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Input-Output Accounting

UNSD SEEA Training of Trainers Seminar

July 7-10, 2014, New York

Joe St. Lawrence

Statistics Canada

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Canada

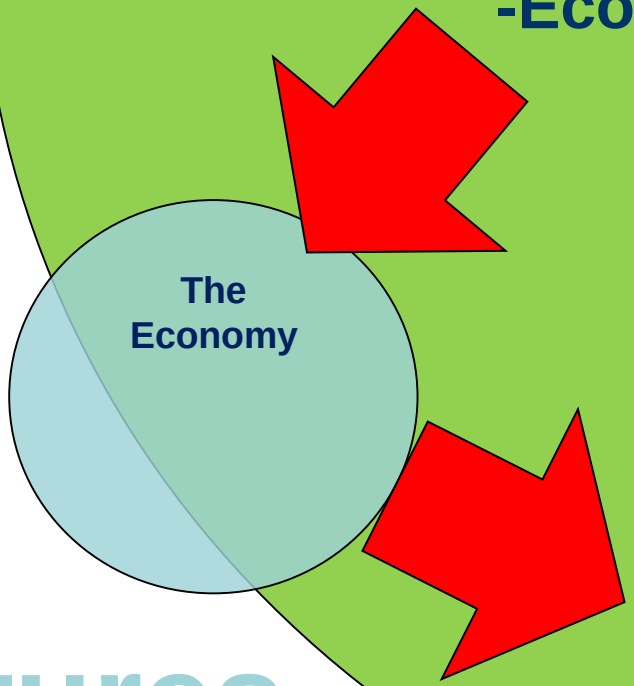
The Economy and The Environment

-Natural Resources
-Ecosystem Services

Stocks

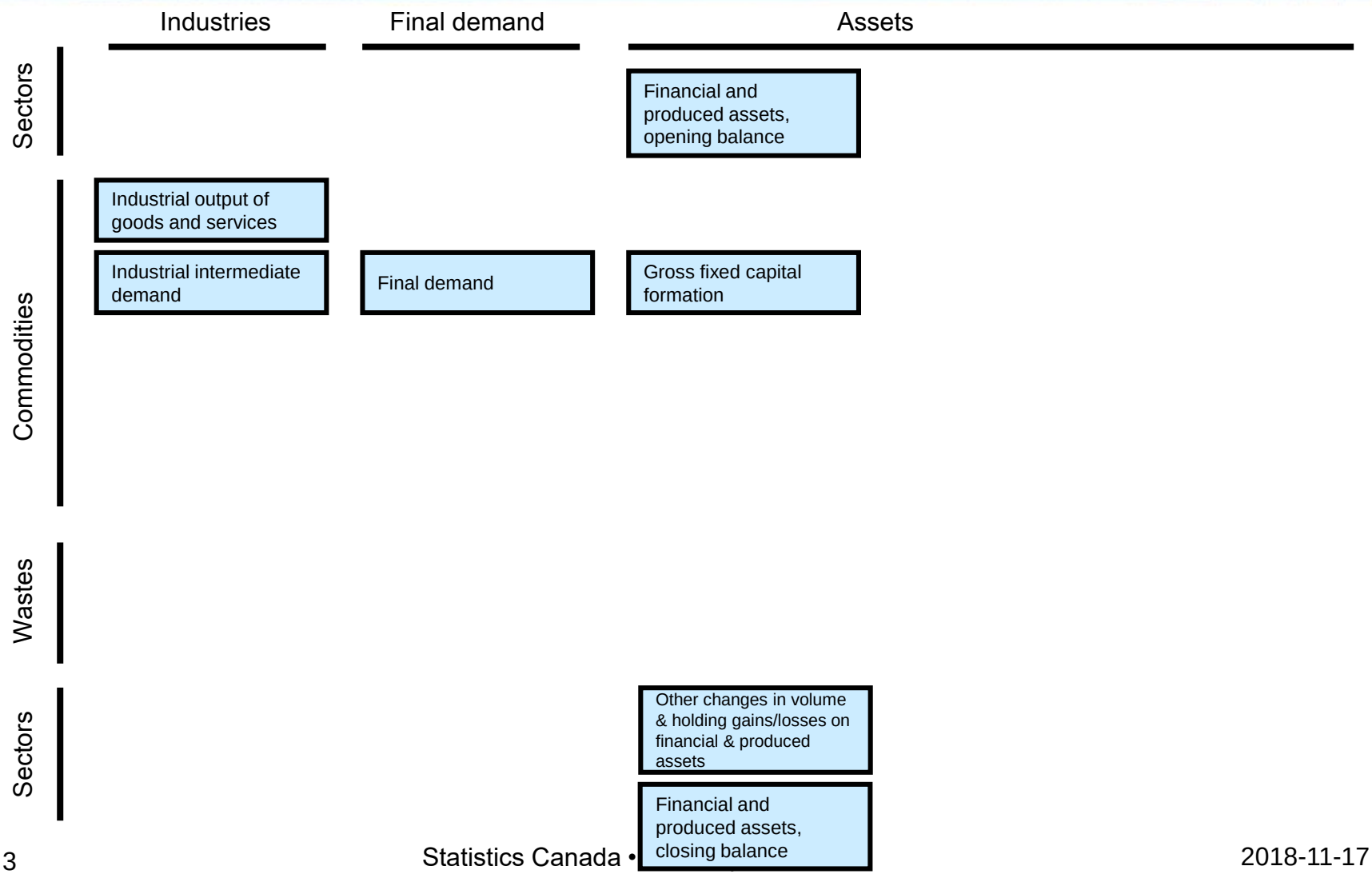
Flows

Expenditures



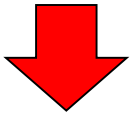
-Residuals

SNA view


Industries
Final demand
Assets
Sectors
Financial and produced assets, opening balance
Commodities
Industrial output of goods and services
Industrial intermediate demand
Final demand
Gross fixed capital formation
Wastes
Sectors
Other changes in volume & holding gains/losses on financial & produced assets
Financial and produced assets, closing balance

Flow Accounting

Table 3.2.1 General physical supply and use table



Supply table

	Production; Generation of residuals		Accumulation	Flows from the rest of the world	Flows from the environment	Total
	Production; Generation of residuals by industries (incl. household production on own account) - classified by ISIC	Generation of residuals by households	Industries - classified by ISIC			
Natural inputs					A. Flows from the environment (incl. natural resource residuals)	Total Supply of Natural Inputs (TSNI)
Products	C. Output (incl. sale of recycled and reused products)			D. Imports of products		Total Supply of Products (TSP)
Residuals	I1. Residuals generated by industry (incl. natural resource residuals) I2. Residuals generated following treatment	J. Residuals generated by household final consumption	K1. Residuals from scrapping and demolition of produced K2. Emissions from controlled landfill sites	L. Residuals received from rest of the world	M. Residuals recovered from the environment	Total Supply of Residuals (TSR)
Total supply						

United Nations, 2012, System *of Environmental-Economic Accounting: Central Framework (white cover draft)*, New York. http://unstats.un.org/unsd/envaccounting/White_cover.pdf

