553,0<br>9                     | 1,70%                                    |
| 12             | 270,922                          | 0,03%                                    | 1488,768<br>941                  | 0,09%                                    | 3445,98                          | 0,10%                                    | -<br>153109,<br>6                | -3,74%                                   |

|                                       |            |        |                   |         |           |         |           |         |
|---------------------------------------|------------|--------|-------------------|---------|-----------|---------|-----------|---------|
| 13                                    | 4066,288   | 0,38%  | 11840,27612       | 0,68%   | 25638,68  | 0,72%   | 318475    | 7,77%   |
| 14                                    | 741,982    | 0,07%  | 19041,45479       | 1,10%   | 3077,45   | 0,09%   | -1183044  | -28,86% |
| 15                                    | 4526,727   | 0,42%  | 12572,37389       | 0,73%   | 25538,83  | 0,72%   | -147971,5 | -3,61%  |
| 16                                    | 864,874    | 0,08%  | 2205,316647       | 0,13%   | 3477,60   | 0,10%   | -72551,26 | -1,77%  |
| 17                                    | 7000,385   | 0,65%  | 13460,53171       | 0,78%   | 38464,32  | 1,08%   | -405826,6 | -9,90%  |
| 18                                    | 2683,231   | 0,25%  | 7366,281142       | 0,43%   | 13859,17  | 0,39%   | -1201979  | -29,32% |
| <b>TL</b>                             | 101536,956 |        | <b>208488,181</b> |         | 1426036,7 |         | 609817,2  |         |
| $\bar{T}$ %                           |            | 9,39%  |                   | 12,051% |           | 12,601% |           | 14,876% |
| <b>Average <math>\bar{T}</math> %</b> |            | 0,553% |                   | 0,709%  |           | 0,741   |           | 0,875   |

Reference: Prepared by the researcher based on the four input-output tables for the period studied.

\*\*Light green cells mean that the value of the indicator is greater than the average (Average  $\bar{T}$  %).

Thus the measurement of TL expresses what Hirschman calls linkage 'importance' but does not include any element which takes into account the degree of linkage effectiveness 'probability' in Hirschman terminology, (Cella. 1984. P. 82). The drawback of this method is the absence of any distinct evaluation of BL and FL, (op. cit. p78).

This is because the resulting estimates obtained from this hypothetical extraction method also include the reduction in gross output which result from reduction in economic activity associated with the indirect effects, in terms of both indirect intermediate purchases and sales of the extracted sector. Leontief Inverse tracks all of these ripple of direct and indirect effects on economic activity.

In order to make the absolute linkages resulting from the complete hypothetical extraction method easier to read in terms of applying it to the Algerian input-output tables to determine the importance of the extracted Agriculture, forestry and fishing sector, the researcher tried to normalize and take the ratio to the output of the extracted sector (01), we will only consider normalized HE linkages that are expressed per unit of output, as shown in the table 05, and the results were the following:

From the complete hypothetical extraction method, according to Asstrassert (1968) method. The columns with title absolute linkage ( $T_j$ ) are considered as a measure of the effect of sector coded (01) if is extracted on each sector, at the bottom of the table the line (yellow) with abbreviation  $T_j$  is considered as a measure of the total effect of sector (01) on the rest of the economy (TL).

The researcher suggests to normalize ( $\bar{T}$ ) the resulting absolute linkage result (AL) by dividing up by the

absolute figures by the value of sector 01’s output to remove size effects, these results appeared in the light green columns for the four years of the study period. the result was three important sectors appeared according to the table no 5, which are (6) steel, mechanical, electrical and electronic industries (ISMME) sector with normalized linkage between 1,269% and 16,314%, following by two sectors chemistry, plastics, rubber sector and agro-food industries sector with normalized linkage were very closed in 2005, 2016 and 2019 (1,68 to 12,288 and 2,83% to -1,372% respectively), which means that the agriculture, forestry and fishing sector is so important to this three sectors steel, mechanical, electrical and electronic industries sector (ISMME), chemistry, plastics, rubber sector and agro-food industries sector. The total normalized linkages was respectively 9,394% ,12,051% , 12,601% and 14,876%.

**6.4 Results obtained from the incomplete hypothetical extraction method, according to Dietzenbacher and van der Linden (1997) method**

**Table no 06 Absolute and Total Backward and Forward Linkage Results If sector 01 is extracted from the system and Classifying of sectors according to Dietzenbacher and van der Linden (1997) method**

