Lecture – 18A & 18B

Energy Resources, Economics and Environment
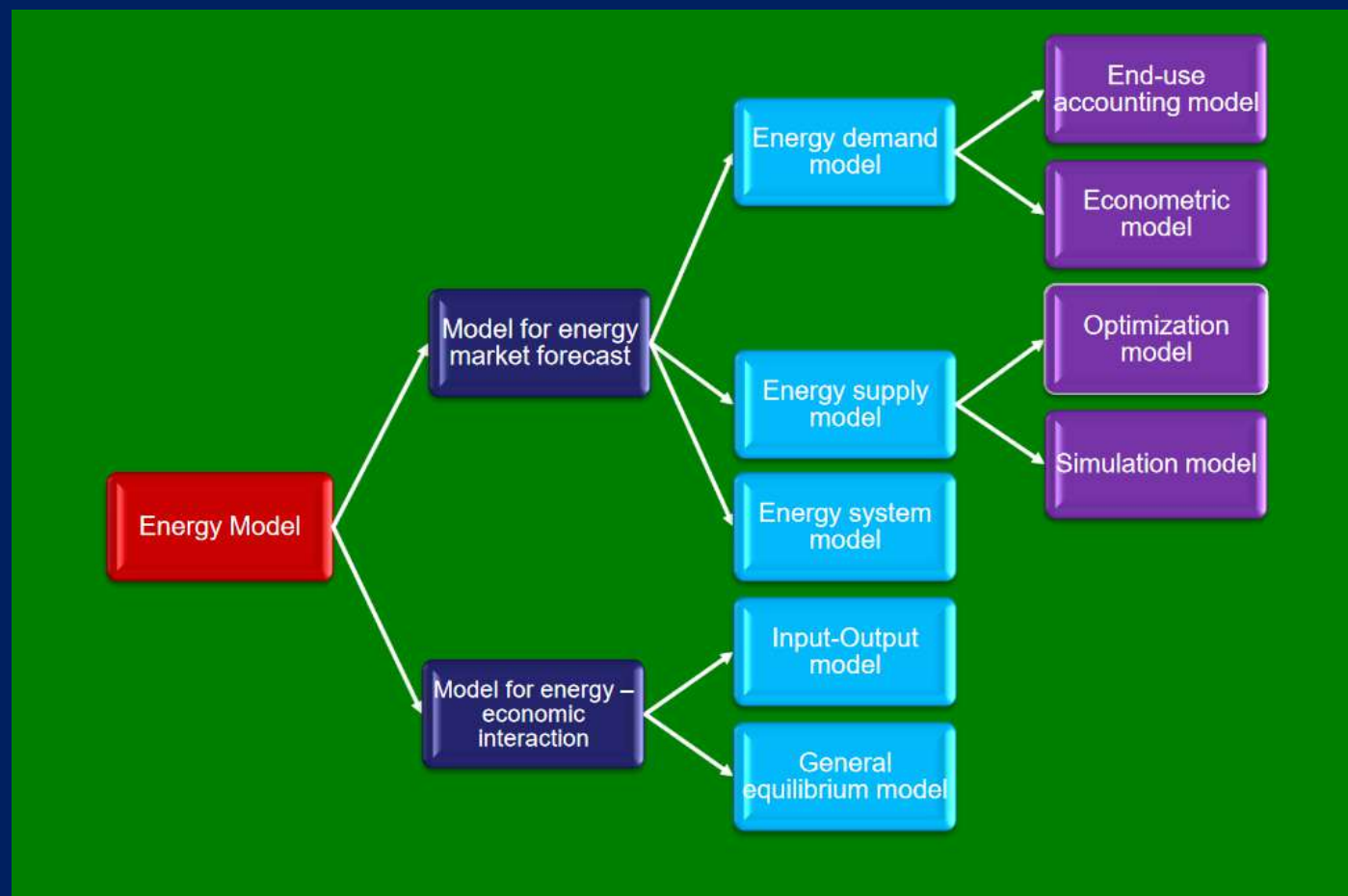
Input-Output Analysis

Rangan Banerjee
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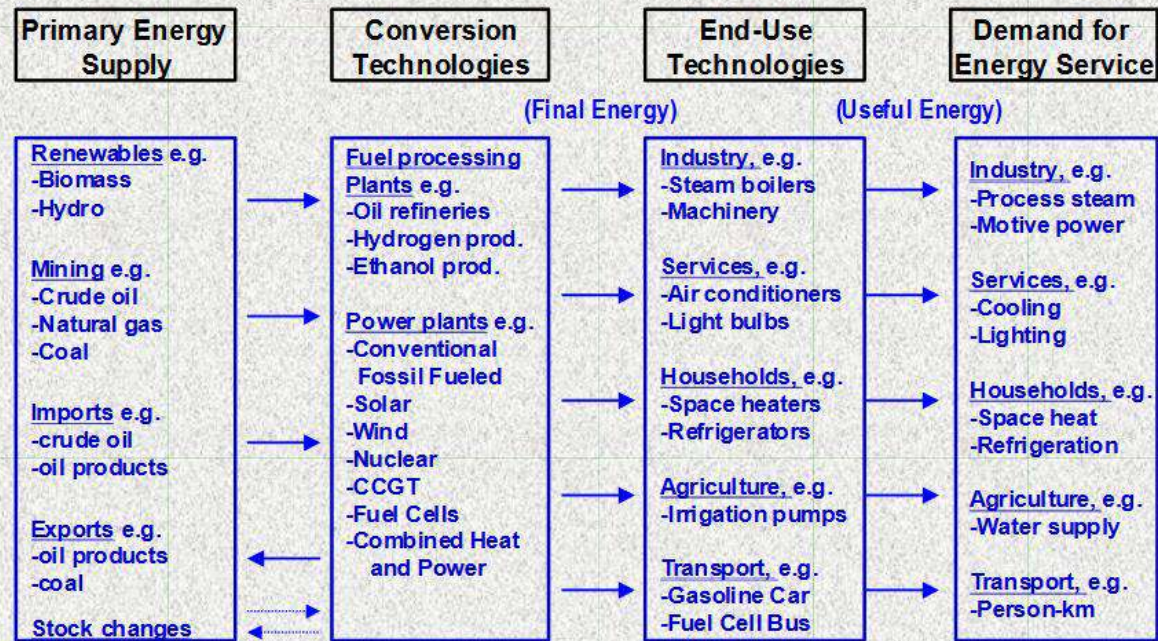
Energy Model classification

