Green Jobs Assessment Model

Basic structure of IOT and excercise

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How to produce cocoa?

in thousand	Agri.
Agriculture	12.5

- Purchase seedlings!

‘Use’ of inputs

in thousand	Agri.
Agriculture	12.5
Manufacture	25

- Purchase knifes, bags and equipment

‘Use’ of inputs

in thousand	Agri.
Agriculture	12.5
Manufacture	25
Service	50

- Pay for extension service!

‘Use’ of inputs

in thousand	Agri.
Agriculture	12.5
Manufacture	25
Service	50
Imports	75

- Import fertilizer!

‘Use’ of inputs

in thousand	Agri.
Agriculture	12.5
Manufacture	25
Service	50
Imports	75
Wages (jobs)	250 (125 jobs)

- Employ workers and pay for labor!

‘Use’ of inputs

in thousand	Agri.
Agriculture	12.5
Manufacture	25
Service	50
Imports	75
Labor & jobs (wages)	250 125 jobs
Capital & profit (Interest)	75

- Pay land owner or interest for loans

Total 'Use' of inputs

in thousand	Agri.
Agriculture	12.5
Manufacture	25
Service	50
Imports	75
Wages (jobs)	250 125 jobs
profit	75
Taxes	12.5
Total Input (payments)	500

- Total inputs/ purchases required to produce

How to make money from cocoa?

in thousand	Agri.
Agriculture	12.5

- Coco beans to farmer

`Supply` of outputs

in thousand	Agri.	Maunf.
Agriculture	12.5	27

- sell cocoa to maunfacturers!

Total `Supply` of outputs

	Agri.	Maunf.	Serv.	Gov. + business	HH	EX	Total
Agri.	12.5	27	60	86.5	40	274	500

- sell to government, households or export!

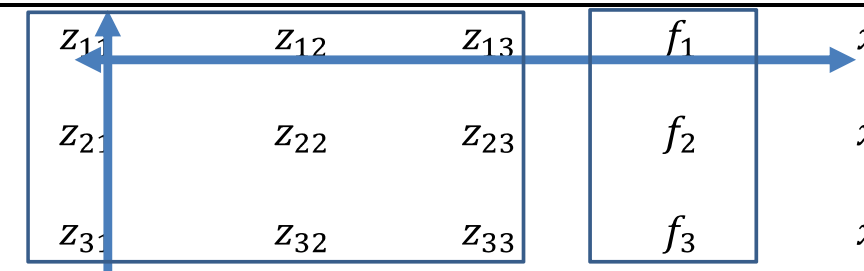
Supply & Use/ Input Output Table

	Agri.	Maunf.	Serv.	Gov. + business	HH	EX	Total
Agriculture	12.5	27	60	86.5	40	274	500
Manufacture	25						
Service	50						
Imports	75						
Wages (jobs)	250 125 jobs						
profit	75						
Taxes	12.5						
Total Input (payments)	500						

Suppose a world where:

- *Each productive activity* generates *only <u>one</u> product*
- Here, the economy is *closed*

		Sector			Final Demand (f).	Total
		Agriculture	**Industry**	**Services**		
Sector	Agric.	z_{11}	z_{12}	z_{13}	f_1	x_1
	Industry	z_{21}	z_{22}	z_{23}	f_2	x_2
	Services	z_{31}	z_{32}	z_{33}	f_3	x_3
Value added		w_1	w_2	w_3		
Total output		x_1	x_2	x_3		



A simplified Input Output Table

		Sector			Final demand (f)			Total output
		Agricul-ture	**Industry**	**Services**	**Household consump-tion**	**Invest-ment**	**Govern-ment consump-tion**	
Sector	Agric.	z_{11}	z_{12}	z_{13}	C_1	I_1	G_1	x_1
	Industry	z_{21}	z_{22}	z_{23}	C_2	I_2	G_2	x_2
	Services	z_{31}	z_{32}	z_{33}	C_3	I_3	G_3	x_3
Value added	Wages	w_{L1}	w_{L2}	w_{L3}				
	Profits	w_{K1}	w_{K2}	w_{K3}				
Net taxes on prod.		t_1	t_2	t_3				
Total output		x_1	x_2	x_3				

Product Output can be consumed as intermediate, as final product or accumulated as capital

Value of output is equal to *value of its inputs*: intermediate consumption of products, value added components and taxes.