|         | 2005            | 2005            | 2010            | 2010            | 2016            | 2016            | 2019            | 2019            |
|---------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Sector# | ABL1            | AFL1            | ABL1            | AFL1            | ABL1            | AFL1            | ABL1            | AFL1            |
| 1       | 333086,9<br>943 | 30614,13<br>373 | 517333,4<br>582 | 70140,87<br>601 | 1002214,<br>085 | 125129,8<br>937 | 1148355,<br>854 | 232426,9<br>886 |
| 2       | 4506,758<br>743 | 345,5378<br>722 | 7777,220<br>185 | 725,9732<br>574 | 13368,50<br>708 | 1463,012<br>194 | 19839,81<br>978 | 5335,754<br>756 |
| 3       | 2784,199<br>042 | 4784,830<br>434 | 7300,270<br>252 | 2760,274<br>003 | 12957,84<br>596 | 9480,424<br>925 | 14690,80<br>929 | 50309,22<br>762 |
| 4       | 47,83999<br>116 | 6272,916<br>748 | 134,7856<br>744 | 2535,927<br>47  | 454,9904<br>919 | 23486,89<br>61  | 110847,3<br>803 | 29477,31<br>715 |
| 5       | 218,1486<br>104 | 217,0486<br>541 | 394,5641<br>115 | 387,1574<br>165 | 1153,544<br>367 | 1843,281<br>757 | 139165,0<br>177 | 2997,084<br>707 |
| 6       | 13711,85<br>413 | 1397,445<br>1   | 33179,72<br>811 | 3336,159<br>215 | 78016,24<br>644 | 13033,93<br>4   | 10524,80<br>92  | 24134,89<br>36  |
| 7       | 773,4016<br>343 | 287,3739<br>566 | 1870,495<br>363 | 246,8559<br>604 | 1337,274<br>705 | 747,0018<br>701 | 7471,815<br>17  | 2587,901<br>064 |
| 8       | 637,5196<br>409 | 2350,284<br>592 | 1025,923<br>219 | 4234,631<br>995 | 4113,766<br>887 | 13266,35<br>511 | 42433,67<br>308 | 39494,71<br>796 |
| 9       | 27299,83<br>547 | 2737,106<br>086 | 29152,92<br>13  | 4425,391<br>512 | 100735,6<br>291 | 13979,86<br>943 | 5334,107<br>645 | 11319,80<br>534 |
| 10      | 30595,03<br>122 | 168419,0<br>311 | 57586,22<br>147 | 286817,8<br>66  | 113706,5<br>162 | 524602,9<br>093 | 45626,59<br>712 | 593674,8<br>591 |
| 11      | 807,9583<br>785 | 462,8293<br>349 | 1705,400<br>056 | 44,15156<br>023 | 7496,759<br>663 | 49,73654<br>48  | 4387,491<br>11  | 372,9431<br>557 |
| 12      | 270,9224<br>567 | 224,5196<br>525 | 1486,973<br>503 | 30,60885<br>348 | 3347,567<br>956 | 50,56597<br>778 | 47401,73<br>341 | 34,41535<br>051 |

|                |                 |                 |                 |                 |                 |                 |                 |                 |
|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 13             | 4066,287<br>773 | 3417,372<br>604 | 11833,74<br>993 | 1817,880<br>329 | 25610,18<br>535 | 4371,038<br>595 | 18136,71<br>072 | 6789,814<br>98  |
| 14             | 741,9820<br>979 | 213,3406<br>707 | 19039,25<br>175 | 93,64229<br>302 | 3068,621<br>458 | 130,3978<br>729 | 30660,01<br>348 | 5589,710<br>058 |
| 15             | 4526,727<br>194 | 31827,02<br>264 | 12571,20<br>176 | 57010,90<br>417 | 25501,21<br>735 | 131538,9<br>877 | 50169,60<br>611 | 144838,3<br>704 |
| 16             | 864,8738<br>52  | 5688,472<br>886 | 2205,772<br>318 | 8663,017<br>418 | 3451,277<br>925 | 17121,73<br>613 | 2701,790<br>992 | 22288,17<br>46  |
| 17             | 7000,384<br>615 | 613,0204<br>697 | 13461,00<br>574 | 851,2042<br>857 | 38460,57<br>971 | 3140,561<br>727 | 87948,64<br>156 | 4690,613<br>364 |
| 18             | 2683,231<br>181 | 132,0990<br>206 | 7366,167<br>664 | 126,4087<br>199 | 13858,98<br>431 | 519,7658<br>418 | 15931,42<br>711 | 873,9072<br>018 |
| ∑BL(ex<br>tr1) | 101536,9<br>56  | 229390,2<br>518 | 208091,6<br>524 | 374108,0<br>544 | 446639,5<br>149 | 758826,4<br>751 | 653271,4<br>438 | 944809,5<br>104 |
| total<br>BL 1  | 434623,9<br>503 | 260004,3<br>856 | 725425,1<br>106 | 444248,9<br>304 | 1448853,<br>6   | 883956,3<br>688 | 1801627,<br>298 | 1177236,<br>499 |

Reference: Prepared by the researcher based on the four input-output tables and the outputs of PYIO From the incomplete hypothetical extraction method, according to Dietzenbacher and van der Linden (1997) method suggests the normalization of the absolute Backward and Forward linkages, only consider normalized HE linkages that are expressed per unit of output, and taking the averages for each year, we can make a simple classification of productive sectors in the Algerian economy, which have values greater than the **average** for the four years, the result was seven important sectors appeared according to the table below no 07, sector (Agriculture, forestry, fishing and Agro-food industries) were key sectors. Sectors (steel, mechanical, electrical and electronic industries sector (ISMME), Chemistry, Plastics, Rubber and Textiles, clothing, hosiery) were driver sectors except sector Textiles, clothing, hosiery in year 2005. Sector (building and public works and hydraulics (BTPH) and Transport and communications) were strategic sectors except sector building and public works and hydraulics (BTPH) in year 2005. And the rest of the sectors are weak, their indices backward and forward linkages measures are less than Average.