http://siteresources.worldbank.org/INTMACEDONIA/Resources/GG_EnergySectorModels.pdf

Energy Model Classification

- Purpose
- Short, Medium , Long Term
- Top down vs Bottom up
- Simulation vs Optimisation
- Geographical coverage: Global, regional, national, state, local

MARKAL

The MARKAL Energy Perspective

Primary Energy Supply	Conversion Technologies	End-Use Technologies	Demand for Energy Service
		(Final Energy)	(Useful Energy)
Renewables e.g. -Biomass -Hydro Mining e.g. -Crude oil -Natural gas -Coal Imports e.g. -crude oil -oil products Exports e.g. -oil products -coal Stock changes	Fuel processing Plants e.g. -Oil refineries -Hydrogen prod. -Ethanol prod. Power plants e.g. -Conventional Fossil Fueled -Solar -Wind -Nuclear -CCGT -Fuel Cells -Combined Heat and Power	Industry, e.g. -Steam boilers -Machinery Services, e.g. -Air conditioners -Light bulbs Households, e.g. -Space heaters -Refrigerators Agriculture, e.g. -Irrigation pumps Transport, e.g. -Gasoline Car -Fuel Cell Bus	Industry, e.g. -Process steam -Motive power Services, e.g. -Cooling -Lighting Households, e.g. -Space heat -Refrigeration Agriculture, e.g. -Water supply Transport, e.g. -Person-km

MARKAL: MARKet ALlocation)

Developed under the Energy Technology Systems Analysis Program of IEA

Linear programming type optimization ; based on Reference Energy System

Detailed modeling of energy resources and supply chains

Includes electricity generation and transmission planning

http://siteresources.worldbank.org/INTMACEDONIA/Resources/GG_EnergySectorModels.pdf

Input Output Analysis
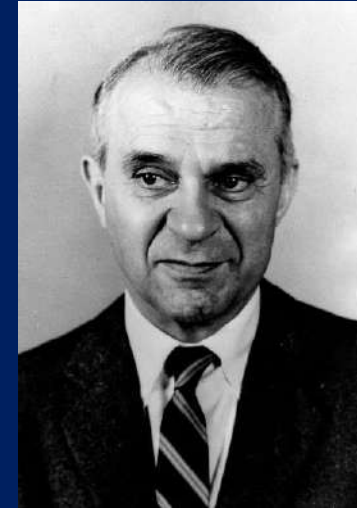

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Input-Output Economics

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STRUCTURE OF THE WORLD ECONOMY

Outline of a Simple Input-Output Formulation*

Nobel Memorial Lecture, December 11, 1973

by

WASSILY LEONTIEF

Harvard University, Cambridge, Massachusetts, USA.

Input-Output Economics

SCIENTIFIC AMERICAN

OCTOBER 1951   VOL. 185, NO. 4

Input-Output Economics

Concerning a new method which can portray both an entire economy and its fine structure by plotting the production of each industry against its consumption from every other

by Wassily W. Leontief

Column headers (INDUSTRY):

1 AGRICULTURE AND FISHERIES · 2 FOOD AND KINDRED PRODUCTS · 3 TEXTILE MILL PRODUCTS · 4 APPAREL · 5 LUMBER AND WOOD PRODUCTS · 6 FURNITURE AND FIXTURES · 7 PAPER AND ALLIED PRODUCTS · 8 PRINTING AND PUBLISHING · 9 CHEMICALS · 10 PRODUCTS OF PETROLEUM AND COAL · 11 RUBBER PRODUCTS · 12 LEATHER AND LEATHER PRODUCTS · 13 STONE, CLAY AND GLASS PRODUCTS · 14 PRIMARY METALS · 15 FABRICATED METAL PRODUCTS · 16 MACHINERY (EXCEPT ELECTRIC) · 17 ELECTRICAL MACHINERY · 18 MOTOR VEHICLES · 19 OTHER TRANSPORTATION EQUIPMENT · 20 PROFESSIONAL AND SCIENTIFIC EQUIPMENT · 21 MISCELLANEOUS · 22 COAL…

