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Theoretical Background of Input-Output Analysis and its Application in Albania

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Abstract

The input-output (IO) method is widely used in economic analysis to understand the relationship between sectors of the economy. One of the major advantages of the IO method is its ability to capture the direct and indirect effects of different policies in one sector on other sectors of the economy. The IO table system is a crucial component of the European System of Accounts, a standardized framework for the production of European Union statistics on economic activities. Utilizing various mathematical techniques and methods, the IO analysis shows adaptability as a tool of analysis. In comparison to alternative methods, one of the primary benefits of the IO method is its flexibility in incorporating aggregate data. This enables researchers and policymakers to gain a more comprehensive understanding of the interrelationships between different sectors of the economy as well as the effects of different policies on multiple sectors of the economy. This paper examines several studies by different authors related to IO analysis, which use official data from IO tables across various countries to analyze the economy of a country, region, and global impact. This paper evaluates the limitations of the application of the IO method in Albania, considering the techniques of constructing symmetrical IO tables and the types of analyses conducted through these data.

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Keywords: Supply Use Table, Symmetric Input-Output Table, IO analyses, Application of IO analysis in Albania

1. Introduction

The majority of works using the IO method pay attention to current issues and concerns such as environmental pollution, income distribution, investments, employment, financial indicators, and international trade relations. The System of Input-Output table is an integral part of the European System of Accounts (ESA 2010). The IO method is commonly used to assess the effects of policies and economic cycles. The IO method has become a common analytical tool for resource allocation and income distribution, and its application is not limited only to the national level but also to the regional level. The tables consist of rows and columns that quantify cross-sector supply chains. The top of each row and column lists the industries, and the data in each column shows the level of inputs used in an industry's production function. The system of supply-use tables (SUT) reconciles national accounts by adjusting and equalizing statistical data from production, expenditure, or income sources. The foundation of the IO system is the compilation and balancing of SUT using current prices. The final product of the balancing process should be a set of fully balanced accounts with a single GDP result.

Baumol (2021) described the IO method as one of the greatest contributions to economics in the 20th century. In 1968, the United Nations published "System of National Accounts, Studies, and Methods," which integrated input-output tables into the system of national accounts and greatly improved empirical analysis of the economy. The System of National Accounts was further updated in 1993 and 2008 (SNA 1993 and 2008) to international standards. The concept of input-output tables was treated as a separate part in the European System of Accounts, 1995 ESA 1995, consisting of three main tables, with greater importance given to source-use tables. The European System of National Accounts, 2010, contains the most recent theoretical treatment related to these tables. Like every model, the I-O model has its advantages and disadvantages. The disadvantage could be considered the lack of links between primary factors, limitations, and final demand. At the same time, the conceptual simplicity of the matrix presentation makes it easy to analyze and describe the circulation of products and services between different industries. Also, the production of a branch of the economy is interdependent with the output of other sectors that use this product as a raw material in production processes, or this product uses products of other branches as raw material.

Using input-output analysis, changes in these linkages can be analyzed by examining how modifications in the demand or output of one industry affect the production and demand of other industries in the economy. This analysis helps to understand the effects throughout the economy caused by changes in a specific industry or sector. Studying changes in backward and forward linkages through input-output methods provides a comprehensive understanding of the interconnected nature of the economy, helping policymakers in decision-making, businesses identify opportunities for growth, and researchers analyze the overall economic structure and dynamics. In developed countries Environmental changes can be analyzed using input-output tables through the application of environmental input-output analysis. This approach focuses on assessing the environmental impact of economic activities and provides insights into resource use, energy consumption, emissions, and other environmental indicators associated with different sectors and final demand categories.

A linear equation should be used to describe the interdependence between sectors and countries, expressing the balance between total inputs and outputs for each good and service produced in a country's economy or in the input-output analysis of the global, regional, or national economy. Empirical studies have revealed that the evolution of technical coefficients is consistent with a stable information structure in the form of tables. The technical coefficients describe the production structure of each sector, quantifying the relationship between inputs and outputs. In analyzing sectoral links, the input-output table for domestic production is used, with attention given to the interdependence between domestically produced and imported inputs. This division allows for a more accurate assessment of economic effects, as locally produced inputs have a greater impact (Midcore et al., 2006).