**Table no 07 Normalized and Average Backward and Forward Linkage Results If sector 01 is extracted and Classifying of sectors according to Dietzenbacher and van der Linden (1997) method**

| year    | 2005   |       | 2010   |       | 2016   |       | 2019   |       | RANK |
|---------|--------|-------|--------|-------|--------|-------|--------|-------|------|
| Sector# | BL %   | FL %  | BL %   | FL %  | BL %   | FL %  | BL %   | FL    |      |
| 1       | 30,82% | 2,83% | 29,90% | 4,05% | 28,17% | 3,52% | 28,01% | 5,67% | KEY  |
| 2       | 0,42%  | 0,03% | 0,45%  | 0,04% | 0,38%  | 0,04% | 0,48%  | 0,13% | NON  |
| 3       | 0,26%  | 0,44% | 0,42%  | 0,16% | 0,36%  | 0,27% | 0,36%  | 1,23% | NON  |
| 4       | 0,00%  | 0,58% | 0,01%  | 0,15% | 0,01%  | 0,66% | 2,70%  | 0,72% | BL   |
| 5       | 0,02%  | 0,02% | 0,02%  | 0,02% | 0,03%  | 0,05% | 3,40%  | 0,07% | BL   |
| 6       | 1,27%  | 0,13% | 1,92%  | 0,19% | 2,19%  | 0,37% | 0,26%  | 0,59% | BL   |
| 7       | 0,07%  | 0,03% | 0,11%  | 0,01% | 0,04%  | 0,02% | 0,18%  | 0,06% | NON  |
| 8       | 0,06%  | 0,22% | 0,06%  | 0,25% | 0,12%  | 0,37% | 1,04%  | 0,96% | BL   |

|                     |               |              |              |              |              |              |              |              |     |
|---------------------|---------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|-----|
| 9                   | 2,53%         | 0,25%        | 1,69%        | 0,26%        | 2,83%        | 0,39%        | 0,13%        | 0,28%        | BL  |
| 10                  | 2,83%         | 15,58%       | 3,33%        | 16,58%       | 3,20%        | 14,75%       | 1,11%        | 14,48%       | KEY |
| 11                  | 0,07%         | 0,04%        | 0,10%        | 0,00%        | 0,21%        | 0,00%        | 0,11%        | 0,01%        | NON |
| 12                  | 0,03%         | 0,02%        | 0,09%        | 0,00%        | 0,09%        | 0,00%        | 1,16%        | 0,00%        | BL  |
| 13                  | 0,38%         | 0,32%        | 0,68%        | 0,11%        | 0,72%        | 0,12%        | 0,44%        | 0,17%        | NON |
| 14                  | 0,07%         | 0,02%        | 1,10%        | 0,01%        | 0,09%        | 0,00%        | 0,75%        | 0,14%        | BL  |
| 15                  | 0,42%         | 2,94%        | 0,73%        | 3,30%        | 0,72%        | 3,70%        | 1,22%        | 3,53%        | key |
| 16                  | 0,08%         | 0,53%        | 0,13%        | 0,50%        | 0,10%        | 0,48%        | 0,07%        | 0,54%        | NON |
| 17                  | 0,65%         | 0,06%        | 0,78%        | 0,05%        | 1,08%        | 0,09%        | 2,15%        | 0,11%        | BL  |
| 18                  | 0,25%         | 0,01%        | 0,43%        | 0,01%        | 0,39%        | 0,02%        | 0,39%        | 0,02%        | NON |
| $\sum BL(e_{xtr1})$ | 9,39%         | 21,22%       | 12,03%       | 21,62%       | 12,56%       | 21,33%       | 15,94%       | 23,05%       |     |
| total BL 1          | <b>40,23%</b> | 24,05%       | 41,93%       | 25,68%       | 40,73%       | 24,85%       | 43,95%       | 28,72%       |     |
| AVER A(extr1)       | <b>0,55%</b>  | <b>1,25%</b> | <b>0,71%</b> | <b>1,27%</b> | <b>0,74%</b> | <b>1,25%</b> | <b>0,94%</b> | <b>1,36%</b> |     |

Reference: Prepared by the researcher based on the four input-output tables

\*\*Light green cells mean that the value of the indicator is greater than the average(AVERA(extr1)).

## 6-5 Sectoral Linkages according to Dietzenbacher and van der Linden (1997) method

### 6-5-1 Backward Linkages

#### 6-5-1-1 Effects of the extraction of Agriculture, forestry and fishing sector

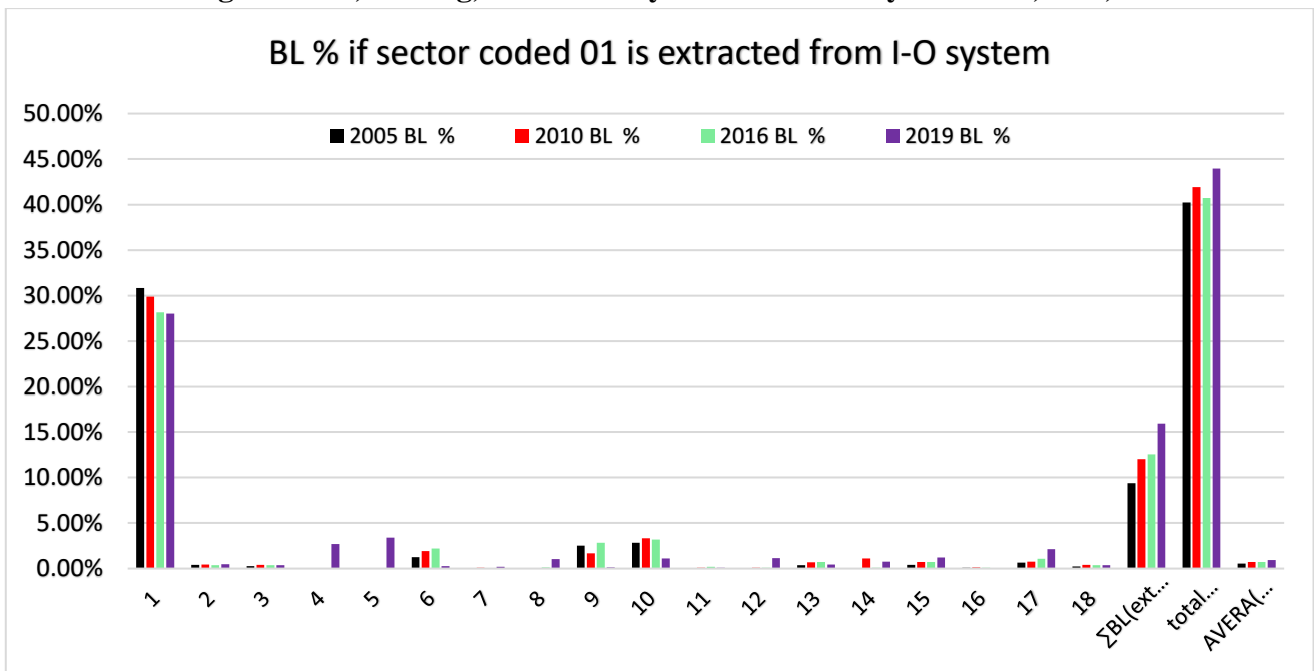
we have applied incomplete HEM to the Algerian economy of the derived Input–Output tables (IOT), which involves 18 sectors (NSO, 2022 ). Of the time series (2005 to 2019) of the Algerian input–output tables, we have used four tables for the years 2005, 2010, 2016 and 2019, which is the latest year available. We have focused on the sector ‘Agriculture, Fishing, and Forestry’. We studied the cases in which the Agriculture, Fishing, and Forestry sector in specific years were – each separately – extracted.

