CHAPTER V

ENERGY MULTIPLIERS AND COEFFICIENTS: AN APPLICATION TO INDIAN ECONOMY

This chapter is organized as follows : Section 5.1 presents a brief theoretical discussion on the various coefficients and multipliers discussed and derived in chapter IV. Section 5 1.2 portrays different coefficients and multipliers discussed and derived from the Input-Output table for the year 1989-90. An explanation is offered taking one particular sector as this would represent the system and enable us to understand the other sectors in the economy. Based on the information from table 5.1, section 5.2 focuses on the top ten energy consuming industries of coal, oil and electricity. Section 5. 3 deals with the final demand sector and their stake on the energy products. The final section probes into the policy implications based on the quantitative measurement derived from earlier sections.

5.1 Input-Output Multipliers and Coefficients

Various input-output multipliers and coefficients have been made use of in this in this chapter to explain the Indian Economy in general and energy sector in particular. All these vectors have been presented in tables starting with 5.1. Before we look at the result it is necessary to understand their theoretical implications. The Vi, a column vector represents the value added coefficients which denote value added per rupee worth of output. . The second vector Mi represents import dependency of various sectors in the economy. These coefficients which shows the proportional relationship between imports and domestic gross

production. The $Vi(I-A)^{-1}$ is made up of income final demand coefficients, showing the total (direct plus indirect) income change in the economy if there is one unit change in the final demand This column should be always equal to 1.0, assuming a closed economy without international trade [1] Column vector $Vi(I-A+M)^{-1}$ indicates the income-final demand coefficients of the open economy The trade through import is reflected in Mi The vector ei represents direct energy coefficients, showing the ratio of the total energy used in monetary units to total sales for each sector. These coefficients are calculated from the summation of the four types of commercial energy (viz, coal, crude, petroleum and natural gas, petroleum products electricity) required to produce sectoral output equal to one rupee. The column vector $ei(I-A)^{-1}$, is energy-final demand coefficients, showing total (direct plus indirect) change in the energy use if there is one unit change in final demand. This shows the case of a closed economy. The vector $ei(I-A+M)^{-1}$, is made up of energy-final demand coefficients under an open economy. Figures in this column should be always smaller than or equal to those of $ei(I-A)^{-1}$ for correspondingsectors. The energy multipliers in the seventh column (Table 5.1) E 1 are derived from elements of column five, $ei(I-A)^{-1}$, divided by elements of column four ei. The energy multiplier shows the total change of energy use in the whole economy if the energy use in a particular sector changes by one unit. Again this column assumes these changes take place in a closed economy. The seventh column, E 2, by contrast, considers an open economy's energy multipliers, deriving from elements of column six, $ei(I-A+M)^{-1}$, divided by elements of column four, ei. Figures in this column should be always smaller than or equal to those of column seven. The ninth column, $ei(I-A+M)^{-1}/Vi(I-A+M)^{-1}$, consists of energy/income final demand coefficients derived from the elements of

column six divided by the elements of column four, reflecting the total (direct and indirect) changes in energy use if the total (direct and indirect) value added of the whole economy changes by one unit. Thus, $[ei(I-A+M)^{-1}/Vi(I-A+M)^{-1}]$ does not mean the one matrix is divided by the other, but rather that each "element" of one matrix is divided by each corresponding "elements" of the other. Having seen the theoritical implications of various coefficients and multipliers, their application to sectoral emperical analysis is presented below.

5.1.1 An Interpretation of Input-Output Coefficients and Multipliers

For demonstrating the practical meaning of figures displayed in Table 5.1, the first sector, Agriculture (Paddy) is used as an example. In the course of explanation, we resort to explain the value in terms of thousand rupees, whereever necessary.

Reading through the first row, V1 = 0.6839 means that for each thousand rupee worth of sales for agriculture, the value added in the agriculture sector would increase by 638.90 rupees.

M1 = 0.0093 means the value of importation is 0.93% of the total agricultural production in the sector 'paddy'. It can be deduced that agriculture sector (paddy) uses imported input less than 1 % of the total input requirement.

Calculation of direct and indirect final income coefficient $vi(I-A)^{-1}$ for a closed economy is not reported here. Theoretically it is assumed to take the value of unity. In the calculation undertaken here, some of the sectors had value of >1 and some of the sectors value of <1, depending upon the direct and indirect import component of inputs. Since the

TABLE 5.1 INPUT-OUTPUT COEFFICIENTS IN THE INDIAN ECONOMY (1989-90)