INDUSTRY PRODUCING (rows):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 AGRICULTURE AND FISHERIES	10.86	15.70	2.16	0.02	0.19	—	0.01	—	1.21	—	—	—	0.05	*	0.01	—	—	—
2 FOOD AND KINDRED PRODUCTS	2.38	5.75	0.06	0.01	*	*	0.03	*	0.79	*	—	0.44	*	*	*	*	*	—
3 TEXTILE MILL PRODUCTS	0.06	*	1.30	3.88	*	0.29	0.04	0.03	0.01	*	0.44	0.09	0.03	—	0.01	0.02	0.05	0.15
4 APPAREL	0.04	0.20	—	1.96	—	0.01	0.02	—	0.03	—	—	*	—	—	*	*	*	0.10
5 LUMBER AND WOOD PRODUCTS	0.15	0.10	0.02	*	1.09	0.39	0.27	*	0.04	0.01	—	0.02	0.02	0.06	0.06	0.09	0.05	0.05
6 FURNITURE AND FIXTURES	—	—	0.01	—	—	0.01	0.01	—	—	—	—	—	—	—	*	0.01	0.10	0.03
7 PAPER AND ALLIED PRODUCTS	*	0.52	0.08	0.02	*	0.02	2.60	1.08	0.33	0.11	0.02	0.05	0.18	*	0.09	0.04	0.07	0.03
8 PRINTING AND PUBLISHING	—	0.04	*	—	—	—	—	0.77	0.02	—	—	—	—	—	0.01	0.01	0.01	—
9 CHEMICALS	0.83	1.48	0.80	0.14	0.03	0.06	0.18	0.10	2.58	0.21	0.60	0.13	0.12	0.18	0.13	0.08	0.20	0.11
10 PRODUCTS OF PETROLEUM AND COAL	0.46	0.06	0.03	*	0.07	*	0.06	—	0.32	4.83	0.01	—	0.05	0.90	0.02	0.04	0.02	0.03
11 RUBBER PRODUCTS	0.12	0.01	0.01	0.02	0.01	0.01	0.01	*	*	*	0.04	0.05	0.01	*	0.01	0.13	0.03	0.50
12 LEATHER AND LEATHER PRODUCTS	—	—	*	0.05	*	0.01	—	*	—	—	—	—	—	—	1.04	—	*	0.02
13 STONE, CLAY AND GLASS PRODUCTS	0.06	0.25	*	*	0.01	0.03	0.03	—	0.26	0.05	0.01	0.01	0.43	0.21	0.07	0.07	0.12	0.19
14 PRIMARY METALS	0.01	*	—	*	0.01	0.11	—	0.01	0.19	0.01	0.01	*	0.04	6.90	2.53	2.02	1.05	1.28
15 FABRICATED METAL PRODUCTS	0.08	0.61	*	0.01	0.04	0.14	0.02	*	0.13	0.08	0.01	0.02	*	0.05	0.43	0.62	0.34	0.97
16 MACHINERY (EXCEPT ELECTRIC)	0.06	0.01	0.04	0.02	0.01	0.01	0.01	0.04	*	0.01	—	—	0.01	0.07	0.28	1.15	0.17	0.63
17 ELECTRICAL MACHINERY	—	—	—	—	—	—	—	—	*	—	—	—	0.01	0.05	0.24	0.58	0.86	0.62
18 MOTOR VEHICLES	0.11	*	—	—	*	—	—	—	—	*	—	—	*	*	0.03	0.03	0.01	4.40
19 OTHER TRANSPORTATION EQUIPMENT	0.01	—	—	—	—	—	*	—	*	*	*	—	*	*	—	—	*	0.01
20 PROFESSIONAL AND SCIENTIFIC EQUIPMENT	—	—	—	—	—	*	0.01	0.03	0.01	—	—	—	*	*	0.04	0.04	0.01	0.07
21 MISCELLANEOUS MANUFACTURING INDUSTRIES	*	0.01	*	0.26	*	0.02	0.01	—	0.03	—	*	0.02	0.01	*	0.02	0.05	0.11	0.02
22 COAL, GAS AND ELECTRIC POWER	0.06	0.20	0.11	0.04	0.02	0.02	0.12	0.03	0.19	0.56	0.04	0.02	0.20	0.35	0.08	0.10	0.05	0.06
23 RAILROAD TRANSPORTATION	0.44	0.57	0.09	0.06	0.14	0.05	0.22	0.07	0.29	0.27	0.04	0.04	0.15	0.52	0.13	0.16	0.07	0.23
24 OCEAN TRANSPORTATION	0.07	0.13	0.01	0.01	0.01	*	0.02	*	0.04	0.09	*	*	0.01	0.08	*	*	*	*
25 OTHER TRANSPORTATION	0.55	0.38	0.08	0.03	0.14	0.04	0.12	0.03	0.10	0.47	0.01	0.02	0.07	0.16	0.03	0.04	0.03	0.07
26 TRADE	1.36	0.46	0.23	0.37	0.06	0.06	0.18	0.03	0.17	0.02	0.05	0.05	0.05	0.36	0.20	0.26	0.14	0.06
27 COMMUNICATIONS	*	0.04	0.01	0.02	0.01	0.01	0.01	0.04	0.02	0.01	0.01	*	0.01	0.02	0.02	0.03	0.02	0.02
28 FINANCE AND INSURANCE	0.24	0.15	0.02	0.02	0.08	0.02	0.02	0.02	0.02	0.13	0.01	0.01	0.05	0.06	0.04	0.05	0.04	0.02
29 REAL ESTATE AND RENTALS	2.39	0.09	0.03	0.10	0.02	0.02	0.03	0.06	0.03	—	0.01	0.02	0.02	0.06	0.03	0.04	0.03	0.02
30 BUSINESS SERVICES	0.01	0.63	0.07	0.10	0.02	0.06	0.02	0.06	0.42	0.04	0.02	0.05	0.01	0.03	0.05	0.09	0.06	0.08
31 PERSONAL AND REPAIR SERVICES	0.37	0.12	*	*	0.04	*	*	0.02	0.01	0.01	*	*	0.03	0.01	0.01	0.01	*	*
32 NON-PROFIT ORGANIZATIONS	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
33 AMUSEMENTS	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
34 SCRAP AND MISCELLANEOUS INDUSTRIES	—	—	0.02	—	—	—	0.25	—	0.01	—	0.01	—	0.01	1.11	0.02	0.05	*	—
35 EATING AND DRINKING PLACES	—	—	—	—	—	—	—	*	—	—	—	—	—	—	—	—	—	—
36 NEW CONSTRUCTION AND MAINTENANCE	0.20	0.12	0.04	0.02	0.01	0.01	0.04	0.01	0.04	0.03	0.01	0.02	0.03	0.10	0.03	0.05	0.02	0.04
37 UNDISTRIBUTED	—	1.87	0.30	1.08	0.73	0.27	0.17	0.50	1.49	0.65	0.27	0.27	0.47	0.32	1.14	1.71	0.89	0.41
38 INVENTORY CHANGE (DEPLETIONS)	2.66	0.40	0.12	0.19	*	0.01	0.09	0.03	0.14	0.01	*	0.03	*	0.11	*	*	≈	0.01
39 FOREIGN COUNTRIES (IMPORTS FROM)	0.69	2.11	0.21	0.28	0.18	0.01	0.62	0.01	0.59	0.26	—	0.04	0.14	0.62	0.01	0.05	—	0.02
40 GOVERNMENT	0.81	1.24	0.64	0.38	0.34	0.11	0.50	0.34	0.76	0.78	0.11	0.14	0.32	0.82	0.48	0.77	0.40	0.66
41 PRIVATE CAPITAL FORMATION (GROSS)	DEPRECIATION AND OTHER CAPITAL CONSUMPTION ALLOWANCES ARE INCLUDED IN HOUSEHOLD ROW																	
42 HOUSEHOLDS	19.17	7.05	3.34	4.24	2.72	1.12	2.20	3.14	3.75	5.04	1.08	1.20	2.35	5.53	4.14	6.80	3.41	3.39
TOTAL GROSS OUTLAYS	44.26	40.30	9.84	13.32	6.00	2.89	7.90	6.45	14.05	13.67	2.82	3.81	4.84	18.69	10.40	15.22	8.38	14.27

