# Input-Output Analysis in Development Planning

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Input–output analysis, first propounded in 1951 by Prof. W. W. Leontief, is gaining increasing importance in recent discussions on development planning. The fact that input-output analysis has reached maturity as an active branch of applied economics during the working life of its author is a tribute to the soundness of the author's original conception of inter–industry relations. Although Leontief's simplification of the Walrasian system appeard too drastic to many of his early critics, it has proved to be an enormously fruitful basis for emperical research. The main difference of the Leontief's system from the Walrasian system lies in the fact that the Leontief's system is devoted to the emperical investigation. "The narrowness lies in its exclusive emphasis of the production of the economy. And demand theory plays on role in the hard core of input–output analysis. The problem is essentially technological**". The systemetic collection of input-output data in the United States, Western Europe and Japan that followed his original study now provide the basis for complex models. In its simplest version, the analysis deals with the question: what level of output should each of the 'n' industries in an economy produce in order to satisfy the total final demand for

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** Baumol, W. J.; Economic Theory and Operation Analysis 3rd edition. pp 504

In a simple economy, the economic activities in the productive sector can be its product, this total final demand being given exogenously. As output of any industry is not all used to satisfy the given final demand and as some of its output is used by other industries, even by the same industry as its input, therefore the correct level of output of any industry will depend on the input requirements of all the 'n' industries. In a simple economy, the economic activities in the productive sector summarized in an input-output table. An input-output table provides two kinds of informations:*

1. It shows how available supplies of labour and other primary inputs used in production are allocated among industries in the economy.

2. It shows how the output of each industry is allocated among industries (including itself) that use it as an input and individuals who consume it.

Thus on the basis of input-output analysis one finds inter industry relations and interdependencies in the entire economy, because the input of one industry is the output of another. In fact the major economic activity we study in the input-output analysis is the fact that in the production of intermediate goods or inputs goods that are outputs for one industry are again employed as input for further production by another industry. When we succeed in constructing the input-output table, assuming technology of production to be constant i.e., technology matrix constant, the total production of each industry can be estimated for any given demand. Thus the main problem is to construct the input output table for any one base period. The following are the steps for the preparation of input-output table:**

1. One should select the industries to be included.

2. One must collect the data for some base year on the following items.

    a) The quantities of primary inputs used by each industry.

    b) The total output produced by each industry;

    c) The quantities of each industry's output that are used as inputs in every other industry.

    d) The quantities of each industry's output that goes to satisfy final demand.

One simple hypothetical table can be used to explain an input-output table clearly.

* Stigum & Stigum: Economics (1968) pp. 265

** op. cit. pp. 266

Table – I

INPUT-OUTPUT TABLE (IN UNITS OF CRORES OF RS.)

| | | Inter-industry Demand | | | Final Demand | Total Demand |
|---|---|---|---|---|---|---|
| | | Agriculture | Industry I | Industry II | | |
| Inter industry supply | Agriculture | 20 | 45 | 20 | 15 | 100 |
| | Industry I | 40 | 15 | 20 | 75 | 150 |
| | Industry II | 10 | 45 | 20 | 25 | 100 |
| Final supply (Labour, primary) | | 30 | 45 | 40 | 0 | 115 |
| Total Supply | | 100 | 150 | 100 | 115 | 425 |

The table shows the output of the three sectors when read row wise and their inputs in column. The total of the first row 100 is the total value of agricultural output of which only 15 has gone to the final demand. Out of 85 remaining units, 20 units are used in agricultural sector itself and the remaining 65 units are shared by the two industrial sectors. Similar explanations can be given for the other two sectors. It is to be noted that zero appearing in the final demand column is meant to imply that labour is not consumed for its own sake, that it does not sell anything to itself.

The items in table I showing the sales of the three sectors among themselves and to each other might be described as non-GNP items. The final demand column represents the output side of GNP and the labour row represents the factor cost side. (This means that the inter industrial sales have no welfare significance. Social benefits come from final consumption and social costs come from the use of labour.) The economy can be viewed as a machine that uses up labour worth 115 units and produces final consumption worth 115 units.

It is possible to derive from table I an input-output coefficient matrix (or simply coefficient matrix) as given below:

Table - 2

INPUT-OUTPUT CO-EFFICIENT MATRIX

| | Agriculture | Industry I | Industry II |
|---|---|---|---|
| Agriculture | 0.2 | 0.3 | 0.2 |
| Industry I | 0.4 | 0.1 | 0.2 |
| Industry II | 0.1 | 0.3 | 0.2 |
| Labour services | 0.3 | 0.3 | 0.4 |

Table II can be interpreted like this: in order to produce one unit of product of (say) industry I, 0.3 unit of product of agriculture, 0.1 unit of product of industry I, 0.3 unit of product of industry II and 0.3 unit of labour is required. Similar explanations can be given for other sectors.

As long as the production technology remains unchanged the input-output coefficient matrix remains constant, so that the output from different sectors can be estimated according to the final demand.