Extraction of the Agriculture, Fishing, and Forestry sector by HEM decreases Algerian **GDP** by 1083,561.962 billion DZD (which is 15,64% of **GDP**). This decrease in Algerian **GDP** can be divided into two parts. For Example in the year 2005, one is a decrease of 333,086.9943 billion DZD in the output in the extracted sector itself (i.e. the Agriculture, Fishing, and Forestry sector), which we call the internal effect. The other part is a decrease of 101,536.956 billion DZD in the output in the other sectors in Algerian economy, which we call the external effect. the absolute values for all sectors are given in Table 06 above. Figure 02 shows the changes in the output of all sectors, the normalized values for all sectors are given in Table 07. The internal effect measures the change in the output in the Agriculture, Fishing, and Forestry sector with a normalized value of (30,82% - 29,90% - 28,17% and 28,01%) in years 2005-2010-2016 and 2019 respectively. the external effect the total change in the output of the other industries, with a normalized value of (9,39% -12,03% - 12,56% and 15,94%). in years 2005-2010-2016 and 2019 respectively. These sectors were (10) Agro-food industries sector as a key sector in all years, followed by (15) Transport and communications in two years (2010 and 2019), and as strategic sector in two years (2005 and 2016). (17) Services provided to businesses sector appeared as a driving sector in all years,

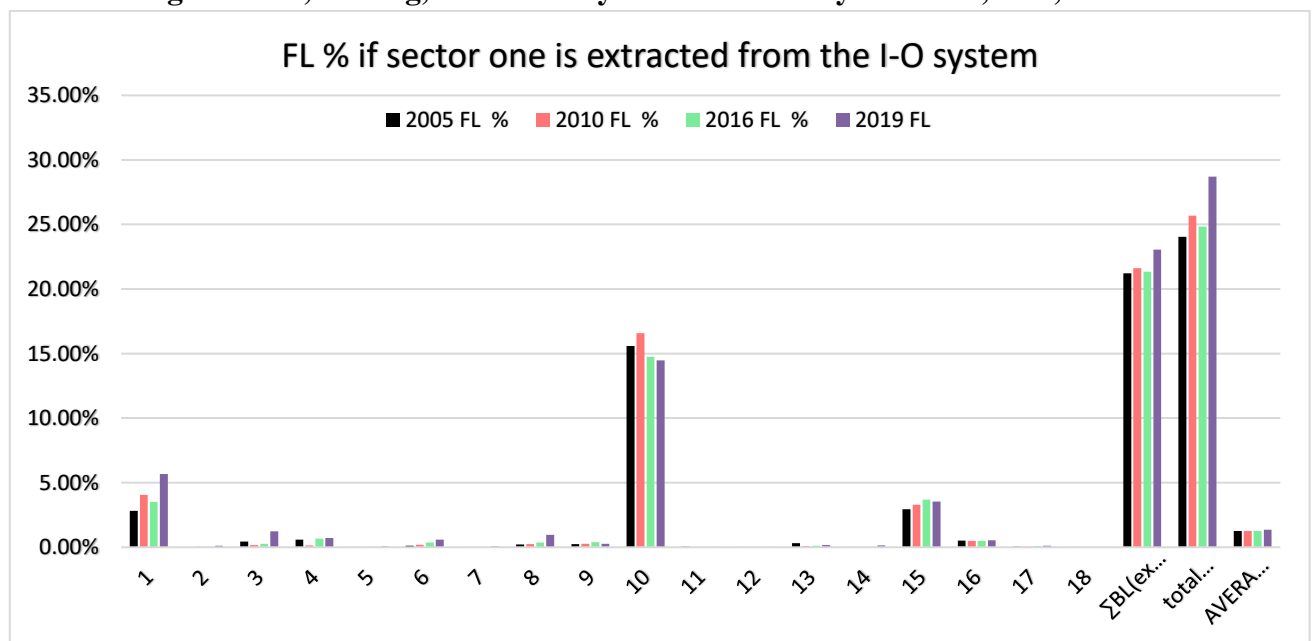


followed by two sectors (6 and 9) steel, mechanical, electrical and electronic industries sector (ISMME), Chemistry, Plastics, Rubber respectively were greatly affected by the extraction of Agriculture, Fishing, and Forestry sector, in the sense that their output is substantially decreased over the four years. In contrast, and perhaps surprisingly, the rest of sectors are barely affected. their output is decreased by below 3,5%. This can be attributed to the fact that these sectors have weakest backward linkages with the Agriculture, Fishing, and Forestry sector.

