

A Multiplier and Linkage Analysis : Case of Algeria

Dr. MATALLAH Kheir Eddine*

Abstract

The development strategy for the Algerian economy in the 1980s and 1990s was based on the establishment of small- and medium-scale industrial units. The effectiveness of this policy could be assessed, using multiplier and linkage analysis.

1. Introduction

The Algerian economy in the 1970s was in many ways not untypical of many other developing economies. It passed through a period of behaving as a socialist command economy, and has suffered gluts and shortages resultant from the inherent inabilities of any government to regulate the economy efficiently. In the 1980s and 1990s, Algeria looked to be in a transition period towards a more international, capitalist economic system. That is, the aim of the development strategy was a shift from capital intensive industrial units to more labour intensive small- and medium-scale industrial units.

The absence of new Algerian input-output table, meant that only economic interpretation of the multipliers and linkages were used in this paper.

The subsequent five sections of this paper are structured as follows. Section 2 deals with the theory of input-output multipliers and linkages. In section 3 the limitations of the techniques used are discussed. Section 4 contains an economic interpretation of the multipliers and linkages. In Section 5 some concluding remarks are offered.

* Senior Lecturer in Economics, Guelma University, Algeria

2. Theory of Multipliers and Linkages

2.1. The Input-Output Multipliers

The input-output multipliers, as defined by (Burdekin and Al-Ali , 1978, 13):

"...give a detailed picture of the impact of changes in final demand on output, income, and employment throughout the economy. They are now well established as indicators of the importance of particular sectors and the interdependence of the industrial structure".

The following notation is used throughout this paper (Miller and Blair, 1985). (A) is a square matrix describing the technical relations of production; (x) is a vector of total output; (y) is a vector of final demand; $(I - A)^{-1}$ is the Leontief inverse matrix. These satisfy the usual basic input-output equation:

$$x = (I - A)^{-1} y$$

2.1.1 The Output Multipliers

An output multiplier is defined as the change in gross output resulting from a unit change in final demand in a given sector. As we are assuming constant returns to scale, the effect on the economy is seen by multiplying $(I - A)^{-1}$ by a final demand vector that has unity in the sector we are concerned with and zero elsewhere, i.e. the vector of value multipliers is defined as $i' (I - A)^{-1}$. This is just the column sum of the Leontief inverse. Here (i) is the unit vector and a prime indicates the transpose.

2.1.2 The Income Multiplier

The income generated in the economy by a change of 1 Algerian dinar (AD) in final demand is defined as $w' (I - A)^{-1}$. Here each

element of (w) is the ratio of wages and salaries to gross output for each sector (i.e. the labour income coefficient). However, a more useful measure of the interdependence of the economy is to look at the total direct and indirect income generated for every 1 AD of direct income generated. Thus the income multiplier for industry (j) has the direct and indirect income effect as numerator and direct income as denominator (Miller and Blair, 1985, 107). We write this as:

$$w' (I - A)^{-1} \hat{w}^{-1}$$

Here (\hat{w}) is the 'diagonalised' matrix, with the vector (w) on the principal diagonal, zeros elsewhere.

2.1.3 The Labour Multiplier

Let us assume that the vector of non-produced inputs, (v) , is related to the total output (x) by: $v_i = x_i r_i$

Here (r) is the vector of non-produced input coefficients. Substituting for (x) in the input-output equation gives:

$$v = \hat{r} (I - A)^{-1} y$$

So the effect of a unit change in any element of final demand will simply be the sum of the corresponding column of the matrix $\hat{r} (I - A)^{-1}$. Therefore, the vector of all these effects can be found by multiplying this matrix on the left by i' , i.e. $i' \hat{r} (I - A)^{-1}$. So the multiplier in this case is:

$$i' (I - A)^{-1}$$

The effect on total employment of increasing final demand by sufficient to require one extra direct unit of non-produced input

would require that final demand in sector i increase by $\frac{1}{r_i}$ units. So we would need to multiply the above matrix by \hat{r}^{-1} , i.e. the non-produced input multipliers is:

$$r' (I - A)^{-1} \hat{r}^{-1}$$

2.2 Linkages

In developing planning it is obviously important to know how closely "linked" sectors are with each other. Of course, the direct linkages are shown in the A matrix, and the direct plus the indirect linkages are revealed by the Leontief inverse (Miller and Blair, 1985, 101). However, we need to distinguish between "backward" linkages and "forward" linkages. Backward linkages are the relationship between the activity in a sector and its purchases. Forward linkages are the relationship between the activity in a sector and its sales. The output multipliers, defined as the column sum of the Leontief inverse, obviously indicate backward linkages. Using the row sums of the Leontief inverse, the output multipliers are given by $(I - A)^{-1} i$. This shows the effect on the total activity in each sector if every sector increases its final demand by unity. This is sometimes referred to as "sensitivity" of the sector.

