ACE155

Life Cycle Analysis

Input-Output method

Leonardo Rosado

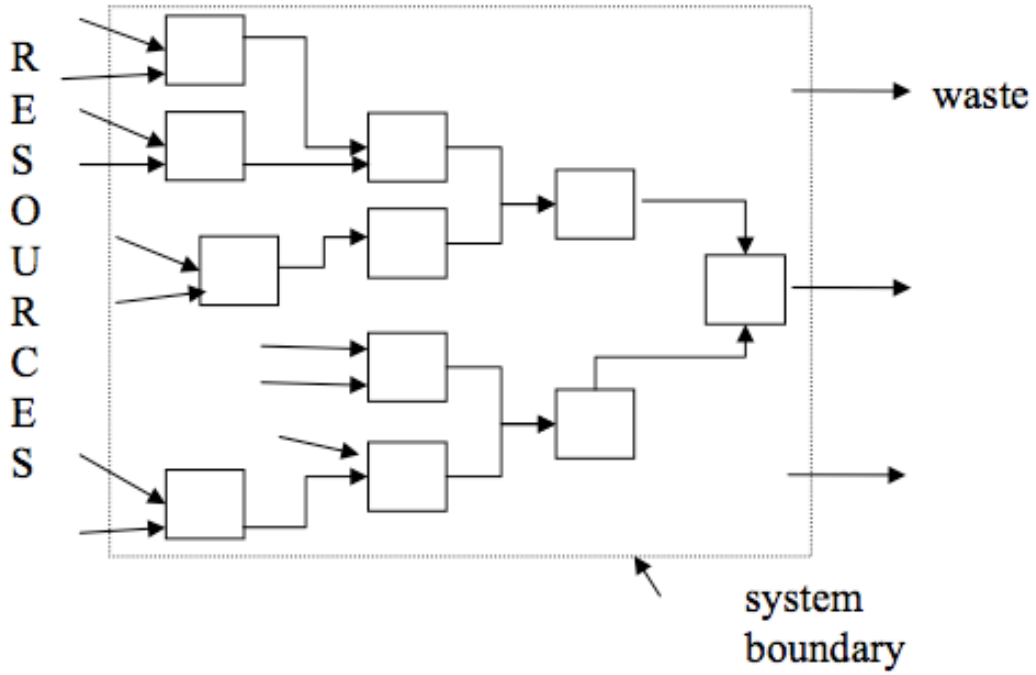
Supported by Circu-Mat project from European Institute of Innovation & Tecnhology - Raw Materials KIC

Economic Input-Output Analysis

"General interdependency" model: quantifies interrelationships among sectors of an economy

Identifies direct and indirect economic inputs of purchases

Can be extended to environmental and energy analysis



Circularity effects in the economy must be accounted

cars are made from steel, steel is made with iron ore, coal, steel machinery, etc. Iron ore and coal are mined using steel machinery, energy, etc...

Total demand = intermediate demand + final demand

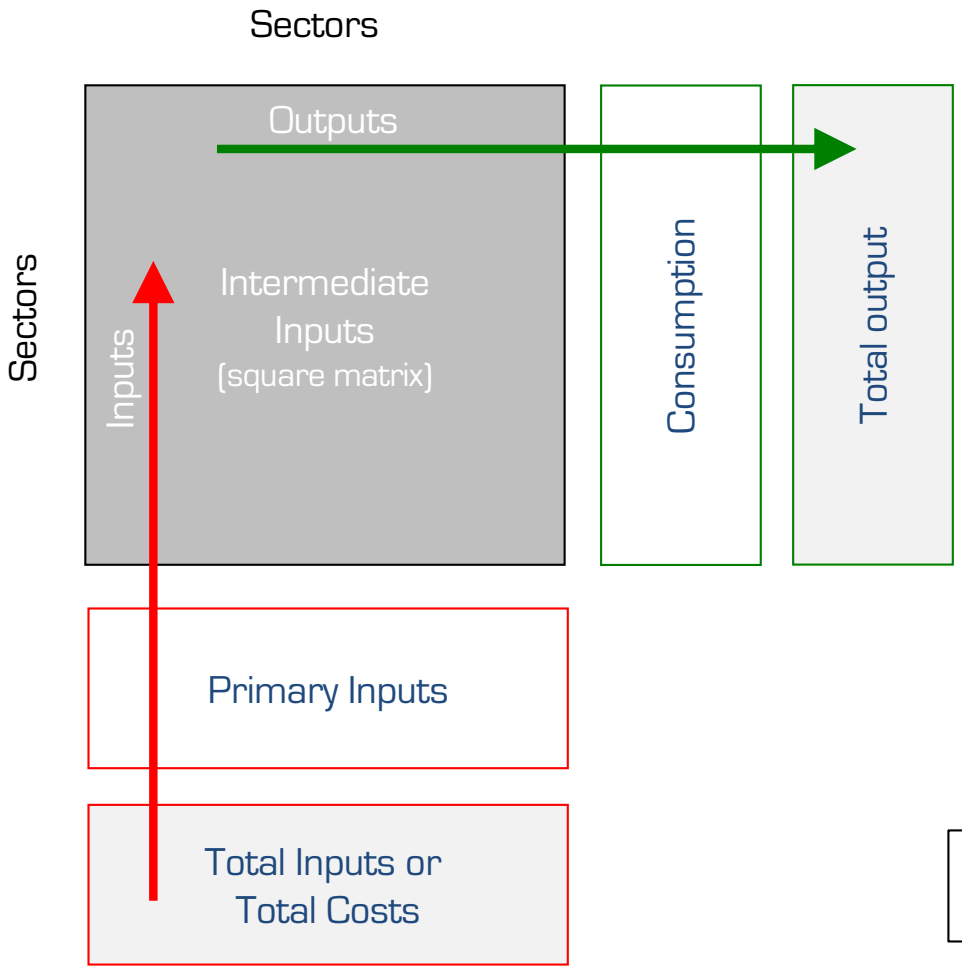
The basic distinction that is made in input-output analysis is between the demand for goods and services sold to 'Final Demand' (households, governments, exports, investment), and the 'Total Demand' in the various sectors, resulting from the direct impact of final demand, and the indirect impacts resulting from inter-industry trading (intermediate demand).

