# SEEA Extensions:

# Input-Output  Modelling

**UNSD SEEA Training of Trainers Seminar**

7-10 July 2015, Santiago

**Joe St. Lawrence**

**Statistics Canada**

# SNA framework



| | 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 |

# SEEA framework



|  | Industries | Final demand | Assets | | |
|---|---|---|---|---|---|
| **Sectors** | | | Financial and produced assets, opening balance | Natural resource assets, opening balance | Natural resource assets, opening balance |
| **Commodities** | Industrial output of goods and services | | | | |
|  | Industrial intermediate demand / Environmental protection expenditures | Final demand / Environmental protection expenditures | Gross fixed capital formation / Capital expenditures for environmental protection | | |
|  | Resource production by industries / Resource use by industries | Resource production by households/gov't / Resource use by households/gov't | | | |
| **Wastes** | Waste consumption by industries / Waste output by industries | Waste consumption by households/gov't / Waste output by households/gov't | | | |
| **Sectors** | | | Other changes in volume & holding gains/losses on financial & produced assets | Changes in and holding gains/losses on natural resource assets | Changes in natural resource assets |
|  | | | Financial and produced assets, closing balance | Natural resource assets, closing balance | Natural resource assets, closing balance |

3

5

# Flow Accounting

## Table 3.2.1 General physical supply and use table
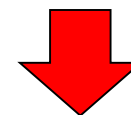
**Supply table**

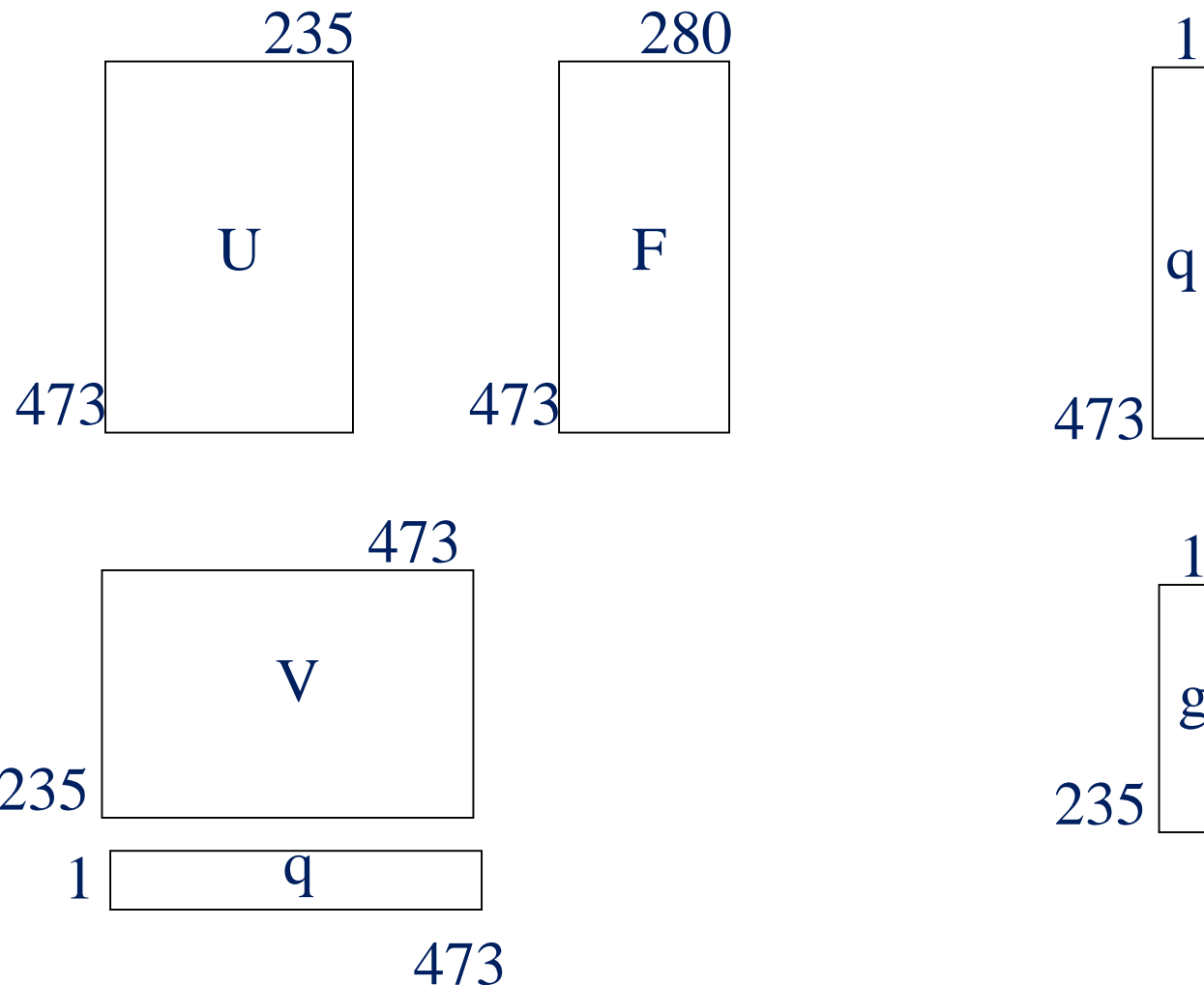| | Production; Generation of residuals | | Accumulation | Flows from the rest of the world | Flows from the environment | Total |
|---|---|---|---|---|---|---|
| | Production; Generation of residuals by industries (incl. household production on own account) - classified by ISIC | Generation of residuals 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) <br><br> 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 | | | | | | |

