



Lecture content

- Understand the use and content of Input-Output Tables (IOT)
- Compare process MFA and Input-Output Analysis (IOA)
- Learn how to apply IOA
- Understand Material Flow Cost Accounting (MFCA)





Input Output Analysis (IOA)

Rationale for Input Output Analysis (IOA)

- Understand the inter-linkages between economic activities
- Conduct MFA from a macro perspective
- Evaluate material and energy flows of the service sector
- Perform screening MFA at low granularity
- Identify hotspots, target activities and resource impacts
- Compare production and consumption perspectives
- Bridge data gaps in process MFA/LCA



Historical background

Wassily Leontief (1905 - 1999), *Die Wirtschaft als Kreislauf* Walter Isard (1919 - 2010), Regional Science

What is the impact on one economic activity or sector resulting from changes in another activity or sector?

☐ Input-Output Tables (IOTs)

Supply Use Tables (SUTs)

Social Accounting Matrices (SAMs)



Which sectors purchase steel?

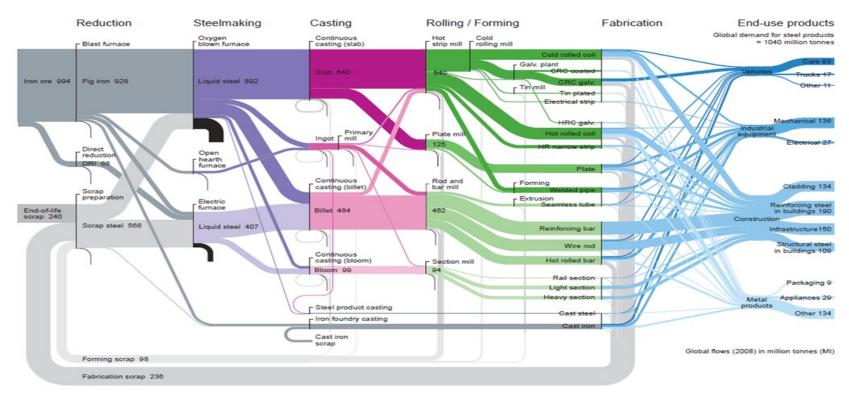
Food and drink Mining and minerals Steel Aluminium Metal products Transport aoods Machinery and equipment Other manufacturing Utilities Construction Transport services Other business and public services



How are construction expenditures allocated?



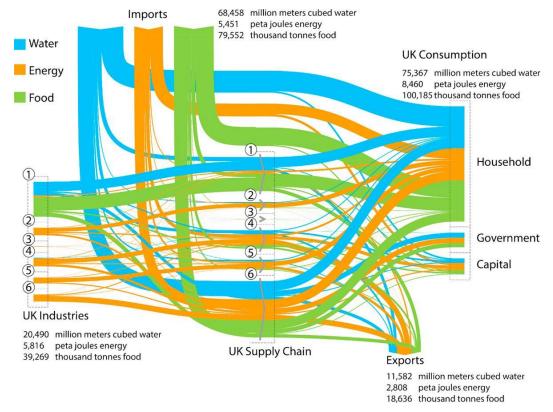
Steel Flow Analysis





Supply chain analysis

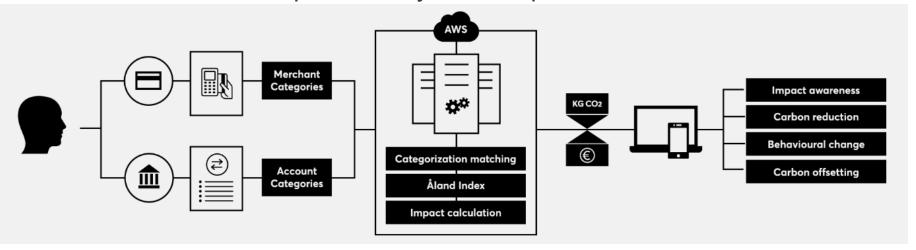
Energy water and food nexus in the UK

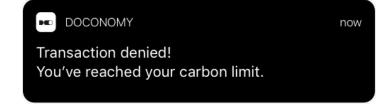




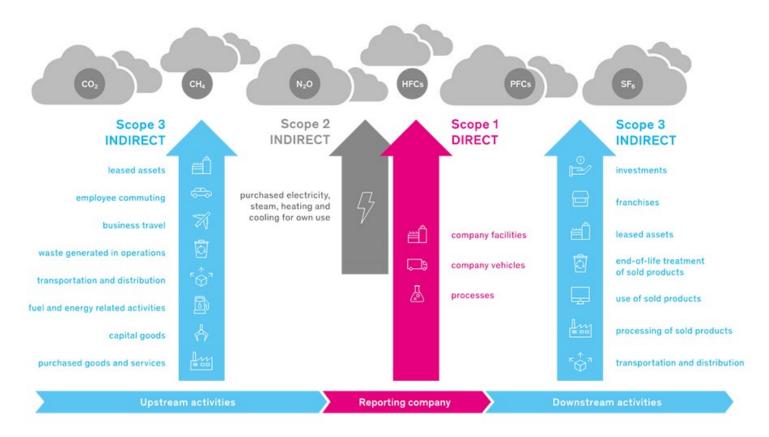
Impact screening

What are the impacts of my consumption choices?