**Figure 02. Change in output and internal and external percent backward effects in Algerian sectors when Agriculture, Fishing, and Forestry is extracted for years 2005,2010,2016 and 2019**



**Figure 03. Change in output and internal and external percent forward effects in Algerian sectors when Agriculture, Fishing, and Forestry is extracted for years 2005,2010,2016 and 2019**



The above Table no 06 represents the absolute and total backward and forward linkages of the first sector Agriculture, forestry and fishing if it is extracted from the Algerian economic system.

We see from the columns (2<sup>th</sup>, 4<sup>th</sup>, 6<sup>th</sup> and 8<sup>th</sup>) which are labeled with the abbreviation ABL1 (absolute backward linkage of sector 01 if is extracted) that, if the agriculture, forestry and fishing sector is hypothetically extracted from the system of input-output, the total output of the Algerian economy will fall by value (total absolute backward linkage) of (434,623.9503 - 725,425.1106 - 1,448,853.6 and 1,801,627.298) million DZD in years 2005, 2010, 2016 and 2019, respectively and by percent (with relative total linkages) 40,23% 41,93% - 40,73% and 43,95% of this sector's actual output (mentioned in table no 8). Also at the sectoral level, the production structures exhibit many variability between the sectors, we notice three levels of backward linkages when we extract the first sector Agriculture, Fishing, and Forestry).

the backward linkages of agro-food industries sector, steel, mechanical, electrical and electronic industries sector ISMMEE and Chemistry, Plastics, Rubber sector with respect to Agriculture, Fishing, and Forestry. According to Table no 07 they amount to 2,83% and 2,53% and 1,27% respectively in year 2005 and these results stay almost stable for the rest of years, 3,33%, 1,69% and 1,92% in (2010), 3,20%, 2,83% and 2,19% in (2016), but in (2019) sector (10) stay with 1,11%, and three new sectors emerged as driving sectors Services and works public Oil tankers sector, Mines and quarries sector and Services provided to businesses with normalized values 2,7%, 3,4% and 2,15% respectively. This figure gives the decrease (loss) of the Agriculture, Fishing, and Forestry output, due to the fact that agro-food industries, steel, mechanical, electrical and electronic industries sector ISMMEE and Chemistry, Plastics, Rubber in addition to the new sectors Services and works public Oil tankers sector, Mines and quarries sector and Services provided to businesses use no inputs from the Agriculture, fishing and forestry. This dependence on inputs reflects the "buyer's dependence," which is directed backwards. In addition, the decrease of the Agriculture, Fishing, and Forestry output is measured as a percentage of the agro-food industries, steel, mechanical, electrical and electronic industries sector ISMMEE and Chemistry, Plastics, Rubber, Services and works public Oil tankers sector, Mines and quarries sector and Services provided to businesses output. This reflects that the buyer's dependence is considered from the buyer's point of view.

**The first level** is the largest backward linkages for the sector itself when it is extracted, (the backward dependence of sector Agriculture, fishing, and forestry upon itself) with 30,82% ; 29,90% ; 28,17% and 28,01% in years 2005, 2010, 2016 and 2019 respectively, and we record one sector, which is the extracted sector itself. Therefore, 9,39% ;12,03% ; 12,56% and 15,94% % respectively, of the total backward linkages is intersectoral and 29,23 percent as Average is upon itself (sector extracted).

**The second level** : weak backward linkages, which was above the average in each year; It includes one sector as a key sector (10) agro-food industries sector, (15) Transport and communications as a key sector in two years (2010 and 2019), and as strategic sector in two years (2005 and 2016), (17) Services provided to businesses sector appeared as a driving sector in all years, followed by two sectors (6 and 9) steel, mechanical, electrical and electronic industries sector (ISMMEE), Chemistry, Plastics, Rubber,

**The third level** of backward linkage the more weakest which are below the average for each year: It includes most of the Algerian productive sectors (between 10 and 13 sectors), which is less than 1 percent. Note that, in contrast, the Agriculture, Fishing and Forestry sector has very strong linkages. It turns out that this sector depends to a large extent on itself.

The results in Table 07 indicate that 29, 23 % of the backward linkages results from only one sector, which is the sector extracted, the key contributor. This means that the Agricultural sector depends strongly on

itself, and may be on the three sectors ( steel, mechanical, electrical and electronic industries sector ISMMEE, Chemistry, Plastics, Rubber sector and Agro-food industries sector) about 7,28 %, 7,72%, 9,3% in 2005, 2010 and 2016; in year 2019 two new sectors appeared (4) and (5) about 10,58% . Moreover, in most cases these weakest sectoral dependencies show a rather similar pattern across sectors and cross years.

### 6.5.2 Forward Linkages

#### 6.5.2.1 Agriculture, forestry and fishing

The forward linkages in Tables 06 and 07 show that, on relative, the big variability in values of absolute and relative forward linkages a range from 0,01 % to 15,58%; for example in year 2005 the production of a Agriculture, forestry and fishing sector falls with 2,83% due to the fact that the output of this sector is no longer used for further production purposes in the Algerian economy, and the production of agro-food industries sector falls with 15,58 percent, and the production of Transport and communications sector falls with 2,94 %.