SECTOR	ei	Mi	Vi(I-A+m)-1	ei	ei (I-A) -1	ei(I-A+m)-1	E1= ei(I-A) /ei	E2= ei(I-A+m) /ei	ei (I-A+m) / vi(I-A+m)
1 PADDY	0.6839	0.0093	0.9387	0.0230	0.1132	0.0954	4.9327	4.1578	0.1017
2 WHEAT	0.6603	0.0014	0.9363	0.0496	0.1859	0.1639	3.7487	3.3053	0.1750
3 OTHER CEREALS	0.7480	0.0031	0.9511	0.0161	0.0904	0.0759	5.6030	4.7032	0.0798
4 PULSES	0.6994	0.0251	0.9458	0.0130	0.0535	0.0455	4.1099	3.4950	0.0481
5 SUGARCANE	0.8082	0.0000	0.9557	0.0205	0.0965	0.0817	4.7037	3.9852	0.0855
6 JUTE	0.8169	0.0111	0.9614	0.0000	0.0386	0.0299	0.0000	0.0000	0.0311
7 COTTON	0.5813	0.0177	0.8961	0.0363	0.1749	0.1442	4.8188	3.9722	0.1609
8 TEA	0.9099	0.0000	0.9820	0.0000	0.0237	0.0185	0 0000	0.0000	0.0188
9 COFFEE	0.6485	0.0000	0.9559	0.0000	0.0465	0.0371	0.0000	0.0000	0.0388
10 RUBBER	0.8502	0.1611	0.8104	0.0000	0.0833	0.0547	0.0000	0.0000	0.0674
11 OTHER CROPS	0.7515	0.0040	0.9634	0.0190	0.0658	0.0566	3.4599	2.9781	0.0588
12 ANIMAL HUSBANDRY	0.5165	0.0069	0.9675	0.0000	0.0414	0.0350	0.0000	0.0000	0.0361
13 FORESTRY & LOGGING	0.9195	0.0492	0.9362	0.0056	0.0280	0.0227	4.9585	4.0269	0.0243
14 FISHING	0.9429	0.0006	0.9880	0.0101	0.0240	0.0216	2.3830	2.1522	0.0219
15 COAL & LIGNITE	0.5125	0.0885	0.7971	0.1331	0.2904	0.2395	2.1814	1.7991	0.3005
16 CRUDE PETROLEUM & N.GAS	0.8234	0.9063	0.4992	0.0237	0.0783	0.0353	3.3066	1.4884	0.0706
17 IRON ORE	0.6810	0.0000	0.9311	0.1695	0.3137	0.2975	1.8508	1.7552	0.3195
18 OTHER METALLIC MINERALS	0.7006	0.1105	0.8418	0.1317	0.2520	0.2136	1.9136	1.6223	0.2538
19 NON MET.& MINOR MINERALS	0.8409	0.0000	0.1843	0.0531	0.1104	0.0194	2.0794	0.3661	0.1054
20 SUGAR	0.1648	0.0173	0.9003	0.0170	0.1631	0.1350	9.6086	7.9494	0.1499

SOURCE : INPUT-OUTPUT TABLE 1989-90 , PLANNING COMMISION,PPD (Compiled by Author)

TABLE 5.1 INPUT-OUTPUT COEFFICIENTS IN THE INDIAN ECONOMY (1989-90)

SECTOR	ei	MI	Vi(I-A+m)-1	ei	ei (I-A) -1	ei(I-A+m)-1	E1= ei(I-A) /ei	E2= ei(I-A+m) /ei	ei (I-A+m) / vi(I-A+m)
21 KHANDSARI BOORA	0.2740	0.0000	0.9171	0.0783	0.2173	0.1986	2.7748	2.5100	0.2143
22 HYDROGENATED OIL	0.0746	0.0057	0.8715	0.0344	0.2124	0.1782	6.1649	5.1726	0.2044
23 OTH.FOOD & BERERAGE IND.	0.1719	0.0163	0.9205	0.0208	0.1264	0.1083	6.0762	5.2096	0.1177
24 COTTON TEXTILES	0.2858	0.0017	0.9040	0.0639	0.2659	0.2356	4.1638	3.6889	0.2606
25 WOOLLEN TEXTILE	0.2857	0.0317	0.8722	0.0419	0.2194	0.1829	5.2405	4.3707	0.2098
26 ART SILK & SYNTH.FIBRE	0.1764	0.0115	0.8666	0.1029	0.3387	0.3030	3.2903	2.9440	0.3497
27 JUTE,HEMP,MESTA TEXTILES	0.2467	0.0019	0.9170	0.0668	0.2356	0.2118	3.5284	3.1718	0.2309
28 OTHER TEXTILE	0.5223	0.0072	0.9237	0.0211	0.1612	0.1390	7.6443	6.5903	0.1505
29 WOOD & WOOD PRODUCTS	0.2486	0.0126	0.9249	0.0121	0.0732	0.0617	6.0409	5.0949	0.0667
30 PAPER & PAPER PRODUCTS	0.2549	0.0949	0.7779	0.0728	0.2794	0.2181	3.8383	2.9952	0.2803
31 LEATHER & LEATHER PROD.	0.2632	0.0087	0.9082	0.0154	0.1360	0.1129	8.8532	7.3492	0.1243
32 RUBBER PRODUCTS	0.2643	0.0138	0.8611	0.0230	0.1587	0.1286	6.9050	5.5963	0.1493
33 PLASTIC PRODUCTS	0.2523	0.0375	0.8209	0.0493	0.2148	0.1716	4.3570	3.4800	0.2090
34 PETROLEUM PRODUCTS	0.0528	0.0884	0.5639	0.5801	0.7158	0.6256	1.2340	1.0784	1.1094
35 COAL TAR PRODUCTS	0.0440	0.0252	0.8243	0.4611	0.8152	0.7478	1.7679	1.6217	0.9072
36 FERTILIZERS	0.1799	0.1971	0.6552	0.2615	0.5878	0.4434	2.2475	1.6956	0.6768
37 PESTICIDES	0.2784	0.0859	0.7880	0.0292	0.1909	0.1422	6.5448	4.8738	0.1804
38 SYNTH.FIBRE & RESIN	0.2312	0.3705	0.6077	0.1142	0.3196	0.2044	2.7976	1.7890	0.3363
39 OTHER CHEMICALS	0.2504	0.1636	0.7338	0.0745	0.2564	0.1902	3.4401	2.5523	0.2582
40 CEMENT	0.3825	0.0012	0.8405	0.1606	0.3234	0.2937	2.0137	1.8290	0.3494

SOURCE : INPUT-OUTPUT TABLE 1989-90 , PLANNING COMMISION,PPD

TABLE 5.1 INPUT-OUTPUT COEFFICIENTS IN THE INDIAN ECONOMY (1989-90)