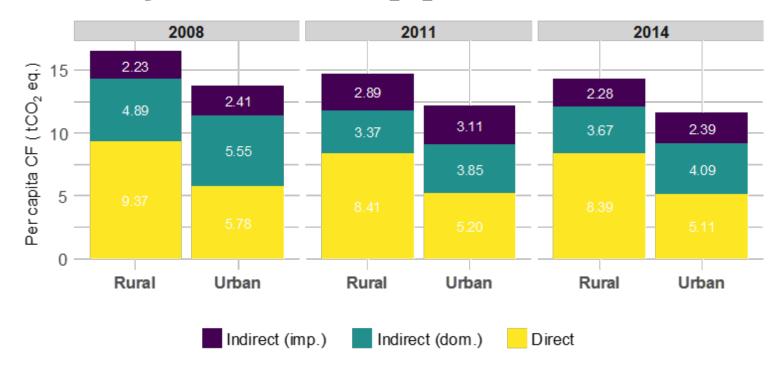


Corporate reporting





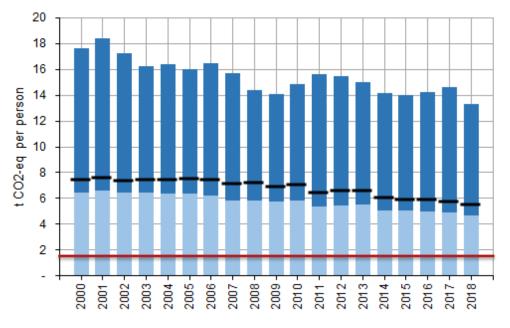
Policy relevance [1]



Direct: consumption of fuels and heating

Indirect: induced by households final consumption of goods and services

Policy relevance [2]



1.5 t CO2-eq per person by 2050

- Consumption-based emissions abroad
- Consumption-based emissions in Switzerland
- Emissions in Switzerland according to Kyoto (territorial perspective)



Policy relevance [3]

Global resource footprint 2007



Process MFA vs. IOA

- Processes vs. economic activities
- System boundaries, spatial and temporal
- Bottom up vs. top down
- Physical units vs. monetary
- Production vs. consumption perspectives

 Σ input = Σ output + net additions to stocks

 Σ revenues = Σ expenditures - savings

Resource and monetary flows move in opposite directions



Input-Output Model: Accounting equation

Domestic inputs + imports = intermediate consumption

- + final consumption (HH + Gov't)
- + capital formation (investment)
- + exports
- = Total output

Hypotheses

Steady state (over an accounting period)

The multiple uses of given products have the same share of imports A given product's availability is proportional to the market share of its producer



Input-Output Tables

Combination of supply (V) and use (U) tables

V is an activity by product matrix of which element vij shows the amount of product j produced by activity i

U is a product by activity matrix of which element uij shows the amount of product i used by activity j

Matrix (A) of n x n economic activities

Diagonal shows net production of each activity in monetary unit worth of gross economic output, and off-diagonal elements aij

Shows the amount of output from activity i used by activity j per unit worth of its output (matrix of transaction coefficients)

Input-Output Tables

Balanced MSUT	Activities	Import	Final use	Export	Valati
Products	v	N			Valuation
Total	g				
Products	U		у	E	
	Labour costs				
Primary production factors	Net taxes				
	Net operating costs				
	Rent				
Total	а				

V': Production by industry and by product

N: Imports by products

Total

U: Intermediate consumption by product and by industry

y: Final use of products

g: Vector of production by industry

q: Vector of total domestic production by product

E: Exports by products



Environmentally extended IO Tables

Satellite accounts (intervention matrices)

Interventions by economic activity matrix, of which elements bij shows the physical amount of ith environmental intervention caused by a unit output of the jth activity (matrix of coefficients)

Examples of satellite accounts/multipliers

```
Production factors (e.g. capital costs, employment) (F) Resources (e.g. energy, land, water) (R) Emissions (e.g. CO2, NOx, etc.) (B) Wastes (W)
```



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Balanced PSUT	Activities	In
Products	V	
Total	g	
Products	U	
Net additions to stocks	-∆ S	
Supply of wastes	-W∨	
Use of wastes	W υ	
Resources	R	
Emissions	-В	
Total	g	

Final use Export

Е

У

Total

Input-Output Tables and satellite accounts

V': Production by industry and by product

N: Imports by products

U: Intermediate consumption by product and by industry

y: Final use of products

g: Vector of production by industry

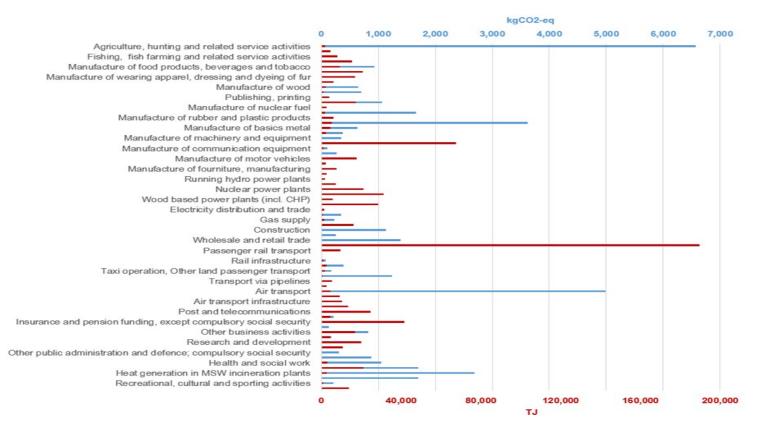
q: Vector of total domestic production by product

E: Exports by products



NAMEA: Air and Energy

National Accounting Matrix including Environmental Accounts (NAMEA)