38 INVENTORY CHANGE (DEPLETIONS) . . . .

39 FOREIGN COUNTRIES (IMPORTS FROM) . . . .

40 GOVERNMENT . . . .

41 PRIVATE CAPITAL FORMATION (GROSS) . . .

42 HOUSEHOLDS . . . .

TOTAL GROSS OUTLAYS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	Agriculture and Fisheries	Food and Kindred Products	Textile Mill Products	Apparel	Lumber and Wood Products	Furniture and Fixtures	Paper and Allied Products	Printing and Publishing	Chemicals	Products of Petroleum and Coal	Rubber Products	Leather and Leather Products	Stone, Clay and Glass Products	Primary Metals	Fabricated Metal Products	Machinery (Except Electric)	Electrical Machinery	Motor Vehicles	Other Transportation Equipment	Professional and Scientific Equipment	Miscellaneous	Coal
1 AGRICULTURE AND FISHERIES	10.86	15.70	2.16	0.02	0.19	—	0.01	—	1.21	—	—	0.05	*	0.01	—	—	—	—				
2 FOOD AND KINDRED PRODUCTS	2.38	5.75	0.06	0.01	*	*	0.03	*	0.79	*	—	0.44	*	*	*	*	*	—				
3 TEXTILE MILL PRODUCTS	0.86	*	1.30	3.88	*	0.29	0.04	0.03	0.01	*	0.44	0.09	0.03	—	0.01	0.02	0.05	0.15				
4 APPAREL	0.04	0.20	—	1.96	—	0.01	0.02	—	0.03	—	—	*	*	—	*	*	*	0.10				

Final Demand

	37	38	39	40	41	42						TOTAL GROSS OUTPUT
0.12	—	—	0.87	0.09	0.17		1.01	1.28	0.57	0.02	9.92	44.26
0.25	*	0.02	3.47	*	0.42		0.88	1.80	0.73	—	23.03	40.30
*	—	0.01	—	0.05	0.52		0.06	0.92	0.10	0.02	1.47	9.84
0.02	*	0.01	0.02	*	0.15		0.21	0.30	0.28	*	9.90	13.32
*	—	0.11	0.01	2.33	0.35		0.17	0.17	0.01	0.04	0.07	6.00
*	—	—	—	0.20	0.20		0.08	0.03	0.05	0.57	1.46	2.89

Column headings (diagonal labels):

- 24 RAILROAD TRANSPORTATION
- 25 OCEAN TRANSPORTATION
- 26 OTHER TRANSPORTATION
- 27 TRADE
- 28 COMMUNICATIONS
- 29 FINANCE AND INSURANCE
- 30 REAL ESTATE AND RENTALS
- 31 BUSINESS SERVICES
- 32 PERSONAL AND REPAIR SERVICES
- 33 NON-PROFIT ORGANIZATIONS
- 34 AMUSEMENTS
- 35 SCRAP AND MISCELLANEOUS INDUSTRIES
- 36 EATING AND DRINKING PLACES
- 37 NEW CONSTRUCTION AND MAINTENANCE
- UNDISTRIBUTED
- 38 INVENTORY CHANGE (ADDITIONS)
- 39 FOREIGN COUNTRIES (EXPORTS TO)
- 40 GOVERNMENT
- 41 PRIVATE CAPITAL FORMATION (GROSS)
- 42 HOUSEHOLDS
- TOTAL GROSS OUTPUT

