

**ENERGY AND INFRASTRUCTURE NEEDS IN INDIA
:AN INPUT-OUTPUT ANALYSIS**

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Abstract

Some traditional economic multipliers and non traditional economic multipliers like energy multiplier, infrastructure multiplier etc. in order to assess the impact of India's economic growth. Input-output technique has been adopted as a method of analysis.

Findings show that basic metal industry has the highest output multiplier effect being closely followed by the food products industry and textile industry sector. Primary energy multiplier is the highest for mining followed by agriculture and equipment sector. Nation's infrastructure multiplier would rise most with it's one unit increase in direct use in the energy products sector being followed by food, equipment, basic metal etc.

Analysis shows that various goals may be conflicting, for example, the agricultural sector that assumes priority in the Ninth Five Year Plan has the second highest primary energy multiplier, but ranks only ninth out of eleven sectors in terms of output multiplier. It is also important to note that relative to other sectors agricultural sector has the second highest communication and electricity multiplier. It is felt that based on the information derived from the energy and infrastructure multipliers, economic planners can better evaluate development alternatives in a logical and quantitative manner.

key words: input-output, energy multiplier, infrastructure multiplier

INTRODUCTION

Infrastructure and energy are the keys to development of industry, trade, commerce and the overall economic growth and prosperity of a nation. At a time when Indian economy is aiming for strong broad based growth it is imperative to assess the impacts associated with growth especially on these two vital sectors :energy and infrastructure. One indicator for assessment of impact may be multipliers. Economic multipliers may be used to know changes in sectoral output, income, employment ,etc. (Chennary and Clark,1965). Energy multipliers may be used to assess impact of alternative economic development strategies on total energy use (Hsu, 1989).

OBJECTIVE

This paper is an attempt to estimate output multiplier and energy multiplier as discussed in the literature. In addition, given the need of the hour, specific formula for infrastructure multipliers related to input-output theory has been put forward. Also , output, energy, and infrastructure multipliers for Indian economy are estimated and interpreted. In this changed economic environment the findings of infrastructure and energy multiplier will help the economic planners to evaluate development alternatives in a logical and quantitative manner. This is because the multiplier analysis would enhance our understanding through estimates of the effects of a change in the direct use of energy and infrastructure on total energy and infrastructure use. Once the information regarding infrastructure and energy multipliers are known for various sectors economic planners can better evaluate development alternative in a logical and quantitative manner.

METHODOLOGY

In this paper the input-output technique has been used as a method of analysis. Input-Output analysis can interrelate industry inputs and outputs with the intermediate and final demand for energy and infrastructure . So the direct energy and infrastructure intensity for different sources can be obtained by using the input-output table. Once this direct energy and infrastructure intensity is known, we utilize the $(I-A)$ inverse matrix to compute the desired direct and indirect effects which would then be used in the computation of primary energy and infrastructure multiplier.

The Output or sales multiplier is defined as follows:

$$S = j (I-A)^{-1} \quad (1)$$

where,

$S = 1 \times n$ vector of output multipliers

$j = 1 \times n$ sum vector.

Thus, the output or sales multiplier is the column sums of the inter-industry matrix $(I-A)^{-1}$.

The primary energy multiplier shows the total change in regional/national primary energy use if direct primary energy use in the i th sector increases by one unit. It is defined as :

$$r = e (I-A)^{-1}$$

$$E_i = r_i / e_i \quad (2)$$

where,

$e = 1 \times n$ vector of direct energy coefficient i.e. the ratio of total energy use to total sales of each sectors; the elements of e are the e_i 's.

$r = 1 \times n$ vector of the direct and indirect changes in energy use.

The elements of r are the r_i 's. These are also referred to as energy final demand coefficients.

E_i = the energy multiplier for the i th sector.

Similarly, Infrastructure Multiplier can be defined as follows:

$$m = q (i-a)^{-1}$$

$$l_i = m_i / q_i \quad (3)$$

where,

$q = 1 \times n$ vector of direct infrastructure coefficient i.e. the ratio of total infrastructure use to total sales for each sectors; the elements of q are the q_i 's.

$m = 1 \times n$ vector of the total direct and indirect changes in infrastructure use.

$l_i =$ the infrastructure multiplier for the i th sector.