Environmentally extended IO Tables

Year: 1970; Unit:	USD; Basic Prices; EoraVersion: 199.82	Afghanista	anista Afghanista Afgh	
Afghanista AFG Afghanista AFG Afghanista AFG	Industries Agriculture Industries Fishing Industries Mining and Quarrying	Audiculture Visionium Modurium Visionium Modurium Visionium Visionium Visionium Visionium Modurium Visionium Visioni	xport.Household Non-profit Governmei Gross Tixec/Changes in Acquisition Fotal BE+03 1.86E+07 1.83E+05 1.79E+04 2.06E+05 5.70E+05 5.25E+02 30E+03 7.94E+05 4.27E+03 9.07E+03 1.23E+02 4.08E+04 1.23E+02 30E+02 7.97E+05 2.96E+02 6.05E+03 2.11E+04 2.47E+05 1.04E+02	Total Total Total Total Total Total 0 3.20E+03 4.11E+03 3.20E+03 3.20E+03 0 3.20E+03 3.20E+03 3.20E+03 3.20E+03 0 3.20E+03 3.20E+03 3.20E+03 3.20E+03
Afghanista AFG Afghanista AFG	Industries Food & Beverages Industries Textiles and Wearing Ap	7.60E-05 1.53E+04 1.91E-04 1.47E+07 3.49E+05 2.54E+05 1.23E+06 7.58E+03 1.26E+04 3.53E+03 1.40E+05 1.88E+05 6.54E+04 1.12E+04 1.61E+05 7.48E+05 7.48E+05 7.48E+07 1.05E+05 4.68E+04 7.47E+06 4.23E+06 2.01E+07 1.00E+05 1.07E+04 3.66	8.48E+02 Domestic.1.08E+02	
Afghanista AFG Afghanista AFG	Industries Wood and Paper Industries Petroleum, Chemical and	\$17000 \$28000 \$17000 \$16000 \$100000 \$10000 \$10000 \$10000 \$100000 \$100000 \$100000 \$100000 \$100	9E+02 5.44E+06 6.23E+04 3.04E+04 8.92E+04 9.82E+04 2.29E+02 5E+02 2.72E+07 4.97E+05 6.64E+04 2.31E+05 1.28E+05 5.46E+02	
Afghanista AFG Afghanista AFG	Industries Metal Products Industries Electrical and Machinery	1.00F-05 538E-00 678E-05 938E-05 100F-05 708E-05 23E-06 23E-07 12E-07 12E-07 12E-07 12F-07 12	5E+02 9.65E+05 1.51E+04 430E+04 9.91E+05 2.89E+05 2.26E+03 2.2EE+02 2.04E+07 1.48E+05 8.8E+06 2.2EE+04 7.53E+05 6.41E+04 2.2EE+07 4.0EE+05 5.8E+06 2.2EE+06	
Afghanista AFG Afghanista AFG	Industries Transport Equipment Industries Other Manufacturing	4/76-01 2/36-01 2/88-00 0.005-01 9/88-01 2/77-01 5/78-00 1/78-	E+02 2.15E+07 4.06E+05 4.5E+06 1.32E+07 1.29E+06 2.32E+04 3E+02 7.30E+06 1.42E+05 2.18E+05 2.03E+06 1.24E+05 4.60E+03	
Afghanista AFG Afghanista AFG	Industries Recycling Industries Electricity, Gas and Wate	4295-00 1728-00 128-05	0E+02 4.50E+05 1.3E+05 2.74E+04 1.04E+02 4.3AE+05 1.EE+02 0E+02 6.65 demand 4.60 fre-02 0E+02 6.65 demand 4.60 fre-05	Exports
Afghanista AFG Afghanista AFG	Industries Construction Industries Maintenance and Repair	2.79E-04 4.29E-02 2.08E-06 1.85E-05 8.59E-04 4.37E-05 1.68E-06 6.52E-05 6.61E-05 1.77E-05 1.38E-05 1.98E-03 6.70E-06 7.97E-05 7.89E-06 9.67E-05 1.28E-06 9.67E-05 1.52E-06 9.67E-05 7.52E-06 9.67E-05 7.89E-06 9.67E-06 7.89E-06 9.67E-06 7.89E-06 9.67E-06 7.89E-06 9.67E-06 7.89E-06 7.8	06-62 6.6510	
Afghanista AFG Afghanista AFG	Industries Wholesale Trade Industries Retail Trade	2.146-05 7.21F-07 7.02F-05 2.50F-06 1.01F-05 2.97F-06 8.12F-06 2.01F-06 8.11F-06 2.44F-06 1.05F-06 7.24F-06 1.02F-05 7.24F-06 1.02F-06 7.24F-06 7.2	3E+02 5.15E+07 7.64E+05 3.73E+05 8.84E+06 3.56E+05 2.00E+04 3E+02 1.14E+08 2 1E+06 2.28E+04 2.43E+06 4.38E+01 5.52E+03	0 3.20E+03 3.20E+03 3.20E+03 3.20E+03 0 3.20E+03 3.20E+03 3.20E+03 3.20E+03
Afghanista AFG Afghanista AFG	Industries Hotels and Restraurants Industries Transport	2.1214-04 1.2814-06 4.2974-07 7.586-04 7.5814-05 7.2814-	1.66-02 8.66-07 domestic 1.066-02	
Afghanista AFG Afghanista AFG	Industries Post and Telecommunica Industries Finacial Intermediation a	7,555-03 5-477-03 1277-05 9595-04 7359-04 3555-05 7381-05 1276-05 1555-05 1276-05 1557	DE+02 3.18E+07 6.12E+05 1.46E+05 4.52E+06 3.27E+03 1.02E+04	
Afghanista AFG Afghanista AFG	Industries Public Administration Industries Education, Health and O	2.40E+03 1.00E+02 2.55E+04 1.67E+04 3.84E+03 2.37E+04 7.41E+04 1.91E+04 1.97E+04 7.86E+03 2.37E+04 2.18E+02 2.8E+03 2.62E+04 1.98E+03 2.57E+04 5.80E+04 7.18E+04 9.76E+04 1.50E+05 1.50E	0E+02 4.42E+06 9.87E+04 7.49E+07 3.09E+17 1.35E+01 6.98E+04	