SECTOR	ai	Mi	vi(I-A+m)-1	ei	ei (I-A) -1	ci(I-A+m)-1	E1= ci(I-A) /ei	E2= ci(I-A+m) /ei	ei (I-A+m) / vi(I A+m)
41 OTH.NON MET.MINERAL PROD	0.3327	0.0206	0.8037	0.1394	0.3199	0.2795	2.2951	2.0055	0.3478
42 IRON & STEEL	0.2499	0.1728	0.7031	0.1031	0.3487	0.2547	3.3831	2.4705	0.3622
43 NON FERROUS METALS	0.1595	0.3768	0.5963	0.1927	0.4850	0.3122	2.5167	1.6200	0.5236
44 TRACTORS & OTH.AGRI.MACH	0.3004	0.0030	0.8491	0.0273	0.2095	0.1666	7.6689	6.0987	0.1962
45 MACHINE TOOLS	0.4321	0.4292	0.5879	0.0279	0.2908	0.1580	10.4183	5.6617	0.2688
46 OTH.NON ELECTRICAL MACH.	0.2832	0.8238	0.4397	0.0243	0.2221	0.0903	9.1238	3.7104	0.2054
47 ELECTRICAL MACHINERY	0.3775	0.1072	0.7697	0.0200	0.1808	0.1230	9.0251	6.1426	0.1598
48 COMMUNICATIONS EQUIPMENT	0.3857	0.1280	0.7818	0.0129	0.1126	0.0768	8.6949	5.9295	0.0982
49 ELECTRONIC EQUIPMENT	0.4661	0.0000	0.3951	0.0057	0.1089	0.0358	19.1503	6.2999	0.0907
50 RAIL EQUIPMENT	0.4342	0.0322	0.8912	0.0319	0.0966	0.0790	3.0248	2.4762	0.0887
51 MOTOR VEHICLES	0.2588	0.0510	0.7943	0.0292	0.2198	0.1647	7.5235	5.6358	0.2073
52 OTH.TRANSPORT EQUIP.	0.4956	0.3996	0.6066	0.0205	0.1538	0.0838	7.5132	4.0942	0.1381
53 OTH. MANUFACTURING	0.4169	0.1685	0.7458	0.0334	0.1822	0.1249	5.4494	3.7341	0.1674
54 CONSTRUCTION	0.3918	0.0000	0.8625	0.0183	0.1589	0.1295	8.6621	7.0614	0.1502
55 ELECTRICITY ETC.	0.4114	0.0000	0.9126	0.3915	0.6243	0.6046	1.5947	1.5444	0 6625
56 RAIL TRANSPORT SERVICE	0.4587	0.0000	0.9059	0.0967	0.2514	0.2272	2.5996	2.3497	0.2508
57 OTHER TRANSPORT SERVICE	0.5559	0.1245	0.8013	0.1187	0.2665	0.2159	2.2455	1.8191	0.2694
58 COMMUNICATION	0.8941	0.0345	0.9466	0.0083	0.0326	0.0273	3.9518	3.3083	0.0289
59 TRADE	0.7924	0.0000	0.9447	0.0088	0.0968	0.0807	11.0520	9.2176	0.0855
60 OTHER SERVICES	0.7862	0.0215	0.8782	0.0098	0.3867	0.3079	39.3661	31.3356	0.3506

SOURCE : INPUT-OUTPUT TABLE 1989-90 , PLANNING COMMISION,PPD

technology matrix ($A = A_d + A_m$) already incorporates the imported components in the inter industrial use, the $Vi(I-A)^{-1}$ tend to deviate from unity. There are ways to decompose the input components into domestically available inputs and imported components of inputs It is outside the capacity of an individual scholar to generate this information. The official sources do not publish the requisit information to take up this analysis. Therefore at this level efforts in net made to decouple these components into their respective constituencies. This is one of the limitations of this analysis. We proceed with our analysis with the assumption intact.

Assuming that $Vi(I-A)^{-1} = 1.0$ means, in a closed economy, that for each thousand rupee of agricultural sales the total value added changes in the economy are exactly thousand rupees.

$Vi(I-A+M)^{-1} = 0.9387$ means, within an open economy, that for each thousand rupee of agricultural sales, the total value added changes in the economy by 938.71 rupees. Sixty one rupees and nine paise are earned by foreign econimies.

Ei = 0.02295 means that for a change of 1000 rupees in agricultural sales, the energy use in the agricultural sector would change by 22.95 rupees. On the other hand $Ei(I-A)^{-1}$ = 0.1132 means, within a closed economy, that for a change of Rs.1000 in sales within the agricultural sector, total energy consumption (direct and indirect) in the whole economy would change by Rs. 113.21.

$Ei(I-A+M)^{-1}$ = 0.0954 means, within an open economy, to induce a change of Rs 1000 in agricultural sales, total energy use in the whole economy would be Rs 95 43 This figure is smaller than 113.20 of $Ei(I-A)^{-1}$ because some energy embodied in the import goods is saved by avoiding domestic production.

Ei = 4.9327, within a closed economy, that the total change of energy use in the economy would be Rs. 4932.67, if the energy use in the agricultural sector changes by Rs. 1000. This figure shows the "Roundedaboutness" of energy use in agriculture. It is relatively high, because the agricultural sector has a significant relationship with the fertilizer sector, which are highly energy intensive activity in the economy. Correspondingly E2 shows the energy multiplier of an open economy. This column should be always less than column E1.

$ei(I-A+M)^{-1}$ / $vi(I-A+M)^{-1}$ = 0.1017 means that in order for the whole to increase by Rs. 1000 initiated by agricultural sales, the use of energy (direct and indirect) in the whole economy would increase by Rs.101.66.

5.1.2 Comparison : Various Measurements Energy Intensities

As discussed in chapter IV when policy makers are facing a choice to developing alternatives in various economic sectors, they consider two points. First, consideration is both benefit and costs within the sectors. Second, they want to look into the resultant direct

and indirect effects on the whole economy. Based on these considerations, the column coefficients of table 5.1 are compared and their relevance is discussed.

