Concepts and Methods of the U.S. Input-Output Accounts: observations and comments

An important method for measuring the Economy of the USA

Methodology and Data from
BEA – Bureau of Economic Analysis – U.S. Department of Commerce

The Concepts and Methods of the Input-Output Accounts are originally obtained through the studies of Drs. Karen J. Horowitz and Mark A. Planting

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Initial Presentation

The "Input-Output Handbook" describes very relevant methodologies directly related to the calculus and projection of the Input-Output Matrix. The concepts and methodologies that underlie and represent the basics of the preparation of the construction and benchmark input-output (I-O) accounts of the United States are presented there in details.

The methodology in the handbook are first of all and primarily based on the 1997 benchmark accounts, Thus, the handbook is intended to be a effectively a living reference of National Accounts.

An Input-Output Matrix, or IOM, presents an essential economic relation, depicted initially by the French economist Jean Baptiste say of the XVIII the century, through his well know table an Economique.

An Input-Output Matrix uses a mathematical frame to put in order and establish through total values, percentages and technical coefficients the relationship between inputs and outputs.

That is to say, the Input-Output Matrix look first to "from here are coming and which are" the factors of production, to then present "in what are used these factors and what's their production" or final output,

In macroeconomics, we tend to define and identify five factors of production, or inputs. They are in a classical denomination:

1- **Raw Materials** – land, earth – it includes minerals, waters, plains, forests and similar (T)
2- **Labor** – the workers' effort, action and period of time, to empreend and economic activity, with effects on the transformation of raw materials (L)
3- **Capital** – Financial resources (K)
4- **Entrepreneurial and Managers Talents** – with them we are able to promote the combination the coordination and the command of the others factors of production, frequently with efficient, looking for the best practices, high productivity and innovate creations (E) and,

5- **Time** – since it is through time that activities, works, productions and transformations are made, in seed of societies demands for products and services (T).

After the identification of the factors of production, we need a production function (Y). Normally it can be established as follows a combination of factors of production generates a final or intermediary production.

$$y = f (T, L, K, E, t)$$

This y function f combines all five factors of production. A synthetic, traditional function considers just two or three factors, such as functions f' and f'':

$$y' = f' (T, L)$$

$$y'' = f'' (T, L, K)$$

With the consideration of substitutability among factors, technical coefficients of production (B) appear and relate them. The Cobb-Douglas function is widely used in agricultural production functions and can be describe as follows:

$$y'''_{CD} = \alpha \cdot T^{\beta} \cdot L^{1-\beta}$$

1 - Comments on chapter 1: Overview of the U.S. Input-Output Accounts – what enters (factors of production and what is produced (final goods and service)

The U.S. input-output (I-O) accounts are a primary component of the U.S. economic accounts.

"The fundamental aim of national economic accounting is to provide a coherent and comprehensive picture of the nation's economy, to answer two questions. First, what is the output of the economy—its size, its composition, and its use? Second, what is the economic process or mechanism by which this output is produced and distributed?"

Specifically, the I-O accounts provide:

• A set of data on the nation's economy that are closely related to the statistics collected by business—for example, sales and cost of sales;

• Information on the output of the economy by industry;

• A consistent set of measures, or accounts, for all sectors of the economy;

• A cross check for the variety of data used to estimate the national accounts;

• A cross check for the product and income accounts; and

• Estimates of final consumption that incorporate the best information available and that are in balance with industry output and inputs.

Input-Output matrixes provide a whole vision of what the economy has at disposition to produce; is able with its ability to produce; and is capable to merchandising internally in the country as well as externally, for purposes of international trade.

2 -Fundamental I-O principles

The preparation of the I-O accounts is a complex process that involves the collection and integration of data from a variety of sources in a way that provides a meaningful picture of economic activity.

1. Under the principle of homogeneity, each industry's output is produced using a unique set of inputs.
2. Under the principle of proportionality, the ratio of each input to one unit of output remains constant over a wide range of output levels.
3. Under the principle of consistency, economic statistics are organized and presented in a uniform manner.

3 - Early history

In the 1930s and 1940s, Nobel laureate Wassily W. Leontief developed I-O tables as a tool for economic analysis and created the first modern-day I-O tables for the United States.