Afghanista AFG	Industries Private Households	1/25-09 126-07 106-07 1	0E+02 1.72E+08 3.83E 6 0 0 5 84E+02 9.69E+03 0E+02 3.57E+06 1.03E 8 0.2E+0 1.03E 12 1.03E+02	
Afghanista AFG Afghanista AFG	Industries Others Industries Re-export & Re-import	4,356:49 1.725:09 3,096:04 3,966:04 3,966:04 3,966:04 3,966:04 3,966:02 1,956:04 1,956:05 1,516:05 1.716:05 1.726:04 1.226:04 1.726:05 1.726:04 1,726:04 1,726:05 1.726:05 1.726:05 1.726:04 1,726:05 1.726:05 1.726:05 1.726:04 1,726:05 1.7	DE+02 3.62E+06 1.03E+05 1.09E+02 1.03E+02 1.09E+01 1.03E+02 DE+01 1.14E+02 1.14E+02 1.17E+02 1.09E+02 1.43E+01 1.09E+02	
Afghanista AFG Afghanista AFG	Primary IncCompensation of employ Primary IncTaxes on production D.2:	3.056-07 5368-06 7988-05 1098-07 6088-06 1388-07 3128-07 2318-07 5388-07 7328-06 5168-07 3328-06 3308-06 3308-06 318-07 2388-0	2E+02	
Afghanista AFG Afghanista AFG	Primary In: Subsidies on production Primary In: Net operating surplus B.	Primary inputs (aka Value Added)	DE+02	
Afghanista AFG	Primary InsNet mixed income B.3n		2E+02	
Afghanista AFG Afghanista AFG	Primary IncConsumption of fixed ca ImportsFroTotal	3,391-07 1938-10 7138-10 3,001-10 1,001-10 3,001-10 1,0	0 0 0 0 0 0	0 8.91E+07 3.20E+03 3.20E+03 3.20E+03
Albania ALB Algeria DZA	ImportsFroTotal ImportsFroTotal		DE+03 5.06E+08 2.68E+07 5.21E+07 1.77E+08 2.61E+07 8.78E+07 DE+03 2.60E+03 2.60E+03 2.60E+03 2.60E+03 2.60E+03 2.60E+03	
Andorra AND Angola AGO	ImportsFroTotal		Domestic FD of	
Antigua A	Simports Fro Total	2007-01 2007-01	0E+03 2.60E+03 2.60E+03 2.60E+03 2.60E+03 2.60E+03 2.60E+03	
Armenia ARM	ImportsFroTotal	Imports into intermediate demand	imported gods	
COU	Imports Fro Total	2606-03 2606-03	DE+03 2.60E+03 2.60E+03 2.60E+03 2.60E+03 2.60E+03	
Statistical ROW 1 I-ENER	ImportsFroTotal GY Energy (by Natural Gas	0.1881-05 0.1881-05 0.1881-05 0.1881-05 2.686-04 4.286-05 2.2776-05 4.476-05 2.2776-05 4.476-05 2.266-05 1.786-05 1.986-05 1.1861-05 1.1	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	
	GY Energy (by Coal GY Energy (by Petroleum	2.1154-01 9385-01 1895-01 9006-01 1605-01 4585-01 1116-02 4685-01 1116-02 5985-01 1795-01 6.165-00 777-01 9065-01 2995-00 5.985-01 5175-01 6006-01 6885-01 5685-01 4206-02 787-01 1985-02 367-00 6975-00 2356-02 1569-01 256-02 15	0 1.01E+03	
4 I-ENER	GY Energy (by Nuclear Electricity GY Energy (by Hydroelectric Electricity	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 3.12E+03 0 0 0 0 0	
6 I-ENER	GY Energy (by Geothermal Electricity	0.000 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	• • Fmictions • •	
8 I-ENER	GY Energy (by Wind Electricity GY Energy (by Solar, Tide and Wave Ele		0 0 0 0 0 0	
9 I-ENER	GY Energy (by Biom 53 and Waste Elec CO2CO2 (Gg) Public electricity and he	281-0 181 181 201 201 201 201 201 201 201 201 201 20	2886 assocated with	
11 I-GHG-I	CO2CO2 (Gg) Other En ry Inclusives CO2CO2 (Gg) Manufacturing Industries	ellite: accounts: (non-monetarys: inputs: 1:1000-25500 25500	0 2.85E+00 0 0 0 0 0	
13 I-GHG-I	CO2CO2 (Gg) Domestic aviation	2.85E+00 2.8	⁰ ^{2.85E+00} domestic FD ⁰	
15 I-GHG-I	CO2CO2 (Gg) Road transportation CO2CO2 (Gg) Rail transportation	285-00 28	0 2.85E+00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	
	CO2CO2 (Gg) Inland navigation CO2CO2 (Gg) Other transportation	285-60 285-70 285	e.g. household	
18 I-GHG-I	CO2CO2 (Gg) Residential and other se		0 1.72E+02	
20 I-GHG-I	CO2CO2 (Gg) Fugitive emissions from		0 2.85E+00 0 0 0 0 0	
22 I-GHG-I	CO2CO2 (Gg) Memo: International avia CO2CO2 (Gg) Memo: International nav		0 0 0 0 0 0	
23 I-GHG-I	CO2CO2 (Gg) Production of minerals		0 0 0 0 0 0	