For instance, almost no iron and steel products are sold directly to domestic consumers (final demand), but a great deal is sold embedded in manufactured goods, such as cars and washing machines

Building an IO model 1/2

- Divide the economy into sectors (Note: could extend to households or virtual sectors)
- Survey industries: Which sectors do you purchase goods/services from and how much? Which sectors do you sell to?
- Construct 'Make' and 'Use' Table Data –purchases and sales of particular sectors. (Note: need to reconcile differing reports of purchases and sales, for example to avoid double counting)
- Form Input-Output Transactions Table –Flow of purchases between sectors.

IO conceptual model

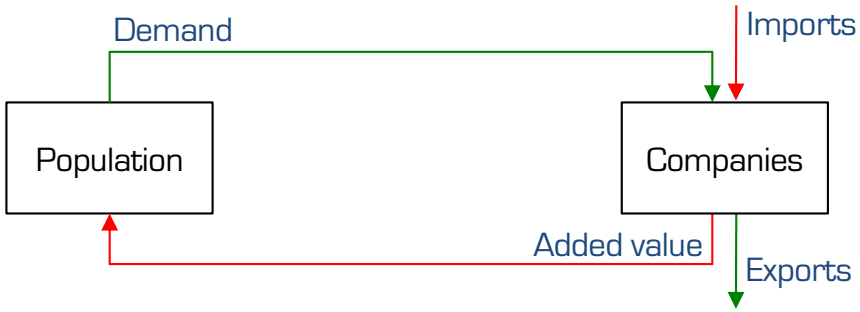


Primary Inputs:

- Intermediate inputs
- Added value (salaries, profits, ...);
- Imports;

Consumption:

- Demand (families, government);
- Exports



Building an IO model 2/2

- Sum of Value Added (non-interindustry purchases) and Final Demand is GDP.
- Transactions include intermediate product purchases and row sum to Total Demand.
- From the IO Transactions Model, form the Technical Requirements matrix by dividing each column by total sector input –matrix A. Entries represent direct inter-industry purchases per monetary unit of output.

Purpose of economic IO

- One of the main uses of input-output analysis is to display all flows of goods and services within an economy, simultaneously illustrating the connection between producers and consumers and the interdependence of industries.
- An advantage of input-output tables is that economic components, such as income, output and expenditure, are presented in a consistent framework reconciling the discrepancies between the estimates of these components.

Mathematical formulation of the IO Model 1|3

S_{ij}
Matrix of the intermediate Input

Y_i
Vector of final consumption

	Intermediate Input			+	Final demand		=	
	Sector 1	Sector 2	Sector 3		Exports	Consumption		Total output
Sector 1	S11	S12	S13		E1	C1		TO1
Sector 2	S21	S22	S23		E2	C2		TO2
Sector 3	S31	S32	S33		E3	C3		TO3
+								
Added value	VA1	VA1	VA1					
Imports	I1	I2	I3					
=								
Total input	TI1	TI2	TI3					

$$\Sigma S_{ij} + Y_i = X_i$$

X_i
Vector of total output

How would this economy react to an unitary increase of the final demand in Sector 1?