DATA AND RESULTS

Based on these multiplier concepts and the 1983-84 and 1989-90 input output tables of India, tables 1 through 4 present the empirical findings of the study. The Indian economy has been divided into eleven sectors. Infrastructure is an umbrella term for many activities. In our analysis we have followed in line with the World Development report which classifies the infrastructure sector as having a coverage of power (Electricity), Transport (Railways, Roads), communication and construction. Thus, to get further breakup for the infrastructure sector the economy has been redefined in terms of fifteen sectors.

Table 1 presents for two years the estimates of the output multiplier, primary energy multiplier and infrastructure multiplier for eleven sectors. Analysis of sectoral multipliers shows that India's primary energy needs would rise the most for one unit rise in direct primary energy use in the mining sector ,(99 units) followed by agriculture sector (39 units), equipment sector (14 units) and other service sector (7 units) respectively. Rise in India's primary energy need would be negligible for one unit rise in direct use of it for the basic metal industries. In case of the infrastructure multiplier we find that India's infrastructure need would rise by 20 units in 1989-90 while it would be only of 2 units rise in 1983-84 for

one unit rise in case of the mining sector which has the highest primary energy multiplier. Another feature is that need of India's infrastructure use would rise by 6 units, 9 units, 5 units for one unit rise in use in case of primary energy sector, energy products manufacturing sector and the equipment sector in 1989-90. The inter-temporal comparison of structure shows that with time need for infrastructure is on the rise. Basic metal industry, food products industry, textile industry, equipments and infrastructure are the ones whose output multipliers are on the higher side as compared to other sectors. However, among these sectors besides infrastructure sector for all others primary energy multiplier is relatively on the lower end.

Table 2 presents multiplier of different infrastructure sectors. This detailed breakup throw more light on the need for specific sector within infrastructure category. The electricity multiplier is the highest for the energy products sector for the year 1989-90 being followed by the other transport service sector, equipment sector and so on. The need of India's electricity use would rise by less than two units which is negligible for both years in case of mining sector, primary energy sector, communication sector for one unit rise in direct use of electricity in these sectors. Energy products sector has high values of multiplier for all the infrastructure sectors. Due to the structural change over time we find that values of multipliers vary considerably especially for the energy products sector. Barring few exceptions all the multiplier in general show a rising trend. It is only for the agriculture sector electricity multiplier has fallen, Similar decline is observed in construction multiplier for electricity, rail, other transport, other services sector, communication multiplier (only marginally) for primary energy, electricity, rail, other transport, manufacturing, other services. For manufacturing sector rail transport multiplier has gone down, but so far other transport service is concerned it has gone down marginally for primary energy sector, basic metal industries, electricity, other services sector.

However, multipliers consider only one aspect - effect of the change in direct energy and infrastructure use but we are interested in effect of changes in final demand for commodities of a particular sector. Thus, besides the size of the multipliers one should also consider the direct coefficients to understand the impact of final demand growth. It is the change in sectoral final demand that initiates the process of change. Table 3 and table 4 present the direct coefficients

of primary energy and infrastructure sectors. In general , except for agriculture over time both primary energy and infrastructure coefficients have declined over the period under study. From the estimates one thing is clear that the direct need of infrastructure sector is bound to surpass direct needs of primary energy with the growing final demand across sectors. Table 4 illustrates that direct electricity coefficients and direct other transport services coefficients are higher than direct coefficients of construction, communication and railway transport services for both the years 1983-84 and 1989-90. Within the infrastructure sector the direct need of electricity and other transport services are bound to surpass the direct need of communication , construction and railway transport services with the growing final demand across sectors.

If we consider the direct coefficients of the primary energy we find that the agricultural sector and the mining sector has a low value of direct primary energy coefficient though its value of multiplier is high. It is the energy products sector which has the highest value of direct primary energy coefficient for the year 1989-90 and 1983-84 followed by the basic metal industry, infrastructure sector, manufacturing sector. If we now come to examine the direct infrastructure coefficient we find that in 1989-90 the mining sector has the lowest value though its infrastructure multiplier is high followed by the other services sector, manufacturing sector, basic metal industry. From table 3(barring few exceptions)general features are that direct coefficients of infrastructure is higher than primary energy across the sector for both the years 1983-84 and 1989-90. Again table 4 illustrates the fact that direct electricity coefficients and direct other transport services coefficients are higher than direct coefficients of construction, communication and railway transport services for both the periods.