An alternative approach is to make a completely different set of assumptions about the flows in an economy. Rather than assuming that intermediate inputs are proportional to total output, one might assume that they are proportional to total inputs (Jones, 1976); i.e. rather than using

$$x_{ij} = a_{ij} X_j$$

we might use

$$x_{ij} = b_{ij} X_i$$

This means that the intermediate flows are supply led rather than demand led. For most economies this is a less acceptable assumption. However, if I define the matrix (B) as above, then the row sums of $(I - B)^{-1}$ are measures of forward linkages.

3. Analytical Limitations

There are some analytical limitations to this technique as applied to the Algerian input-output table which should be discussed before the technique is applied to the case of the Algerian economy.

3.1 Internal limits

(1). The results obtained are not neutral to the level of aggregation. In fact, a high level of aggregation may have the following results. First, aggregation reduces the technological factor of the intersectoral relationship described by the input-output table, i.e. reducing the impact of a sector on the economy. Second, it reduces the homogeneity of sectors. In an input-output table, classification and division of the economic sectors might affect the sectoral hierarchy. For instance, the creation of a petroleum services and public works sector, Algerian case, would apparently reduce the impact of the hydrocarbon sector on the economy.

(2). The inter-sectoral relationship derived from an input-output table should reflect the technological structure of the national economy. In fact, the elements of an input-output table are the result of a complex interaction of several factors, i.e. economic, technical, institutional, etc. Further, the pricing policy adopted by the government in the 1980s and 1990s would tend to decrease the economic significance of the price system, and therefore of the technical coefficient expressed in money terms.

3.2 External limits

(1). The methods used and the results obtained are based mainly on the current interindustry flow matrices. They do not take into account the transaction of fixed capital within the economy. The integration of fixed capital would modify the results already obtained. Their integration would necessitate the construction of the capital matrices and the utilisation of a dynamic Leontief model (Miernyk, 1977).

(2). The effects induced by the spending of revenues paid to households are not included. Their integration once more would modify the classification of the economic sectors. Theoretically speaking, their integration is seen as possible by making them endogenous within the economic system (Morrison and Smith, 1979).

3.3 Objections to the methods used

(1). The first objection concerns the hypothesis of stable technical coefficients, which is based on the assumptions of the static Leontief model. The economy is mainly in a continuous dynamic state, which means that the sectoral hierarchy might not be stable

(2). The second objection is advanced from the relation between linkages and the efficiency of the economy. The indices calculated do not take into account the differential efficiency of the several branches of the national economy. For instance, backward linkages might favour those sectors with limited efficiency with regard to intermediate consumption.

(3). The third objection concerns the problem of employment. The methods used do not take the variable of employment into account, bearing in mind that economic sectors have different potential with regard to this aspect.

4. The economic interpretation of the multipliers and linkages

The absence of new Algerian input-output table, meant that only economic interpretation of the multipliers and linkages is given to serve as a background to the analysis for future studies. It should be mentioned that, the latest Algerian input-output table was for 1989, being published in 1994.

4.1 The economic interpretation of the multipliers

The output multipliers

The value multipliers for each sector enable the estimation of the total direct and indirect effects of a unit change in activity in each sector. The higher the multiplier the greater the impact on inter-related domestic industries of a sectoral output change. The relatively high value multipliers for these industries are indicative of economic linkage of these industries with other industries. Industries with very low value multipliers will have little or no connection with other industries, i.e. any multiplier effects produced by these sectors, therefore, occur outside the economy. By summing the rows in the Leontief inverse a multiplier is derived which estimates the impact of a dinar change in gross output in all domestic industrial sectors upon each sector. The higher the value of these 'row' multipliers the greater the change induced by one dinar change in gross output in all industries.

The income multiplier

These multipliers can be used to assess the importance of income generated in each industry. For example, the high income multipliers in the hydrocarbon industry, for oil rich-developing economies, is not only because of its low direct coefficients, capital intensive industry, but also because of its significant domestic inter-industry linkages.

The labour multiplier

It should be mentioned here that, the 1989 Algerian input-output table has been used in the analysis below.

By using employment data for each industry, the effective full-time work force of each industry can be calculated. These effective employment figures are then combined with the Leontief inverse matrix to give the labour multipliers for each sector. The labour multipliers in terms of the effect of an extra person employed in each sector on employment in all other sectors using the latest Algerian input-output table, were discussed in a separate paper (Matallah & Proops, 1994), and can be briefly summarized as in Table 1. The labour multiplier for food, drink and tabacco is 6.92 which signifies for every one extra person employed in food, drink and tabacco it is necessary for 5.92 persons to be employed elsewhere in the Algerian economy.