EPFL IO Model

Intermediate consumption + final consumption = Total output

$$AX + Y = X$$
$$a_{ij} = x_{ij}/X_j$$

$$\begin{cases} a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + \dots + a_{1n}x_n + y_1 = x_1 \\ a_{21}x_1 + a_{22}x_2 + a_{23}x_3 + \dots + a_{2n}x_n + y_2 = x_2 \\ & \vdots \\ a_{n1}x_1 + a_{n2}x_2 + a_{n3}x_3 + \dots + a_{nn}x_n + y_n = x_n \end{cases}$$

Leontief inverse L

$$AX + Y = X$$
 $Y = X - AX$
 $Y = IX - AX = (I - A)X$
 $X = (I - A)^{-1}Y$
 $X = LY$
Note $I = \text{diag (1,1,...,1)}; L = (I - A)^{-1}$



Input-Output model satellite accounts

Vector of resource flows b to satisfy final demand Y given matrix B of interventions per unit of output X:

$$b = BX = B(I - A)^{-1}Y$$

Vector of impacts d given matrix C of characterization factors (LCIA):

$$d = Cb = CB(I - A)^{-1}Y$$



Example [1]

Symmetric IO table of inter-industry transactions (mio CHF)

	Industry A	Industry B	Industry C	Final demand	Total output
Industry A	0	20	45	35	100
Industry B	30	0	30	140	200
Industry C	0	80	0	70	150
Value added	70	100	75		
Total input	100	200	150		



Example [2]

From satellite accounts

1. Direct energy use per unit of output X

Х	mio CHF	F /	MJ/CHF	TJ
Α	100		5	500
В	200		7	1400
С	150		2	300

2. Energy use of suppliers per industry

	Α	В	С	F	MJ/CHF	TJ
Α	0	20	45		5	210
В	30	0	30		7	260
С	0	80	0		2	435



Example [3]

3. Matrix of transaction coefficients A

	Α	В	С
Α	0	0.1	0.3
В	0.3	0	0.2
С	0	0.4	0

Leontief inverse $L = (I - A)^{-1}$

4. Total output X per industry to satisfy final demand Y

	А	В	С	Υ	mio CHF	Χ	mio CHF
Α	1.1	0.3	0.4		35		100
В	0.4	1.2	0.3		140		200
С	0.1	0.5	1.1		70		150



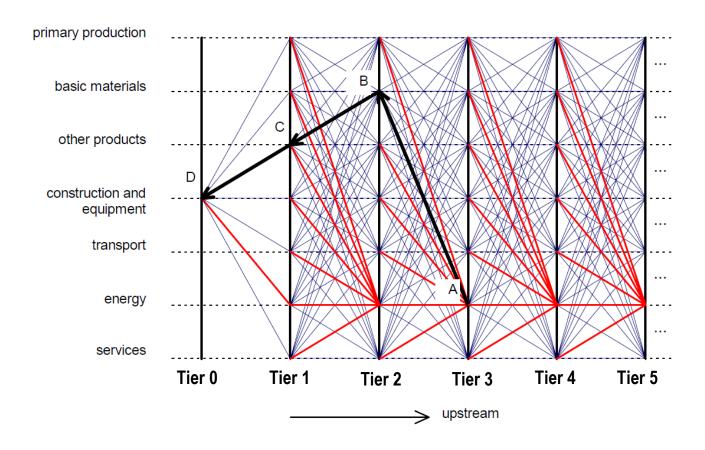
Example [4]

5. Energy use per sector to satisfy final demand and total energy use

f	TJ		Total TJ	
Α	500		2200	
В	1400			
С	300		F	
			Energy	y used in direct operations
6. Com	parison			Energy used by direct suppliers
A	 	Induced TJ 210	Total TJ 500	Total energy used to satisfy demand
В	 	260	1400	
	300	435	300	



Structural path analysis



10 Model

To satisfy final demand Y, the total output X is given by :

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

With the Leontief inverse $L = (I - A)^{-1}$:

$$X = LY$$

The transaction coefficients a_{ij} of A are $0 < a_{ij} < 1$ so L can be expanded into a Taylor – Maclaurin series :

$$L = (I - A)^{-1} = I + A + A^{2} + A^{3} + \cdots$$



Path or tier analysis with IO

For a final demand *Y*, the output *X* is given by:

Tier 0	X = IY
Tier 1	X = AY
Tier 2	$X = A(AY) = A^2Y$
Tier 3	$X = A(A(AY)) = A^3Y$

Total output

$$X = IY + AY + A^{2}Y + A^{3}Y + \cdots$$

 $X = (I + A + A^{2} + A^{3} + \cdots)Y$
 $X = (I - A)^{-1}Y$

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Example [continued]

1. Total output per industry

	X [mio CHF]
Α	100
В	200
С	150

2. Output X of suppliers per industry (Tier 1)

	Α	В	С		Y [mio CHF]		X [mio CHF]
Α	0	0.1	0.3		35		35
В	0.3	0	0.2	*	140	=	25
С	0	0.4	0		70		56



Example [continued]

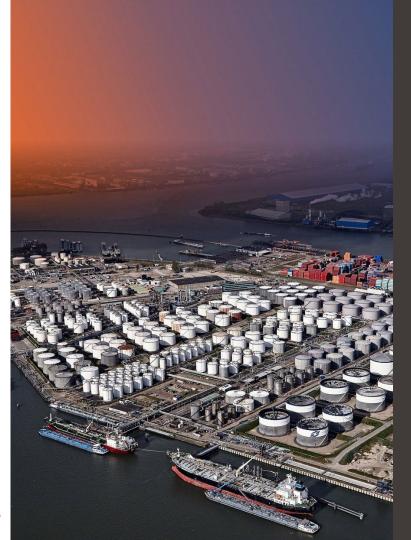
3. Output X of suppliers of suppliers per industry (Tier 2)

	А	В	С		Y [mio CHF]		X [mio CHF]
Α	0.03	0.12	0.02		35		19.25
В	0	0.11	0.09	*	140	=	21.7
С	0.12	0	0.08		70		9.8

4. Total output X per industry to satisfy final demand Y

	А	В	С		Y [mio CHF]		X [mio CHF]
А	1.1	0.4	0.1		35		100
В	0.3	1.2	0.5	*	140	=	200
C	0.4	0.3	1.1		70		150

