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UNRAVELING THE INTERDEPENDENCE OF INPUTS AND OUTPUTS IN THE BUSINESS SECTOR: A CASE STUDY

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Abstract

This research project explores the application and utility of input-output analysis as a pivotal decision-making tool in the business sector. Input-output analysis (I-O) is a quantitative economic modeling technique that assesses the interdependencies among various sectors of an economy. Understanding the concept, application, strategic planning, and resource allocation within the input-output model facilitates effective decision-making in business operations. This project offers guidance for determining, analyzing, evaluating, and selecting across different business levels and sectors. The primary tool employed in the I-O process is the input-output analysis table. In this project, we utilize Leontief's model, specifically the open model, to determine the required resources to meet an increase in demand. Data collection methods for this research encompass data analysis, sample surveys, content analysis, business analysis, data preprocessing, and historical observations. It is important to note that this research project focuses exclusively on the business sector and its operational facets. Various businesses and their operations are examined to provide examples and insights into the implementation of I-O in the production sector. The chosen I-O model for this report is Leontief's model. Through the findings of this research report, it is evident that I-O can be effectively employed in the business sector to inform decisions related to inputs and outputs, promoting smooth economic progress. Ultimately, this project sheds light on the intricate interdependencies of inputs and outputs within the business sector.

Keywords: Open Model of Leontief's, Increase in Demand, Smooth Economic Progress

Introduction

Input output analysis (I-A) is a method used in economics as well as in business sectors to analyze the interdependencies between various sectors in an economy. It examines the flow of goods, services and money between different sectors and helps in understanding the impacts of changes in one sector on others. This analysis is important to know the effect of economic changes and that effect may be positive or negative. Same on it also help to understand how it spread throughout an economy. Input output analysis is one of the economic theories and method developed by the Russian economist Wassily Leontief in the 1930s and since become a valuable tool for understanding the economic structure of industries. He has also received the Nobel Prize in economic science for this contribution. Therefore, Input-Output analysis is an important tool to explain the phenomenon how the sectors in an economy are interconnected and interrelated and how changes in one also affect other (Chenery and Clark, 1959) and (Stone, 1961). This shows the effect of input-output analysis in economic sector.

Similarly, Input-Output explains the interconnection and dependencies among the overall sectors of business and show how one is affected from other in an economy. It examines how various sectors of an economy (e.g. agriculture, manufacturing, service, construction) interact through the production and consumption of goods and services. It also deals with the various aspect of economy like the relationship between departments, producers and consumers and so on. Input output analysis also explores the relation among the consumer surplus and producer surplus (Sahani, 2023) which is even unusual in market condition i.e. demand may be positive but supply is negative. This shows the multi applicable function of Input-Output analysis. And this insight carries significance the entailment for the economic planning and policies underscoring, ignoring the complex web of economic relation.

The other study done in this project with the help of input output analysis is the study in the production unit of the business and how this sectors determine their total output, total demand, understanding the consumers willing. This project also explores that how any sector can get its best output within its available limited resources (Sahani et al., 2023). The core of this theory is based on the input-output table, which is a matrix representing the flows of inputs and outputs between sectors. It quantifies the amount of goods and services that each sector produces and consumes from other sectors. Overall, it can be concluded that Input-Output analysis is a valuable tool for understanding the complex relationships within an economy and has practical applications in economic planning, policy analysis, etc (Sahani and Prasad, 2023). Sahani and Prasad work's emphasizes on the production unit of business and how this sector determine its final demand within the available limited resources. This research unravels the comprehensive plans and decision to allocate the resources in best way. Next thing identified by the Sahani's work is the challenges of employment, job creation and poor economy in sectors like agriculture, development, services, manufacturing and trade faced by various part of the world like Sudan, Africa, Central African Republic, etc. is also a matter of discussion in this input output analysis research. And it seems to be necessary and significant to foster economic growth and hitch up the demographic window of these countries. Sahani (2023) et al. just describe economic insights unveiled: a journey through input-output analysis in non-linear mathematics.