A comparison of the value multipliers and the labour multipliers shows considerable differences in the industrial rankings although the Spearman's rank correlation coefficient of 0.58 is significantly different from zero at the 1% significance level. Analogous to the output multiplier analysis, there are also multipliers which show the sensitivity of each sector to a change in employment by one person in all of the sectors in the economy. These employment sensitivity multipliers are shown in Table 1. The industrial sectors in the top quartile of sensitivity multipliers are agriculture, services, chemicals and iron and steel. The sensitivity of employment in the agriculture sector to changes in the general level of employment in Algeria suggests that employment in agriculture can be used as an economic indicator of cyclical changes in the local economy. Industrial sectors in the bottom quartile indicating sector employment insensitivity to employment changes in the rest of Algerian economy are: mining and quarrying; leather and footwear; cement and building materials; and other industries.

Table 1. Value and Labour Multipliers, Input-Output Table 1989

Sectors	Value Multiplier		Labour Multiplier		Sensitivity Multiplier	
	Value	Rank	Value	Rank	Value	Rank
Agriculture, Forestry and Fishing	1.539	5	1.087	16	7.930	1
Energy and Water	1.208	11	1.269	14	1.533	6
Hydrocarbon	2.110	1	2.943	3	1.506	9
Hydro. Services & Public Works	1.238	10	1.669	5	1.512	8
Mining and Quarrying	1.127	14	1.183	15	1.215	13
Iron and Steel	1.759	3	1.293	12	2.158	4
Porcelain and Glass	1.195	12	1.285	13	1.310	11
Cement and Building materials	1.071	15	1.602	7	1.135	15
Chemicals, Rubber and Plastics	1.722	4	1.786	4	3.125	3
Food, Drink and Tobacco	1.343	7	6.920	1	1.265	12
Textiles and Clothing	1.305	8	1.392	11	1.311	10
Leather and Footwear	1.133	13	1.617	6	1.151	14
Timber, Furniture and Paper	1.351	6	1.499	8	1.615	5
Other industries	1.051	16	4.192	2	1.006	16
Transport and Communication	1.302	9	1.484	9	1.515	7
Services	1.857	2	1.478	10	3.448	2

Source: Tableau des Entrées-Sorties (1989), O.N.S., 1994.

By combining the labour multiplier with the total employment, the column headed 'the total effect of a 1% change in sector employment' is derived. Consider, for example, the agriculture sector with a labour multiplier of 1.087 and total employment of 975,110 (i.e. 54% of total Algerian employment), the effect of a 1% change in agriculture employment would generate a change in employment in Algeria of 10,596 employees. In contrast the food, drink and tobacco sector with a high labour multiplier of 6.92 but relatively small total employment of 71,352 for a 1% change in employment in food, drink and tobacco would change total employment in Algeria by only 4,937 jobs (Table 2).

There are obviously significant differences in the ranking of sectors by the size of the labour multiplier and the size of the total employment impact of a 1% change in sector employment. This can be seen by comparing the sectoral rankings in Table 2. Table 2 shows clearly that the sectors with the largest total employment effects are those with the greatest employment and not those with the largest labour multipliers.

The spearman rank correlation coefficient between the ranking of the total employment effect and the labour multiplier the coefficient is -0.04 which is not significantly different from zero.

Table 2. Total Effect of 1% Change in Sector Employment

Key	Labour Multiplier (LM)		Total employment (E)		T. effect	$\frac{E}{100}$ (LM)	
	Value	Rank	Employment	% of theTotal		Rank	% of Total Effects
1	1.087	16	975110	53.5	10596.5	1	38.7
2	1.269	14	30640	1.7	388.8	12	1.4
3	2.943	3	35000	1.9	1031.6	7	3.8
4	1.669	5	25411	1.4	431.8	11	1.6
5	1.183	15	10434	0.6	123.5	14	0.5
6	1.293	12	136212	7.5	1760.8	5	6.4
7	1.285	13	29280	1.6	376.4	13	1.3
8	1.602	7	160120	8.8	2565.8	3	9.4
9	1.786	4	26786	1.5	478.5	9	1.7
10	6.920	1	71352	3.9	4937.3	2	18.1
11	1.392	11	43044	2.4	599.3	8	2.2
12	1.617	6	11982	0.7	193.8	15	0.7
13	1.499	8	30260	1.6	453.5	10	1.6
14	4.192	2	945	0.1	39.6	16	0.1
15	1.484	9	77733	4.3	1153.7	6	4.2
16	1.478	10	154643	8.5	2285.7	4	8.3

Source: Tableau des Entrées-Sorties (1989), O.N.S., 1994.

