Lecture – 19A & 19B

Energy Resources, Economics and Environment

Input-Output Analysis-II

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2003 US Direct requirements matrix A

	Sector	1	2	3	4	5	6	7
1	Agriculture	.2008	.0000	.0011	.0338	.0001	.0018	.0009
2	Mining	.0010	.0658	.0035	.0219	.0151	.0001	.0026
3	Construction	.0034	.0002	.0012	.0021	.0035	.0071	.0214
4	Manufacturing	.1247	.0684	.1801	.2319	.0339	.0414	.0726
5	Trade, Transportation & Utilities	.0855	.0529	.0914	.0952	.0645	.0315	.0528
6	Services	.0897	.1668	.1332	.1255	.1647	.2712	.1873
7	Other	.0093	.0129	.0095	.0197	.0190	.0184	.0228

2003 US total requirements matrix L

	Sector	1	2	3	4	5	6	7
1	Agriculture	1.2616	.0058	.0131	.0576	.0037	.0069	.0072
2	Mining	.0093	1.0748	.0122	.0343	.0193	.0033	.0073
3	Construction	.0075	.0034	1.0047	.0064	.0065	.0111	.0250
4	Manufacturing	.2292	.1192	.2615	1.3419	.0692	.0856	.1261
5	Trade, Transportation & Utilities	.1493	.0850	.1371	.1563	1.0887	.0598	.0853
6	Services	.2383	.2931	.2700	.2918	.2712	1.4116	.3138
7	Other	.0243	.0239	.0231	.0367	.0280	.0297	1.0338

I-O table example in physical units

	1	2	d_i	q_i	Physical units of measure
1	75	250	175	500	bushels
2	40	20	340	400	tons

I-O table example in monetary units

	1	2	f_i	x_i	$ Price per physical unit
1	150	500	350	1000	2
2	200	100	1700	2000	5

I-O table example in revised physical units

	1	2	d_i	q_i	Revised physical units of measure
1	150	500	350	1000	1/2 bushels
2	200	100	1700	2000	1/5 tons