IO model components

- $\boldsymbol{S}$ intermediate input matrix (€)
- $\boldsymbol{Y}$ final consumption matrix (€)
- $\boldsymbol{w}$ factor inputs vector (€)
- $\boldsymbol{x}$ total output vector (€)
- $\boldsymbol{e}$ emissions vector (ton CO2 eq)
- $\boldsymbol{A}$ technical coefficients matrix (€ / €) – direct requirements matrix
- $\boldsymbol{L}$ Leontief inverse matrix (€ / €) – total requirements matrix
- $\boldsymbol{B}$ emission coefficients matrix (ton CO2 eq/ €)

Notation for vector uses the small letter i.e. $\boldsymbol{w}$, $\boldsymbol{e}$, $\boldsymbol{y}$, $\boldsymbol{b}$

Mathematical formulation of the IO Model 2|3

Matrix of the intermediate consumption coefficients: $A_{ij} = S_{ij} / X_j$

$\Rightarrow \Sigma(A_{ij}X_j) + Y_i = X_i$

$\Rightarrow Y_i = X_i - \Sigma(A_{ij}X_j)$

$\Rightarrow [X] = ([I] - [A])^{-1} * [Y]$

$\Rightarrow [X] = [R] * [Y]$, [R] is the inverted matrix of Leontief

$\Rightarrow ([I] - [A])^{-1} = [I] + [A] + [A]^2 + [A]^3 + \ldots = \Sigma [a]^i$, i = infinit.

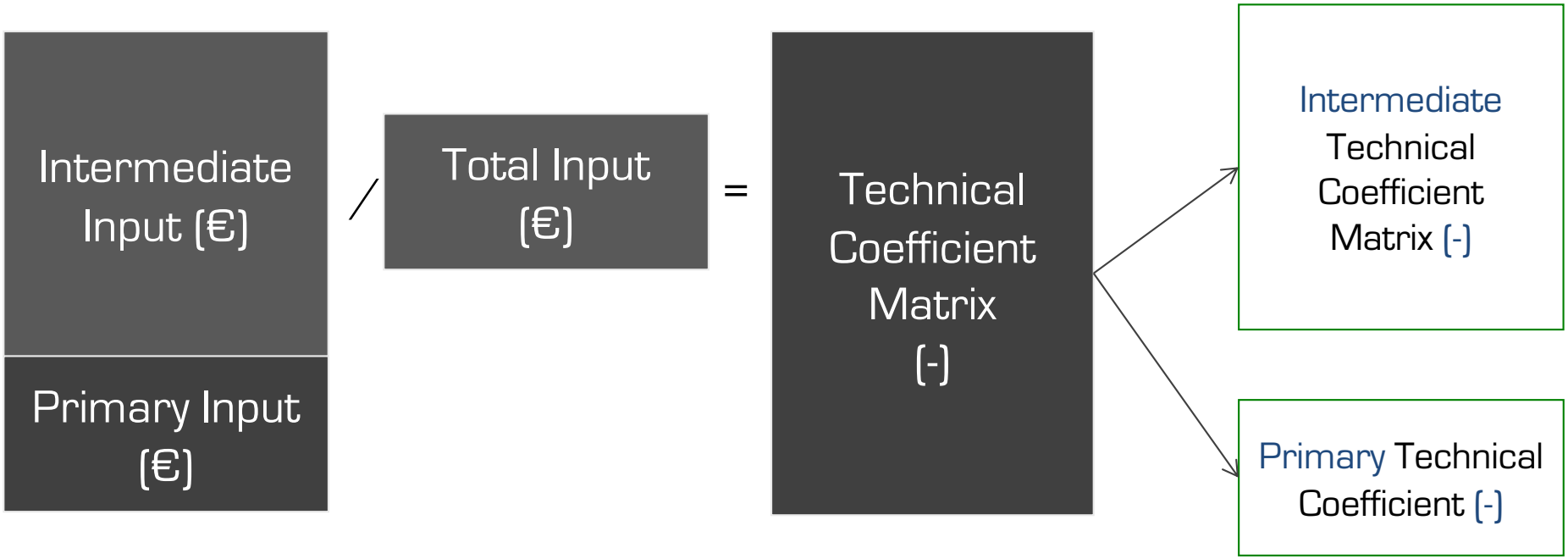
Mathematical formulation of the IO Model 3|3

To evaluate the effect of the unitary increase in the final demand of S1:

=> $[\Delta Y] = \{ 1, 0, 0 \}$

=> $[\Delta X] = \{ R_{11}, R_{21}, R_{31} \}$, the total output in the economy is $R_{11} + R_{21} + R_{31}$

Technical Coefficients Matrix



Input-Output Analysis example 1|3

Macro-Economy Application (example)

Given the following matrix of the intermediate input for an economy with only 3 sectors (Agriculture, Industry and Services), and the respective values for the exports, imports, consumption and added value.