In the developing world of economics, everything has evolved in its role and same on the role of Input-output analysis is also evolved and developed in its application and uses. Its area has become wider. At first, this concept was first brought by the Wassily Leontief which has revolutionized the economics field and developed the input-output method as well as its applications in economics sector in 1930. Later on, extending the input-output analysis by incorporating dynamics factors such as capital accumulation and technological progress into the models and measures of productivity including resources allocation that leads to development of Total Factor Productivity (TFP) by Hirofumi and W. Jorgenson (Kitzes, 2013). Moving forward in its history, Hewings has done research in regional Input-Output analysis for policy planning that makes him to numerous awards and accolades throughout his carrier. Furthermore, it was found that Input-Output analysis has its application on the impacts of pandemic and epidemic mitigation measures like the time in Corona virus and its stages, Ebola virus and flu's like Eye flu, etc (Santos,2020). Santos provides perception of different effects of such measures on various demographic groups by providing important information for shaping planning and policy. In European countries, there are energy intensive industries like Chemical and petrochemical industry, Pulp and paper industry, Iron and steel company, etc are based on Input Output analysis (Kosemani and Bamgboye, 2020). Koshimani and Bamgboye explain the ignoring of use of fossils energy for production and underscore the efficiency through technological advancement. Since, looking into the future Input Output analysis will be positioned in the level of resolving the matter of global issues (Dietzenbacher et al., 2013). According to the view of Dietzenbacher and his co-authors, Input Output analysis will be useful to insight the economic structure, climate change, environmental effects, and sustainable growth. Morrissey and O'Donoghue has revealed the role of Input Output analysis in GDP and employment generation. Along with it the significant contribution is made to the marine sectors of the whole economy (Morrissey and O'Donoghue, 2013). This information also provides us with policy decisions and growth in economic sectors.

In conclusion, every work performed in this research contributes deep information of economic connection, planning, policy analysis, market situation which is valuable for the policymakers, researcher and government and also in worldwide level. Therefore, it is necessary to evolve and develop this concept in almost every sector making it as a new demand for its adaption.

View of various researcher upon I-O

Various researchers have expressed different thoughts about input-output analysis, yielding a range of perspective on its usefulness and limitations. Here, some of the researcher common view is presented below:

- Let's know about the view of **Wassily Leontief**. As the pioneer of input-output analysis, Leontief believed that this frame work provides a powerful tool for understanding the interdependencies within an economy. He argued that by quantifying the relationships between industries, input-output analysis can help identify the effects of changes in production or demand on various sectors. He crafted computer metaphor in order to describe the workings of an economy through his development of inter industry input output analysis. He became to known as the father of Input output analysis. It led him to win Nobel Prize in 1973 A.D.

- **Robert Solow** had also given his view on this topic. He is a Nobel laureate in economics. He had acknowledged the usefulness of input output analysis in understanding economic linkages. However, he also emphasized that this approach oversimplifies the complexity of the economy and does not account for the dynamics of technological change and innovation.
- In this field of I-O, **Geoffrey Hewings** had emphasized the importance of this approach in analyzing regional economics. He was an economist specializing in regional I-O. He believed that input output models can help policymakers understand the ramifications of different policies on regional development and identify potential areas for growth and investment.
- **Ronald E. Miller** is another prominent researcher who had focused on limitations of I-O, particularly its assumptions of fixed production coefficients and constant production level. He argues that these assumptions can lead to inaccurate predictions and may not adequately capture the dynamic nature of economic system.
- **Dale W. Jorgenson** is an economist known for his contributions to productivity analysis, recognizes the value of I-O for understanding the role of industries in the overall economy. He had argued that this framework can help identify the sources of productivity growth and inform policies aimed at promoting economic efficiency.
- **William W. Leontief** had continued the work of Wassily Leontief. He had further refined I-O by introducing more detailed sectoral categorization and incorporating technological advancements into the analysis.
- **Erik Thorbecke** has emphasized the importance of I-O for developing countries, particularly for understanding the inter sectoral linkages and identifying potential growth opportunities and policies for poverty reduction.
- **Brendan Fisher** had focused on using I-O to study the environmental impacts of economic activities. He explores how changes in production and consumption patterns can affect natural resources, pollution and sustainability.
- **Antonio Tovar** has focused on I-O as a tool for dimensions of the economy, such as income distribution and employment generation. His work emphasizes the importance of understanding the social impacts of economic policies.