There are two distinct components in table 5.1, column one, column four shows the income coefficients (which can be considered benefits) and from column four to nine show the energy coefficients (costs) of each sector. For example, when the government of India in one of their studies aims to analyse the direct energy coefficients, ei, was used for companies energy intensity between sectors. Obviously they missed points :(i) the sectors benefit side and (ii) indirect energy use for producing the increased intermediate inputs required by that sector. In another study, sectoral energy demand in India (1999)[2] used ei/vi as the comparing criterian. Although both benefits and costs are considered in ei/vi, the indirect value added and energy use for producing the required intermediate inputs are still missing. The quantity $ei(I-A+M)^{-1}$ / $vi(I-A+M)^{-1}$ avoids these problems by evaluating both benefits and costs within each sector through an interindustry context which considers the total (direct and indirect) effects of both value added and energy use.

5.2 Energy Intensive Industries

So far the analysis was concerned with only the total (direct and indirect) energy in the production process such an analysis is useful to gain an insight into the efficiency of energy use. The analysis did not consider about the individual components of energy used, i.e., individual energy sources used up in the production process, in the whole economy. An

insight into the different sources of energy going into the production process in different sectors would be of interesting to know the security threat that a particular industry faces in the eventualities of energy disruption in the international energy market. If an industry relies on the naturally endowed commercial energy resources of its economy like coal and nuclear and hydro sources, then, the security threat arising from disruption in the supply of energy sources from import does not impeade the production process. If some sectors on the other hand, rely on heavily on the imported energy input, then, the possibility of energy disruption in the international energy market likely to paralyse the production process in those sectors and other sectors which have forward and backward linkages with that sector. When we analyze the energy sources, we make distinction between primary and secondary sources of energy. Three Primary energy forms are those available from the gift of nature (coal, lignite, crude petroleum) secondary form of energy are these that are available when the primary forms of energy undergo a transformation process (Gasoline, Hsd, FO, thermal power). The consumption of primary and secondary energy sources can further be classified into interindustrial use component and final demand component. Table 5.2 presents the direct energy coefficients by type of fuel for 60 sectors of the economy for the year 1989-90. These coefficients are ratios of monetary values of production and energy used.

The use of three components of energy fuels by major industries classified by their consumption are displayed in graphs 5.1, 5.2 and 5.3. From the graph 5.1 one can infer that most of the coal intensive production processes are of electricity, coal and tar products, iron and steel and other non-metallic and mineral products in that order. Coal being a primary

sources of energy, its use in electricity generation is very high. The sectors which are most intensive in the consumption of oil are (graph 5.2) (Oil include both petroleum and natural gas) railway transport services Transport services, petroleum products, fertilizers, other chemicals in that order. As far as the use of electric power (graph 5.3) for the most intensive sectors are construction, iron and steel, textiles, other chemicals followed by electricity (due to transmission and distribution losses, the electricity intensity in the electricity sectors is very high).

When we consider final demand for commercial energy, industrial sectors are the major consumer. However, the scene of final demand for energy would look different if we consider commercial and non-commercial sources of energy taken together. The entire consumption of non-commercial energy has been supposed to be used in household sector. Looking at the table 5.3 from this respective, it is evident that private consumption constitutes the largest component in the final energy demand. In the year 1989-90, non-commercial use was at the order of 150 million cubic meters, that works out to be 32 million tons of oil equivalent, (see appendix 3.1 for conversion factor). This finding corroborates with the estimates of final private consumption expenditure[5]. Expenditure on food is typically has the lions share of total consumption budget, and not surprisingly, accounts for the maximum share of energy consumed. The private energy consumption would cover wide varieties of activities ranging from fuel for cooking, transportation, lighting, domestic use and others. This trend likely to sustain its momentum, as liberalization spreads its wings, creating more opportunity for urbanization and consumerism. The consequence is that the demand

for commercial energy for private consumption will continue to grow, substituting commercial energy for non-commercial energy sources. Transport sector accounts for the second largest share, after food consumption expenditure which includes all modes of transportation except railways. The vehicle population records phenomenon growth and the future potential is sky rocketing with the multi-nationals flooding into the production line after the liberalization process initiated in 1991. The production of passenger cars was 153.9 thousand in 1992-93 jumped to 249.3 thousand in 1994. The same scenario prevails in the two wheeler segments. The consequence is that consumption of energy, particularly oil, (middle distillaries) bound to grow leap and bounds. Railway's shift from coal locomotive to diesel locomotive can further escalate the energy crisis in the future. Public expenditure is incurred to run the government burocracy and to provide for the public goods and services. Expenditure in the sectors of electricity, construction and other services contribute roughly two thirds of energy required directly and indirectly.

TABLE 5.2 : SECTORWISE ENERGY COEFFICIENTS BY TYPE OF FUEL(1989-90)