If we move to year 2019, we observe the following notes:

The forward linkages in Table no 8 shows that, on relative, the variability on relative forward linkages a range from 0,00% to 14,48%;

According to the average of this year 1,36%, there were three sectors only above that average. For example the production of a Agriculture, forestry and fishing sector falls with 5,67 percent due to the fact that the output of this sector is no longer used for further production purposes in the economy; The production of agro-food industries sector falls with 14,48 %, and the production of transport and communications sector falls with 3;53%; by the way these sectors were key sectors for all the four years. The rest of sectors are below 1,36% .

### 6.6 Backward and Forward indices Linkages

In order to make the backward and forward linkage indicators derived from the non–complete hypothetical extraction method easier to read in terms of their application for the identification and analysis of key sectors both linkage indicators shall be normalized with an average of 1 as follows: (*Ian P. Cassarl. WP/01/2017. p19*).

$$BL_{index,j} = \frac{nBLex_j}{\sum_{j=1}^n BLex_j} \quad j = 1, \dots, n \quad (23-1)$$

$$FL_{index,i} = \frac{nFLex_i}{\sum_{i=1}^n FLex_i} \quad i = 1, \dots, n \quad (24-1)$$

**Table no: 08 Backward and Forward indices Linkages Results If Agriculture, forestry and fishing is extracted and Classifying of sectors according to Dietzenbacher and van der Linden (1997) method**

| SECTOR | BL index 2005 | FL INDEX 2005 | BL INDEX 2010 | FL INDEX 2010 | BL index 2016 | FL index 2016 | BL INDEX 2019 | FL INDEX 2019 |
|--------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 1 KEY  | 13,79         | 2,119         | 12,84         | 2,842         | 11,54         | 2,548         | 12,38         | 3,554         |
| 2 WEAK | 0,19          | 0,024         | 0,19          | 0,029         | 0,15          | 0,030         | 0,21          | 0,081         |
| 3 WEAK | 0,12          | 0,332         | 0,18          | 0,112         | 0,15          | 0,193         | 0,16          | 0,769         |
| 4 WEAK | 0,00          | 0,434         | 0,00          | 0,103         | 0,01          | 0,478         | 1,20          | 0,451         |

|    |           |      |        |      |        |      |        |      |       |
|----|-----------|------|--------|------|--------|------|--------|------|-------|
| 5  | WEAK      | 0,01 | 0,015  | 0,01 | 0,015  | 0,01 | 0,038  | 1,50 | 0,046 |
| 6  | WEAK      | 0,57 | 0,097  | 0,82 | 0,135  | 0,90 | 0,265  | 0,11 | 0,369 |
| 7  | WEAK      | 0,03 | 0,020  | 0,05 | 0,010  | 0,02 | 0,015  | 0,08 | 0,039 |
| 8  | WEAK      | 0,03 | 0,162  | 0,03 | 0,172  | 0,05 | 0,270  | 0,46 | 0,604 |
| 9  | driving   | 1,13 | 0,189  | 0,72 | 0,179  | 1,16 | 0,285  | 0,06 | 0,173 |
| 10 | KEY       | 1,27 | 11,660 | 1,43 | 11,621 | 1,31 | 10,682 | 0,49 | 9,077 |
| 11 | WEAK      | 0,03 | 0,032  | 0,04 | 0,002  | 0,09 | 0,001  | 0,05 | 0,006 |
| 12 | WEAK      | 0,01 | 0,016  | 0,04 | 0,001  | 0,04 | 0,001  | 0,51 | 0,001 |
| 13 | WEAK      | 0,17 | 0,236  | 0,29 | 0,074  | 0,29 | 0,089  | 0,20 | 0,104 |
| 14 | WEAK      | 0,03 | 0,015  | 0,47 | 0,004  | 0,04 | 0,003  | 0,33 | 0,085 |
| 15 | strategic | 0,19 | 2,203  | 0,31 | 2,310  | 0,29 | 2,679  | 0,54 | 2,215 |
| 16 | WEAK      | 0,04 | 0,394  | 0,05 | 0,351  | 0,04 | 0,348  | 0,03 | 0,341 |
| 17 | WEAK      | 0,29 | 0,043  | 0,33 | 0,034  | 0,44 | 0,064  | 0,95 | 0,071 |
| 18 | WEAK      | 0,11 | 0,009  | 0,18 | 0,005  | 0,16 | 0,011  | 0,17 | 0,013 |

Reference: Prepared by the researcher based on the four input-output tables .

### 6.6.1 Sectoral Linkages according to Dietzenbacher and van der Linden (1997) method and classification of sector

The Backward and forward linkage indices based on the Dietzenbacher and van der Linden (1997) hypothetical incomplete extraction method specification were generated in terms of the effect expressed in percentage of total gross output, resulting from the hypothetical partial extraction of Agriculture, forestry and fishing sector for each of the four IOTs. These indices were derived by applying respectively equations (23-1) and (24-1). Table no 08 provides these indices of both types of linkage and classify Algerian economic sectors, specially Agriculture, forestry and fishing of interest and with data for a specific period of time, which is (2005 – 2010 – 2016 and 2019), a table of this type for each period will give a good classification of sectors for the economic and planning development of the Algerian economy and a good measure of the importance of the sector which will be extracted and this method offers a comprehensive examination of the Algerian economy's actual structure and the interrelationships among its sectors. It highlights the weaknesses, strengths, threats, and potential opportunities that experts and decision-makers in the country can leverage to steer development in the right direction and make necessary adjustments based on the findings from these scientific methods. .