Leontief's I-O model was partly inspired by the Walrasian (Leon Walras, 1834-1910) analysis of general equilibrium via interindustry flows, which in turn was inspired by Quesnay's (Francois Quesnay, 1694-1774) Tableau Economique. Leontief's I-O model recognized that the object of economic activity is the satisfaction of final demand. In the I-O system, final demand (household consumption, government consumption and investment, private investment, and exports) is assumed to be determined by outside factors, so the system is called an "open model."

As Leontief stated, "Input-output analysis is a practical extension of the classical theory of general independence which views the whole economy of a region, a country, and even the entire world as a single system and sets out to describe and to interpret its operation in terms of directly observable basic structural relationships."

4 - Classification and accounting systems

Industry classification systems are essential tools for the development of I-O tables. The early I-O tables prepared by BLS and BEA were based on the Standard Industrial Classification (SIC) system, which dates back to 1941.

I-O table is released in 2007, it will be more closely integrated with the GDP-by-industry accounts.

In 2004, BEA and the Census Bureau initiated programs to begin collection of annual expense data for industries. These new data will enable improvements to the estimates of value added by industry.

In 2005, BEA began exploring the conversion of the currently published make and use tables to the basic value supply and use tables format recommended by the 1993 SNA.

In the future, the I-O framework will continue to play a vital role in economic analysis and development, and the detail and content of the I-O tables will need to change to keep pace with the ever-evolving U.S. economy.

Improvements in the I-O tables will also reflect progress in three interrelated areas. First, technological advancements will enable faster and more accurate analysis of highly complex data sets. Second, more comprehensive surveying techniques will facilitate higher quality data and greater information detail. Third, the integration of an international template for I-O reporting will facilitate international comparisons.

Table 1 - Make Table: Industries producing commodities

INDUSTRIES \ COMMODITIES	Agriculture, forestry, fishing and hunting	Mining	Utilities	Construction	Manufacturing	Wholesale trade	Ratail trade	Transportation and warehousing	Information	Finance, insurance, real estate, rental, and leasing	Professional and business services	Educational services, health care, and social assistance	Arts, Entertainment, recreation, accomodation, and food services	Ohter services, except governments	Government	Other	Scrap, used and second-hand goods	TOTAL INDUSTRY OUTPUT
Agriculture, forestry, fishing and hunting	■																	
Mining		■																
Utilities			■															
Construction				■														
Manufacturing					■													
Wholesale trade						■												
Ratail trade							■											
Transportation and warehousing								■										
Information									■									
Finance, insurance, real estate, rental, and leasing										■								
Professional and business services											■							
Educational services, health care, and social assistance												■						
Arts, Enterttainment, recreation, accomodation, and food services													■					
Ohter services, except governments														■				
Government															■			
TOTAL COMMODITY OUTPUT																		

Total Industry output
Total commodity output
Primary product of the industry

Table 1.2 - Make Table: Industries producing commodities

	INDUSTRIES																FINAL USES (GDP)							TOTAL COMMODITY
	Agriculture, forestry, fishing and hunting	Mining	Utilities	Construction	Manufacturing	Wholesale trade	Ratail trade	Transportation and warehousing	Information	Finance, insurance, real estate, rental, and leasing	Professional and business services	Educational services, health care, and social assistance	Arts, Enterttainment, recreation, accomodation, and food services	Ohter services, except governments	Government	Total Intermediate	Personal consuption expenditures	Private fixed investment	Change in private inventories	Exports of goods and services	Imports of goods and services	Government consumption expenditures and gross	Total Final Uses (GDP)	
Agriculture, forestry, fishing and hunting																								
Mining																								
Utilities																								
Construction																								
Manufacturing																								
Wholesale trade																								
Ratail trade																								
Transportation and warehousing																								
Information																								
Finance, insurance, real estate, rental, and leasing																								
Professional and business services																								
Educational services, health care, and social assistance																								
Arts, Enterttainment, recreation, accomodation, and food services																								
Ohter services, except govern-ments																								
Government																								
Other																								
Scrap, used and secondhand goods																								
Total Intermediate																								
Compensation of employees																								
Taxes on production and imports, less subsidies																								
Gross operating surplus																								
Total Value Added																								
Government																								
TOTAL INDUSTRY OUTPUT																								

COMMODITIES

Value Added

☐ Total industry output
■ Total Commodity output

Source: U.S. Bureau of Economic Analysis of the U.S. Department of Commerce

5 – Comments on CHAPTER 3: DATA SOURCES

The benchmark input-output (I-O) accounts are prepared by incorporating a vast amount of information from a wide variety of sources. This chapter leads with a discussion of the primary I-O data source, the Economic Census, which is conducted once every 5 years by the U.S. Bureau of the Census. It then describes source data from other Census Bureau programs and concludes with descriptions of several other important data sources.