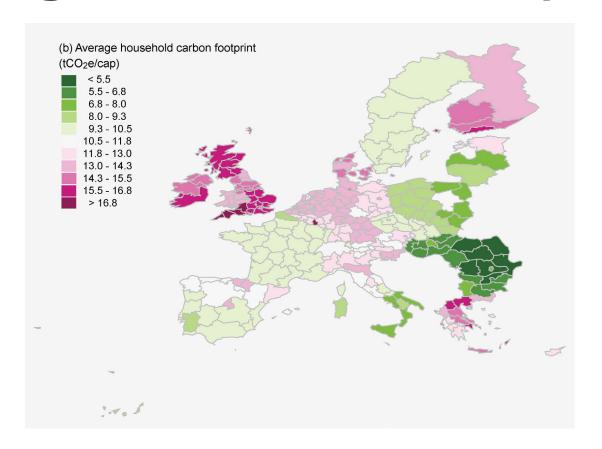




Multi regional IOT



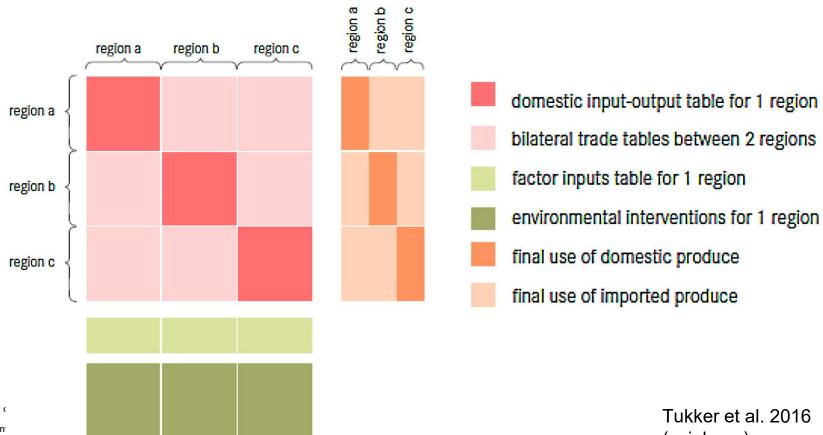
Regional level flows in Europe (NUTS2)



Ivanova et al. 2017



Multiregional IO tables (MRIOTs)

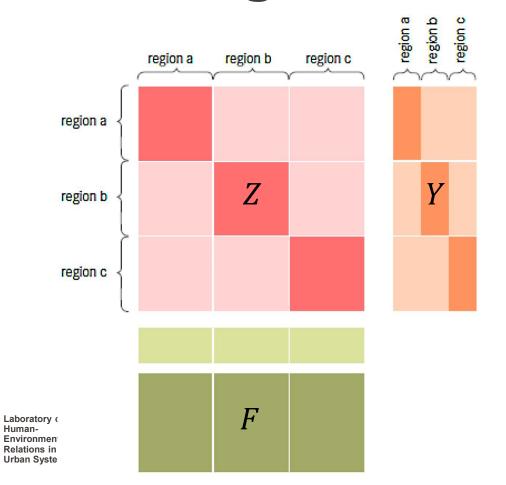


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(exiobase)



Multiregional IO tables (MRIOTs)



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

$$A = ZX^{-1}$$

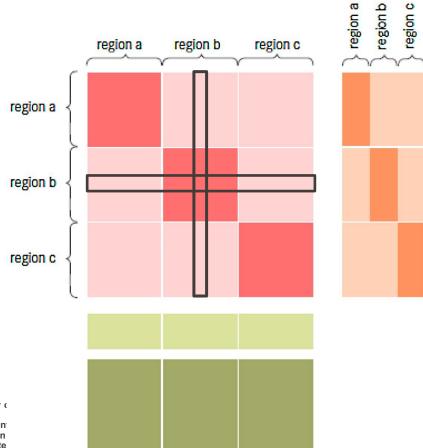
$$S = FX^{-1}$$

$$M = SL$$

$$D = MY$$



Multiregional IO tables (MRIOTs)

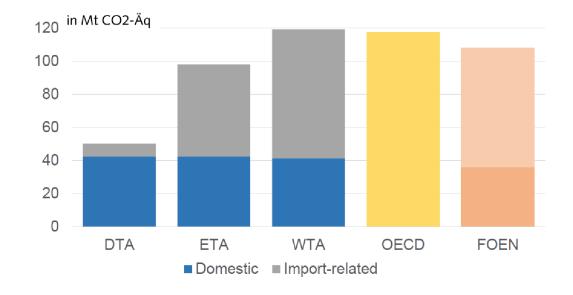


The sum of colums minus diagonal matrix, equals imports

The sum of rows minus diagonal matrix, equals exports



Consumption perspective on CH footprint



Domestic technology assumption (DTA), European technology assumption (ETA) World technology assumption (WTA), Federal Office of the Environment (FOEN)



Summary

Input-Output analysis

Ideal for analysing service activities, the impacts of trade

Different methods address different problems

Top-down and bottom-up methods and data sources

Structural path analysis

Accounting for each stage/tier in the analysis
Time series of IO data make for more dynamic analysis

Extension of IO databases and satellite accounts

Approaching the vision of Leontief

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Strengths and weaknesses

- Top down, screening analysis
- Large coverage, no thresholds
- Consistent with economic activities
- Interactions between economic activities

- Data intensive, yet low granularity
- Subject to inflation and price volatility
- Allocation of co-producing activities
- Steady state hypothesis



Recommended IO tables to work with...

- EXIOBASE Multi-regional EEIO Database (NAMEA) https://www.exiobase.eu/ https://zenodo.org/record/5589597
- Swiss IOA projects (energy, GHG)
 https://www.aramis.admin.ch/Grunddaten/?ProjectID=31264
 https://www.aramis.admin.ch/Grunddaten/?ProjectID=43188
- Forwast project Physical IO Tables (EU)
 http://forwast.brgm.fr/results_deliver.asp





Where to find data?