If $x_1$, $x_2$, $x_3$ are the productions from agriculture, industry I and industry II sectors respectively for the given final demand and if final demand is known, the problem will arise only to find the values of $x_1$, $x_2$, and $x_3$ separately corresponding to the respective final demands.

Suppose agriculture sector has to produce an output just sufficient to meet the input requirements as well as the final demand ($d_1$) of the open sector, its output level $x_1$) must satisfy the following equation:

$$x_1 = 0.2x_1 + 0.3x_2 + 0.2x_3 + d_1$$

i. e. $d_1 = (1-0.2)\,x_1 - 0.3x_2 - 0.2x_3 \ldots\ldots$ (i)

Similarly for the industry I and II sectors, final demand being $d_2$ and $d_3$ must satisfy the following equations:

$$d_2 = -0.4x_1 + (1-0.1)x_2 - 0.2x_3 \quad \ldots \quad \ldots \quad \text{(ii)}$$

$$\text{and } d_3 = -0.1x_1 - 0.3x_2 - (1-0.2)x_3 \quad \ldots \quad \ldots \quad \text{(iii)}$$

The system of equations can be written as,

$$\begin{pmatrix} d_1 \\ d_2 \\ d_3 \end{pmatrix} = \begin{pmatrix} 1-0.2 & -0.3 & -0.2 \\ -0.4 & 1-0.1 & -0.2 \\ -0.1 & -0.3 & 1-0.2 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix}$$

That is.

$$d = (I-A)x \quad \ldots \quad \ldots \quad \text{(iv)}$$

$$\text{Where } d = \begin{pmatrix} d_1 \\ d_2 \\ d_3 \end{pmatrix} \quad x = \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix}$$

$$I = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \quad \text{and } A = \begin{pmatrix} 0.2 & 0.3 & 0.2 \\ 0.4 & 0.1 & 0.2 \\ 0.1 & 0.3 & 0.2 \end{pmatrix}$$

Equation (iv) can be written as,

$$x = (I - A)^{-1}d \quad \ldots \quad \ldots \quad \text{(v)}$$

Thus as long as the coefficient matrix A remains constant, different values of x can be estimated for different demand, d. Here in our example,

$$\begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} = (I - A)^{-1}d = \begin{pmatrix} \frac{0.66}{0.384} & \frac{0.30}{0.384} & \frac{0.24}{0.384} \\ \frac{0.34}{0.384} & \frac{0.62}{0.384} & \frac{0.24}{0.384} \\ \frac{0.21}{0.384} & \frac{0.27}{0.384} & \frac{0.60}{0.384} \end{pmatrix} \begin{pmatrix} d_1 \\ d_2 \\ d_3 \end{pmatrix}$$

In special case when the final demand is as given 15, 75, 25 total output for agriculture sector is

$$x_1 = \frac{0.66 \times 15}{0.384} + \frac{0.30 \times 75}{0.384} + \frac{0.24 \times 25}{0.384} = 100$$

Similarly total outputs for the industry I sector and industry II sector are respectively,

$$x_2 = \frac{0.34 \times 15}{0.384} + \frac{0.62 \times 75}{0.384} + \frac{0.24 \times 25}{0.384} = 150$$

$$x_3 = 100$$

These figures, we have already obtained in the hypothetical table I. The point of this exercise is to show that if there were to be an increase of final demand say an increase in final demand in agriculture sector by one unit the production of agriculture sector should increase by $\frac{0.66}{0.384}$, production of industry I sector by $\frac{0\,3}{0.384}$ and production of industry II by $\frac{0.24}{0.384}$. Similarly an increase of one unit of industry I sector will require producing $\frac{0.34}{0.384}$ of agriculture, $\frac{0.62}{0.384}$ of industry I and $\frac{0.24}{0.384}$ of industry II. And so on. This is indeed useful information and will be a guide for planning out the production increase for a given growth rate of final demand for each sector's output.

In similar way for different sets of final demands d's, different sets of productions x's can be estimated. We simply go through the following steps:

a. Obtain the input coefficient matrix.
b. Substract it from a unit matrix.
c. Obtain the increase of the unit matrix minus the coefficient matrix.
d. Multiply the increase by final demand.

Thus applying these steps for the future estimated demands the same coefficient matrix can be utilized and consistent forecasting for the set productions can be made.

"Yet despite the completeness of the system which largely reduces the actual analysis to a computational problem once the model is constructed, judgement is needed at three levels of the analysis. First, the economist must consider the relavance of the model to the specific problem. Can the assumed linearities, constancies, fixities, of the model be granted for the set of circumstances and the time period involved ? Second; what industries can be considered endogenous in the specific application and what supplementary techniques must be used to complete the model ? And third is the level of accuracy of any specific answer* adequate for the policy decision that is to be made ?"

Though here a simple open static input-output model is discussed, the idea can be extended to the dynamic input-out model which is more appropriate than the static approach in an economy rapidly changing and fastly moving towards economic development.

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* O. Eckstein – "The input–output system – its nature and use". Economic Activity Analysis edited by Osker Morgenstern pp. 77.

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6. Stigum & Stigum : Economics.