5.1 - The universe of Census – Number and Value of Organizations

In order to understand the most important coverage that are made in transiting from the Census data to the I-O tables understanding a comprehensive "universe" (mailing list or directory) of businesses to canvas. The Economic Census uses a centralized, multipurpose, computerized data file of U.S. business establishments and companies that includes both those with employees and payrolls and those without employees and payrolls (nonemployers). This list, now called the Business Register, first became operational as the Standard Statistical Establishment List (SSEL) for data year 1974. "Businesses" are legal or administrative entities that are assigned an employer identification number (EIN) by the Internal Revenue Service (IRS). For the 1997 Economic Census, the Business Register included over 19 million businesses—180,000 multi-establishment companies with about 1 1/2 million affiliate establishments, 5 million single-establishment companies, and nearly 14 million nonemployer businesses.

The Business Register also uses information from the Social Security Administration (SSA) and the Bureau of Labor Statistics to develop the mailing list for the Economic Census.

5.2 - Report forms and sampling

The 1997 Economic Census covered over 14 million establishments.

The 1997 Economic Census report on *Nonemployer Statistics* shows about 10.8 million service establishments (employer and nonemployer) in the services industries.

Table 3.B Principal Data Sources for Industry or Commodity Outputs, 1997 Benchmark I-O Accounts

INDUSTRY OR COMMODITY	SOURCE
FINANCIAL ACTIVITIES	Census Bureau, 1997 Economic Census, NAICS Sector 52, Finance and Insurance Census Bureau, 1997 Economic Census, NAICS Sector 53, Real Estate and Rental and Leasing Federal Deposit Insurance Corporation, 1997 Statistics on Banking Federal Reserve Board, 1997 Annual Report National Credit Union Administration, 1997 Yearend Statistics for Federally Insured Credit Unions Internal Revenue Service, 1997 Statistics of Income, Corporation Source Book, 1997 New York Stock Exchange, 1998 Annual Report Securities and Exchange Commission, 1997 FOCUS Report and 1997 Annual Report Health Care Financing Administration, 1997 Private Health Insurance Data A. M. Best and Company, Best's 1997 Aggregate and Averages Property/Casualty Insurance Mortgage Insurance Companies of America, 2001 - 2002 Factbook U.S. Department of Labor, Pension Welfare Benefits Administration, 1997 Income Statement of Pension Plans with 100 or More Participants American Council of Life Insurers, 1997 Life Insurance Fact Book Bureau of Economic Analysis, National Income and Product Accounts
PROFESSIONAL AND BUSINESS SERVICES	Census Bureau, 1997 Economic Census, NAICS Sector 54, Professional, Scientific, and Technical Services Census Bureau, 1997 Economic Census, NAICS Sector 55, Management of Companies and Enterprises Census Bureau, 1997 Economic Census, NAICS Sector 56, Administrative and Support Services and Waste Management and Remediation Services Census Bureau, 1997 Service Annual Survey
EDUCATION AND HEALTH SERVICES	U.S. Department of Education, National Center for Education Statistics, 2000 Digest of Education Statistics Census Bureau, 1997 Economic Census, NAICS Sector 61, Educational Services Census Bureau, 1997 Economic Census, NAICS Sector 62, Health Care and Social Assistance Census Bureau, 1997 Service Annual Survey
LEISURE AND HOSPITALITY	Census Bureau, 1997 Economic Census, NAICS Sector 71, Arts, Entertainment, and Recreation Census Bureau, 1997 Economic Census, NAICS Sector 72, Accommodation and Food Services Census Bureau, 1997 Service Annual Survey
OTHER SERVICES	Census Bureau, 1997 Economic Census, NAICS Sector 81, Other Services (except Public Administration) Bureau of Economic Analysis, National Income and Product Accounts Census Bureau, 1997 Service Annual Survey
GOVERNMENT INDUSTRIES	Census Bureau, 1997 Census of Governments Census Bureau, 1997-98 Government Finances Census Bureau, 1996-98 Public Employment Census Bureau, 1997 Monthly Construction Statistics Federal Budget Data and Federal Government Agency Reports Center for Medicare and Medicaid Services Bureau of Economic Analysis, National Income and Product Accounts
NONCOMPARABLE IMPORTS	Bureau of Economic Analysis, International Transactions Accounts

Source: U.S. Bureau of Economic Analysis of the U.S. Department of Commerce

6 – Comments on CHAPTER 5: OUTPUT

There are several works for production. Among them, we cite production supply, delivery and output.