SECTOR	Oil & N.Gas	Coal	Petroleum	Electricity
1 PADDY	0.063	0.011	0.041	0.039
2 WHEAT	0.076	0.021	0.049	0.088
3 OTHER CEREALS	0.054	0.009	0.034	0.027
4 PULSES	0.031	0.005	0.020	0.018
5 SUGARCANE	0.048	0.010	0.031	0.039
6 JUTE	0.019	0.005	0.012	0.015
7 COTTON	0.093	0.017	0.061	0.065
8 TEA	0.012	0.003	0.008	0.009
9 COFFEE	0.018	0.008	0.012	0.020
10 RUBBER	0.043	0.010	0.028	0.031
11 OTHER CROPS	0.039	0.006	0.027	0.020
12 ANIMAL HUSBANDRY	0.022	0.004	0.015	0.015
13 FORESTRY & LOGGING	0.019	0.002	0.013	0.007
14 FISHING	0.019	0.001	0.013	0.003
15 COAL & LIGNITE	0.079	0.041	0.053	0.170
16 CRUDE PETROLEUM & N.GAS	0.045	0.009	0.030	0.025
17 IRON ORE	0.148	0.023	0.100	0.143
18 OTHER METALLIC MINERALS	0.073	0.024	0.049	0.155
19 NON MET.& MINOR MINERALS	0.067	0.008	0.045	0.036
20 SUGAR	0.074	0.023	0.049	0.066
21 KHANDSARI BOORA	0.116	0.025	0.079	0.076
22 HYDROGENATED OIL	0.078	0.037	0.052	0.097
23 OTH.FOOD & BERERAGE IND.	0.058	0.019	0.039	0.050
24 COTTON TEXTILES	0.096	0.039	0.064	0.131
25 WOOLLEN TEXTILE	0.075	0.038	0.050	0.107
26 ART SILK & SYNTH.FIBRE	0.080	0.043	0.054	0.215
27 JUTE,HEMP,MESTA TEXTILES	0.089	0.032	0.059	0.114
28 OTHER TEXTILE	0.055	0.025	0.036	0.082
29 WOOD & WOOD PRODUCTS	0.033	0.009	0.022	0.030
30 PAPER & PAPER PRODUCTS	0.075	0.060	0.050	0.145

SOURCE : SAME AS TABLE 5.1

TABLE 5.2 : SECTORWISE ENERGY COEFFICIENTS BY TYPE OF FUEL(1989-90)

SECTOR	Oil & N.Gas	Coal	Petroleum	Electricity
31 LEATHER & LEATHER PROD.	0.056	0.019	0.037	0.061
32 RUBBER PRODUCTS	0.069	0.021	0.046	0.069
33 PLASTIC PRODUCTS	0.079	0.026	0.052	0.110
34 PETROLEUM PRODUCTS	0.674	0.009	0.132	0.033
35 COAL TAR PRODUCTS	0.130	0.492	0.086	0.193
36 FERTILIZERS	0.327	0.063	0.210	0.197
37 PESTICIDES	0.072	0.025	0.049	0.094
38 SYNTH.FIBRE & RESIN	0.139	0.044	0.093	0.137
39 OTHER CHEMICALS	0.112	0.032	0.075	0.113
40 CEMENT	0.066	0.100	0.044	0.157
41 OTH.NON MET.MINERAL PROD	0.154	0.078	0.103	0.088
42 IRON & STEEL	0.104	0.095	0.069	0.149
43 NON FERROUS METALS	0.162	0.050	0.109	0.273
44 TRACTORS & OTH.AGRI.MACH	0.075	0.043	0.050	0.091
45 MACHINE TOOLS	0.092	0.058	0.060	0.141
46 OTH.NON ELECTRICAL MACH.	0.073	0.042	0.049	0.107
47 ELECTRICAL MACHINERY	0.065	0.026	0.044	0.089
48 COMMUNICATIONS EQUIPMENT	0.038	0.017	0.025	0.058
49 ELECTRONIC EQUIPMENT	0.037	0.016	0.025	0.055
50 RAIL EQUIPMENT	0.036	0.014	0.026	0.046
51 MOTOR VEHICLES	0.080	0.038	0.053	0.102
52 OTH.TRANSPORT EQUIP.	0.057	0.027	0.038	0.070
53 OTH. MANUFACTURING	0.059	0.034	0.039	0.090
54 CONSTRUCTION	0.048	0.036	0.032	0.074
55 ELECTRICITY ETC.	0.065	0.176	0.043	0.383
56 RAIL TRANSPORT SERVICE	0.115	0.043	0.075	0.093
57 OTHER TRANSPORT SERVICE	0.217	0.012	0.146	0.038
58 COMMUNICATION	0.011	0.004	0.007	0.018
59 TRADE	0.042	0.012	0.028	0.042
60 OTHER SERVICES	0.107	0.073	0.072	0.207