Relevant databases [1]

Monetary IO Tables

- EU IO Supply Use Tables (EU27 + Norway, Macedonia, Turkey)
 https://ec.europa.eu/eurostat/web/esa-supply-use-input-tables
- OECD STAN IO Tables (extended with GHG)
 https://stats.oecd.org/Index.aspx?DataSetCode=IOTS
- EORA Multi-regional IO Database (global, extended)
 http://www.worldmrio.com/
- World IO Database (NAMEA) http://www.wiod.org/
- GTAP IO Tables (extended with GHG)
 https://www.gtap.agecon.purdue.edu/databases/default.asp

EPFL

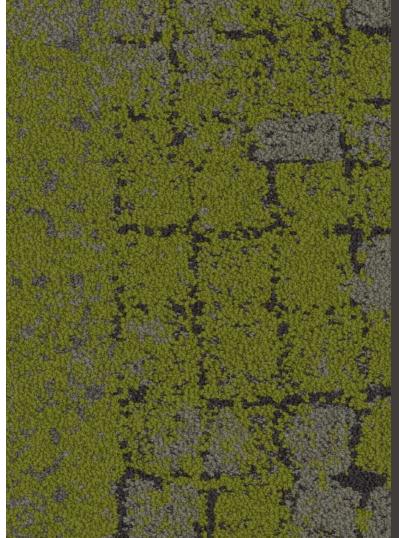
Relevant databases [2]

- Carnagie Mellon's EEIO LCA (US IO Tables)
 http://www.eiolca.net/
- CEDA EEIO Database (commodity based)
 https://watershed.com/solutions/ceda
- EXIOBASE Multi-regional EEIO Database (NAMEA)
 https://www.exiobase.eu/ https://zenodo.org/record/5589597
- Swiss IOA projects (energy, GHG)
 https://www.aramis.admin.ch/Grunddaten/?ProjectID=31264
 https://www.aramis.admin.ch/Grunddaten/?ProjectID=43188

Physical IO Table

Forwast project - Physical IO Tables (EU)
 http://forwast.brgm.fr/results_deliver.asp





Material Flow Cost Accounting (MFCA)

Introduction



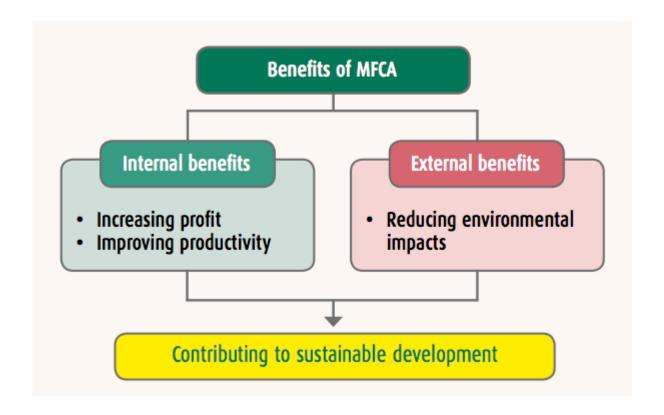
Material Flow Cost Accounting

Why account for the costs of materials in productive activities? For example, to retain the value associated with wastes, energy or material losses.





Potential benefits of MFCA





Monetary and material statements

Income statement or balance sheet:

Details a company's revenues and expenses over an accounting period

Focuses on the four key items:

- Revenue
- Expenses
- Gains
- Losses



Monetary statement

The cost of production factors

Cost of Goods Manufactured Statement						
Cost Element	Decision(s)	Information Required				
Material	Supplier A, B, C, or D Order size, material X Number of orders, material X Order size, material Y Number of orders, material Y	List prices Quantity discounts Carrying cost Cost of placing an order				
Direct labor (variable)	Number of factory workers Wage rate Budgeted production	Units of equipment Wage rate function Production budget				
Manufacturing overhead	Type of finishing department equipment Order size of material Factory labor compensation	Capacity required Carrying cost of inventory Overhead rate Variable cost rates Salaries, supervisors				

"MFCA is a management tool that can assist organizations to better understand the potential environmental and financial consequences of their material and energy use practices, and seek opportunities to achieve both environmental and financial improvements via changes in those practices."

(ISO 14051, 2011)

ISO 14051 Environmental Management – Material flow cost accounting 2011

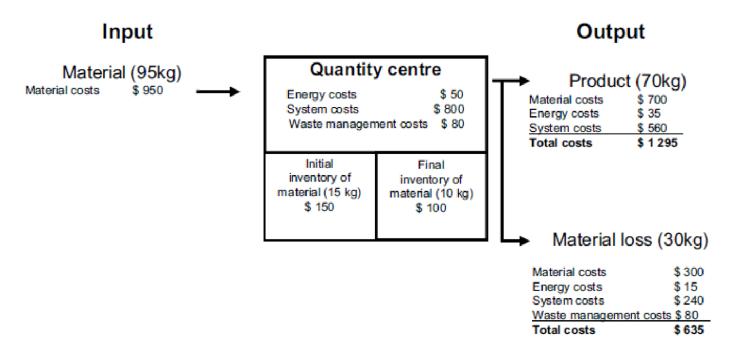
Aim: Link resource costs and uses

- Provide a general framework for the analysis of material flows and their costs
- Promote transparency of resource consumption practices
- Quantify the real costs of material and other losses
- Standardized but not certified

EPFL

MFCA standard

Material flow accounting



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Material costs (1000\$) = Input (950) + Initial inventory (150) - Final inventory (100)



MFCA standard: definitions

- Cost: Monetary value of resources used to perform activities
- Cost allocation: Indirect attribution of a cost between different objects, such as a product or process, by using an appropriate apportionment basis
- Cost assignment: Direct attribution of a cost to a specific object, such as a product or process