Flow Accounting

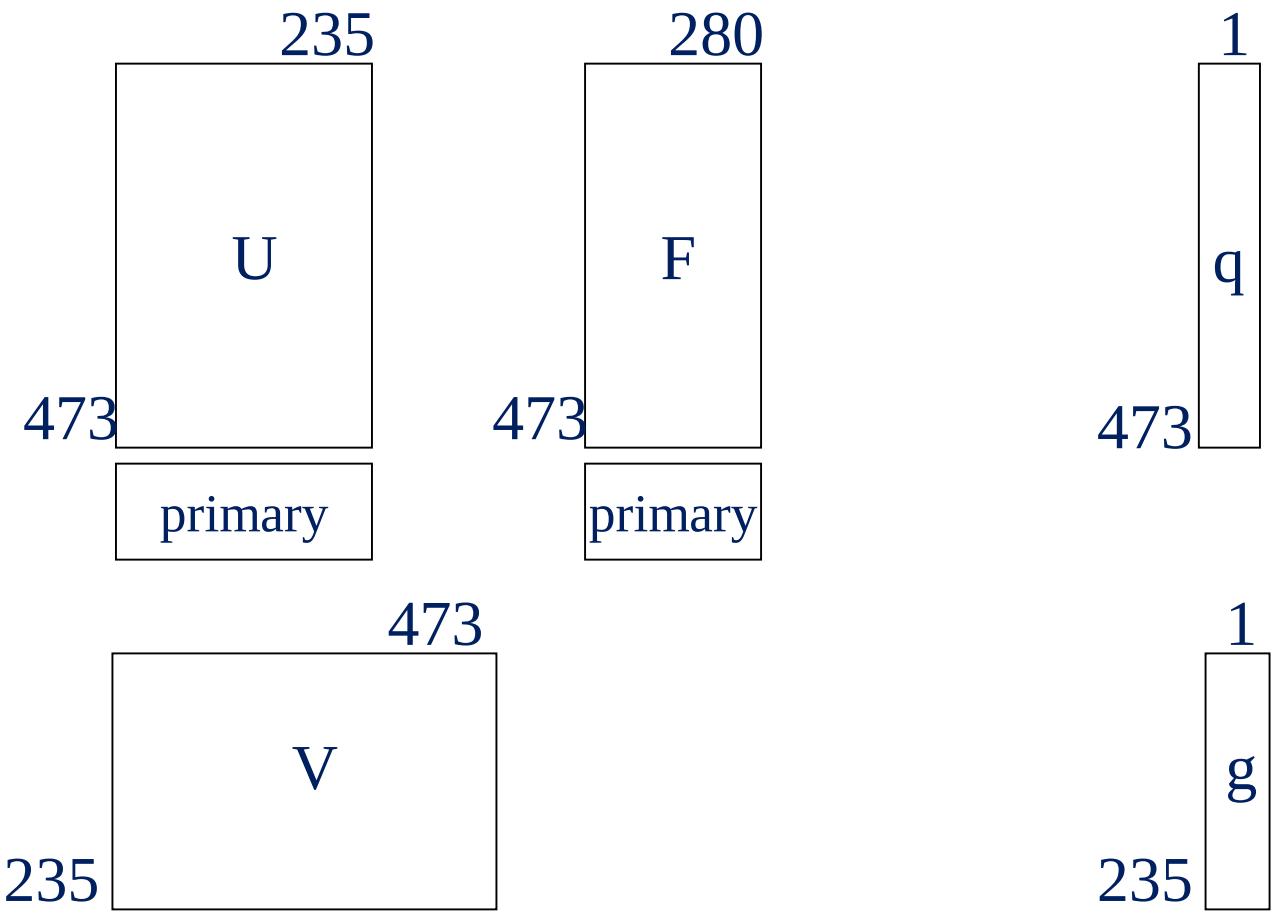
Use table

	Intermediate consumption of products; Use of natural inputs; Collection of residuals	Final consumption*	Accumulation	Flows to the rest of the world	Flows to the environment	Total
	Industries - classified by ISIC	Households	Industries - classified by ISIC			
Natural inputs	B. Extraction of natural inputs B1. Extraction used in production B2. Natural resource residuals					Total Use of Natural Inputs (TUNI)
Products	E. Intermediate consumption (incl. purchase of recycled and reused products)	F. Household final consumption (incl. purchase of recycled and reused products)	G. Gross Capital Formation (incl. fixed assets and inventories)	H. Exports of products		Total Use of Products (TUP)
Residuals	N. Collection and treatment of residuals (excl accumulation in controlled landfill sites)		O. Accumulation of waste in controlled landfill sites	P. Residuals sent to the rest of the word	Q. Residual flows to the environment Q1. Direct from industry and households (incl. natural resource residuals & landfill emissions) Q2.Following treatment	Total Use of Residuals (TUR)
Total use						

*No entries for government final consumption are recorded in physical terms. All government intermediate consumption, production and generation of residuals is recorded against the relevant industry in the first column of the PSUT.