Example 1- Labour

	1	2	f_i	x_i
1	150	500	350	1000
2	200	100	1700	2000
3 (Labor)	650	1400	1100	3150

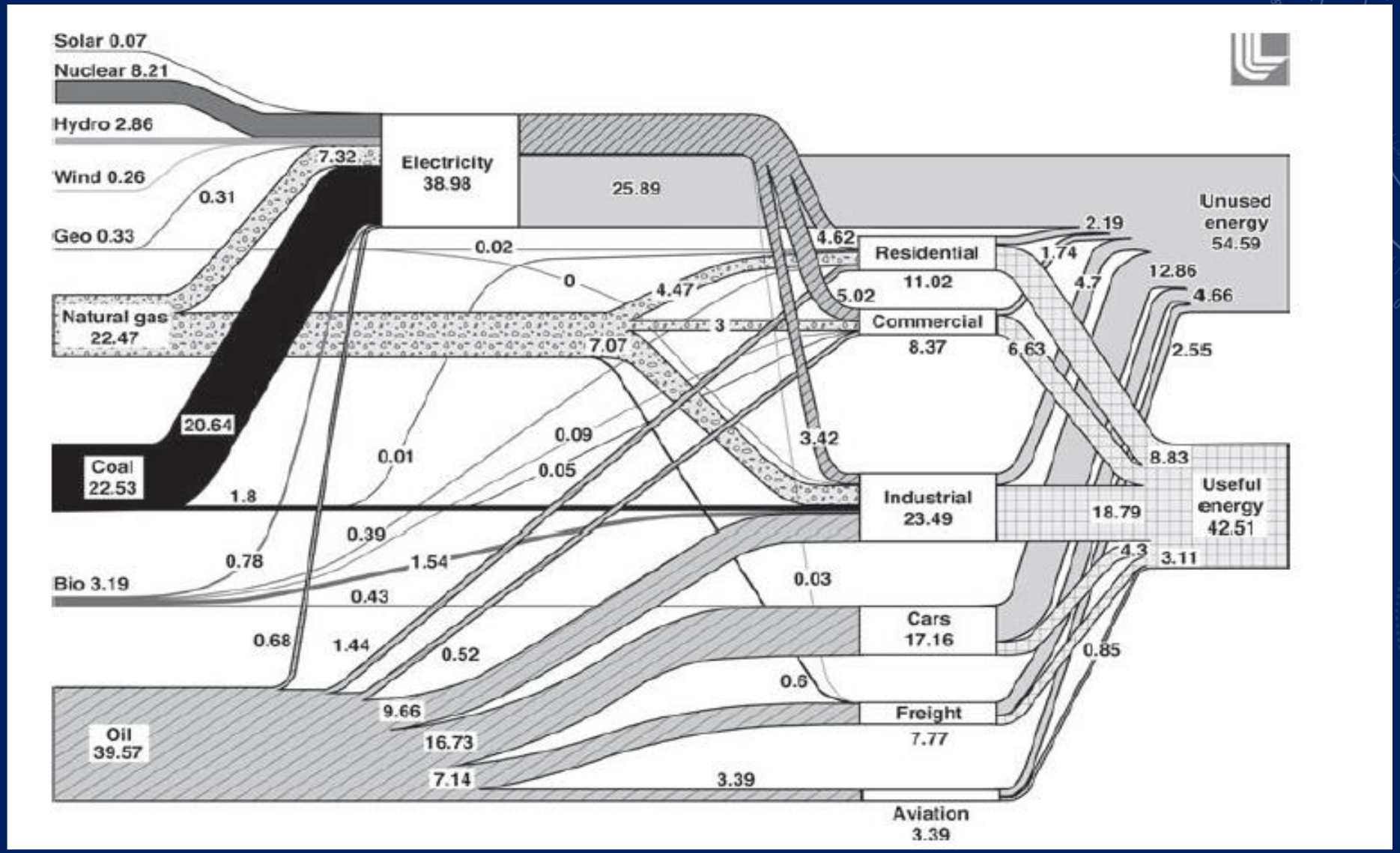
$$v_c^0 = \begin{bmatrix} .65 \\ .70 \end{bmatrix} = \begin{bmatrix} \bar{a}_{31} \\ \bar{a}_{32} \end{bmatrix}$$

Only labour in last row

$$\begin{bmatrix} 1.254 & .264 \\ .330 & 1.122 \end{bmatrix} \begin{bmatrix} .65 \\ .70 \end{bmatrix} = \begin{bmatrix} 1.00 \\ 1.00 \end{bmatrix}$$

$$\Delta\tilde{\mathbf{p}} = \begin{bmatrix} 1.254 & .264 \\ .330 & 1.122 \end{bmatrix} \begin{bmatrix} .195 \\ 0 \end{bmatrix} = \begin{bmatrix} .245 \\ .064 \end{bmatrix}$$

Sample Energy Balance US



Hybrid I-O

$$\mathbf{Z}^* = \begin{bmatrix} BTU & BTU \\ \$ & \$ \end{bmatrix},$$

$$\mathbf{f}^* = \begin{bmatrix} BTU \\ \$ \end{bmatrix},$$

$$\mathbf{x}^* = \begin{bmatrix} BTU \\ \$ \end{bmatrix}$$

$$\mathbf{g}^* = \begin{bmatrix} BTU \\ 0 \end{bmatrix}.$$

Example 9.1

	Widgets	Energy	Final Demand	Total Output
Value Transactions in Million of Dollars				
Widgets	10	20	70	100
Energy	30	40	50	120
Energy Transactions in Quadrillions of BTUs				
Energy	60	80	100	240

Inter-industry

- Zi + f = x
- Ei+ q =g
- Z-matrix of inter-industry transactions
- f – matrix of total final demands
- x – matrix of total final outputs

Inter-industry Energy flows

- Zi + f = x
- Ei+ q =g
- E-matrix of flows from energy producing sectors to all sectors
- q –vector of energy deliveries to total final demands
- g –vector of total energy consumption

Ex 9.2 Millions of US $

	Crude Oil	Refined Petroleum	Electric Power	Autos	Final Demand	Total Output
Crude Oil	0	5	5	0	0	10
Refined Petroleum	2.5	2.5	0	2.5	12.5	20
Electric Power	2.5	1.25	1.25	2.5	12.5	20
Autos	0	0	0	0	20	20