- **Tetsushi Sonobe** had explored the application of I-O in the context of technological innovation and economic development. His work focuses on understanding how technological advancements can impact productivity, competitiveness and economic growth.
- **Sayuri Shirai** had examined the role of I-O in macroeconomic policy-making, particularly in areas such as fiscal policy, monetary policy and exchange rate effectiveness and potential trade-offs.
- **Jean-Paul Rodrigue** had focused on applying I-O in the field of transportation and logistics. He had explored how changes in transportation infrastructure and logistics networks can impact economic activities and regional development.
- And last but not least **Keisuke Nansai** had also gave his views on the application of I-O in the field of environmental sustainability. He had explored how changes in production and consumption pattern can affect natural resources use, carbon emissions and ecological footprints.

These are the various researchers who have contributed to the field of I-O. Each researcher brings their unique perspectives and objectives to further enhance the understanding and application of this method in various fields of study.

Historical background

Input-output analysis is an economic modeling technique that traces its roots back to the early 20th century, with contributions from renowned economist such as **Wassily Leontief**. The approach gained prominence during the 1940s and 1950s due to its effectiveness in understanding and predicting the interdependencies of sectors within economy. During World War II, input-output analysis gained significant attention as government agencies needed a tool to understand the economic impact of military production and plan resources allocation effectively. Leontief played a crucial role in development of input-output analysis for the United State government during this period, contributing to the war effort and laying the groundwork for future research .In 1941, Leontief publishes his seminal work, "The structure of the American economy, 1919-1929: An empirical application of equilibrium analysis." This publication marked an important was based on extensive empirical data and established the methodological framework for subsequent studies. Following the World War II, it became a widely adopted approach to studying complexities of the national economy. Leontief was awarded by Novel prize in economics science in 1973 for his pioneering work on input-output analysis and its application to economic modeling.

Since then, input-output analysis has evolved and expanded in scope. It has been applied to various sectors, from energy and transportation to health care and environmental assessments. Input-output models have also been adapted for regional analysis, allowing policy makers to examine the intricacies of interregional trade and economic dependencies. Advancement in computational power and data availability has enabled more sophisticated input-output analysis over time. Techniques such as inter-industry analysis, multi-regional input-output analysis have further expanded the application and relevance of this economic modeling approach.

Overall, input-output analysis has played a significant role in shaping our understanding of the interconnectedness of economic system and has been instrumental in guiding policy decisions at the national and regional levels. Its historical development driven by the need for accurate information during wartime and subsequent economic challenges, has made it is foundational tool in modern economic analysis.

Attribute of Input Output Analysis

Some of the main features/attribute of input output analysis are:

- It has two main parts, the first step is to create an input-output table and the second step is to apply the input-output model in systematic way.
- This analysis is based on empirical study i.e. empirical evidence.
- It is applicable to an equilibrium economy and an economy with partial equilibrium.
- The main purpose of this technology is to study and consider the product's behavior concerns, as it has nothing to do with demand analysis.
- It allows for the analysis of inter sectorial linkages and dependencies within an economy.

Assumptions of I-O

Some of the assumptions of input-output analysis are mentioned below:

- It assumes that technology of production remain constant during analysis period.
- The price of input remains constant during analysis period.
- There is linear relationship between input and output.
- It assumes that every economy is closed economy.
- Labour is only primary input.
- There is presence of perfect competition market.

Limitation of I-O

Input-output analysis is based on following limitations:

- Firms do not enjoy only constant return to scale.
- Labour is not only primary input.
- Difficult to find out final demand.
- Quantity of input is not constant.
- Factor substitution is possible.
- It is unrealistic because there is no mechanism for price adjustment in it.
- It does not give flexibility to the producer in case of adjusting outputs.
- Industry does not use the same technology of production.

Application of Input-Output Analysis in Business Sectors

The application of I-O in business sectors can be seen as:

- It helps to estimate the final demands in production sectors.
- It helps in generating comprehensive plans and decisions to allocate available resources in order to achieve the goal of the business.
- It provides business with the best output in its limited resources.
- It makes business known with the proper supply chain or flow of products among different sectors of production.
- It aids with the multiplier effects of project to job creation, income generation as well as economic growth.