SOURCE : SAME AS TABLE 5.1

Fig 5.1 **Top ten coal Consuming Industries**

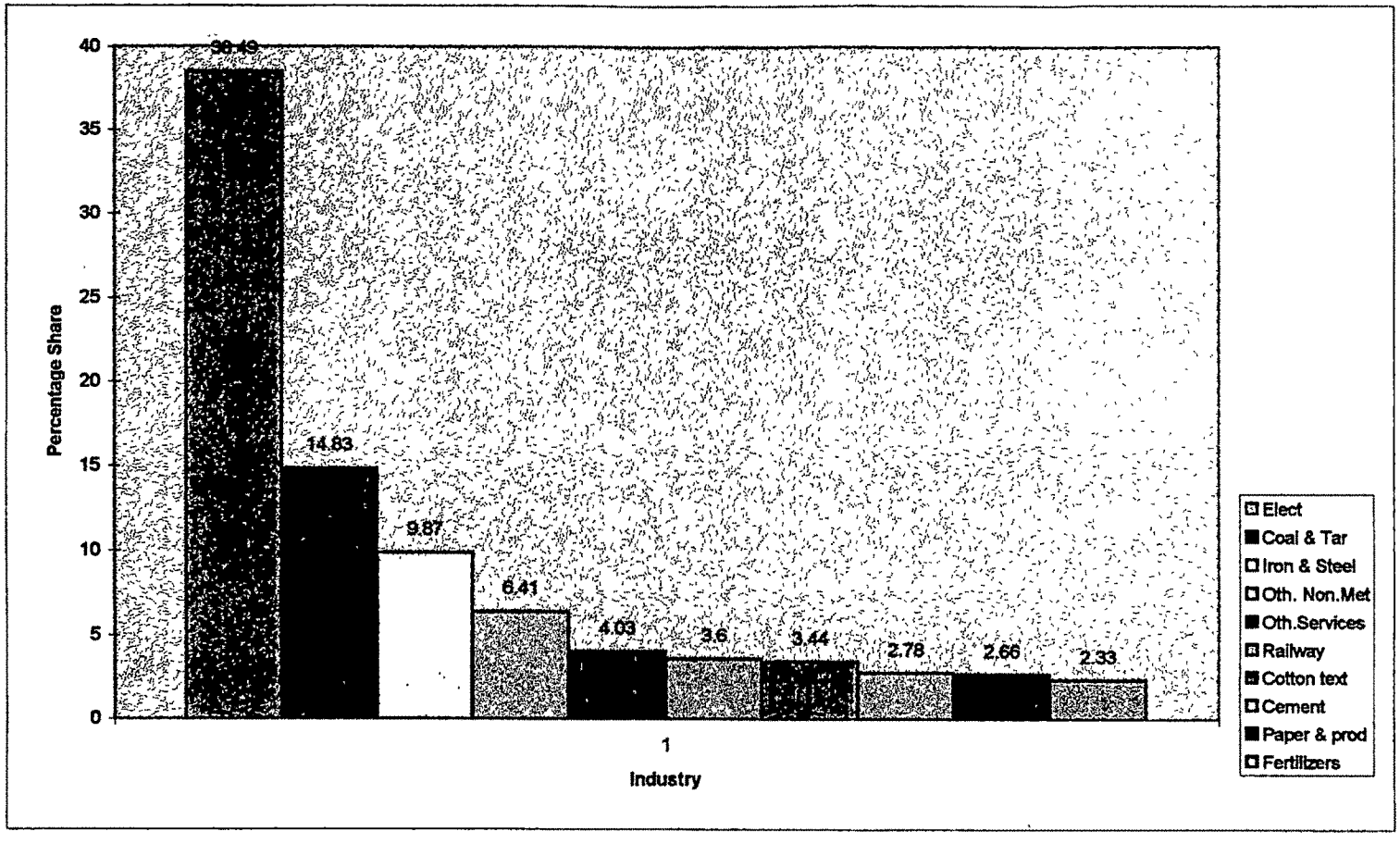

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Fig 5.2 **Top Ten Petroleum Consuming Industries**