The development of supply and use tables and symmetric input-output tables is a recent task for Albania's statistical practices, and INSTAT has taken up it under the IPA 2007 project. The first tables for supply, which use SUT at current prices for the years 2009–2011, and the derived symmetric input-output table (TSIO) for the year 2011 were published in February 2015. The source, uses, and input-output tables for the years 2012–2014 were compiled and published in 2016 and 2017. In accordance with Eurostat's methodology and requirements, the compilation and publication of these tables take place three years after the reference year (t+3) (Eurostat 2013).

2. Literature Review

According to the OECD guidelines, the input-output matrix is constructed based on the simple principle that goods and services produced by different sectors of the economy should be recorded in a table according to their origin and destination. When one sector purchases agricultural production from another sector, it is considered an input for the purchasing sector. This is known as intermediate demand, which refers to inter-industry transactions where goods and services are purchased from other firms and

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used in production (Yamano et al., 2006). On the other hand, products delivered for final consumption include purchases made by individuals for personal use, firms for investment (in fixed capital such as buildings, cars, etc., which is known as gross capital formation), the government, and foreign countries through exports. The use of the term "final demand" indicates that purchases made from this sector are not intended for use in production (Kodderitzsch, S. 1999).

Besides the intermediate inputs mentioned earlier, firms also use primary inputs, which are services not bought by other firms but by individuals. These services are known as factors of production and include wages and payments for labor services, interest paid for borrowing, rent paid for the use of equipment, buildings, and land, and profits paid for entrepreneurship, which is a function of organization and risk-taking (Common and Stagl, 2005). Furthermore, the matrix of imported intermediate products is also referred to as the imported input matrix (Sönmez, H. A. K. A. N. 2023).

The input-output method examines the relationships between industries and final demand in an economy. The static input-output system, which is based on the linear Leontief production function, was developed by Wassily Leontief and serves as the foundation for input-output analysis. As previously noted, input-output models are consistency models that are capable of assessing the primary aspects of interdependence between economic sectors and the effects of economic changes and external shocks. However, despite their longstanding use, analytical techniques that rely on input-output models have limitations that have been documented in research within this field.

The production functions of the industry are simple linear models that are based on final demand, and they do not consider changes in consumption patterns that may occur due to income changes. Furthermore, these models have limitations in their treatment of international trade, as they consider exports and final demand to be exogenous variables, and imports are not treated as being competitive. However, the analysis methodology of TIOs has evolved to the point where it has the potential to identify new modes of operation and physical variables that can be useful in solving a range of problems. This approach can also provide insights into physical processes that have not been analyzed extensively. As a result, methodological evolution can be employed to address problems that may not yet be fully understood (Ramsden, 1956).

The process of technical coefficient evolution is characterized by a gradual and consistent pace. While the coefficients may fluctuate based on specific factors, their transformation is so gradual that it will not have a significant impact on the fundamental structural models of input-output tables.

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As a result, the structural patterns that define the economy will remain relatively stable over extended periods of time (Szyrmer et.al., 1985).

Input-output analysts aim to achieve the highest degree of separation when constructing a fundamental transaction table. The demand-driven nature of these models disregards supply constraints, assuming that an increase in demand for a product will result in increased output, regardless of resource availability (Norbu, 2021). This suggests that the industry resource curve is perfectly elastic. These models exogenously determine prices and do not consider the impact of economic policies or external shocks on prices. The fixed coefficient assumption and fixed input structure assumption of I-O models are unrealistic as they do not account for technological advancements in various industries. Another limitation of these models is the lack of connection between primary factor constraints and final demand (Hellgate, (2008).