We notice two key sectors: (1) Agriculture, forestry and fishing sector and (10) Agro-food industries sector except in year 2019 was strategic sector; one strategic sector, which was sector (15) Transport and communications sector, and one driving sector, which is Chemistry, Plastics, Rubber sector, in two years

(2005 and 2016 and A weak sector in 2010 and 2019; the rest of the sectors, which are 14 sector, were weak. Noting that the Algerian economy, according to these input-output tables, contains 18 sector, these results reflect the weak linkages between sectors and the lack of diversity in the Algerian economy.

**Table N°: 09 Classification of national sectors by each method During the period 2005 2010 2016 and 2019**

| YEAR                                     | 2005                     |                  |                       |            | 2010                     |                             |               |         | 2016               |                  |              |               | 2019                              |                    |             |      |   |        |
|--|--------------------------|------------------|-----------------------|------------|--------------------------|-----------------------------|---------------|---------|--------------------|------------------|--------------|---------------|-----------------------------------|--------------------|-------------|------|---|--------|
| CLASSIFICATION OF SECTORS BY EACH METHOD |                          |                  |                       |            |                          |                             |               |         |                    |                  |              |               |                                   |                    |             |      |   |        |
| METHOD                                   | K                        | S                | D                     | W REST     | K                        | S                           | R             | D       | W REST             | K                | S            | R             | D                                 | W REST             | K           | S    | D | W REST |
| Rasmussen<br>Hirschman                   | 7<br>10<br>2             | 1<br>9<br>3<br>6 | 4<br>1<br>1<br>1<br>5 | REST<br>OF | 2<br>11<br>4             | 6<br>3<br>12<br>9<br>7<br>1 | 8<br>10<br>15 | REST    | 2<br>4<br>15<br>3  | 1<br>9<br>1<br>3 | 5<br>8<br>10 | REST          | 2<br>15<br>10                     | 1<br>3<br>14<br>18 | 4<br>7<br>8 | REST |   |        |
| Net backward                             | 8<br>10<br>3<br>11<br>15 | NON-KEY          |                       |            | 8<br>10<br>3<br>4<br>15  | NON-KEY                     |               |         | 8<br>10<br>4<br>15 | NON-KEY          |              |               | 8<br>10<br>15                     | NON-KEY            |             |      |   |        |
| Strassert (1968)                         | 6<br>9<br>10<br>17       | NON-KEY          |                       |            | 6<br>9<br>10<br>14<br>17 | NON-KEY                     |               |         | 6<br>9<br>10<br>17 | NON-KEY          |              |               | 2<br>3<br>6<br>7<br>9<br>11<br>13 | NON-KEY            |             |      |   |        |
| DIETZENBACHE<br>R 1997 %                 | 1<br>10                  | 1<br>5           | 6<br>9<br>1<br>7      | REST       | 1<br>10<br>15            | 6<br>14<br>17               | 9<br>REST     | 1<br>10 | 1<br>5             | 6<br>17          | 9<br>REST    | 1<br>10<br>15 | 4<br>5<br>8<br>12<br>17           | REST               |             |      |   |        |
| DIETZENBACHE<br>R 1997 INDEX             | 1<br>10                  | 1<br>5           | 9<br>REST             | 1<br>10    | 15                       | REST                        | 1<br>10       | 1<br>5  | 9<br>REST          | 1<br>10          | 15           | 4<br>5        | REST                              |                    |             |      |   |        |

Reference: Prepared by the researcher based on the four input-output tables .

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|                      |                   |                         |                       |                    |
|----------------------|-------------------|-------------------------|-----------------------|--------------------|
| <b>RANK BY COLOR</b> | <b>KEY SECTOR</b> | <b>STRATEGIC SECTOR</b> | <b>DRIVING SECTOR</b> | <b>WEAK SECTOR</b> |
|----------------------|-------------------|-------------------------|-----------------------|--------------------|

**Table 09 summarizes the four methods we detailed previously. The result in this table is:** According to the Rasmussen method we have three key sectors for each year, except year 2016 we have four key sectors.

According to the net backward linkage method, there are between three and five key sectors, three of which are constantly emerging every year ( 8 , 10 and 15). The classification of sectors is either key or non-key sector.

According to the hypothetical extraction method of Strassert 1968, there are between four and seven key sectors. we find the same four sectors in each year that are considered important in the economy 6,9,10 and 17 which are (steel, mechanical, electrical and electronic industries ISMMEE sector, Chemistry, Plastics, Rubber sector and Agro-food industries sector and Services provided to businesses sector) except year 2019.

The most recent and reliable method in this analysis is the incomplete extraction method by Erik Dietzenbacher. This method consistently identifies Agriculture, forestry, and fishing and Agro-food industries as key sectors each year, with the Agro-food industries sector being classified as a strategic sector in 2019. Additionally, the Chemistry, Plastics, Rubber sector is identified as a driving sector in both 2005 and 2016. In 2019, two new sectors emerged: Services and public works, Oil tankers and Mines, and quarries. The Transport and communications sector is considered a strategic sector across all years. In 2019, the Agro-food industries sector became a strategic sector alongside Transport and communications. The analysis suggests that this method aligns closely with logic and reality, as extracting a sector like agriculture can significantly impact the food industry sector due to their interdependence.