United Nations, 2012, System *of Environmental-Economic Accounting: Central Framework (white cover draft)*, New York. http://unstats.un.org/unsd/envaccounting/White_cover.pdf

Integration – the IO tables



Integration – the common denominator

$$\alpha = E/g$$

$$\overset{1}{\underset{235}{\boxed{\alpha}}} = \overset{1}{\underset{235}{\boxed{E}}} \Big/ \overset{1}{\underset{235}{\boxed{g}}}$$

Integration – the IO model

- ***Basic identity: supply = demand***

$$q + inv_{-} + m = u + fd + x + inv_{+}$$

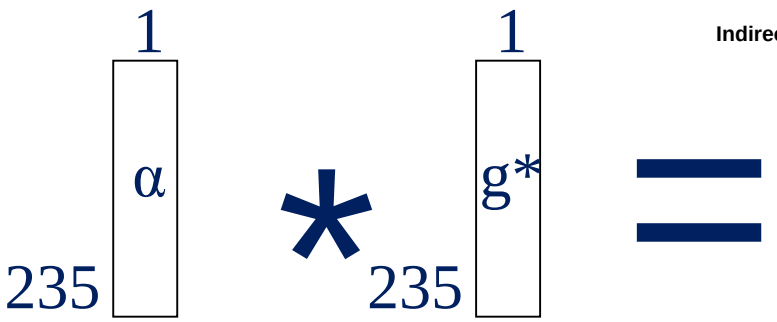
By substituting for market share ($D=V/q$) and technology ($B=U/g$), we get:

$$g = (I - DB)^{-1}Df$$

- ***Allows an estimate of the gross production (g) required from each industry to satisfy a given final demand (f) based on pre-defined relationships of market-share (D) and technology (B)***