S	Intermediate Input			+	Exports	Demand	=	X
	Agriculture	Industry	Services					
Agriculture	5	?	0		20	30		75
Industry	20	20	?		30	40		120
Services	10	30	20		10	30		100
+								
VA	20	40	30					
Imports	20	?	40					
=								
Total inputs	75	120	100					
Emissions	50	200	100					

Input-Output Analysis example 2|3

Macro-Economy Application (example)

Given the following matrix of the intermediate input for an economy with only 3 sectors (Agriculture, Industry and Services), and the respective values for the exports, imports, consumption and added value.

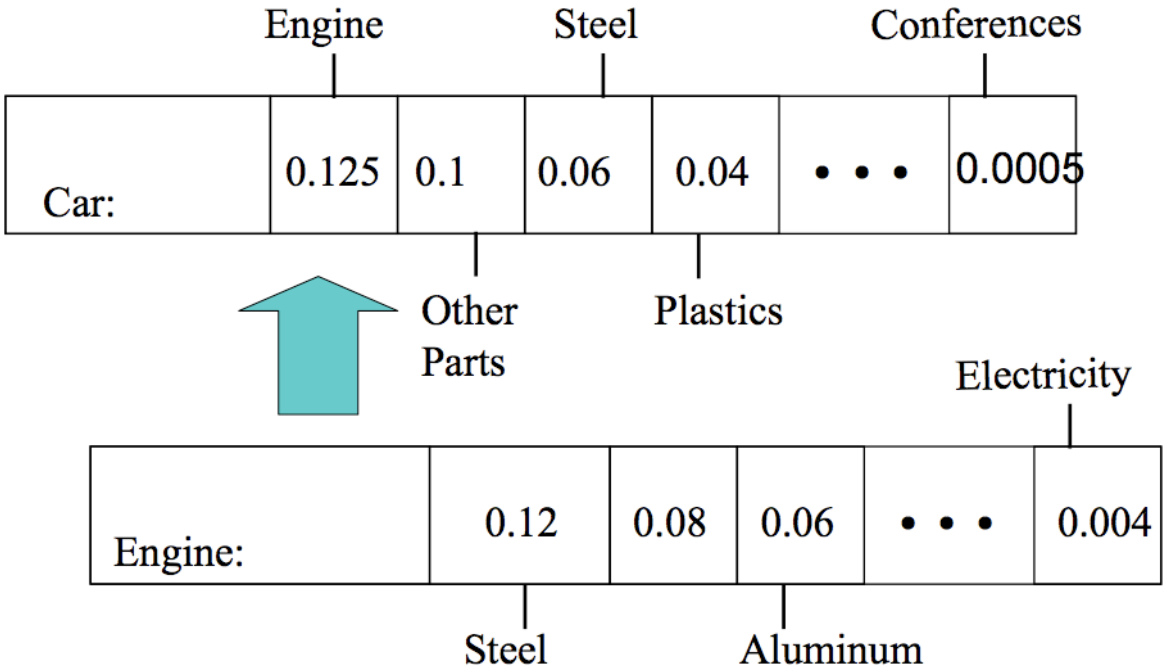
S	Intermediate Input			+	Exports	Demand	=	X
	Agriculture	Industry	Services					
Agriculture	5	20	0		20	30		75
Industry	20	20	10		30	40		120
Services	10	30	20		10	30		100
+								
VA	20	40	30					
Imports	20	10	40					
=								
Total inputs	75	120	100					
Emissions	50	200	100					

Input-Output Analysis example 3|3

Open excel file:

L07Input-Output method.xlsx

- Identify the main components of an input-output matrix
- Calculate the technical coefficients matrix ***A,*** the emissions coefficient vector ***b*** and the Leontief matrix ***L***
- Setup a scenario where you increase the final demand for services in 1 SEK
- Calculate the amount of additional emissions created



Supply Chain Buildup

- First Level: (I + A)Y
- Second Level: A(AY)
- Multiple Level: X = (I + A + AA + AAA + ...)Y

Y: vector of final demand (e.g. $ 20,000 for auto sector, remainder 0)
I: Identity Matrix (to add Y demand to final demand vector)
A: Requirements matrix, X: final demand vector

Summary

- Given a desired vector of final demand (e.g. purchase of a good/service), the Leontief model gives the vector of sector outputs needed to produce the final demand throughout the economy.

- For environmental impacts, can multiply the sector output by the average impact per unit of output.