With the availability of Algerian derived input-output tables for the research period 2005-2019 and using the PYIO package for analysis, the researcher examined the agricultural, fishing, and forestry sectors' contributions to the national economy. This was done through various quantitative IOA techniques, including both complete and incomplete hypothetical extraction methods. The data analysis yielded the following results:

### **Results and discussions:**

The paper analyzed the role of the agricultural, fishing and forestry sector specially, in the Algerian economy. The aim is to evaluate the role played by the sector and its importance by measuring its relationships that link him with other productive sectors. The study indices showed that the agriculture, forestry, and fishing sector, according to Rasmussen-Hirschman, was classified as a strategic sector throughout the research period 2010-2019, as it has a forward linkage index greater than 1. This means that the rest of the sectors need its outputs to be used as inputs in their production processes. in 2005 it was classified as driver sector; It has a multiplier effect on other economic sectors. Following the extraction method as Strassert (1968) or Dietzenbacher (1997), agriculture, forestry, and fishing sector was classified as a key sector all the period of study. This means that the agricultural sector (01) has a great weight in the national economy and, moreover, it is a sector with high added value, closely integrated on the sales side but very little on the purchasing side. The indicators measuring sectoral integration in this research paper highlight that agriculture has a strategic and key position in Algeria's economic scenario.

The researcher summarized the results with respect to the influence on output by using incomplete hypothetical extraction proposed by Erik Dietzenbacher (1997), and from the Leontief and Ghosh models he calculated indices measures of linkages to explore the key sectors. Finally; empirical results indicate that the rankings of economic sectors in Algeria are stable and have not changed between 2005 and 2019. This stability suggests that the structure of the Algerian economy is evolving slowly, with a static technical level. This represents a major obstacle to national economic development. But it may also indicate a lack



of innovation and adaptation to global changes. A certain economic model such as the stagnant one can hinder progress, as it does not respond to dynamic market needs or technological advances. For that and to overcome these obstacles, policies aimed at encouraging innovation, diversification of economic sectors and improvement of technical skills could be beneficial.

The most striking result is that the linkages related to the sector vary significantly from year to year. For each year, if we extracted this sector, it leads to a relative reduction in the total output of the Algerian economy by a different percentages compared to the actual output of the extracted sector. This ranges from 71.008% to 231.396% for backward linkages, and from 36.371% to 126.427% for forward linkages. On average, during this period, these values were 113.967% and 60.344%, respectively. So this variability highlights the crucial importance of each sector in the Algerian economy and underscores the challenges linked to dependence on certain sectors, which could have significant implications for economic policies and strategic planning.

The analysis indicates that the relative sectoral linkages between different sectors are generally very weak and inconsistent. If this sector was removed, it would lead to a reduction in output for the other sectors (excluding sector 01), with the impact varying from 0.0175% to 4.59% of the removed sector's output. This highlights the particularly weak linkages between the agriculture, forestry, and fishing sector and the other sectors.

Despite the significant variation in linkages across sectors (within a column), the results indicate that the majority of sectors have linkages below the sectoral averages of 1.44% for backward linkages and 2.9% for forward linkages.

We observed that above the sectoral averages of 1.44% for backward linkages and 2.9% for forward linkages, there are six sectors (06, 08, 09, 10, 11, 15) with linkages larger than average. The majority of the linkages are concentrated in two sectors: the agriculture, fishing, and forestry sector, and the agro-food industries. The rest of the sectors have linkages barely above zero, indicating that the interdependencies between sectors in the Algerian economy are very weak, if not absent. This lack of consistency and interconnectedness is further highlighted when extracting a sector such as the agriculture, fishing, and forestry sector, posing a real challenge to the coherence of the Algerian economic structure.

The agricultural sector is classified as a “strategic sector,” meaning that its outputs are in demand from other sectors for use as intermediate production, particularly in the agro-food industry. The value of this sector in the economy is well-known, especially in terms of food security. If the government’s policy aims to achieve goals such as increasing wealth, the agricultural sector is considered one of the main sectors, alongside the oil sector, to achieve such goals for both the public and private sectors.

The sector ranks almost last in terms of contribution to output, which requires increased attention for its modernization. It is essential to invest in scientific research and genetic engineering to improve quality and increase productivity. Currently, the sector imports about 28% of the food needed to meet the needs of citizens, and it has almost no tendency to export.

As a summary of the above analysis, most of the challenges facing the Algerian agricultural sector can be summarized, with the possibility of mentioning some solutions to rescue it from its current situation, in the following several key issues:

- 1. Low Contribution to Economy:** As for the output, the sector’s contribution is still far away, as it ranks low in terms of its contribution to the overall economy, suggesting a need for strategic improvements.
- 2. Need for Modernization:** There's an urgent call for modernization within the sector, which implies

that current practices may be outdated and need upgrading to enhance efficiency and output.

3. **Importance of Scientific Research:** The emphasis on scientific research and genetic engineering indicates that innovation could play a crucial role in improving the quality of food products and increasing agricultural productivity.
4. **High Dependency on Imports:** Importing 28% of food suggests a significant reliance on external sources to meet local demand. This poses risks related to food security and economic stability, indicating a need for increased local production.
5. **Limited Export Capacity:** The mention of almost non-existent export tendencies underscores a lack of competitiveness in the global market, which could be addressed through better practices and product improvement.

To address these challenges, it may be beneficial to invest in research and development, incentivize local farmers to adopt modern agricultural techniques, and enhance marketing strategies to improve exports. Collaborative efforts between government, private sector, and academic institutions could also drive innovation and improve the sector's overall performance.

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