Sample results – attribution to demand

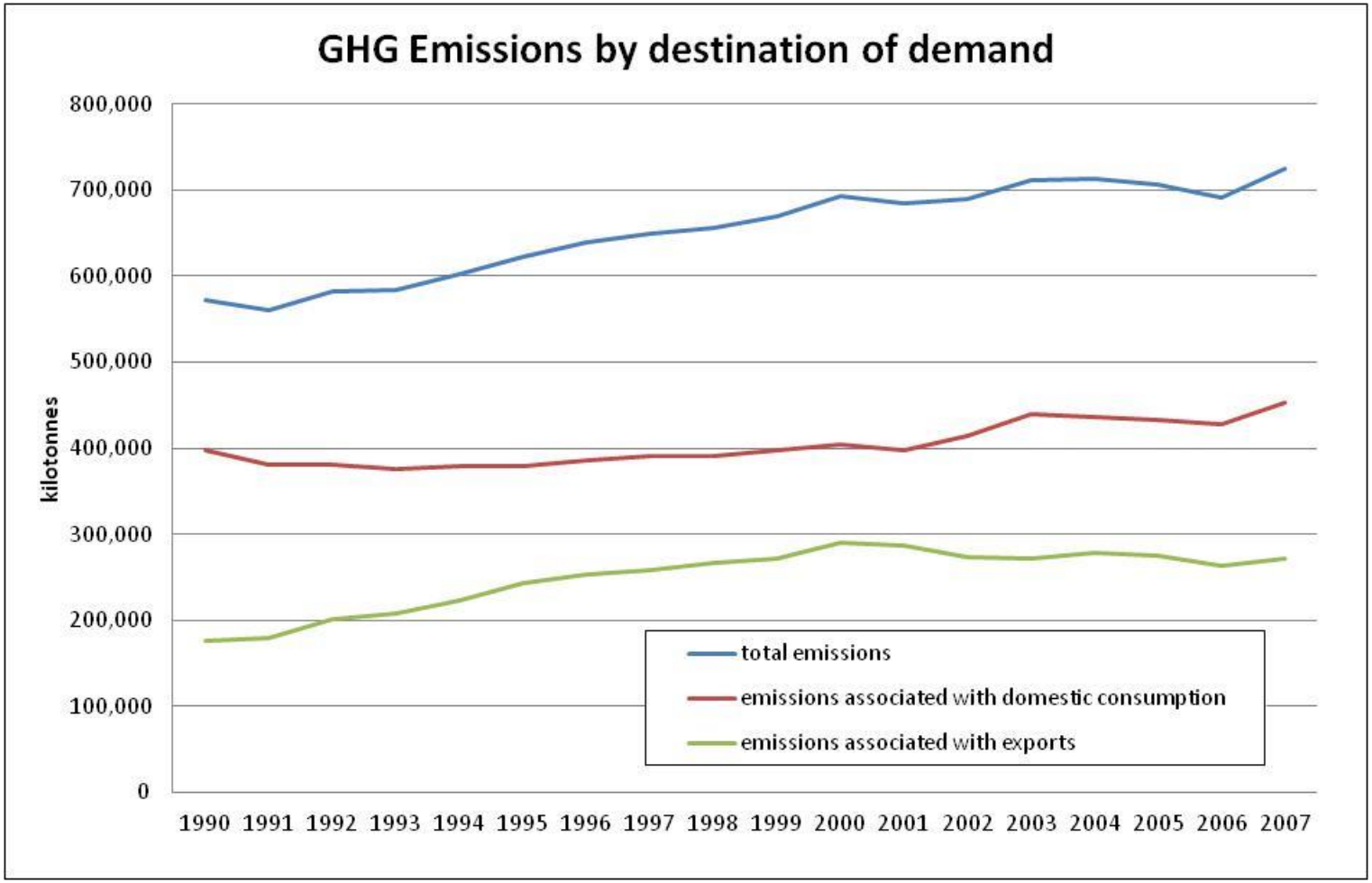
$$g^* = (I - DB)^{-1} Df_{pe}$$



Greenhouse Gas Emissions (carbon dioxide equivalents) attributable to household purchases and consumption, 2002

		kilotonnes	%
Indirect emissions	Motor vehicles, parts & repairs	5,023	1.6%
	Furniture and household appliances	3,066	1.0%
	Other durable goods	3,741	1.2%
	Clothing and footwear	4,750	1.5%
	Other semi-durable goods	5,521	1.7%
	Food and non-alcoholic beverage	38,874	12.1%
	Motor fuels and lubricants	15,554	4.8%
	Electricity	43,343	13.5%
	Natural Gas	7,315	2.3%
	Other fuels	2,281	0.7%
	Other non-durable goods	10,781	3.4%
	Gross rent (imputed and paid)	14,555	4.5%
	Restaurants & hotels	15,972	5.0%
	Other services	39,011	12.2%
	Sub total, indirect emissions	**209,787**	**65.3%**
Direct emissions	Heating, lighting and appliances	41,719	13.0%
	Motor fuels and lubricants	69,557	21.7%
	Sub total, direct emissions	**111,276**	**34.7%**
Total GHG emissions attributable to households		**321,064**	**100.0%**

Sample results – time series



Sample results – direct and indirect intensities (multipliers)

$$\begin{matrix}1\\235\end{matrix}\left[\alpha\right] * \begin{matrix}235\\235\end{matrix}\left[(I - DB)^{-1}\right] =$$

Direct plus indirect energy intensity by industry, 1990-2007

Industry[1]		1990	1991	1992	1993	1994
1	Crop and animal production	18.70	20.57	21.63	19.70	18.68
2	Forestry and logging	11.80	11.96	12.24	10.73	10.48
3	Fishing, hunting and trapping	11.81	12.56	11.41	9.60	13.57
4	Support activities for agriculture and forestry	11.78	10.91	11.30	10.83	10.53
5	Oil and gas extraction	32.49	37.12	36.93	33.72	31.93