POLICY IMPLICATION AND CONCLUSION

In the changed economic environment of India, the economic planners can evaluate development alternatives in a logical & quantitative manner once the information on both multipliers and direct coefficients are available. Now what will be the desirable objectives- one may be of output maximization; the other may be of minimization of primary energy use or infrastructure use to indirectly reduce the burden on investable funds or any combination. If we consider

the objective of output maximization growth of basic metal industry must be targeted . But this will raise the need for infrastructure. Again, within the infrastructure sector, direct use of electricity, construction, communication, other transport services will be higher & indirect use of rail transport services will be lower. So provision of these sectors must match the growth of basic metal industry. Again if the objective be of minimization of primary energy use the growth of energy products sectors is desirable for both the years but it will raise the infrastructure needs of the economy . Again within the infrastructure it will indirectly reduce the use of other transport services and rail transport services and directly increase the use of electricity, construction and communication. So provision of these sectors must match the growth of energy products sector. Finally if our objective is to reduce the use of infrastructure needs of the economy then growth of other service sector is desirable. Multiplier analysis shows that various goals may be conflicting, for example, the agricultural sector that assumes priority in the Ninth Five Year Plan has the second highest primary energy multiplier, but ranks only ninth out of eleven sectors in terms of output multiplier. It is also important to note that relative to other sectors agricultural sector has the second highest communication and electricity multiplier. But has low direct coefficient. The direct coefficients and multipliers do not move together. So both needs to be considered in policy formulation. Thus the ultimate production and investment plan must consider both direct and indirect needs and a compromise among multiple objectives.

References

- Chenery H B and Clark P G. 1965. *Interindustry Economics*. New York: Wiley.
- Hsu George J Y. 1988. Energy Multipliers For Economic Analysis - An Input Output Approach. *Energy Economics* (January) 33-38.
- World Bank. 1994. *World Development Report*.

Appendix I

Eleven sectoral representation of the Indian economy has been prepared from 1989-90's 60x60 Input-Output Matrix for

India.

1. Agriculture (Agri.): this includes following sectors- paddy, wheat, other cereals, pulses, sugar-cane, jute, cotton, tea, coffee, rubber, other crops, animal husbandry, forestry and logging, and fishing.
2. Food: includes sugar, khandsari, hydrogenated oil, and other food and beverages industry.
3. Textile: includes cotton textiles, wollen textiles, art silk and synthetic fibre, jute, hemp and mesta textiles, and other textiles.
4. Mining: includes iron ore, other metallic minerals, and non metallic and minor minerals.
5. Primary Energy (primary): includes coal and lignite, and crude petroleum and natural gas.
6. Energy Products (Energy): includes petroleum products and coal tar products
7. Basic Metal (Basic) : includes iron and steel, and non ferrous metals.
8. Infrastructure (infrastruct): includes electricity, construction communication, rail transport services and other transport services.
9. Other Manufacturing (mfg): includes wood and wood products, paper and paper products, leather and leather products, rubber products, plastic products, synthetic fibre and resin, other chemicals, cement, other non metallic mineral production, tractors and other agricultural machinery, machine tools, other non electrical machinery, electrical machinery, fertilisers, and pesticides.

10. Other Services (other serv): includes trade and other services.

11. Equipment : includes communication equipment, electronic equipment, rail equipment, motor vehicles, other transport equipment and other manufacturing equipment

Fifteen sectoral representation excludes from the above list aggregate infrastructure sector and includes Infrastructure following disaggregated sectors:

1. Electricity (Elect)

2. Construction (constn)

3. Communication (commn)

4. Railway Transport Services (Rail)

5. Other Transport Services (other tr.ser)

Table-1. Output, Primary Energy and Infrastructure Multipliers for the years 1983-84 and 1989-90.

Sector	Output	Primary	Infrastructure
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	Multiplier		Energy Multiplier		Multiplier	
	1983-84	1989-90	1983-84	1989-90	1983-84	1989-90
1. Agriculture	1.53	1.60	51.00	38.74	2.01	1.67
2. Food	2.21	2.35	6.95	5.93	2.95	6.66
3. Textile	2.003	2.31	6.53	5.81	2.13	3.18
4. Mining	1.30	1.41	50.24	99.56	1.44	19.88
5. Primary	1.24	1.63	8.07	5.57	1.47	5.56
6. Energy	1.38	2.29	1.09	1.16	1.69	8.20
7. Basic metal	2.44	2.43	3.90	3.40	2.10	4.33
8. Infrastruct.	2.10	1.95	4.00	3.16	1.65	1.45
9. Mfg	2.44	2.24	5.10	4.42	2.45	2.36
10. Other Ser.	1.48	1.32	7.89	6.46	1.48	1.25
11. Equipment	2.05	2.03	13.30	14.44	2.72	4.65

Table 2. Multipliers of different infrastructure sectors for the years 1983-84 and 1989-90.