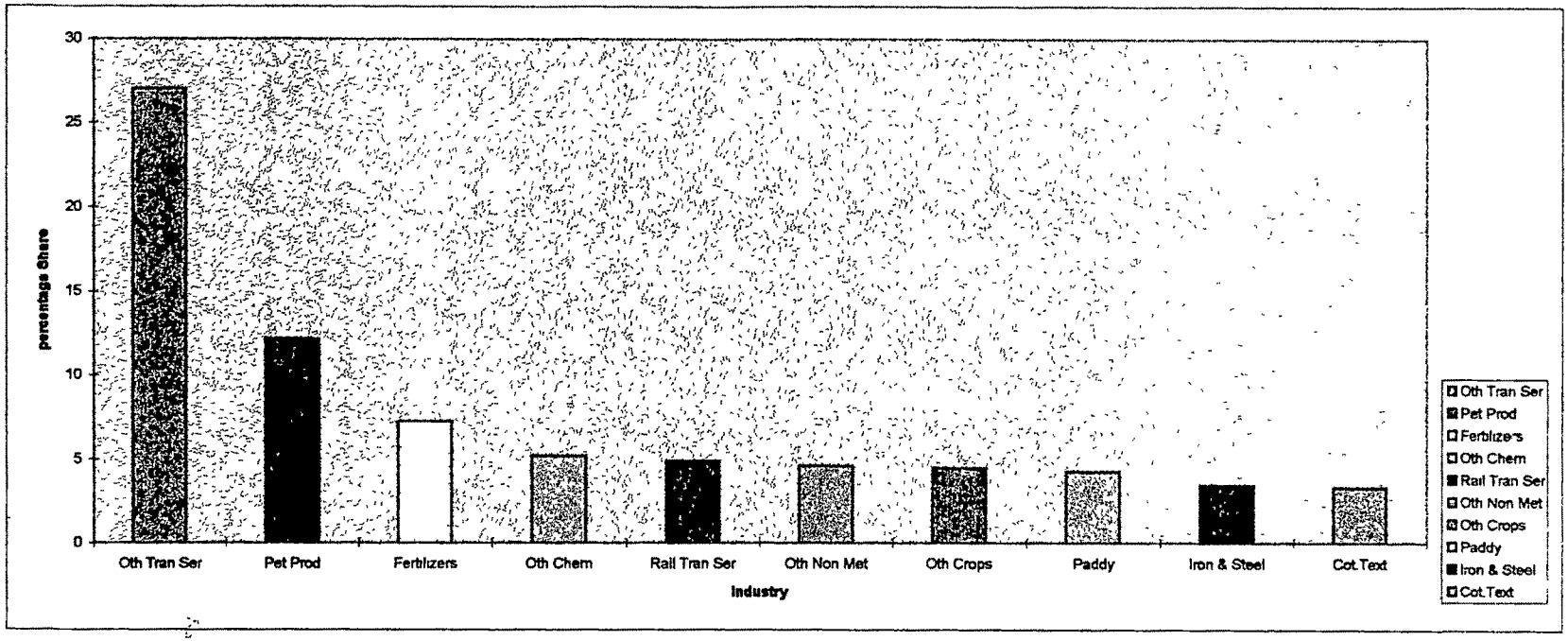

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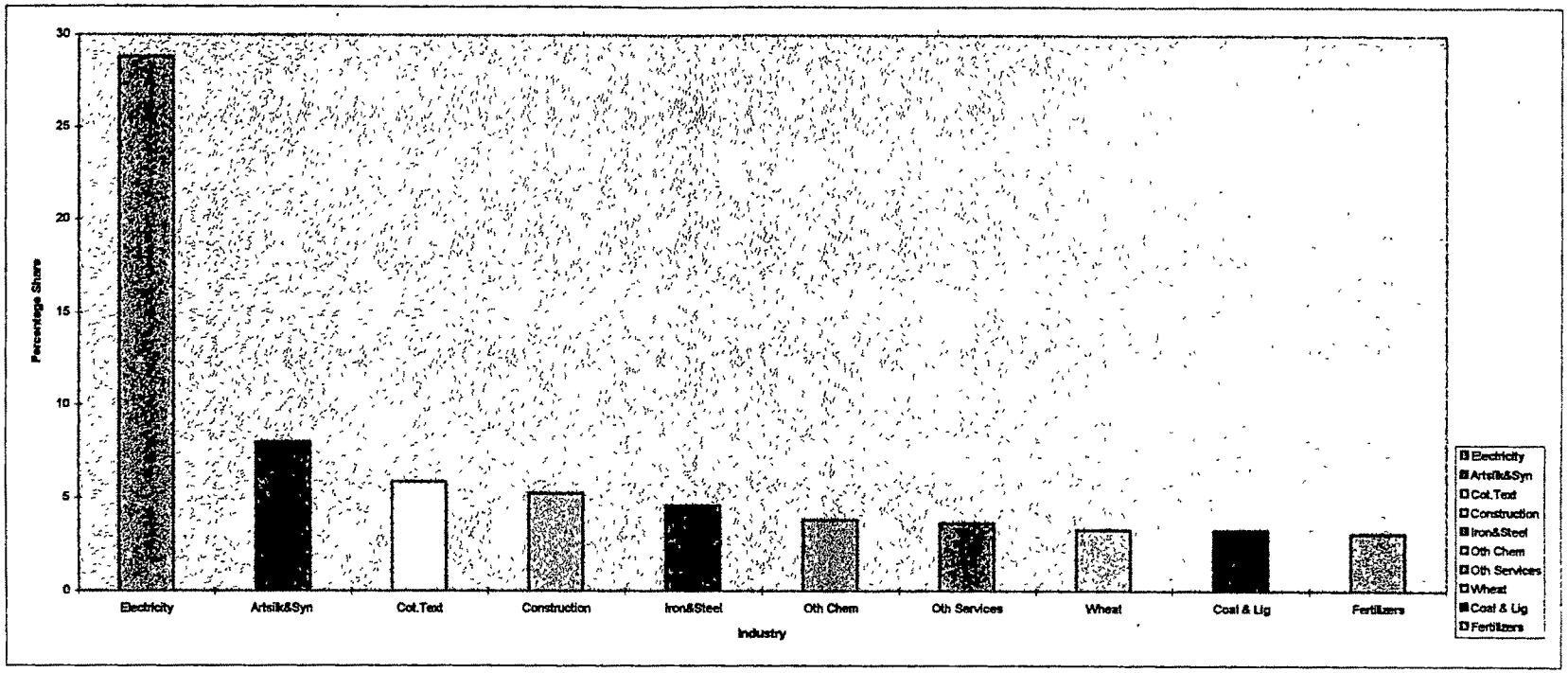
Fig 5.3 **Top Ten Electricity Consuming Industries**



5.3.1 Consumption Demand for Capital Formation

Capital formation is the resource buildup, an imperative for a developing economy without which future production, capabilities and private consumption possibilities will take a beat for the worse. Capital formation are mostly machinery and construction having a pervasive effect on all the sectors of economy with varying magnitude. Capital expenditure on these two items accounts for approximately 80 percent of the total energy demand which can be attributed directly and indirectly to the gross capital formation in India.

5.3.2 Export and Imports

Trade balances has been one of vexing problem in India. Export in most cases did not keep pace with the imports, especially after the oil crisis. Hence a closer look at the problem is inevitable. The gross output sector in the I-O table provides information on both exports and final demand by comparing across the different export commodities, one can ask for their relative impact on the over all energy consumption to energy resources in the country. The

energy coefficient provided in table 5.2 will be of an insight. If the economy strives to achieve maximum benefit from aggregate export with minimum energy use, we can prioritize the promising sector, even though they may be highly energy intensive ones. For 1989-90 we could see from the Input-Output table that the single most contributor of export earnings is the non-metallic mineral product sector excluding railway, transport services has the next highest share followed by Textiles. All the top export sectors demand energy directly and indirectly, mostly in the form of coal, except non railway transport services which requires oil. There are certain auxiliary industries, in relation to exports, which do not directly contribute to the growth of exports but are vital to the survival of the export oriented units, like electricity. In order to asses the gain from trade, we need to have energy prices in accordance with economic principles. Once such pricing policy is in existence, then, there is no reason to prioritize , the economies will guide the trade strategies and tell us what is the real energy drain on the economy.

When we look at the imports, there are two ways of looking at it. (i) Competitive imports (ii) Non-competitive imports. Competitive imports are completely perfect substitutes for domestically produced goods, while the non-competitive imports are the goods for intermediate as well as final consumption for which no domestic capacity exists and for which no substitutes by domestic output is possible, whatever the domestic output and prices may be[7]. An increased import necessarily avoids the burden on the final energy demand assuming that energy embodied in the imported goods are energy saved domestically. The energy 'savings' due to import spread out over a number of sectors, top among them are, machinery,

TABLE - 5.3
ENERGY USE CORRESPONDING TO FINAL DEMAND CATEGORIES, 1989-90(MTOE)

CATEGORY	COAL	OIL & GAS	ELECTRI-CITY	FUEL WOOD	TOTAL ENERGY
A. Intermediate					
i. Private Consumption	59.68	29.50	13.58		102.76
ii. Public Cunsumption	13.13	3.10	1.75		17.98
iii.Gross Capital Formation	41.70	8.40	6.16		56.26
iv. Exports	12.93	4.60	1.83		19.36
v. Imports	20.72	7.60	3.58		31.90
Total	106.72	38.00	19.74		164.46
B. Direct					
i. Private Consumption	0.49	13.50	2.50		16.49
ii. Public Consumption	0.00	3.20	1.25		4.45
Total	0.49	16.70	3.75		20.94
Total (A+ B+ Fuelwood)					
i. Private Consumption	60.17	43.00	16.08	32.00	151.25
ii. Public Cunsumption	13.13	6.30	3.00		22.43
iii.Gross Capital Formation	41.70	8.40	16.16		56.26
iv. Exports	12.93	4.60	1.83		19.36
v. Imports	20.72	7.60	3.58		31.90
Grand total	107.21	54.70	23.49	32.00	217.40

F.D = (Private Consumption+Public Consumption+Gross Capital Formation + Exports - Imports)

steel, chemicals and fertilizers, mostly in the form of coal. Ofcourse, saved energy need to be gauged at the export earnings. In order to effectively compete in the international market, domestic industrial sectors need to be competitive and efficient.