24	25	26	27	28	29	30	31	32	33	34	35	36	37	Undist.	38	39	40	41	(a)	(b)	(c)	42	TOTAL GROSS OUTPUT
—	*	*	—	*	*	0.01	—	*	—	—	—	—	0.12	—	—	0.87	0.09	0.17	1.01	1.28	0.57	0.02	9.52	44.26
—	0.01	0.02	*	0.08	0.01	0.03	0.07	0.01	—	—	—	*	0.25	*	0.02	3.47	*	0.42	0.88	1.80	0.73	—	23.03	40.30
0.01	0.05	0.08	0.07	—	0.01	0.01	0.03	*	—	—	*	0.03	*	—	0.01	—	0.05	0.52	0.06	0.92	0.10	0.02	1.47	9.84
0.01	*	*	*	*	*	*	0.02	*	—	—	—	0.02	0.02	*	0.01	0.02	*	0.15	0.21	0.30	0.28	*	9.90	13.32
0.03	*	0.06	0.06	—	0.01	*	0.03	*	—	0.14	*	*	*	—	0.11	0.01	2.33	0.35	0.17	0.17	0.01	0.04	0.07	6.00
0.02	*	—	*	—	—	*	—	*	0.04	0.08	—	—	*	—	—	—	0.20	0.20	0.08	0.03	0.05	0.57	1.46	2.89
0.02	0.08	0.07	*	*	—	*	0.57	*	*	—	*	0.06	0.03	—	0.68	0.06	0.17	0.31	0.04	0.15	0.06	—	0.34	7.90
—	*	—	*	0.04	*	0.02	0.10	0.03	0.21	—	2.45	0.03	0.17	0.01	0.81	0.03	—	0.68	*	0.07	0.16	0.09	1.49	6.45
0.02	0.05	0.17	0.06	0.03	0.01	0.02	0.07	*	*	—	0.01	0.20	0.22	*	0.03	0.04	0.64	1.25	0.30	0.81	0.19	—	1.56	14.05
0.01	*	0.01	0.47	0.27	0.09	0.45	0.20	*	0.01	0.78	*	0.06	0.06	*	0.01	0.01	0.62	0.36	0.06	0.68	0.18	*	2.44	13.67
0.01	*	0.04	*	*	—	0.13	0.06	*	0.01	*	—	0.07	*	—	*	*	0.06	0.47	0.09	0.17	0.02	0.01	0.71	2.82
*	0.01	0.01	*	—	—	*	*	—	—	—	—	0.03	0.01	—	0.01	—	*	0.29	0.11	0.08	0.03	0.02	2.05	3.81
0.01	0.03	0.06	0.02	0.01	*	*	0.04	*	—	—	—	0.02	0.01	—	*	0.06	1.74	0.36	0.10	0.21	0.02	0.01	0.34	4.84
0.43	0.07	0.20	0.05	0.20	—	0.01	—	*	—	—	—	—	*	—	0.15	*	1.19	1.24	0.16	0.77	0.02	—	0.02	18.69
0.10	0.07	0.04	*	0.03	*	0.01	0.06	*	—	—	*	0.03	0.01	—	0.06	0.02	3.09	1.44	0.21	0.39	0.05	0.28	0.95	10.40
0.22	0.03	*	0.03	0.06	—	0.01	0.01	—	0.02	—	—	0.15	*	—	0.67	—	0.51	2.24	0.37	1.76	0.18	5.82	1.22	15.22
0.12	0.03	0.02	0.02	0.04	—	0.01	0.01	0.05	—	—	0.01	0.09	*	—	0.04	—	0.77	1.27	0.25	0.44	0.17	1.75	0.93	8.38
*	—	—	0.01	*	—	0.13	0.02	*	—	*	—	1.05	*	—	0.07	*	0.04	0.67	0.40	1.02	0.15	2.98	3.13	14.27
0.30	—	—	*	0.04	0.08	0.13	—	—	—	—	—	*	—	—	0.01	—	*	0.46	0.02	0.32	1.25	1.20	0.17	4.00
0.02	0.18	0.02	*	—	—	*	—	*	—	—	0.01	0.05	0.18	—	0.01	—	0.02	0.24	0.03	0.18	0.06	0.26	0.62	2.12
*	0.03	0.16	*	*	*	*	0.01	*	—	—	0.15	0.16	0.05	0.05	0.11	0.02	0.03	0.68	0.04	0.19	0.08	0.51	1.89	4.76