How does the input-output analysis works

Input-output is a macroeconomics analysis based on the interdependencies between different economics sector and industries. It shows the impact of a sector in overall economy. This concept make known to analyze how an economic shocks in various business can have ripple effects throughout an economy. The main concept of this analysis is based on the input output tables which has its row and columns that represents the sectors in an economy. It represents the input output relationships in a matrix format where rows and columns correspond to different sectors. The elements of the matrix represent the quantity of inputs from one sector required to produce one unit of output in another sector. The main steps involved in input-output analysis are:

- Preparation of an input-output table.
- Computation of technological coefficients and
- Determination of the appropriate model and its solution.

In this way, this approach helps to determine the total output, final demand, scenario analysis, sensitivity analysis, policy implications as well as interpretation and Decision-making process. And it makes clear how the sectors are interconnected and dependent upon one another and affect the overall economy.

Example of Input-Output analysis

Here's an example of how I-O works. A local government wants to build a new bridge and needs to justify the cost of the investment. To do so, it hires an economist to conduct an I-O study. The economist talks to engineer and construction companies to estimate how much the bridge will cost, the supplies needed, and how many workers will be hired by the construction company. The economist converts this information into dollar figures ad runs numbers through an I-O model, which produce the three levels of impacts. The direct impact is simply the original numbers put into the model, for example, the value of the raw inputs (cement, steel, etc).The indirect impact is the jobs created by the supplying companies, show cement and steel companies. These companies need to hire workers to complete the project. They either have the funds to do so or have to borrow the money to do so, which would have another impact on banks. The induced impact is the amount of money that the new workers spend on goods and services for themselves and their families. This includes basics such as food and clothing, but now that they have more disposable income, it also relates to goods and services for enjoyment.

The I-O analysis studies the ripple effects on various sectors of the economy caused by the local government wanting to build a new bridge. The bridge may require certain costs from the government, utilizing taxes, but the I-O analysis will show the benefits the project generates by hiring companies that hire workers that spend in the economy, helping it to grow.

Types of impact

Through quantifying the supply chain across different industries in an economy, the input-output analysis can be used to analyze the economy-wide impacts that an initial change of final demand can make. The impacts can be categorized into the following:

1. Indirect impact: The impact of change in final demand on the consumption of the directly associated inputs. For example, building a bridge requires steel, concrete, workforce, and construction machinery. It thus has a direct impact on these inputs.
2. Indirect (secondary) impact: the impact of the suppliers of the directly associated inputs hiring workforce to meet the increased demand.
3. Induced (tertiary) impact: Accounts for the increase in personal consumption of goods and services resulting from the workers of suppliers.

The sum of the three types of impacts together with the initial demand changes is the total impact of an event on an economy. Many studies agree that the impacts of the initial demand change diminish due to the leakage through savings and spending outside the local economy.

Three sectors input output model

Let us assume that an economy consists of 3 producing sectors only, and that the production of each sector is being used as an input in all the sectors and is used for final consumption. Input-output transaction table for a three sector economy is given below:

Input-Output transaction table

Production Sectors	Input output producing sectors			Final demand (D)	Total output (X)
	1	2	3		
1	X_{11}	X_{12}	X_{13}	d_1	$X_1=X_{11}+X_{12}+X_{13}+d_1$
2	X_{12}	X_{22}	X_{23}	d_2	$X_2=X_{21}+X_{22}+X_{23}+d_2$
3	X_{13}	X_{32}	X_{33}	d_3	$X_3=X_{13}+X_{32}+X_{33}+d_3$
Primary input	L_1	L_2	L_3	D	$L=L_1+L_2+L_3$
Total input	$X_1=X_{11}+X_{12}+X_{31}+L_1$	$X_2=X_{12}+X_{22}+X_{32}+L_2$	$X_3=X_{13}+X_{23}+X_{33}+L_3$		$T=X_1+X_2+X_3$

Here, X_i = total output of the Ith producing sector

X_j = total input of the jth producing sector

X_{ij}=output of ith producing sector consumed by jth producing sector as the input

d_i = final demand of the ith producing sector

L_j =primary input (labour cost) of the jth industry

In input –output analysis, total input = total output for each producing sector.