5.4 Energy Intensive Economic Growth !

This is one of most vexing questions that evades the answer for long. Many see the ill of Indian economy in some of the inefficient manufacturing sector, mainly the public sector units. In a macro sense, inefficient use of resources is the order of the Indian manufacturing industries in recent years[8].

A review of World Bank [9] experience in the energy sector of the developing countries shows why energy efficiency is low and what the gains from greater efficiency might be.

The reason for failure in many instances relate to one or more of the following factors.

(i) Weak or absent competitive market forces

(ii) Subsidized fuel and electricity prices

(iii) Administered trade barriers and discriminatory taxes and subsidies

(iv) The relatively high weight given to first cost consideration where making equipment purchases

(v) Lack of government follow-through on agreed commitments to efficiency

related policy and institutional changes

(vi) The absence of specific efficiency incentives, such as mandated energy performance codes and standards for industry and transport

The manufacturing sector is the single largest user of commercial energy in India. Manufacturing sector consists of two categories of industries, one referred to as the registered sector consisting of factories registered under Factories Act and the other unregistered sector. Among the registered sectors, some are Large Energy Consuming industries (LEC). The large energy consuming industries may not necessarily be energy intensive industries in terms of their growth and volume of output, like sugar, chemicals, textiles, cement and paper and pulp. These industries account for more than fifty percent of the energy consumed in the industrial sector and have grown rapidly over the last two decades. On the other hand the unregistered manufacturing sector is a very important contributor to the total industrial production and contributes over one third of value added in industries, consuming less of energy resources.

A comparison of energy intensity with other developed nations reveal that though India's output grows slowly but its requisite energy input has been much higher compared to Brazil, Korea, Kenya and China. One important explanation for this high industrial energy demand would appear to center on the fuel composition of industrial energy demand[10]. Since India has abundant coal reserves most industries have been developed by utilizing coal as their energy source. However coal is generally used in a less efficient manner in the process

heating and burner boilers. Secondly India is one of the very few countries which has a production base for heavy industries such as iron and steel, fertilizers, chemicals and metal industries.

Industrial structure along with fuel mix and substitution of fuels certainly a major contributor to the energy intensity. However an expanding industrial base along with economic growth induces certain structural changes in the medium and long term. In order to understand the growth induced changes in the structure of the industries, changes should be traced over fairly a long period time. However, table below traces the structure of energy demand for the period 1984-85 and 1989-90.

In order to understand the total energy intensity over a period of five years, 1984-85 and 1989-90 Input-output tables are used. These tables are aggregated to 24 industries (Table 5.4). All the industries have undergone change over the period of time, namely, increase in the energy intensity, except for four industries, viz, coal and lignite, Iron ore. Other minerals and services. At the same time, other services, along with reducing energy intensity, the energy required per unit of value added, it also increased its contribution to the value added. Formost of the industries the coal intensities have reduced with increase in oil and electricity intensities. This indicates the changing production pattern overtime.

Given the structure of energy demand, what is the scope for enhanced growth in the coming decades. What is the energy requirements for our growing economy. These concerns are the main focal point of chapter VI.

Table 5.4 Intensity of Energy as Inputs in Various Industries (1984-85 = 100)

Sector	Coal& Lignite	Petroleum Products	Elect & Gas	Total
1. Foodgrains	65.67	144.29	147.25	139.53
2. Fibre	106.09	258.10	263.18	246.32
3. Other Crops	38.54	172.18	141.36	139.06
4. Other Allied Agri.Sector	71.34	150.63	151.95	142.57
5. Coal and Lignite	59.23	196.84	73.29	82.37
6. Iron Ore	46.38	49.34	138.74	78.85
7. Other Minerals	46.84	70.81	78.58	71.98
8. Food & Beverages	99.37	149.24	189.46	157.65
9. Textiles	71.70	133.30	166.83	140.67
10. Wood Paper & Leather products	60.83	119.34	156.89	126.21
11. Rubber & Plastic Products	57.94	125.79	169.65	130.58
12. Petroleum Products	30.91	194.71	133.40	149.83
13. Fertilizers & Pesticides	70.16	185.74	177.62	164.09
14. Other Chemicals	66.12	154.50	179.67	130.51
15. Cement & Other Non-Metalic Min	142.52	135.54	217.89	174.68
16. Iron & Steel and Basic Metals	149.92	132.00	148.95	144.61
17. Non Electrical Machinery	84.79	105.43	117.74	108.89
18. Electrical Machinery	84.36	112.66	129.15	116.23
19. Transport Equipment	81.47	119.50	118.24	112.94
20. Other Manufacturing	69.56	128.39	134.23	117.74
21. Construction	98.77	74.80	141.75	141.55
22. Electricity And gas	59.34	170.73	171.07	139.96
23. Transport and Communication	42.18	155.68	95.79	123.54
24. Other Services	24.17	56.48	86.39	60.05

Source : (i) Hashim S.R & Satyanarayana
(ii) Input -Output Table 1989-90