6	Coal mining	18.18	19.21	18.80	16.99	17.24
7	Metal ore mining	17.78	19.49	18.76	20.00	17.93
8	Non-metallic mineral mining and quarrying	22.87	23.82	22.70	22.37	21.75
9	Support activities for mining and oil and gas extraction	14.87	14.42	17.02	16.09	13.54
10	Electric power generation, transmission and distribution	62.63	57.47	57.87	51.07	49.54
11	Natural gas distribution, water and other systems	12.34	10.67	12.06	13.52	11.65
12	Residential building construction	8.94	9.37	9.69	9.41	9.12
13	Non-residential building construction	7.87	8.37	8.57	8.65	8.26
14	Transportation engineering construction	18.63	19.36	18.94	18.08	17.64
15	Oil and gas engineering construction	11.59	12.26	12.87	11.95	11.17
16	Electric power engineering construction	6.97	7.12	7.27	7.14	6.70
17	Communication engineering construction	7.58	8.66	8.57	8.48	8.21
18	Other engineering construction	8.17	8.69	9.14	8.80	8.11
19	Repair construction	8.06	8.33	8.56	8.19	7.92
20	Other activities of the construction industry	9.53	10.40	10.42	10.41	10.02
21	Animal food manufacturing	15.57	16.16	16.44	15.73	15.32
22	Sugar and confectionery product manufacturing	9.74	11.03	10.23	9.58	9.54
23	Fruit and vegetable preserving and specialty food manufactu	13.12	12.54	12.71	12.50	12.57
24	Dairy product manufacturing	15.46	16.25	16.98	15.88	15.43
25	Meat product manufacturing	15.87	16.67	17.11	16.34	15.67
26	Seafood product preparation and packaging	10.45	11.13	11.42	10.25	11.21
27	Miscellaneous food manufacturing	12.04	10.82	11.24	11.31	11.45
28	Soft-drink and ice manufacturing	10.73	11.12	10.26	10.97	11.45
29	Breweries	8.95	8.09	8.46	8.08	7.55