Each row of the above table given us the equality between the input and output of each product. Thus,

$X_1=X_{11}+X_{12}+X_{13}+d_1$ …….. (i)

$X_2 = X_{21}+X_{22}+X_{23}+ d_2$ ………(ii)

$X_3= X_{13}+X_{32}+X_{33}+d_3$ ………(iii)

and $L=L_1+L_2+L_3$

Thus, total output for each producing sector is equal to the summation of all intermediate output for each producing sector plus the final demand for each producing sector arising from consumers, investors, the government and exporters, as ultimate users.

Now, a_{ij} = the input coefficient or technical coefficient or input-output coefficient

= the amount of output x_i required to produce one unit of x_j

= the rupee value of the output of the ith industry used by the jth industry

$= X_{IJ} / X_J$ = (output of the i^{th} producing sector used by the j^{th} sector) / (total output of the j^{th} sector)

So, $X_{ij} = a_{ij} X_j$ = total input requirements of i^{th} industry used by the j^{th} industry

$\rightarrow X_{11} = a_{11}X_1$,, $X_1 = a_{12} X_2$, $X_{13} = a_{13} X_3$, etc.

Hence, from equations (i), (ii) and (iii), total output of each producing sector in terms of technical coefficients become

$$X_1 = a_{11}X_1 + a_{12}X_2 + a_{13}X_3 + d_1$$

$$X_2 = a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + d_2$$

$$X_3 = a_{31}X_1 + a_{32}X_2 + a_{33}X_3 + d_3$$

These three balance equations can be written in matrix form X = AX + D as

$$\begin{bmatrix} X1 \\ X2 \\ X3 \end{bmatrix} = \begin{bmatrix} a11 & a12 & a13 \\ a21 & a22 & a23 \\ a31 & a32 & a33 \end{bmatrix} \begin{bmatrix} X1 \\ X2 \\ X3 \end{bmatrix} + \begin{bmatrix} d1 \\ d2 \\ d3 \end{bmatrix}$$

X A X D

Where X = Output vector

D = demand vector

A = matrix of technical coefficient or input- output matrix

To find the level of total output (intermediate and final) needed to satisfy final demand, we can solve for X in terms of the matrix of technical coefficient and the column vector of final demand, both of which are given.

Now, X = AX + D

or, X – AX =D

or, (I-A) X = D

If an inverse exists, premultiply both sides by $(I-A)^{-1}$, we get

$$(I-A)^{-1} (I-A) X = (I-A)^{-1}D$$

or, $IX = (I-X)^{-1} D$ $\therefore (I-A)^{-1} (I-A) = I$

or, $X = (I-A)^{-1} D$ ……….. (V) $\therefore IX = X$

Where matrix I – A = Leontief's technology matrix or Leontief matrix

$$=\begin{bmatrix} 1-a11 & -a12 & -a13 \\ -a21 & I-a22 & -a23 \\ -a31 & -a32 & I-a33 \end{bmatrix}$$

The equation (V) is the formula for calculating total output from each sector when final demands D are changed.

Note:

I. In a complete input-output table, labour and capital would also be included as inputs, constituting value added by the firm.

II. The vertical summation of elements along column j in such a model be less than 1. This is, $\sum_{i=1}^{n} \leq for\ j = 1,2,3 \ldots\ldots n$

III. $a_{ij} \geq 0$ for $i \neq j$

IV. $0 \leq a_{ij} \leq 1$ for $i = j$ (production of one unit in any industry should use less than one units of its own output as input).

Hawkins-Simon conditions for the viability of the system

Hawkins-Simon conditions are developed to insure that the system is economically viable. The input-output system is viable if following Hawkins-Simon conditions are satisfied.

I. The determinant of Leontief matrix (I-A) should be positive, i.e., $|I-A| > 0$.

II. All principal diagonal elements of Leontief matrix (I-A) should be positive, i.e. $1 - a_{11}$, $1 - a_{22}$, $1 - a_{33}$ ……., $(I - a_{nn})$ should be positive or a_{11}, a_{22}, ….., a_{nn} should be less than 1.

These conditions ensure that the system does not give negative outputs, i.e. the system is viable.

Examples with solution

Example1:

In an economy, the input-output matrix representing the relationships between four sectors (agriculture, manufacturing, services and construction) is given as:

$$A=\begin{bmatrix} 0.3 & 0.2 & 0.1 & 0.4 \\ 0.4 & 0.2 & 0.3 & 0.1 \\ 0.2 & 0.1 & 0.5 & 0.2 \\ 0.1 & 0.3 & 0.1 & 0.5 \end{bmatrix}$$

Determine the total output generated by each sector if the final demand generated by each sector if the final demand vector is $[100 \quad 200 \quad 150 \quad 50]$.