Ex 9.2 10^{15} BTU

	Crude Oil	Refined Petroleum	Electric Power	Autos	Final Demand	Total Output
Crude Oil	0	20	20	0	0	40
Refined Petroleum	1	3	0	1	15	20
Electric Power	2.5	1.25	1.25	2.5	12.5	20

Example 9.3

	Coal	Electric Power	Autos	Final Demand	Total Output
Coal (Quadrillion BTU)	0	300	0	0	300
Electric Power (Quadrillion BTU)	20	20	20	60	120
Automobiles (million dollars)	0	0	0	100	100

USA I-O Hybrid table

Table 9.5 Input–Output Transactions for the US Economy in Hybrid Units (1967)*

		Coal Mining	Oil & Nat. Gas	Ref. Petrol.	Elec. Utilities	Gas Utilities	Chem.	Agric.	Mining & Manuf.	Transp. & Comm.	Rest of Economy	Final Demand	Total Output
1.	Coal Mining	96			7,750	14	551	71	4,702			2,740	15,924
2.	Oil & Nat. Gas.		1,113	23,326		17,737	148					499	42,823
3.	Ref. Petroleum	32	43	1,624	906	14	741	847	4,030	3,691	2,037	14,037	28,002
4.	Elec. Utilities	16	43	56	445		381	71	1,343	75	509	1,181	4,120
5.	Gas Utilities		86	896	3,148	977	868	212	1,343	151	1,528	4,948	14,157
6.	Chemicals	48	171	616	41		4,025	2,540	10,075	75	1,018	2,672	21,281
7.	Agriculture						763	19,898	36,270	75	3,055	10,498	70,559
8.	Mining & Manuf.	350	1,328	868	943	283	3,008	6,562	255,235	4,897	49,902	348,295	671,671
9.	Transp. & Comm.	32	171	1,344	610	42	635	1,552	16,120	6,102	17,313	31,412	75,333
10.	Rest of Economy	366	4,197	2,968	3,650	849	1,271	11,007	82,616	13,108	99,294	289,873	509,199

*Transactions are in millions of dollars for nonenergy sectors and in Quads (10^{15} BTU) for energy sectors.

US I-O direct coefficients 2006

US Technical Coefficients 2006	*1*	*2*	*3*	*4*	*5*	*6*	*7*
1 Agriculture	0.2403	0.0000	0.0014	0.0345	0.0001	0.0018	0.0007
2 Mining	0.0028	0.1307	0.0079	0.0756	0.0310	0.0004	0.0066
3 Construction	0.0035	0.0002	0.0010	0.0019	0.0039	0.0072	0.0242
4 Manufacturing	0.1858	0.0959	0.2673	0.3311	0.0581	0.0558	0.1027
5 Trade, Transport & Utilities	0.0774	0.0379	0.1063	0.1003	0.0698	0.0329	0.0439
6 Services	0.0875	0.1298	0.1262	0.1239	0.1846	0.2889	0.2029
7 Other	0.0102	0.0096	0.0095	0.0233	0.0223	0.0192	0.0225

US I-O total coefficients 2006

US Total Requirements 2006	*1*	*2*	*3*	*4*	*5*	*6*	*7*
1 Agriculture	1.3365	0.0101	0.0238	0.0735	0.0075	0.0101	0.0118
2 Mining	0.0482	1.1716	0.0566	0.1470	0.0525	0.0162	0.0306
3 Construction	0.0091	0.0036	1.0058	0.0081	0.0079	0.0120	0.0286
4 Manufacturing	0.4275	0.2064	0.4650	1.5972	0.1424	0.1438	0.2173
5 Trade, Transport & Utilities	0.1728	0.0823	0.1826	0.2013	1.1076	0.0719	0.0911
6 Services	0.3041	0.2799	0.3294	0.3829	0.3344	1.4661	0.3698
7 Other	0.0346	0.0239	0.0323	0.0525	0.0359	0.0342	1.0382