3. Theoretical Description of the Methodology

An input-output table is not an economic model in and of itself. Rather, it is an analytical representation intended to be as comprehensive as possible regarding the flows of goods and services that occur between actors within an economic system. When we begin from the premise that the economic system presented in the table is stationary, reproducing itself in the same manner year after year, and we assume that the labor force employed by each sector is fixed, as is the technical knowledge or technology that determines the necessary quantities of other goods to produce a certain good, we refer to it as a Leontief model, Parra, F (2020). The linear equation describes the balance between total inputs and outputs.

$$a_{11} X_1 + a_{12} X_2 + \ldots\ldots + a_{1n} X_n + Y_1 = X_1$$
$$a_{21} X_1 + a_{22} X_2 + \ldots\ldots + a_{2n} X_n + Y_2 = X_2$$
$$a_{n1} X_1 + a_{n2} X_2 + \ldots\ldots + a_{nn} X_n + Y_n = X_n$$

(1)

The underlying assumption of this model is that inputs are used in fixed proportions relative to output, and that changes in the prices of production factors do not affect the technical coefficients of inputs. The computation of the input matrix coefficients is expressed mathematically as follows:

$$a_{ij} = \frac{x_{ij}}{x_j}$$

(2)

as:

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a_{im} = correlation coefficients,
$xI\ j$ = output of branch "I" used in branch "j",
x_j = branch output.

Another method for calculating the coefficients is the matrix transformation of equation 2:

$$AX + Y = X \tag{3}$$

Matrix A is called matrix of input-output coefficients, vector X is the vector of output and vector Y is the vector of final demand.

$$X - AX = X$$
$$(I - A)\ X = Y$$
$$X = (I - A)\text{-}1\ Y \tag{4}$$

Where I is the unit matrix and *(I – A)-1* is the inverse matrix of *(I – A)* which is known as the Leontief matrix:

$$(I - A)^{-1} = \begin{bmatrix} 1 - a_{11} & -a_{12} \\ a_{21} & 1 - a_{22} \end{bmatrix} \tag{5}$$

Input-output models are based on the structure of inputs, which is represented by the matrix A and the inverse matrix $(I\text{-}A)^{-1}$. These matrixes form the foundation upon which input-output models are constructed. The input-output models are based on two matrices, matrix A and its inverse matrix $(I\text{-}A)^{-1}$, which reveal the inter-industry relationships and the impact of changes in final demand on production. Apart from Leontief demand-side models, another family of I-O models exists, which is based on production coefficients and was developed by Ghosh in 1958 (Ghosh, A. (1958).

The Leontief model is an analytical representation of an input-output table (IOT), which includes a symmetric input-output table, an internal intermediate consumption matrix (r), an inventory demand matrix, and a primary input matrix. The intermediate consumption matrix calculates the terms of trade between different branches of production, while the final demand matrix records the portion of goods and services produced that is intended for final users. The primary input matrix records the payments made by companies and administrations for the use of factors originating in production, such as labor income and business surplus (Wixted et al., 2006).

The matrix of primary inputs provides the added value of each branch, which is obtained by subtracting the total intermediate consumption from the value of production. Each element of the intermediate consumption matrix

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($x_{i,j}$) represents the consumption of the products of branch i that branch j makes. If this consumption comes from resident companies in the territorial reference area of the input-output table, it is referred to as "r," while those imported by non-resident units are referred to as "m." The output of a branch (X_j) is the sum of the elements appearing in each column, including intermediate consumption of resident units, imports, and value-added (V). The rows show the destinations of domestic production (X_j) and imports (M_j), which are intermediate demand (purchases made by other sectors) and final demand.

The I-O model aims to determine the production levels of each industry in order to meet a change in final demand, assuming that the structure of the economy does not change. The analysis of inter-industrial linkages is a crucial macroeconomic analysis that demonstrates the weight of each sector producing goods and services. This analysis is one of the central methods of macroeconomic modeling.