0.03	0.01	0.03	1.27	0.44	*	0.09	0.49	0.01	0.06	3.15	*	0.31	0.16	0.05	—	0.22	0.03	0.02	0.03	0.35	0.29	—	—	9.21
0.04	0.01	0.03	0.15	0.41	*	0.06	0.08	*	0.01	0.42	0.03	0.03	0.05	*	0.03	0.25	0.71	0.30	0.08	0.59	0.33	0.27	2.53	9.95
*	*	0.01	*	—	0.22	—	—	—	—	—	—	—	—	—	*	—	—	*	—	1.16	0.31	—	0.10	2.29
0.01	0.01	0.01	0.03	0.19	0.04	0.25	0.31	*	*	0.13	0.03	0.01	0.02	*	0.02	0.10	0.57	0.17	0.04	0.32	0.35	0.10	4.77	9.86
0.07	0.04	0.05	0.05	0.03	0.01	0.42	0.20	0.01	0.04	0.75	0.14	0.37	0.29	0.01	0.09	1.06	2.52	1.01	0.20	1.00	0.05	2.34	25.82	41.66
0.01	0.01	0.01	0.02	0.02	*	0.04	0.33	0.06	0.09	0.06	0.43	0.12	0.07	0.01	—	0.01	0.04	0.08	—	0.84	0.15	—	1.27	3.17
0.02	0.01	0.02	0.05	0.02	0.12	0.30	1.00	*	1.85	0.56	0.02	0.12	0.09	0.03	—	0.07	0.40	—	—	0.14	0.03	—	6.99	12.81
0.02	0.01	0.03	0.05	0.02	0.01	0.15	1.96	0.05	0.21	0.21	0.06	0.71	0.40	0.18	—	0.39	0.08	—	—	—	0.22	0.80	20.29	28.86
0.01	0.05	0.06	0.01	0.02	*	0.03	1.71	0.09	0.14	0.04	0.06	0.12	0.02	0.10	—	0.06	0.13	0.42	—	*	0.04	—	0.18	5.10
*	*	*	0.02	0.11	0.01	0.26	1.42	0.02	0.11	0.03	0.07	0.56	0.06	0.02	0.03	0.23	0.82	1.17	—	—	0.08	0.27	8.35	14.30
—	—	—	—	*	*	—	—	0.02	—	—	—	0.09	—	—	—	—	—	0.16	—	—	5.08	—	8.04	13.38
—	—	—	—	—	—	—	—	—	—	—	—	0.01	0.39	—	—	—	—	0.01	—	0.13	—	—	2.40	2.94
—	*	—	—	—	—	0.04	0.39	0.01	0.11	0.03	0.02	*	*	0.01	—	—	*	0.01	—	0.03	*	—	—	2.13
—	—	—	—	—	—	—	0.01	—	—	—	—	—	0.15	—	—	—	—	—	—	—	—	—	13.11	13.27
0.02	0.01	0.02	0.27	1.12	*	0.13	0.18	0.18	0.03	4.08	*	0.06	0.34	0.02	—	0.07	0.01	—	—	—	5.28	15.70	0.15	28.49
0.34	0.19	0.87	0.25	0.10	0.04	0.03	2.59	0.01	0.71	0.36	0.31	1.13	0.91	0.22	—	0.59	0.43	—	—	—	—	—	—	21.60
0.01	0.05	0.16	*	—	—	—	—	*	—	—	—	—	—	—	0.40	—	—	—	0.02	—	—	—	—	4.43
0.01	0.05	0.14	0.01	0.04	0.50	0.08	—	0.03	0.10	—	—	—	—	*	0.07	—	—	0.01	—	—	1.31	—	1.32	9.52
0.12	0.13	0.19	1.14	0.91	0.26	0.77	3.30	0.44	1.11	4.80	0.21	0.50	0.17	0.32	0.07	1.41	0.47	2.19	0.34	0.83	3.46	0.22	31.55	63.69
1.95	0.90	2.17	5.11	5.70	0.90	6.20	26.42	2.15	7.93	14.96	1.08	8.20	5.41	1.50	—	4.20	10.73	2.27	—	0.85	30.06	—	2.12	223.58
4.00	2.12	4.76	9.21	9.95	2.29	9.86	41.66	3.17	12.81	28.86	5.10	14.30	13.39	2.94	2.13	13.27	28.49	21.60	5.28	17.21	51.29	33.29	194.12	