US I-O direct coefficients 1997

US Technical Coefficients 1997	*1*	*2*	*3*	*4*	*5*	*6*	*7*
1 Agriculture	0.2618	0.0001	0.0015	0.0401	0.0013	0.0020	0.0008
2 Mining	0.0017	0.1150	0.0062	0.0306	0.0236	0.0003	0.0036
3 Construction	0.0039	0.0002	0.0011	0.0020	0.0052	0.0060	0.0101
4 Manufacturing	0.1740	0.1162	0.2372	0.3627	0.0758	0.0583	0.0424
5 Trade, Transport & Utilities	0.0731	0.0643	0.0975	0.0980	0.0847	0.0288	0.0267
6 Services	0.1110	0.2570	0.1376	0.1232	0.2294	0.2146	0.0902
7 Other	0.0063	0.0181	0.0086	0.0177	0.0212	0.0169	0.0167

US I-O total coefficients1997

US Total Requirements 1997	*1*	*2*	*3*	*4*	*5*	*6*	*7*
1 Agriculture	1.3795	0.0166	0.0269	0.0920	0.0130	0.0111	0.0068
2 Mining	0.0226	1.1433	0.0270	0.0638	0.0369	0.0070	0.0089
3 Construction	0.0094	0.0046	1.0051	0.0074	0.0089	0.0089	0.0117
4 Manufacturing	0.4361	0.2745	0.4365	1.6687	0.1849	0.1373	0.0953
5 Trade, Transport & Utilities	0.1704	0.1271	0.1683	0.2038	1.1298	0.0594	0.0472
6 Services	0.3253	0.4617	0.3094	0.3612	0.3785	1.3206	0.1521
7 Other	0.0264	0.0368	0.0262	0.0424	0.0350	0.0267	1.0226

Tutorial 9 Problem 1

	Sec 1-Agri	Sec 2-Manuf	Final Demand	Total Output
Sec 1-Agri	300	500	800	
Sec 2-Manuf	200	400	1500	
Payments Sector			1000	
Total Outlay				

Units Millions of Indian Rupees

Consider a 2 sector economy with an Input output table as shown for 2017. Fill in the blanks in the I-O table. Compute the A matrix and the L matrix

Consider two cases a) Agricultural final demand increases by 200 Million Rs in 2018 while the final demand for manufacturing remains constant

b) Agricultural final demand in 2018 remains constant while the final demand for manufacturing increases by 200 Million Rs. Compare the two cases in terms of the input output tables. Is the total output of the economy the same in both the cases? Explain how you can use the input output table to compute the impact on employment of two different options

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An integrated modeling framework for energy economy and emissions modeling: A case for India