In addition to the link between industries and the matrix of coefficients, the input-output table analysis can calculate and analyze the following multipliers:

The production multipliers for a particular sector, denoted as "j," can be expressed as the aggregate value of the changes in production across all sectors of the economy required to produce a single unit of product j for final consumption. These multipliers, denoted as "Oj," are calculated as the sum of the coefficients in the inverse Leontief matrix. In other words, the production multipliers represent the indirect effects of changes in the production of a given sector on the wider economy.

$$O_j = \sum_1^n a_{ij}$$

Income multipliers, like output multipliers, are used to evaluate the effect of alterations in final demand on the income earned by households from employment. The equation that measures the direct and indirect demand for wages in one unit of output for final use is:

$$Z = B\,(I - A)^{-1}$$

B = vector of imputation coefficients for wages, I = unit matrix,
A = The matrix of coefficients for intermediate consumption imputation
Z = vector with direct and indirect results of wage demand.

Employment multipliers are calculated using coefficients of physical labor inputs. They show direct and indirect labor demand as a result of changes in final demand. Employment multipliers are calculated using the following equation:

$$Z = E(I - A)^{-1}$$

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E = matrix of input coefficients of work (physical number of people per million ALL output),
Z = matrix with direct and indirect results of labor demand (physical number of employees).
Forward and Backward Links are two very important indicators. In the input-output analysis and system, increasing output from a given industry has two effects on

$$BL^{CW}{}_{j} = \sum_{1}^{n} a_{ij}$$

$BL^{CW}{}_{j}$ means the attractive links of the sector j,

$$O_j = \sum_{1}^{n} a_{ij} \qquad BL^{CW}{}_{j} = \sum_{1}^{n} a_{ij}$$

where:
a_{im} is the matrix of input coefficients is represented by the symbol A.
The CW thrust connections are equal to the row-wise sum of the matrix of output coefficients, matrix B. The CW thrust connections for sector I are defined as:

$$FL^{CW} i = \sum_{1}^{n} b_{ij} \tag{10}$$

where:
$FL^{CW}{}_{i}$ means the sector's driving ties I,
b_{ij} means the output coefficients of sector I in the sector j.
To analyze key sectors of the economy, are used normalized forward and backward linkages, which are calculated using the following formulas: when industry j increases production, it requires more inputs from both itself and other related industries.

4. Limitations and results of the Input Output method (case of Albania)

One of the limitations of IO analysis has been its static nature. Regarding reference years 2012 and 2015, for these years we had the IO table and static technical coefficients. This inconvenience was solved by elaborating the IO table every year to make dynamic modeling possible. However, in Albania, this inconvenience continues to exist because of the type of model used to construct symmetric input and output tables. The construction of input-output tables necessitates the classification of economic activities into sectors. This process involves aggregating economic activities into sectors in order to facilitate analysis. However, this aggregation procedure may introduce a trade-off by sacrificing detailed information, which can impede the comprehension of specific sub-sectors or industries. Furthermore,

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constructing input-output tables is a time-intensive undertaking that demands periodic updates to account for evolving economic conditions. Limitations arise from the assumptions made during the construction process, such as the adoption of constant technical coefficients or fixed relationships between sectors. These assumptions may fail to accurately represent the dynamic nature of the economy, thereby imposing restrictions on the analysis and policy implications derived from the input-output tables (Humbatova, & Hajiyev, 2020).

Environmental measures with insignificant economic impact may not be effectively captured by input-output (I-O) analysis. Therefore, I-O analysis is usually most applicable to actions that have a significant economic influence, such as constructing large infrastructures, altering port activities, or enacting environmental policies that target complete sectors, sub-sectors, or branches of economic activities (Alsamawi et al., 2017).

However, I-O analysis can also be useful for evaluating the collective impact of several policies, each of which may have a relatively small impact but whose combined effect could significantly impact the economy of a country or region. In addition to these limitations (Pearson, 1989).

The incorporation of demand changes resulting from price fluctuations should be included in I-O models, but this may increase the complexity of the model due to the presence of multiple products and/or different response functions. I-O matrices offer a static representation of the economy, making projections challenging. Nevertheless, dynamic I-O matrices can be developed, although this requires more advanced techniques (Christ, 1955). Additionally, I-O tables are typically released by national and regional authorities with a considerable time lag, sometimes spanning several years. The use of absolute data for I-O analysis is likely to yield erroneous findings for subsequent years. Nonetheless, techniques for updating dated I-O matrices do exist. Additionally, in situations where regional analysis is deemed necessary, the absence of regional I-O tables and solely national I-O tables poses yet another limitation, requiring the implementation of regionalization techniques. This requirement adds a layer of complexity to the analysis, warranting further attention (Lenzen et al., 2013).