Numerical example

USE (U)	farms	mines	food manuf.	other manuf.	services
cattle	10	0	80	10	0
iron ore	0	0	0	100	0
milk	10	5	100	0	5
cheese	0	5	0	0	5
fuel	100	200	10	50	50
steel	0	5	0	145	0
cars	10	5	5	5	10
advertising	5	15	20	40	20

Numerical example

USE (U)	farms	mines	food manuf.	other manuf.	services
cattle	10	0	80	10	0
iron ore	0	0	0	100	0
milk	10	5	100	0	5
cheese	0	5	0	0	5
fuel	100	200	10	50	50
steel	0	5	0	145	0
cars	10	5	5	5	10
advertising	5	15	20	40	20

MAKE (V)	cattle	iron ore	milk	cheese	fuel	steel	cars	advertising
farms	100	0	100	10	0	0	0	0
mines	0	100	0	0	1000	0	0	0
food manuf.	0	0	80	200	0	0	0	0
other manuf.	0	0	0	0	10	150	200	0
services	0	0	0	0	0	0	0	100

Numerical example

USE (U)	farms	mines	food manuf.	other manuf.	services	Final Demand
cattle	10	0	80	10	0	0
iron ore	0	0	0	100	0	0
milk	10	5	100	0	5	60
cheese	0	5	0	0	5	200
fuel	100	200	10	50	50	600
steel	0	5	0	145	0	0
cars	10	5	5	5	10	165
advertising	5	15	20	40	20	0

MAKE (V)	cattle	iron ore	milk	cheese	fuel	steel	cars	advertising
farms	100	0	100	10	0	0	0	0
mines	0	100	0	0	1000	0	0	0
food manuf.	0	0	80	200	0	0	0	0
other manuf.	0	0	0	0	10	150	200	0
services	0	0	0	0	0	0	0	100

Numerical example

USE (U)	farms	mines	food manuf.	other manuf.	services	Final Demand
cattle	10	0	80	10	0	0
iron ore	0	0	0	100	0	0
milk	10	5	100	0	5	60
cheese	0	5	0	0	5	200
fuel	100	200	10	50	50	600
steel	0	5	0	145	0	0
cars	10	5	5	5	10	165
advertising	5	15	20	40	20	0

MAKE (V)	cattle	iron ore	milk	cheese	fuel	steel	cars	advertising	g
farms	100	0	100	10	0	0	0	0	210
mines	0	100	0	0	1000	0	0	0	1100
food manuf.	0	0	80	200	0	0	0	0	280
other manuf.	0	0	0	0	10	150	200	0	360
services	0	0	0	0	0	0	0	100	100
q	100	100	180	210	1010	150	200	100	

Numerical example

B (U/g)	farms	mines	food manuf.	other manuf.	services
cattle	0.05	0.00	0.29	0.03	0.00
iron ore	0.00	0.00	0.00	0.28	0.00
milk	0.05	0.00	0.36	0.00	0.05
cheese	0.00	0.00	0.00	0.00	0.05
fuel	0.48	0.18	0.04	0.14	0.50
steel	0.00	0.00	0.00	0.40	0.00
cars	0.05	0.00	0.02	0.01	0.10
advertising	0.02	0.01	0.07	0.11	0.20
Σ	0.6	0.2	0.8	0.97	0.9