The principal measure of output in the input-output (I-O) accounts is gross output, which includes the value of both intermediate product and final product.

The input-output (I-O) accounts show the value of what is produced by each industry (the make table) and the value of what is consumed by each industry and final user in the economy (the use table). Gross output, the principal I-O measure of output, consists of both the value of what is produced and then used by others in their production processes—that is, intermediate product—and the value of what is produced and sold to final users—that is, final product.

For the 1997 benchmark I-O, the sum of industry output was $14.9 trillion, while the sum of value added was $8.3 trillion.

6.1 - Defining output

Output can be understood as total production or total supply of goods and services.

In order to measure gross output and GDP, national economic accountants have to define "the production boundary"—that is, they have to determine the parts of the myriad of human activity that are to be included in and excluded from the measure of production in the economy. Most production takes place in the business sector and is distributed in the market economy.

The business sector includes corporate and noncorporate private entities organized for profit and certain other entities that are treated as business (mutual financial institutions, private noninsured pension funds, cooperatives, nonprofit institutions that primarily serve business, Federal Reserve Banks, federally sponsored credit agencies, and government enterprises).

Outside of the business sector, output includes households (measured as the compensation paid to domestic workers), nonprofit institutions that primarily serve individuals (measured as their operating expenses), and general government (measured as operating expenses—that is, compensation of employees, consumption of fixed capital, and current-account purchases of goods and services).

Output can be "market" or "nonmarket." Market output is produced by establishments that sell all or most of their output. Nonmarket output is produced by establishments that typically provide their services free of charge or for prices that are not economically meaningful.

Own-account also includes the value of housing services produced by owner-occupiers and the value of food produced and consumed by subsistence farmers.

Two human activities are excluded from the gross output measure for practical reasons—they are difficult or impossible to measure. First, illegal activities, such as gambling and prostitution in some states, are excluded because they are by their very nature conducted out of sight of public scrutiny, and thus, data are not available to measure them. Second, most activities in the home—such as housework, hobbies, and do-it-yourself projects—are excluded because of the lack of data to measure them and because of the difficulty in assigning a value to the output.

Certain natural processes may be included in or excluded from production, depending upon whether they are under the ownership or control of an entity in the economy. For example, the fish that are living in the ocean are not counted as part of the economy until they are caught, but the growing of fish in fish farms is part of economic activity. Similarly, the growth of uncultivated forests is not part of production, but the harvesting of trees is included.

Some chapters are not commented or analyzed in this brief article, since they have others purposes, different for those we are looking for. Our main focus remains on total production.

APPENDIX TO CHAPTER 8

Table 8.A - Major Commodity Taxes and Industries Collecting the Taxes, 1997 Benchmark Input-Output Accounts (Page 1 of 2)

I-O INDUSTRY	INDUSTRY DESCRIPTION	TAX DESCRIPTION	1997 TAX (MILLIONS)
FEDERAL EXCISE TAXES BY INDUSTRY			
339920	Sporting and athletic goods manufacturing	Federal tax on bows and arrows	23
339920	Sporting and athletic goods manufacturing	Federal tax on fishing equipment	84

Table 8.E Sample of Retail Product Lines

PRODUCT LINE	DESCRIPTION
0163	Vitamins, minerals, and other dietary supplements
0164	Health aids (including first-aid, foot, and eye/contact lens care products; prescription access; convalescent aids; orthopedic equip; artificial limbs)
0169	All other drugs and health & beauty aids (including prescription and nonprescription drugs, etc)

Table 8.G Retail Category Codes, 1997 Benchmark Input-Output Accounts

RETAIL CATEGORY CODE	DESCRIPTION
1112	Recreational vehicles and trailers
2030	Shoes and other footwear
2051	Men's and boys' clothing and accessories
4110	Boats
4130	Toys, sport supplies, and sporting equipment (including guns)
4150	Bicycles and motorcycles

Source: U.S. Bureau of Economic Analysis of the U.S. Department of Commerce

7 – Some comments on CHAPTER 10: RECONCILIATION OF FINAL USES

Input-Output (I-O) estimates of gross domestic product and its final-use components must be reconciled with their counterparts in the national income and product accounts (NIPAs).