Amount of steel ingots – tonnes of steel for 1000 $ of output in 1939

	TONS OF STEEL INGOTS PER $1000 OF PRODUCTION
CONSTRUCTION	1.65
METAL FABRICATING	2.9
MOTOR VEHICLES AND INDUSTRIAL EQUIPMENT	2.5
TRADE AND RESTAURANTS	.23
CHEMICALS	.3
RUBBER PRODUCTS	.2
FOOD PROCESSING	.26
FUEL AND POWER	.22
LUMBER, PAPER, PRINTING, FURNITURE	.46
AGRICULTURE AND FISHING	.15
TRANSPORTATION	.28
ALL OTHER	.66
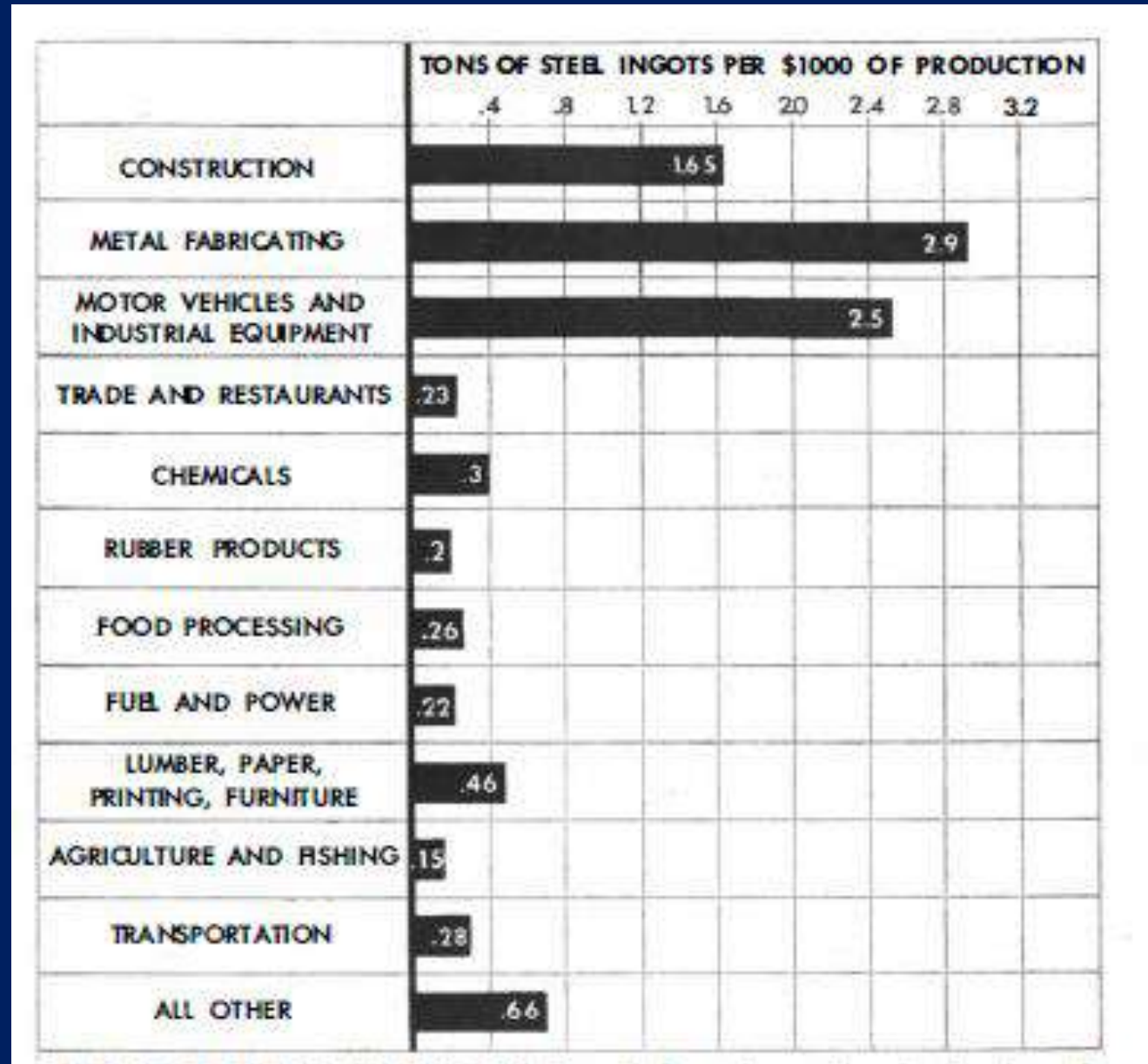
Input to Auto industry from other industries for $1000 of output from Auto industry in 1939

	PURCHASES PER $1000 OF PRODUCTION					
	$20	$40	$60	$80	$100	$120
FERROUS METALS						$133.60
IRON AND STEEL FOUNDRY PRODUCTS		$44.90				
INDUSTRIAL AND HEATING EQUIPMENT	.40					
MACHINE TOOLS	$3.30					
ELECTRICAL EQUIPMENT	$29.20					
IRON AND STEEL			$67.50			
NONFERROUS METALS AND THEIR PRODUCTS	$30.70					
NONMETALLIC MINERALS AND THEIR PRODUCTS	$20.40					
PETROLEUM PRODUCTION AND REFINING	$5.50					
COAL MINING AND MANUFACTURED SOLID FUELS	$3.60					
MANUFACTURED GAS AND ELECTRIC POWER	$6.60					
CHEMICALS	$11.30					
LUMBER AND TIMBER PRODUCTS	$3.30					
FURNITURE AND OTHER MANUFACTURES OF WOOD	$3.30					
WOOD PULP AND PAPER	.40					
TEXTILE MILL PRODUCTS	$22.30					
APPAREL AND OTHER FINISHED TEXTILE PRODUCTS	.40					
LEATHER AND LEATHER PRODUCTS	$1.50					
RUBBER			$64.62			
ALL OTHER MANUFACTURING	$2.56					
STEAM RAILROADS	$32.13					
TRADE	$25.92					
BUSINESS AND PERSONAL SERVICES	$23.73					

Effect of 10% increase in wages

Leontief's Nobel Prize Talk

WORLD ECONOMY IN 1970
(Billions of 1970 dollars)

DEVELOPED COUNTRIES

	Extraction Industry	Other Production	Abatement Industry	FINAL DEMAND		Total output
				Domestic	Trade	
Extraction Industry	0	76	0	2	-15	63
Other Production	21	1809	21	2414	19	4284
Pollution	5	62	-63	60	0	64
Employ-ment	18	1372	20	287	0	
Other Value Added	21	996	22	0	0	

Leontief's Nobel Prize Talk

LESS DEVELOPED COUNTRIES

	Extraction Industry	Other Production	Abatement Industry	FINAL DEMAND		Total Output
				Domestic	Trade	
Extraction Industry	0	8	0	2	15	25
Other Production	7	197	0	388	-19	573
Pollution	2	8	0	11	0	21
Employment	9	149	0	99	0	
Other Value Added	8	220	0	0	0	

Case I- 2000 Projection -LDC

LESS DEVELOPED COUNTRIES

	Extraction Industry	Other Production	Abatement Industry	FINAL DEMAND		Total Output
				Domestic	Trade	
Extraction Industry	0	52	0	12	226	290
Other Production	85	1255	0	2668	-357	3650
Pollution	25	53	0	73	0	151
Employ-ment	36	316	0	226	0	
Other Value Added	112	1143	0	0	0	

Case III- 2000 Projection -LDC

LESS DEVELOPED COUNTRIES

	Extraction Industry	Other Production	Abatement Industry	FINAL DEMAND		Total Output
				Domestic	Trade	
Extraction Industry	0	51	0	13	225	289
Other Production	85	1254	37	2735	-461	3650
Pollution	25	53	-111	75	0	42
Employ-ment	36	316	12	232	0	
Other Value Added	189	1125	40	0	0	