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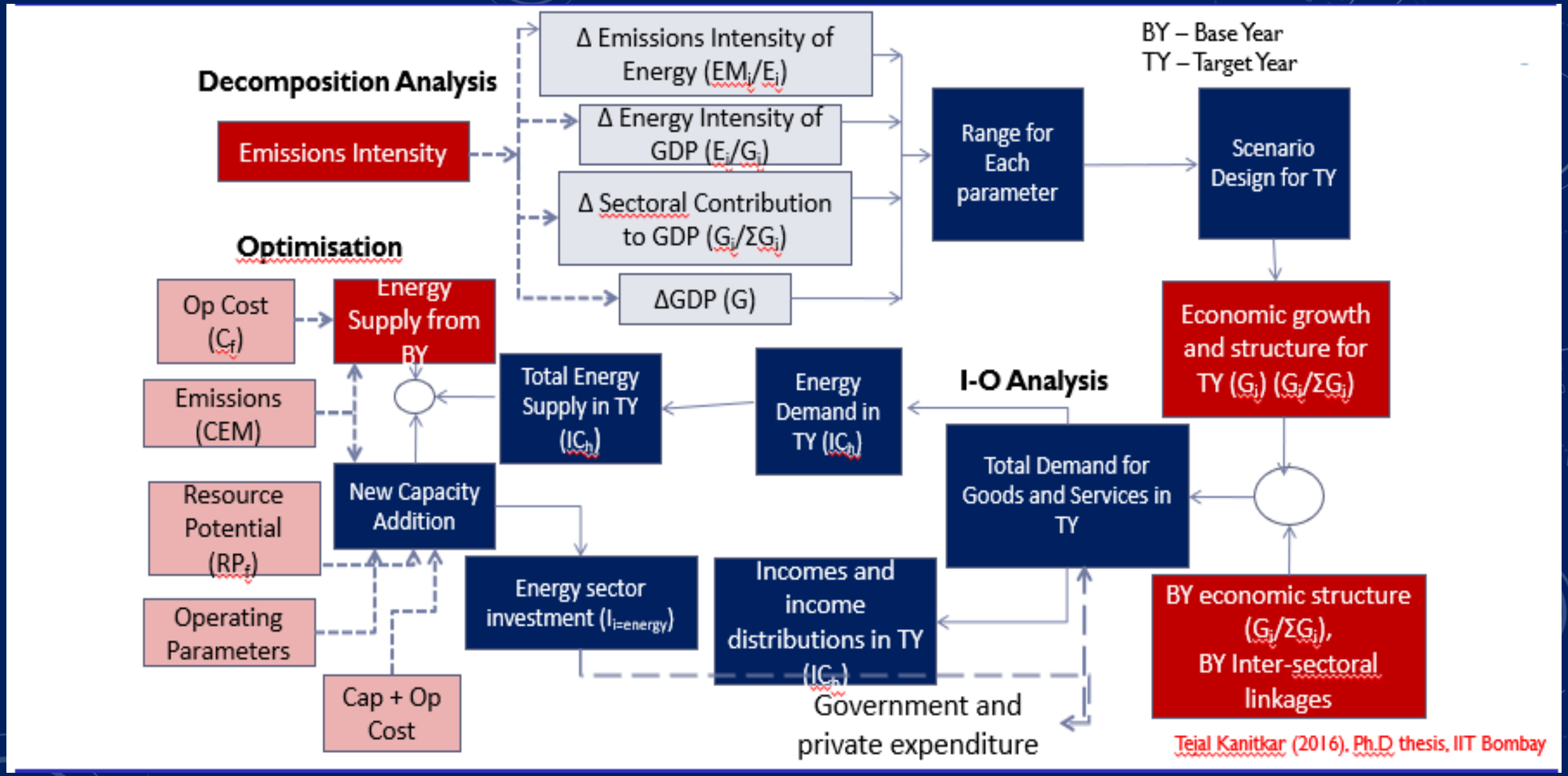
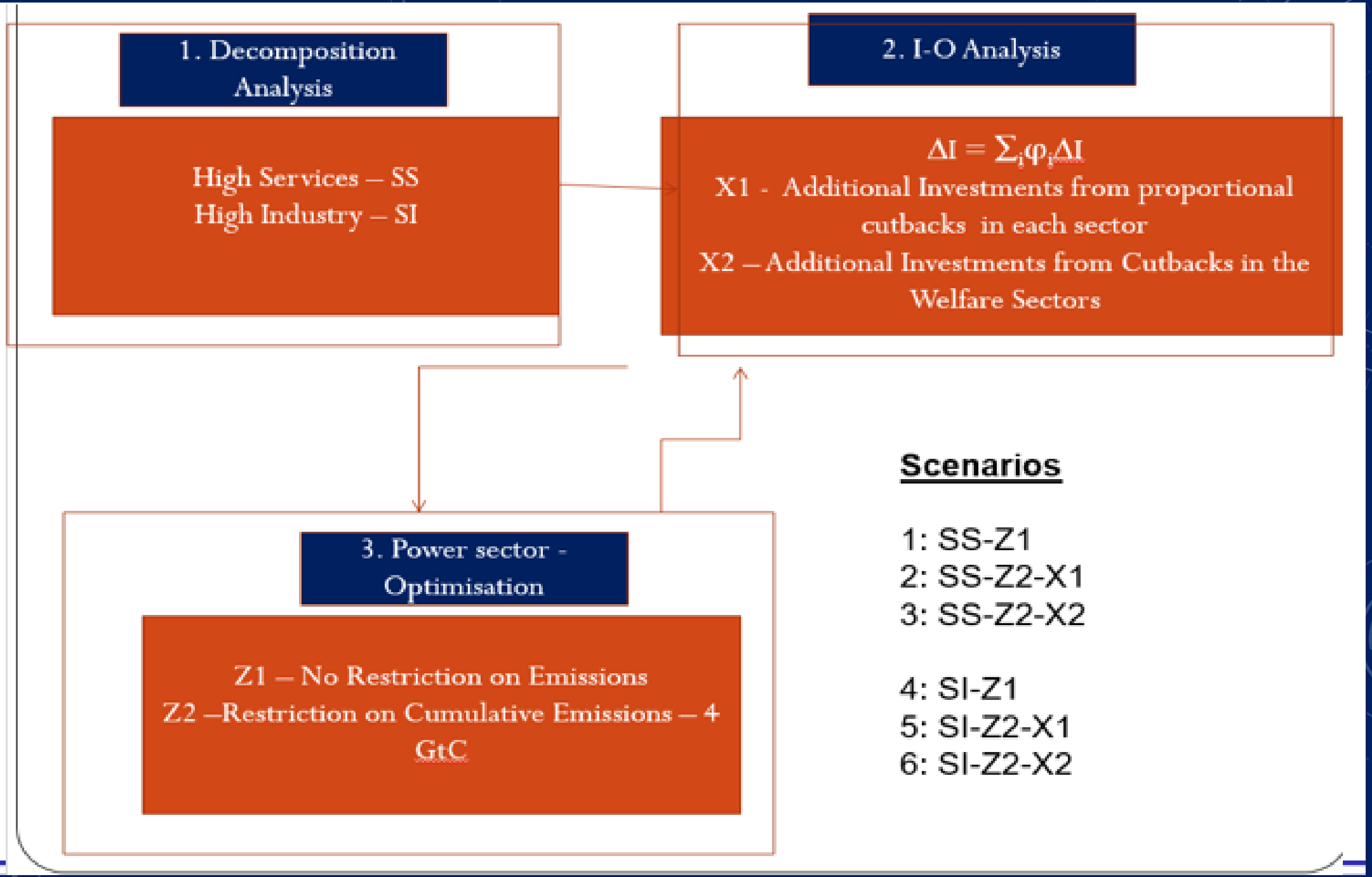