SUT and IOT provide GDP and macro & sectoral estimates

SUTs bring together the components of each of the three approaches to measuring GDP:

Production approach:
GDP = Output (at basic prices) - Intermediate consumption + Taxes less subsidies on products

Income approach:
GDP = Compensation of employees + Gross operating surplus + Other taxes less subsidies on production + Taxes less subsidies on products

Expenditure approach:
GDP = Final consumption + Gross capital formation + Exports - Imports

Fundamental economic relationships at sector and aggregate level

Ex. IO integrated model Germany

INPUT-OUTPUT TABLE (Billions of Euro)

			PRODUCTS						FINAL USE					Total output at basic prices
									Final consumption		Gross fixed capital formation	Changes in inventories	Exports	
			Agricul-ture	Manufac-turing	Construc-tion	Trade, trans.and comm.	Finance and business service	Other services	Households	Governmnet				
No.	PRODUCTS		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1)	Agriculture	Domestic	3	20				1	9			3	5	42
(2)	Manufacturing	Domestic	7	394	48	56	11	30	250	7	95	- 58	611	1 451
(3)	Construction	Domestic	1	11	18	8	28	10	5		153		1	234
(4)	Trade, transport and comm.	Domestic	4	139	17	181	38	40	317	15	39	6	111	907
(5)	Finance and business services	Domestic	6	131	30	124	261	51	313	3	25		66	1 010
(6)	Other services	Domestic		18	3	12	17	47	147	472	2		2	721
(7)	Total at basic prices		21	713	116	382	355	179	1 041	497	314	- 49	795	4 365
(8)	Agriculture	Imported	1	11				1	8			1	2	23
(9)	Manufacturing	Imported	4	246	15	21	3	12	111	7	57	27	160	664
(10)	Construction	Imported							1			3	20	25
(11)	Trade, transport and comm.	Imported		9	1	31	4	2						47
(12)	Finance and business services	Imported		16	1	6	24	5	8	2	4		8	73
(13)	Other services	Imported						1						1
(14)	Imports		5	283	17	58	31	21	128	9	61	31	189	833
(15)	Taxes less subsidies on products		2	10	2	12	17	24	151	6	34			257
(16)	Total at purchasers' prices		27	1 007	135	452	402	224	1 319	513	409	- 18	984	5 455
(17)	Compensation of employees	Value add.	6	308	69	294	191	364						1 232
(18)	Other taxes less subsidies on production	Value add.	- 6	- 2		- 1	5	- 7						- 12
(19)	Consumption of fixed capital	Value add.	8	79	5	60	160	63						375
(20)	Net operating surplus/Net mixed income	Value add.	7	60	25	101	252	77						523
(21)	GVA		15	445	99	454	608	497						2 117
(22)	Total input at basic prices		42	1 451	234	907	1 010	721	1 319	513	409	- 18	984	

EMPLOYMENT (1,000 persons)											
(29)	Wage and salary earners	295	6 787	1 948	9 821	5 693	11 356				35 900
(30)	Self-employed	359	275	463	1 297	1 017	1 059				4 470
(31)	Total	654	7 062	2 411	11 118	6 710	12 415				40 370
ENERGY (Petajoule)											
(32)	Coal and coal products		1 714	1	1		6	17	- 41	40	1 738
(33)	Brown coals and lignite products		1 617				1	21	- 9	24	1 654
(34)	Crude oil		4 294						- 7	5	4 291
(35)	Gasolines	3	91	4	25	20	15	868	4	248	1 278
(36)	Diesel fuels	106	123	79	476	93	74	387		355	1 693
(37)	Jet fuels				434		4		10	176	624
(38)	Heating oil, light	25	188	14	87	26	85	514	13	100	1 052
(39)	Fuel oil, heavy		336		17				- 13	217	557
(40)	Other petroleum products	2	1 190	101	35	2	3	48	- 1	161	1 540
(41)	Natural gas and other gases	12	1 797	12	125	49	184	936	228	465	3 808
(42)	Renewable Energy	6	1 178	5	45	7	6	299	1	18	1 564
(43)	Electric power and other energy	23	2 641	14	289	76	197	678	127	198	4 242
(44)	Total	178	15 167	230	1 535	273	574	3 767	311	2 006	24 043
EMISSIONS (1,000 tons)											
(45)	Carbon dioxide (CO2)	9 260	550 893	9 162	80 990	12 077	24 173	222 268			908 823
(46)	Methane (CH4)	1 247	925	1	49	3	10	79			2 313
(47)	Nitrous oxide (N2O)	137	62		2			4			206
(48)	Nitrogen oxides (NOx)	153	538	46	398	33	45	314			1 526
(49)	Sulfur dioxide (SO2)	3	373	1	41	2	8	42			469
(50)	Organic compounds (NMVOC)	13	574	6	40	3	7	310			952
(51)	Ammonia (NH3)	541	16		2			20			579
(52)	Particulate matter (PM10)	47	42	7	43	2	3	48			192
(53)	Hydroflurocarbons (HFC)		12								12
(54)	Perflurorocarbons PFC										
(55)	Sulfur hexafluoride (SF6)										
(54)	Total	11 402	553 435	9 222	81 565	12 120	24 246	223 084			915 073
GLOBAL WARMING AND ACID DEPOSITION (1,000 tons)											
(55)	Greenhouse gases 1)	77 990	589 463	9 232	82 710	12 195	24 482	225 115			1 021 188
(56)	Acid deposition 2)	110	749	33	320	25	39	261			1 537
(57)	Tropospheric ozone formation 3)	1 413	2 036	52	487	38	61	703			4 792
WASTE, SEWAGE AND WATER											
(58)	Waste (1.000 tons)	804	122 849	194 098	4 945	5 510	3 931	36 033			368 171
(59)	Sewage (Mio. cbm)	21	26 970	38	173	193	137	3 118			30 650
(60)	Water from waterworks (Mio. cbm)	136	- 3 725	14	194	216	154	3 011			
(61)	Water from nature (Mio. cbm)	303	37 608	25	9	10	7	25			37 986