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# 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<br>B1. Extraction used in production<br>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<br><br>Q1. Direct from industry and households (incl. natural resource residuals & landfill emissions)<br>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

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# Monetary Input-Output tables

235

U

473

280

F

473

1

q

473

473

V

235

1    q

473

1

g

235

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# Numerical example (U: Use)

| 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 |
| parts | 10 | 5 | 5 | 5 | 10 |
| advertising | 5 | 15 | 20 | 40 | 20 |

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# Numerical example (V: Make)

| 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 |
| parts | 10 | 5 | 5 | 5 | 10 |
| advertising | 5 | 15 | 20 | 40 | 20 |

| MAKE (V) | cattle | iron ore | milk | cheese | fuel | steel | parts | 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 |

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# Numerical example (F: final demand)

**Final Demand**

| | |
|---|---|
| | 0 |
| | 0 |
| | 60 |
| | 200 |
| | 600 |
| | 0 |
| | 165 |
| | 0 |

**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 |
| parts | 10 | 5 | 5 | 5 | 10 |
| advertising | 5 | 15 | 20 | 40 | 20 |

**MAKE (V)**

| | cattle | iron ore | milk | cheese | fuel | steel | parts | 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 |

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**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 |
| parts | 10 | 5 | 5 | 5 | 10 | 165 |
| advertising | 5 | 15 | 20 | 40 | 20 | 0 |

**MAKE (V)**

| | cattle | iron ore | milk | cheese | fuel | steel | parts | advertising | | g |
|---|---|---|---|---|---|---|---|---|---|---|
| farms | 100 | 0 | 100 | 10 | 0 | 0 | 0 | 0 | Σ → | 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 |

Σ ↓

| q | 100 | 100 | 180 | 210 | 1010 | 150 | 200 | 100 |
|---|---|---|---|---|---|---|---|---|

# Numerical example (overview)

**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 |
| parts | 10 | 5 | 5 | 5 | 10 | 165 |
| advertising | 5 | 15 | 20 | 40 | 20 | 0 |

**MAKE (V)**

| | cattle | iron ore | milk | cheese | fuel | steel | parts | advertising | | **g** |
|---|---|---|---|---|---|---|---|---|---|---|
| farms | 100 | 0 | 100 | 10 | 0 | 0 | 0 | 0 | | 210 |
| mines | 0 | 100 | 0 | 0 | 1000 | 0 | 0 | 0 | Σ → | 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 |