Numerical example

B (U/g)	farms	mines	food manuf.	other manuf.	services
cattle	0.05	0.00	0.29	0.03	0.00
iron ore	0.00	0.00	0.00	0.28	0.00
milk	0.05	0.00	0.36	0.00	0.05
cheese	0.00	0.00	0.00	0.00	0.05
fuel	0.48	0.18	0.04	0.14	0.50
steel	0.00	0.00	0.00	0.40	0.00
cars	0.05	0.00	0.02	0.01	0.10
advertising	0.02	0.01	0.07	0.11	0.20
Σ	0.6	0.2	0.8	0.97	0.9

D (V/q)	cattle	iron ore	milk	cheese	fuel	steel	cars	advertising
farms	1.00	0.00	0.56	0.05	0.00	0.00	0.00	0.00
mines	0.00	1.00	0.00	0.00	0.99	0.00	0.00	0.00
food manuf.	0.00	0.00	0.44	0.95	0.00	0.00	0.00	0.00
other manuf.	0.00	0.00	0.00	0.00	0.01	1.00	1.00	0.00
services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Σ	1	1	1	1	1	1	1	1

Numerical example

$(I-DB)^{-1}$	farms	mines	food manuf.	other manuf.	services
farms	1.11	0.01	0.65	0.08	0.12
mines	0.74	1.26	0.59	1.13	1.01
food manuf.	0.04	0.01	1.22	0.03	0.12
other manuf.	0.13	0.03	0.14	1.80	0.27
services	0.07	0.03	0.16	0.27	1.32

meaning? dollars of output from industry at row to deliver (to final demand) a dollar of output from industry at column

Numerical example

$(I-DB)^{-1}$	farms	mines	food manuf.	other manuf.	services	$g=(I-DB)^{-1}De$	g
farms	1.11	0.01	0.65	0.08	0.12	210	210
mines	0.74	1.26	0.59	1.13	1.01	1100	1100
food manuf.	0.04	0.01	1.22	0.03	0.12	280	280
other manuf.	0.13	0.03	0.14	1.80	0.27	360	360
services	0.07	0.03	0.16	0.27	1.32	100	100

meaning? dollars of output from industry at row to deliver (to final demand) a dollar of output from industry at column

Numerical example

$(I-DB)^{-1}$	farms	mines	food manuf.	other manuf.	services	De	farms only	$g=(I-DB)^{-1}De$
farms	1.11	0.01	0.65	0.08	0.12	42.86	47.51138	210
mines	0.74	1.26	0.59	1.13	1.01	594.06	7.0069	1100
food manuf.	0.04	0.01	1.22	0.03	0.12	217.14	141.1847	280
other manuf.	0.13	0.03	0.14	1.80	0.27	170.94	14.29702	360
services	0.07	0.03	0.16	0.27	1.32	0.00	0	100
							210	

decompostion of row one of $(I-DB)^{-1}$ times column one of De (Row 1 of $(I-DB)^{-1}$ times column of De)

1.11 * 42.86 ($1.11 of production from farms is required to deliver a dollar of production from farms, so to get 42.86 of final demand we need farms to produce 47.5 dollars of output)

Plus: 0.01 * 594.06 ($0.01 of production from farms is required to deliver a dollar of production from mines, so to get 594.06 of final demand we need farms to produce 7 dollars of output)

Plus: 0.65 * 217.14 ($0.65 of production from farms is required to deliver a dollar of production from food manufacturers, so to get 217.14 of final demand we need farms to produce 141.2 dollars of output)

Plus: 0.08 * 170.94 ($0.08 of production from farms is required to deliver a dollar of production from other manufacturers, so to get 170,94 of final demand we need farms to produce 14.3 dollars of output)

Plus: 0.12 * 0 ($0.12 of production from farms is required to deliver a dollar of production from services, so to get 0.00 to final demand we need farms to produce 0 dollars of output)

So, to deliver all of final demand, farms must produce 210 dollars of gross output

Sample results – direct and indirect intensities (multipliers)

$$\begin{matrix} 1 \\ 235 \end{matrix} \left[\alpha \right] * \begin{matrix} 235 \\ 235 \end{matrix} \left[(I - DB)^{-1} \right] =$$