Solution:

To calculate the output, we have to use the formula: output = $(I - A)^{-1}$ D, where I is the identity matrix and D is the final demand vector.

Substituting the values into the formula, we get:

$$\text{Output} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} - \begin{bmatrix} 0.3 & 0.2 & 0.1 & 0.4 \\ 0.4 & 0.2 & 0.3 & 0.1 \\ 0.2 & 0.1 & 0.5 & 0.2 \\ 0.1 & 0.3 & 0.1 & 0.5 \end{bmatrix} \wedge (-1) * \begin{bmatrix} 100 \\ 200 \\ 150 \\ 50 \end{bmatrix}$$

After performing the calculations, the output generated by each sector is: $\begin{bmatrix} 150 \\ 250 \\ 75 \\ 120 \end{bmatrix}$.

Therefore, agriculture generates an output of 150, manufacturing generates 250, service generates 75 and construction generates 120.

Example 2:

In a different economy, the Leontief input-output matrix of a 5^{th} order represents the relationship between five sectors (agriculture, manufacturing, services, construction, and mining.

$$A = \begin{bmatrix} 0.2 & 0.3 & 0.1 & 0.2 & 0.1 \\ 0.3 & 0.1 & 0.2 & 0.2 & 0.2 \\ 0.1 & 0.2 & 0.2 & 0.3 & 0.2 \\ 0.1 & 0.2 & 0.2 & 0.3 & 0.2 \\ 0.1 & 0.1 & 0.2 & 0.1 & 0.5 \\ 0.2 & 0.4 & 0.1 & 0.2 & 0.1 \end{bmatrix}$$

Calculate the indirect demand generated by each sector when final demand vector is $[250 \quad 150 \quad 200 \quad 100 \quad 75]$.

Solution:

To calculate the indirect demand, we use the formula: indirect demand

= (I-A)^(-1) * D, where I is the identity matrix and D is the final demand vector.

Substituting the values into the formula, we get:

$$\text{Indirect demand} = \left(\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} - \begin{bmatrix} 0.2 & 0.3 & 0.1 & 0.2 & 0.1 \\ 0.3 & 0.1 & 0.2 & 0.2 & 0.2 \\ 0.1 & 0.2 & 0.2 & 0.3 & 0.2 \\ 0.1 & 0.1 & 0.2 & 0.1 & 0.5 \\ 0.2 & 0.4 & 0.1 & 0.2 & 0.1 \end{bmatrix} \right) \text{^ (-1) *} \begin{bmatrix} 250 \\ 150 \\ 200 \\ 100 \\ 75 \end{bmatrix}$$

After performing the calculations, the indirect demand generated by each sector is: $\begin{bmatrix} 362.5 \\ 296.875 \\ 309.375 \\ 78.125 \\ 379.688 \end{bmatrix}$.

Therefore, agriculture generates an indirect demand of 362.5, manufacturing generates 296.875, service generates 309.375, construction generates 78.125 and mining generates 379.688.

Example3:

In an economy, the Leontief input-output matrix representing the relationship between four sectors (agriculture, manufacturing, services, and construction) is given as:

$$A=\begin{bmatrix} 0.2 & 0.1 & 0.3 & 0.2 \\ 0.3 & 0.2 & 0.1 & 0.2 \\ 0.1 & 0.3 & 0.4 & 0.2 \\ 0.1 & 0.1 & 0.2 & 0.6 \end{bmatrix}.$$

Determine the total output generated by each sector if the final demand vector is $[200 \quad 300 \quad 150 \quad 100]$.

Solution:

Using the formula: output = (I-A)^(-1) * D, where I is the identity matrix and D is final demand vector.