Energy Input-Output Table

		PRODUCERS AS CONSUMERS								FINAL DEMAND			
		Agric.	Mining	Const.	Manuf.	Trade	Transp.	Services	Other	Personal Consumption Expenditures	Gross Private Domestic Investment	Govt. Purchases of Goods & Services	Net Exports of Goods & Services
PRODUCERS	Agriculture												
	Mining												
	Construction												
	Manufacturing												
	Trade												
	Transportation												
	Services												
	Other Industry												
VALUE ADDED	Employees	Employee compensation								GROSS DOMESTIC PRODUCT			
	Business Owners and Capital	Profit-type income and capital consumption allowances											
	Government	Indirect business taxes											

Basics of input -output

X_i total output of sector i

Z_{ij} input from sector i to sector j

f_i final demand of sector i

All values are in monetary units

$$X_i = Z_{i1} + Z_{i2} + \cdots + Z_{in} + f_i$$

Equations

$$x_1 = z_{11} + \cdots + z_{1j} + \cdots + z_{1n} + f_1$$

$$\vdots$$

$$x_i = z_{i1} + \cdots + z_{ij} + \cdots + z_{in} + f_i$$

$$\vdots$$

$$x_n = z_{n1} + \cdots + z_{nj} + \cdots + z_{nn} + f_n$$

Input Output Matrices

$$\mathbf{x} = \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix}, \quad \mathbf{Z} = \begin{bmatrix} z_{11} & \cdots & z_{1n} \\ \vdots & \ddots & \vdots \\ z_{n1} & \cdots & z_{nn} \end{bmatrix} \quad \text{and} \quad \mathbf{f} = \begin{bmatrix} f_1 \\ \vdots \\ f_n \end{bmatrix}$$

Output is related to input use through fixed coefficients (linear relation)

Technological coefficient, a_{ij}

input from sector i required to produce a unit output from sector j

I-O Equation

$$(I - A)x = f$$

Transactions

		Buying Sector				
		1	$\cdots$	j	$\cdots$	n
Selling Sector	1	z_{11}	$\cdots$	z_{1j}	$\cdots$	z_{1n}
	$\vdots$	$\vdots$		$\vdots$		$\vdots$
	i	z_{i1}	$\cdots$	z_{ij}	$\cdots$	z_{in}
	$\vdots$	$\vdots$		$\vdots$		$\vdots$
	n	z_{n1}	$\cdots$	z_{nj}	$\cdots$	z_{nn}

$$f_1 = c_1 + i_1 + g_1 + e_1$$

Example – Two processing sectors

		Processing Sectors		Final Demand				Total Output ($\mathbf{x}$)
		1	2					
Processing	1	z_{11}	z_{12}	c_1	i_1	g_1	e_1	x_1
Sectors	2	z_{21}	z_{22}	c_2	i_2	g_2	e_2	x_2
Payments	Value Added ($\mathbf{v'}$)	l_1	l_2	l_C	l_I	l_G	l_E	L
Sectors		n_1	n_2	n_C	n_I	n_G	n_E	N
	Imports	m_1	m_2	m_C	m_I	m_G	m_E	M
Total Outlays ($\mathbf{x'}$)		x_1	x_2	C	I	G	E	X

Balance Equations

$$X = x_1 + x_2 + L + N + M$$

$$X = x_1 + x_2 + C + I + G + E$$

$$L + M + N = C + I + G + E$$

Some definitions

- L labour services (employment)
- N all other value added
- M Imports
- C Consumption (Household)
- I Investment goods
- G Government
- E Export

Example

		To Processing Sectors		Final Demand (f_i)	Total Output (x_i)
		1	2		
From	1	150	500	350	1000
Processing Sectors	2	200	100	1700	2000
Payments Sector		650	1400	1100	3150
Total Outlays (x_i)		1000	2000	3150	6150

Technical coefficients

	Sector 1 (Agriculture)	Sector 2 (Manufacturing)
Sector 1 (Agriculture)	.15	.25
Sector 2 (Manufacturing)	.20	.05

Example continued

If final demand for agricultural output were to increase to 600$ next year and for manufacturers were to decrease to $1500 $

$$f^{new} = \begin{bmatrix} f_1^{new} \\ f_2^{new} \end{bmatrix} = \begin{bmatrix} 600 \\ 1500 \end{bmatrix}$$

Computing the output

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

$$\Delta f = f^1 - f^0$$

$$\Delta x = Lf^1 - Lf^0 = L\Delta f$$

Computing the output

$$\mathbf{L} = \begin{bmatrix} 1.2541 & .3300 \\ .2640 & 1.1221 \end{bmatrix}$$

$$\mathbf{x}^{new} = \mathbf{Lf}^{new} = \begin{bmatrix} 1.2541 & .3300 \\ .2640 & 1.1221 \end{bmatrix} \begin{bmatrix} 600 \\ 1500 \end{bmatrix}$$

$$= \begin{bmatrix} 1247.52 \\ 1841.58 \end{bmatrix}$$

Final Input-Output Table

		To Processing Sectors		Final Demand (f_i)	Total Output (x_i)
		1	2		
From	1	187.13	460.40	600	1247.52
Processing Sectors	2	249.50	92.08	1500	1841.58
Payments Sector		810.89	1289.11	1100	3200.00
Total Outlays (x_i)		1247.52	1841.58	3200	6289.10