Σ ↓

| **q** | 100 | 100 | 180 | 210 | 1010 | 150 | 200 | 100 |
|---|---|---|---|---|---|---|---|---|

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# 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:**

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

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

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# Numerical example (B: Technology)

| 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 |
| parts | 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 |

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# Numerical example (D: Market share)

| 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 |
| parts | 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 | parts | 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 |

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# Numerical example (The inverse)

| (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 (De)

**Final Demand**

| |
|---|
| 0 |
| 0 |
| 60 |
| 200 |
| 600 |
| 0 |
| 165 |
| 0 |

**De**

| |
|---|
| **42.86** |
| 594.06 |
| 217.14 |
| 170.94 |
| 0.00 |

$$= 60* 0.56 + 200* 0.05$$

Actually $= 60*0.555 + 200*0.0476$

(display table is rounded)

| D (V/q) | cattle | iron ore | milk | cheese | fuel | steel | parts | 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 |

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# Numerical example: $(I-DB)^{-1}De$

| $(I-DB)^{-1}$ | 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 |

| De | |
|---|---|
| | 42.86 |
| | 594.06 |
| | 217.14 |
| | 170.94 |
| | 0.00 |

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# Numerical example: $(I-DB)^{-1}De$

| $(I-DB)^{-1}$ | farms | mines | food manuf. | other manuf. | services | De | | g=$(I-DB)^{-1}De$ |
|---|---|---|---|---|---|---|---|---|
| farms | 1.11 | 0.01 | 0.65 | 0.08 | 0.12 | 42.86 | 47.5114 | 210 |
| mines | 0.74 | 1.26 | 0.50 | 1.13 | 1.01 | 594.06 | 7.0069 | 1100 |
| food manuf. | 0.04 | 0.01 | 1.22 | 0.03 | 0.12 | 217.14 | 141.185 | 280 |
| other manuf. | 0.13 | 0.03 | 0.14 | 1.80 | 0.27 | 170.94 | 14.297 | 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

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# 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 |

| De | |
|---|---|
| | 42.86 |
| | 594.06 |
| | 217.14 |
| | 170.94 |
| | 0.00 |

| g calc | g=(I-DB)⁻¹De |
|---|---|
| | 210 |
| | 1100 |
| | 280 |
| | 360 |
| | 100 |

| real g | g |
|---|---|
| | 210 |
| | 1100 |
| | 280 |
| | 360 |
| | 100 |

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# Calculating output required for different categories of demand...

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

- *Recall that this provides an estimate of the gross output (g) required from each industry to satisfy a given final demand (e) based on pre-defined relationships of market-share (D) and technology (B)*

- *So, if I wanted to calculate the gross output from each industry required to produce the demand related to household personal expenditure, I could calculate...*

$$g_{pe} = (I - DB)^{-1} De_{pe}$$

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$$\alpha = E/g$$

$$_{235}\boxed{^{1}\alpha} = {}_{235}\boxed{^{1}E} \Big/ {}_{235}\boxed{^{1}g}$$

$$g_{pe} = (I - DB)^{-1}De_{pe}$$

$$1 \boxed{\quad \alpha \quad} \quad 235 \;\; * \;\; \begin{matrix} 1 \\ \boxed{\begin{matrix} g_{pe} \\ \end{matrix}} \\ 235 \end{matrix} \;\; = \;\; 1 \boxed{\begin{matrix} 1 \\ E_{pe} \end{matrix}}$$

# Demand-based perspectives

**Table 153-0129**[1, 2, 5]

## Physical flows by final demand category

annual

| Data table | Add/Remove data | Manipulate | Download | Related information | Help |

The data below is a part of CANSIM table 153-0129. Use the Add/Remove data tab to customize your table.