4.2 The economic interpretation of the linkages

It should be noted that, in theory, the ranking of the sectors is commonly used as a criterion. Further, an index can be constructed to measure the relative strength of the forward and backward linkages by dividing each of the sectors' forward and backward linkages by their respective averages for the whole economy. Using z_{ij} as an element of $(I-A)^{-1}$ and q_{ij} as an element of $(I-B)^{-1}$ we can define:

$$\text{backward linkage} \equiv n \sum_j z_{ij} / \sum_j \sum_i z_{ij}$$

$$\text{forward linkage} \equiv n \sum_i q_{ij} / \sum_j \sum_i q_{ij}$$

Here n refers to the number of economic sectors. Also, Jones's (1976) measurement of forward linkages can be used, i.e. the "supply led" assumption.

Sectors possessing weak forward linkage indices meant that these industries sell their output mostly to final demand and hence do not figure significantly in the measures as they depend on intermediate flows. Sectors possessing weak backward linkage indices meant that their dependence on other sectors for their inputs is comparatively very low, i.e., their principal inputs are provided mainly by imports.

Key sectors, according to Hirschman (1958), are those sectors with both backward and forward indices greater than unity. However, the most interesting aspect which might emerge, for developing economies, is the appearance of sectors that 'nearly' qualify as key sectors.

This conclusion was first introduced by Matallah and Proops (1990), and further developed by Matallah (1996), and can be summarized by defining "strong", "intermediate", and "weak" linkages. We use

$$\begin{array}{ll} \text{Strong} & \text{linkage index} \geq 1 \\ \text{Intermediate} & 1 > \text{linkage index} \geq 0.9 \\ \\ \text{Weak} & 0.9 > \text{linkage index} \end{array}$$

5. Conclusions

From my analysis I draw two conclusions.

First, a summary of the results of the various multiplier analysis will show the importance of those industries in terms of capacity to

stimulate output, income and employment in the rest of the economy.

The grouping of a large number of industries within a narrow range of values, the output multipliers, means that the ranking of these industries is likely to be sensitive to future changes and also that any policies aimed at increasing demand in all or some of these industries is likely to prove almost equally effective in terms of stimulating the rest of the economy..

Second, the most interesting aspect which might emerge is the appearance of sectors that ‘nearly’ qualified as key sectors. In particular, if these sectors, compared with other sectors, were relatively underdeveloped, and thus offered considerable potential in any growth strategy.

Areas for Future Study

The present paper has illuminated some interesting aspects of the limitations of the theory of multipliers and linkages. Still other issues obviously require further study. Further work could examine the following:

(1): With a new input-output table the above analyses can be repeated and updated.

(2): Test the assumption: “strong”, “intermediate”, and “weak” linkages.

References

- Bulmer-Thomas, V. (1982), "Input-Output Analysis in Developing Countries", John Wiley & Sons Ltd, London.
- Burdekin, R., & Al-Ali, H. (1978), "An Analysis of Some Aspects of the Scottish Economy Using Input-Output Techniques", Report 96, IBM, UK Scientific Centre.
- Hirschman, A.O. (1958), "The Strategy of Economic Development", New Haven, CT, Yale University Press.
- Jones, L. (1976), "The Measurement of Hirschmanian Linkages", Quarterly Journal of Economics, 90, pp.323-333.

Leontief, W (1951), "The Structure of the American Economy, 1919-39", Oxford. University Press, Oxford.

Matallah, K. & Proops, (1992), "Algerian Economic Development; 1968-1979: A Multiplier and Linkage Analysis", Economic Systems Research, Vol. 4, pp. 257-267.

Matallah, K. & Proops, (1994), "An Input-Output Assessment of Algerian development", Working Paper Series, Department of Economics, University of Keele, U.K.

Matallah, K. & Proops, (1996), "Measurement of Tachnological Change in the Algerian Economy Via the Iutput –Output Tables, 1979-1989", Working Paper Series, Department of Economics, University of Keele, U.K.

Miernyk, H. (1977), "The projection of technical coefficients for medium term forecasting", in W.F. Gosling (ed.), "Medium Term Dynamic Forecasting", Prentice Hall, New Jersey.

Miller, R., & Blair, (1985), "Input-Output Analysis: Foundations and Extensions", Englewood Cliffs, NJ, A Prentice Hall Company, USA.

Office National des Statistiques (ONS), (1993). No. 58, Algiers.

Tableau des Entrées-Sorties 1989, "Ministère de la Planification et de l'Aménagement du Territoire", (1994), Algiers.