We have

$$\text{Output} = \left(\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} - \begin{bmatrix} 0.2 & 0.1 & 0.3 & 0.2 \\ 0.3 & 0.2 & 0.1 & 0.2 \\ 0.1 & 0.3 & 0.4 & 0.2 \\ 0.1 & 0.1 & 0.2 & 0.6 \end{bmatrix} \right) \text{^ (-1) *} \begin{bmatrix} 200 \\ 300 \\ 150 \\ 100 \end{bmatrix}$$

After performing the calculations, the output generated by each sector is: $\begin{bmatrix} 125 \\ 200 \\ 75 \\ 100 \end{bmatrix}$.

Therefore, the agriculture generates an output of 125, manufacturing generates 200, service generates 75 and construction generates 100.

Example 4

In a different economy, the Leontief input-output matrix of a 5th order represents the relationships between five sectors (agriculture, manufacturing, services, construction, and mining) as:

$$A=\begin{bmatrix} 0.3 & 0.2 & 0.15 & 0.1 & 0.25 \\ 0.25 & 0.3 & 0.1 & 0.2 & 0.15 \\ 0.1 & 0.15 & 0.3 & 0.2 & 0.25 \\ 0.2 & 0.1 & 0.25 & 0.3 & 0.15 \\ 0.15 & 0.25 & 0.2 & 0.15 & 0.25 \end{bmatrix}$$

Calculate the indirect demand generated by each sector when the final demand vector is $[400 \quad 300 \quad 250 \quad 200 \quad 150]$.

Solution:

Using the formula: indirect demand = (I-A)^(-1) * D, where I is the identity matrix and D is the final demand vector.

We have,

$$\text{Indirect demand} = \left(\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} - \begin{bmatrix} 0.3 & 0.2 & 0.15 & 0.1 & 0.25 \\ 0.25 & 0.3 & 0.1 & 0.2 & 0.15 \\ 0.1 & 0.15 & 0.3 & 0.2 & 0.25 \\ 0.2 & 0.1 & 0.25 & 0.3 & 0.15 \\ 0.15 & 0.25 & 0.2 & 0.15 & 0.25 \end{bmatrix}\right) \text{^(-1)} * \begin{bmatrix} 400 \\ 300 \\ 250 \\ 200 \\ 150 \end{bmatrix}$$

After performing the calculations, the indirect demand generated by each sector is:

$$\begin{bmatrix} 426.847 \\ 389.122 \\ 458.122 \\ 395.548 \\ 465.366 \end{bmatrix}.$$

Therefore, agriculture generates an indirect demand of 46.847, manufacturing generates 389.122, service generates 458.122, construction generates 395.548 and mining generates 465.366.

Advantages of input-output analysis

The advantages of input-output analysis are given below:

- Holistic resources mapping: Holistic resource planning is one of the advantage of input output analysis. It goes beyond traditional resources tracking by providing a holistic map of interdependencies, revealing nuanced relationships that can be leveraged for strategic decision making.
- Dynamic Scenario planning: Another is dynamic Scenario, it allows for dynamic scenario planning, enabling businesses to stimulates and analyze the potential impacts of various changes in inputs or outputs, fostering adaptive strategies.
- Customized risk mitigation strategies: Input-output analysis can aid in crafting customized risk mitigation strategies by pinpointing vulnerable points in the production chain and allowing for proactive measures.
- Best utilization of resources: Input output analysis guide the way to allocate the available resources in the best way in order to achieve best output. It also provides the way to have best output within the available limited resources.
- Boots interrelationships: Input output analysis boots the relationship between the various sectors in an economy. It maintains strong relation among department of a business organization.

Conclusion

Todays, in the 21st century people are involving in their businesses in high range which lack all to have time but we all want to known the interrelationship as well as interconnection between various sectors in an economy. So, as mentioned in this report input output analysis acts as one of the powerful tool to perform effective decisions in business operations. It analyzes, determines, evaluates and selects the best output level for the available resources in an economy. It explains the relations between departments, sectors among the overall economy. In three sectors economy, there's we saw inputs and outputs relationships where demand for the consumer, investors, stakeholder and government can also be satisfied. It is useful to all levels of business, services, construction purpose as well as to government.

From this report, it can also be learned about Leontief's matrix method or open model of Leontief's. It helps to guide the solutions to the challenges of various problems faced by an economy. Although it has its limitations and assumption in which it is based but it is widely used in all over world and have a good perspective for it. Simply, in conclusion Input output analysis is an important tool in economy and it simplifies the complex relation between the sectors in an economy and lead to economic growth and development.

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