**Selected items [Add/Remove data]**

**Geography** = Canada
**Flow** = Greenhouse gas emissions by final demand category (kilotonnes)

| Sector | 2009 | 2010 | 2011 |
|---|---|---|---|
| Total, industries and households | 714,937 | 727,805 | 732,927 |
| Personal expenditure (households)[4] | 313,692 | 314,140 | 310,336 |
| Non-profit institutions serving households' consumption expenditure | 6,153 | 5,678 | 5,900 |
| Government net current expenditure | 44,184 | 45,857 | 45,642 |
| Gross fixed capital formation | 74,832 | 82,694 | 82,693 |
| International exports | 276,077 | 279,436 | 288,356 |

# Sample results – direct and indirect intensities (multipliers)

$$1 \underset{235}{\boxed{\quad \alpha \quad}} \; * \; \underset{235}{\overset{235}{\boxed{(I - DB)^{-1}}}} \; =$$

**Table** 153-0115 [1, 2, 3, 4, 5, 6, 8]

Direct plus indirect energy and greenhouse gas emissions intensity, by industry

annual

| Data table | Add/Remove data | Manipulate | Download | Related information | Help |

The data below is a part of CANSIM table 153-0115. Use the Add/Remove data tab to customize your table.

**Selected items [Add/Remove data]**

**Geography** = Canada
**Intensity** = Direct plus indirect energy intensity (gigajoules per thousand current dollars of production)

| Sector | 2011 |
| --- | --- |
| **Total, industries** | 4.91 |
| **Crop and animal production [BS11A00]** | 11.28 |
| **Forestry and logging [BS11300]** | 7.74 |
| **Fishing, hunting and trapping [BS11400]** | 7.49 |
| **Support activities for agriculture and forestry [BS11500]** | 9.71 |
| **Oil and gas extraction [BS21100]** | 13.48 |
| **Coal mining [BS21210]** | 5.71 |
| **Metal ore mining [BS21220]** | 4.32 |
| **Non-metallic mineral mining and quarrying [BS21230]** | 5.76 |
| **Support activities for mining and oil and gas extraction [BS21300]** | 6.32 |

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# Numerical example: Multipliers

### emissions per unit of output (direct emissions intensity)

| $\alpha$ | farms | mines | food manu | other manu | services |
|---|---|---|---|---|---|
| $CO_2$/g | 0.5 | 0.8 | 0.3 | 0.4 | 0.1 |

| $(I-DB)^{-1}$ | 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 |

### alpha inverse

| | | | | |
|---|---|---|---|---|
| 1.218388 | 1.030774 | 1.234589 | 1.698604 | 1.139405 |

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# Numerical example: Multipliers

emissions per unit of output (direct emissions intensity)

| α | farms | mines | food manu | other manu | services |
|---|---|---|---|---|---|
| co2/g | 0.5 | 0.8 | 0.3 | 0.4 | 0.1 |

alpha inverse

| | | | | |
|---|---|---|---|---|
| 1.218388 | 1.030774 | 1.234589 | 1.698604 | 1.139405 |

| $(I-DB)^{-1}$ | farms | mines | food manu | other manu | services |
|---|---|---|---|---|---|
| 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 |
| other manu | 0.13 | 0.03 | 0.14 | 1.80 | 0.27 |
| services | 0.07 | 0.03 | 0.16 | 0.27 | 1.32 |

**So, $\alpha*(I-DB)^{-1}$ for row of $\alpha$ 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:) **0.5543**

**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:) **0.59495**

**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:) **0.01171**

**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:) **0.00668**

This is the total emissions required (direct plus indirect) from all industries per dollar of output from farms. **1.21839**

this basically converts emissions per unit of output (direct intensity) to total emissions required to deliver a unit of final demand (direct plus indirect intensity)

# Questions?

**Joe St. Lawrence**

**Statistics Canada | 170 Tunney's Pasture Driveway, Ottawa ON K1A 0T6**
**Statistique Canada | 170, promenade Tunney's Pasture, Ottawa ON K1A 0T6**
**Joe.StLawrence@statcan.gc.ca**
**Telephone | Téléphone 613-882-8598**
**Facsimile | Télécopieur 613-951-0634**
**Government of Canada | Gouvernement du Canada**