Decomposition Analysis
Emissions Intensity
Δ Emissions Intensity of Energy (EM_i/E_i)
Δ Energy Intensity of GDP (E_i/G_i)
Δ Sectoral Contribution to GDP ($G_i/\Sigma G_i$)
ΔGDP (G)
Range for Each parameter
BY – Base Year
TY – Target Year
Scenario Design for TY
Economic growth and structure for TY (G_i) ($G_i/\Sigma G_i$)
Optimisation
Op Cost (C_f)
Energy Supply from BY
Emissions (CEM)
Total Energy Supply in TY (IC_h)
Energy Demand in TY (IC_h)
I-O Analysis
Total Demand for Goods and Services in TY
Resource Potential (RP_f)
New Capacity Addition
Operating Parameters
Energy sector investment ($I_{i=energy}$)
Incomes and income distributions in TY (IC_h)
BY economic structure ($G_i/\Sigma G_i$), BY Inter-sectoral linkages
Cap + Op Cost
Government and private expenditure
Teial Kanitkar (2016), Ph.D thesis, IIT Bombay


1. Decomposition Analysis
High Services – SS
High Industry – SI
2. I-O Analysis
$\Delta I = \sum_i \varphi_i \Delta I$
X1 - Additional Investments from proportional cutbacks in each sector
X2 – Additional Investments from Cutbacks in the Welfare Sectors
3. Power sector - Optimisation
Z1 – No Restriction on Emissions
Z2 –Restriction on Cumulative Emissions – 4 GtC
Scenarios
1: SS-Z1
2: SS-Z2-X1
3: SS-Z2-X2
4: SI-Z1
5: SI-Z2-X1
6: SI-Z2-X2

	Base year	1-SS-Z_1	2-SS-Z_2-X_1
GDP (Billion $)	415	2415	2354
GDP Growth p.a.	-	7.08%	6.98%
Per Capita Income of all Households ($/year/person)	338	1354	1308
Per Capita Income of all Households class RH1($/year/person)	62	185	154
Per Capita Income of all Households RH4 ($/year/person)	354	1662	1600
Per Capita Income of all Households UH1($/year/person)	77	108	92
Per Capita Income of all Households UH3 ($/year/person)	323	1231	1185
GINI Coefficient	0.497	0.531	0.536