In the I-O accounts, final uses are estimated as part of the process of creating the use table.

The benchmark I-O accounts are considered the single most important source for the 5-year comprehensive revisions of the national income and product accounts (NIPAs).

Thus, the levels of GDP and its major components that are published in the benchmark I-O accounts are used as the basis for the "preliminary revised NIPA estimates" that provide the first look at the impact of the forthcoming comprehensive revision.

8 – Some brief comments on CHAPTER 12: INPUT-OUTPUT

MODELING AND APPLICATIONS

The input-output (I-O) accounts consist of a set of tables that provide a detailed model of the interworkings of the U.S. economy and that provide tools for analyzing these interworkings.

Mathematical Derivation of the Total Requirements Tables for Input-Output Analysis [25]

We maintain the traditional symbol, which are intended to be universal, as well as their definitions.

q: A column vector in which each entry shows the total amount of the output of a commodity. It is a commodity-by-one vector.

g: A column vector in which each entry shows the total amount of each industry's output, including its production of scrap. It is an industry-by-one vector.

U: Intermediate portion of the use matrix in which the column shows for a given industry the amount of each commodity it uses—including noncomparable imports, scrap, and used and secondhand goods. This is a commodity-by-industry matrix.

V: Make matrix, in which the column shows for a given commodity the amount produced in each industry. This is an industry-by-commodity matrix. V has columns showing only zero entries for noncomparable imports and for scrap.

^: A symbol that when placed over a vector indicates a square matrix in which the elements of the vector appear on the main diagonal and zeros elsewhere.

B: Direct input coefficients matrix in which entries in each column show the amount of a commodity used by an industry per dollar of output of that industry. This is a commodity-by-industry matrix.

$$B = U\hat{g}^{-1} \quad (1)$$

D: A matrix in which entries in each column show, for a given commodity (excluding scrap), the proportion of the total output of that commodity produced in each industry. D is an industry-by-commodity matrix. D is also referred to as the market share matrix.

$$D = V\hat{q}^{-1} \ (\,2\,)$$

i: Unit (summation) vector containing only l's.

I: Identity matrix, where $I = \hat{i}$.

e: A column vector in which each entry shows the total final demand purchases for each commodity from the use table.

h: A column vector in which each entry shows the total amount of each industry's production of scrap. Scrap is separated to prevent its use as an input from generating output in the industries in which it originates.

p: A column vector in which each entry shows the ratio of the value of scrap produced in each industry to the industry's total output.

W: An industry-by-commodity matrix in which the entries in each column show, for a given commodity, the proportion of the total output of that commodity produced in each industry adjusted for scrap produced by the industry. W is referred to as the transformation matrix.

From the above definitions, the following identities are derived:

$$q = Ui + e \ (\,3\,)$$

$$g = Vi + h \ (\,4\,)$$

Scrap output in each industry is proportional to total output of the industry, then:

$$h = \hat{p}g \, (\,5\,)$$

The model expressed in equations (1) through (5) thus involves three constants (*B, D, p*) and six variables (*U, V, h, e, q, g*).

Commodity-by-commodity total requirements matrix:

$$(I - BW)^{-1}$$

Shows commodity output required per dollar of each commodity delivered to final users.

Industry-by-commodity total requirements matrix:

$$W(I - BW)^{-1} \quad (13)$$

which shows the industry output required per dollar of each commodity delivered to final users.

And the industry-by-industry total requirements matrix:

$$(I - WB)^{-1}$$

Shows the industry output required per dollar of each industry product delivered to final users.

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[25] The notation and derivation of the tables presented here follow those recommended by the United Nations in the *System of National Accounts*. See *A System of National Accounts Studies in Methods*, Series F No. 2 Rev. 3, United Nations, New York, 1968; see also R. Stone, M. Bacharach, and J. Bates, "Input-Output Relationships, 1951-1966," *Programme for Growth*, Volume 3, London, Chapman and Hall, 1963.