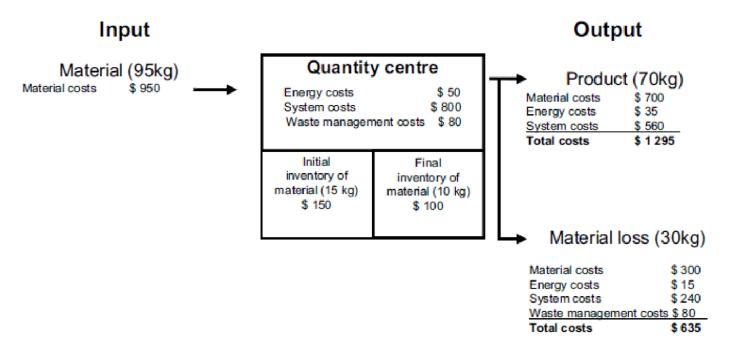
MFCA standard: definitions

- Quantity cost: Selected part or parts of a process for which inputs and outputs are quantified in physical and monetary units (warehouses, production, inspection, shipping points, heating units)
 = Process
- System cost: Cost incurred in the course of in-house handling of the material flows, except for material cost, energy cost
- Waste management cost: cost of handling material losses generated in a quantity centre



MFCA standard: unit process

Material flow accounting



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Material costs (1000\$) = Input (950) + Initial inventory (150) - Final inventory (100)



MFCA standard: unit process

Material flow cost matrix for a quantity centre

	Mass kg	Material costs \$	Energy costs \$	System costs \$	Waste management costs \$	Total costs \$
Total inputs	100	1 000	50	800	80	1 930
Product	70 (70 %)	700 (70 %)	35 (70 %)	560 (70 %)	0 (0 %)	1 295 (67 %)
Material loss	30 (30 %)	300 (30 %)	15 (30 %)	240 (30 %)	80 (100 %)	635 (33 %)
Total outputs	100	1 000	50	800	80	1 930

For simplicity, this table only includes physical data on materials, not energy.

The total inputs and material costs include materials in inventory as in the previous slide:

Total material used (100 kg) = Input (95 kg) + Initial inventory (15 kg) - Final inventory (10 kg)

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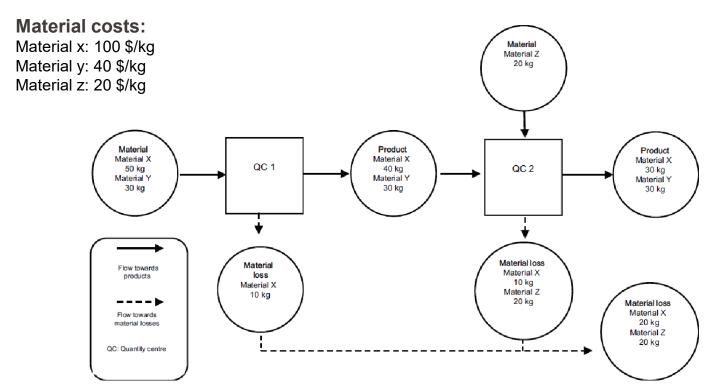
MFCA procedure

Two-step procedure:

- Spread costs across a process or production between different quantity centres
- 2. Allocate costs to the levels of qualifications between products and material losses



Production system with 2 quantity centres (QC)





Cost matrix for a production system with 2 QC

Composition of products and material losses		QC 1 QC 2			Result of production (mass)	Total		
Products	Mass	Unit costs	Costs	Mass	Unit costs	Costs	60 kg	\$ 4 200
Material X	40 kg	\$ 10 0 -	4 000	30 kg	\$ 10 0	3 000	→ 30 kg	\$3 000
Material Y	30 kg	\$ 40	\$1200	30 kg	\$ 40	\$ 1 200	30 kg	\$ 1 200
Material Z	_	\$ 20	_		\$ 20			\$0
Materials losses	M\ s	Unit costs	Costs	M ds	Unit costs	Costs	40 kg	\$ 2 400
Material X	10 kg	\$ 100	\$ 1 000	10 kg	\$ 100	\$ 1 000	20 kg	\$ 2 000
Material Y		\$ 40	_		\$ 40	_	_	\$0
Material Z	_	\$ 20		20 kg	\$ 20	\$ 400	20 kg	\$ 400
otal material costs in this process					\$ 6 600			

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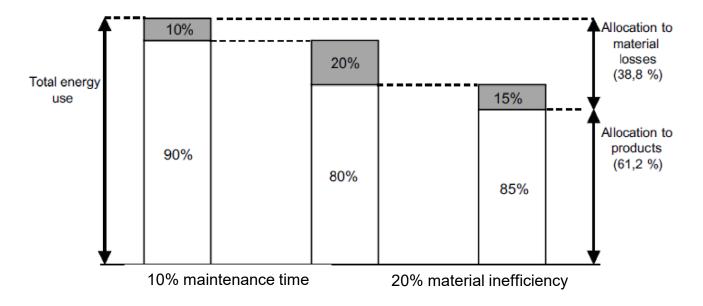


Cost matrix for a production system with 2 QC

Composition of products and material losses		QC 1		QC 2			Result of production (mass)	ion
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Materials losses	Mass	Unit costs	Costs	Mass	Unit costs	Costs	40 kg	\$ 2 400
Material X	10 kg	\$ 100	\$ 1 000	10 kg	\$ 100	\$ 1 000	20 kg	\$ 2 000
Material Y	<u> </u>	\$ 40	<u>—</u>	¥	\$ 40	_		\$ 0
Material Z	<u> </u>	\$ 20		20 kg	\$2 0	\$ 400	20 kg	\$ 400
otal material costs in t	this process	5						\$ 6 600



More detailed criteria for distribution



Energy allocation to products: 90% * 80% * 85% = 61.2% Energy allocation to material losses: 100% - 61.2% = 38.8%



Thank you for your attention!