Proper interpretation and utilization of input-output tables require a comprehensive understanding of their inherent limitations and assumptions. Users must exercise caution when drawing conclusions and formulating policy decisions based on the results obtained from input-output analysis, taking into consideration the constraints associated with the construction process. Despite these limitations, it is important to acknowledge the enduring value of input-output tables as an analytical tool that facilitates the comprehension of interconnections within an economy and informs policy discussions (Joghee, 2020).

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Regarding the Albanian case, I-O analysis is limited because of the data provided by INSTAT. The employment database should be in a vector matrix divided by 35 industries, just like the input-output symmetric table. In this case, we cannot calculate the employment multiplier, and so we are not able to identify the impact of the change in employment in one sector on the other sectors and the impact on the economy.

Recommendation for INSTAT should implement different databases for employment and gas emissions regarding the classification of national accounts to expand the level of analysis that researchers could do with the data provided by this institution by using input-output analysis. At this level, even Albania has the possibility of taking an approach with EU countries using input-output analysis for better implementing policies and economic growth. Emission of O2 from different industries is another missing piece of information regarding the interindustry impact of pollution when demand or production changes. Also, because the because the Albanian economy is small and highly dependent on imports, the multiplier effect for a given sector may be overestimated.

There are still missing analyses for the case of Albania related to the input-output tables. In relation to other countries, these analyses are also related to the indicators of employment and the environment, giving a clearer and more complete picture of the impacts that the sectors give on each other and on the economy. In Albania, this analysis is limited to only five basic analyses related to backward and forward linkages, Le Masne, simulations, vertical integration of products, and graphs (Duarte et al., 2011).

Conclusions

This paper presents a literature review on the use of the IO symmetric tables for the inter-branch connections of the different economies.

Empirical studies have revealed that the evolution of technical coefficients is consistent with a stable information structure in the form of tables. Recent developments in the field of IO analysis involve empirical analyses that address various issues related to globalization phenomena.

When examining the relationships between different industries, analysts utilize the domestic production input-output table, which focuses on the interconnectedness between domestically produced inputs and those that are imported. Input-output matrices provide a useful solution to different problems, as they take into account both direct and indirect effects. This is particularly valuable when assessing the economic impact of policy changes, both ex-ante and ex-post. Furthermore, the impact on the environment can also be analyzed by incorporating environmental data into the classic input-output tables, thus creating green I-O tables. By analyzing the tables, it is possible to determine how the production of goods and services affects carbon emissions,

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water consumption, and waste generation. Additionally, it can be used to identify the sectors that have the most significant environmental impact and target environmental policies accordingly. Input-output (I-O) analysis is not only beneficial in assessing the economic effects of individual policies but also in evaluating the cumulative impact of multiple policies. While individual policies may have minimal effects, the collective impact of several policies could substantially influence the economy of a country or region. By using I-O analysis to model the impacts of these policies, researchers and policymakers can gain insights into how they could interact to affect the economy's performance. Furthermore, I-O analysis can be useful in determining the optimal combination of policies that would yield the greatest economic benefit. By analyzing the interactions between different policies, I-O analysis can identify policies that complement one another and those that could lead to unintended consequences. Moreover, I-O analysis can be used to forecast the long-term economic impact of policy changes. By simulating different scenarios and analyzing their economic effects, policymakers can make informed decisions on which policies to adopt, modify, or discard. In summary, I-O analysis is a powerful tool for evaluating the collective impact of policies and predicting their economic effects. By providing insights into how different policies interact, I-O analysis can inform policymaking and help promote sustainable economic growth. The author summarizes various uses of I-O analysis.

INSTAT should implement different databases for employment and gas emissions regarding the classification of national accounts to expand the level of analysis that researchers could do with the data provided by this institution by using input-output analysis. At this level, even Albania has the possibility of taking an approach with EU countries using input-output analysis for better implementing policies and economic growth.

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