Thank you!

Please ask questions

www.ilo.org/greenjobs

Exercice

The example economy: Ourland (values in unit)

	Agriculture	Manufacturing	Services	Household demand	Private investment	Government demand	Exports	**Total output**
Agriculture	12.5	27.0	60.0	40.0	4.5	82.0	274.0	**500.0**
Manufacturing	25.0	54.0	75.0	120.0	594.0	16.0	16.0	**900.0**
Services	50.0	54.0	15.0	80.0	4.5	85.3	461.2	**750.0**
Imports	75.0	108.0	30.0	160.0	297.0	206.7		**876.7**
Taxes minus subsidies	12.5	18.0	15.0					**45.5**
Wages and salaries	250.0	540.0	450.0					**1240.0**
Profits	75.0	99.0	105.0					**279.0**
Total input	**500.0**	**900.0**	**750.0**	**400.0**	**900.0**	**390.0**	**751.2**	**4591.2**

Developing the coefficient matrix

	Agriculture	Manufacturing	Services	Final demand	Output (sales)
Agriculture	12.5/500 = **0.025**	27/900 = **0.03**	60/750 = **0.08**	400.5	500
Manufacturing	25/500 = **0.05**	54/900 = **0.06**	75/750 = **0.1**	746	900
Services	50/500 = **0.1**	54/900 = **0.06**	15/750 = **0.02**	631	750
Imports	75/500 = 0.15	108/900 = 0.12	30/750 = 0.04	663.7	876.7
Taxes minus subsidies	12.5/500 = 0.025	18/900 = 0.02	15/750 = 0.02		45.5
wages and salaries	250/500 = 0.5	540/900 = 0.6	450/750 = 0.6		1240
profits	75/500 = 0.15	99/900 = 0.11	105/750 = 0.14		279
Total input (payment)	1	1	1	400	4591.2

Developing the Leontief inverse

$$\begin{pmatrix} 0.025 & 0.03 & 0.08 \\ 0.05 & 0.06 & 0.1 \\ 0.1 & 0.06 & 0.02 \end{pmatrix}$$

A

- Take the upper left quadrant of the table
- This is your coefficient matrix A
- Remember, it gives you the respective share of inputs from each sector to the production in the sector heading the column
- It collects the coefficients of the equation system connecting inputs with outputs

Developing the Leontief inverse

$$\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} - \begin{pmatrix} 0.025 & 0.03 & 0.08 \\ 0.05 & 0.06 & 0.1 \\ 0.1 & 0.06 & 0.02 \end{pmatrix} = \begin{pmatrix} 0{,}975 & -0{,}03 & -0{,}08 \\ -0{,}05 & 0{,}94 & -0{,}1 \\ -0{,}1 & -0{,}06 & 0{,}98 \end{pmatrix}$$

I - A = (I - A)

Developing the Leontief Inverse

$$\begin{pmatrix} 0.975 & -0.03 & -0.08 \\ -0.05 & 0.94 & -0.1 \\ -0.1 & -0.06 & 0.98 \end{pmatrix}^{-1} = \begin{pmatrix} 1.04 & -0.03 & -0.08 \\ -0.05 & 0.94 & -0.1 \\ -0.1 & -0.06 & 0.98 \end{pmatrix}$$

What can we do with it?