Direct plus indirect energy intensity by industry, 1990-2007

Industry[1]		1990	1991	1992	1993	1994
1	Crop and animal production	18.70	20.57	21.63	19.70	18.68
2	Forestry and logging	11.80	11.96	12.24	10.73	10.48
3	Fishing, hunting and trapping	11.81	12.56	11.41	9.60	13.57
4	Support activities for agriculture and forestry	11.78	10.91	11.30	10.83	10.53
5	Oil and gas extraction	32.49	37.12	36.93	33.72	31.93
6	Coal mining	18.18	19.21	18.80	16.99	17.24
7	Metal ore mining	17.78	19.49	18.76	20.00	17.93
8	Non-metallic mineral mining and quarrying	22.87	23.82	22.70	22.37	21.75
9	Support activities for mining and oil and gas extraction	14.87	14.42	17.02	16.09	13.54
10	Electric power generation, transmission and distribution	62.63	57.47	57.87	51.07	49.54
11	Natural gas distribution, water and other systems	12.34	10.67	12.06	13.52	11.65
12	Residential building construction	8.94	9.37	9.69	9.41	9.12
13	Non-residential building construction	7.87	8.37	8.57	8.65	8.26
14	Transportation engineering construction	18.63	19.36	18.94	18.08	17.64
15	Oil and gas engineering construction	11.59	12.26	12.87	11.95	11.17
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18	Other engineering construction	8.17	8.69	9.14	8.80	8.11
19	Repair construction	8.06	8.33	8.56	8.19	7.92
20	Other activities of the construction industry	9.53	10.40	10.42	10.41	10.02
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22	Sugar and confectionery product manufacturing	9.74	11.03	10.23	9.58	9.54
23	Fruit and vegetable preserving and specialty food manufactu	13.12	12.54	12.71	12.50	12.57
24	Dairy product manufacturing	15.46	16.25	16.98	15.88	15.43
25	Meat product manufacturing	15.87	16.67	17.11	16.34	15.67
26	Seafood product preparation and packaging	10.45	11.13	11.42	10.25	11.21
27	Miscellaneous food manufacturing	12.04	10.82	11.24	11.31	11.45
28	Soft-drink and ice manufacturing	10.73	11.12	10.26	10.97	11.45
29	Breweries	8.95	8.09	8.46	8.08	7.55

Numerical example

Intensity indicators																
	emissions per unit of output (direct emissions intensity)															
	α	farms	mines	food manu	other manu	services		**(I-DB)⁻¹**	farms	mines	food manu	other manu	services			
	co2/g	0.5	0.8	0.3	0.4	0.1		farms	1.11	0.01	0.65	0.08	0.12			
								mines	0.74	1.26	0.59	1.13	1.01			
								food manu	0.04	0.01	1.22	0.03	0.12			
	alpha inverse							other manu	0.13	0.03	0.14	1.80	0.27			
		1.218388	1.030774	1.234589	1.698604	1.139405		services	0.07	0.03	0.16	0.27	1.32			
	So, α*(I-DB)⁻¹ for row of α times column 1 of (I-DB)⁻¹ is...															
	0.5 * 1.11 (1.11 dollars of production from farms is required to deliver a dollar of production from farms. Farms emit .05 CO2 per dollar of output,so in terms of emissions this is:)															0.554299
plus	0.8 * 0.74 (0.74 dollars of production from mines is required to deliver a dollar of production from farms. Mines emit .8 CO2 per dollar of output, so in terms of emissions this is:)															0.594947
plus	0.3 * 0.04 (0.04 dollars of production from food manuf. Is required to deliver a dollar of production from farms. Food manuf. Emit .3 CO2 per dollar of output, so in terms of emissions:															0.011714
plus	0.4 * 0.13 (0.13 dollars of production from other manuf. Is required to deliver a dollar of output from farms. Other manuf. Emit .4 CO2 per dollar of output, so in terms of emissions:)															0.05075
plus	0.1 * 0.01 (0.01 dollars of production from services is required to deliver a dollar of output from farms. Services emit .1 CO2 per dollar of output, so in terms of emissions this is:)															0.006678
															SUM	**1.218388**
	This is the total emissions required (direct plus indirect) from all industries per dollar of output from farms.															

Questions?

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