- The Leontief equation helps us to calculate the economic response to
  - Structural changes
  - Demand changes
- It shows the response in all economic sectors
- Helps to track the response through all economic sectors, because sometimes, sectors‘ involvement is not obvious from the demand change
- Allows to discover how negative impacts in one sector can be compensated by additional demand on another sector

Impact analysis example 1: positive demand change

- Additional demand for (domestically) manufactured products and services, e.g. a national infrastructure program demanding more building materials and more planning services:
  - Additional demand vector Δ D = (0 change in agriculture, +25 in manufacturing, +30 in services)
- Question: how does output Δ X for all three sectors change?

Example 1 continued

Multiplication of the Leontief Inverse with the demand change vector

$$\begin{pmatrix} 1.04 & -0.03 & -0.08 \\ -0.05 & 0.94 & -0.1 \\ -0.1 & -0.06 & 0.98 \end{pmatrix} * \begin{pmatrix} 0 \\ 25 \\ 30 \end{pmatrix} = \begin{pmatrix} 4 \\ 30 \\ 33 \end{pmatrix}$$

Example 1: positive demand change

- Additional demand for 25 units from manufacturing and 30 service units leads to
  - 4 additional units of production in agriculture !
  - 30 additional units of production in manufacturing
  - 33 additional units of production in services.
- The change in output is larger than the change in demand, there is a multiplier effect.
- Producing additional units needs additional resources from ALL sectors.

Impact analysis example 2: negative demand change in one sector

- Climate change policies and the implementation of NDC is often coming with decreasing the activities in certain sectors.
- E.g.: decrease fossil fuel use, increase biofuels
- Hence the example: -20 units in manufacturing, 50 units in agriculture, 200 units in services.

Example 2 continued

Multiplication of the Leontief Inverse with the demand change vector

$$\begin{pmatrix} 1.04 & -0.03 & -0.08 \\ -0.05 & 0.94 & -0.1 \\ -0.1 & -0.06 & 0.98 \end{pmatrix} * \begin{pmatrix} 50 \\ -20 \\ 200 \end{pmatrix} = \begin{pmatrix} 69 \\ 5 \\ 211 \end{pmatrix}$$

Example 2: interpretation of results

- Although manufacturing suffered from a demand decrease, the total impact of the whole demand change vector is positive
- Loss in output due to demand shift is compensated by additional demand for manufactured goods from the other sectors.
- Needs to be kept in mind for policy design.

And employment?

- Information about total employment by sector/ or employment coefficients is necessary. ILO provides this for a lot of countries.
- https://ilostat.ilo.org/data/
- For Ourland, lets assume we have the following structure:

	Agriculture	Manufacturing	Services
Output	500	900	750
Employment	125	96	89

Calculation of a change in employment

- Similar procedure as before:
  - Calculate coefficients e
  - Apply the Leontief equation to E (employment)

$$\Delta E = e^{*}(I-A)^{-1} * \Delta D$$

Step 1: employment coefficients

- Answer the question: how labor intensive is a sector?

	Agriculture	Manu.	Services
Output	500	900	750
Employment	125	96	89
Coefficient	0.25	0.11	0.12

- Agriculture is the most labor intensive, followed by services.

Step 2: Employment change in example 1

$$\begin{pmatrix} 0.25 & 0.11 & 0.12 \end{pmatrix} * \begin{pmatrix} 4 \\ 30 \\ 33 \end{pmatrix} = \begin{pmatrix} 1 \\ 3 \\ 4 \end{pmatrix}$$

Coefficients

Demand change

Resulting additional employment

And emissions?

- Very similar procedure gives a first estimate for emissions
- Let's assume, we know emissions by sector
- For Ourland, lets assume we have the following structure:

	Agriculture	Manufacturing	Services
Output	500	900	750
Emissions	100	150	80

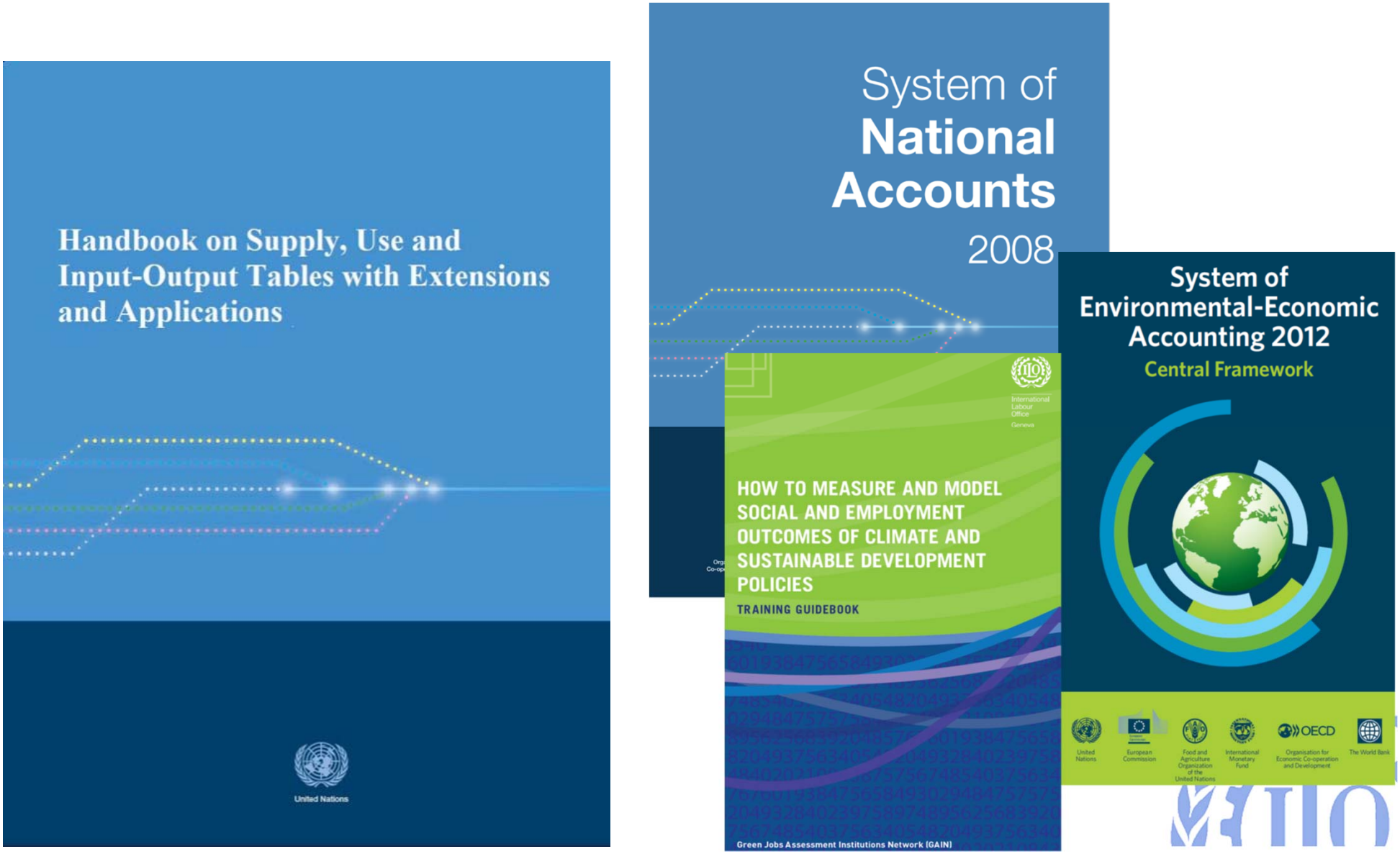
Structural change from brown to green

- Note: These estimates assume constant structures
  - Labor intensities vary within a sector: eg organic agriculture, large scale industrial agriculture, traditional agriculture have different coefficients
  - Emission intensities vary, e.g. due to fuel switches from conventional to renewable

Exercise

- Produce the Leontief inverse
- Calculate and interpret output multipliers
- Calculate and interpret employment multipliers
- Calculate and interpret emissions multiplier
- Simulate a growth scenario 2.7% manufacturing and 4.0 % service
- What is the impact on employment and emissions?

Sources


Handbook on Supply, Use and Input-Output Tables with Extensions and Applications
United Nations
System of National Accounts 2008
HOW TO MEASURE AND MODEL SOCIAL AND EMPLOYMENT OUTCOMES OF CLIMATE AND SUSTAINABLE DEVELOPMENT POLICIES
TRAINING GUIDEBOOK
International Labour Office
Geneva
Green Jobs Assessment Institutions Network (GAIN)
System of Environmental-Economic Accounting 2012
Central Framework
United Nations
European Commission
Food and Agriculture Organization of the United Nations
International Monetary Fund
OECD
Organisation for Economic Co-operation and Development
The World Bank