Sectors	Electricity		Construction		Communication		Rail transport		Other Transport services	
	83-84	89-90	83-84	89-90	83-84	89-90	83-84	89-90	83-84	89-90
1. Agri.	3.74	2.96	1.44	1.46	4.30	5.83	1.98	2.18	1.94	2.34

2. Food	2.86	3.60	4.01	4.50	2.52	3.06	2.86	3.14	1.97	2.03
3. Textile	2.00	2.42	4.11	4.98	2.42	2.96	3.93	4.39	1.86	2.08
4. Mining	1.45	1.51	2.89	3.07	1.73	1.74	2.72	3.38	1.51	1.64
5. Primary	1.57	1.64	1.34	1.45	3.46	3.29	1.38	1.43	3.04	2.72
6. Energy	2.26	7.31	3.89	11.64	3.56	6.87	1.25	2.14	1.68	2.34
7. Basicmetal	2.25	2.31	2.89	2.93	2.78	2.99	1.88	2.22	2.53	1.99
8. Electricity	1.42	1.44	2.99	2.03	2.57	2.22	1.51	1.60	2.98	2.56
9. Construct.	3.44	3.654	4.75	3.65	2.33	2.67	1.69	1.82	1.89	1.97
10. Commn.	1.86	2.17	1.103	1.10	2.10	2.14	1.30	1.45	1.43	1.47
11. Rail	2.88	2.22	1.79	1.13	4.49	3.40	3.18	2.40	2.50	2.74
12. Other tr ser.	3.97	3.87	4.28	2.38	2.08	1.40	2.30	2.35	1.67	1.26
13. Mfg	2.42	2.57	2.17	3.69	3.15	1.93	3.44	2.34	2.05	2.07
14. Other ser.	1.90	2.32	2.70	1.19	1.46	1.19	1.62	2.34	1.76	1.27
15. Equipment	2.11	3.76	1.30	3.33	1.29	1.67	2.09	3.23	1.35	2.75

Table 3: Direct coefficients of primary energy & Infrastructure for the years 1983-84;1989-90.

Sectors	Direct Primary energy coefficient		Direct infrastructure coefficient	
	1983-84	1989-90	1983-84	1989-90

1. Agriculture	0.0004	0.00042	0.0259	0.056
2. Food	0.0050	0.00491	0.0277	0.014
3. Textile	0.0065	0.00622	0.0520	0.037
4. Mining	0.0009	0.00033	0.0475	0.001
5. Primary	0.0028	0.00643	0.0350	0.009
6. Energy	0.507	0.48272	0.0349	0.007
7. Basic metal	0.0408	0.03158	0.0999	0.020
8. Infrastruct.	0.0351	0.02297	0.1151	0.123
9. Mfg.	0.0181	0.01476	0.0587	0.052
10. Other ser	0.0028	0.00150	0.0675	0.096
11. Equipment	0.0052	0.00263	0.04306	0.014

Table 4: Direct coefficients of the infrastructure sectors.

Sectors	Electricity		Construction		Communication		Rail transport.		other transport	
	83-84	89-90	83-84	89-90	83-84	89-90	83-84	89-90	83-84	89-90

1. Agri.	0.006	0.008	0.011	0.020	0.0002	0.0003	0.0034	0.0038	0.0068	0.0087
2. Food	0.007	0.010	0.003	0.002	0.0007	0.0015	0.0034	0.0038	0.0136	0.0265
3. Textile	0.030	0.032	0.002	0.002	0.0009	0.002	0.0027	0.0027	0.0159	0.0321
4. Mining	0.035	0.056	0.001	0.002	0.0006	0.002	0.0026	0.0025	0.0085	0.0144
5. Primary	0.017	0.058	0.008	0.001	0.0002	0.001	0.0078	0.0184	0.0021	0.0087
6. Energy	0.007	0.010	0.001	0.0005	0.0003	0.0005	0.016	0.0162	0.01004	0.0174
7. Basic	0.049	0.061	0.007	0.002	0.0014	0.0023	0.0262	0.0211	0.015	0.0224
8. Elect.	0.255	0.248	0.009	0.003	0.0016	0.0026	0.0507	0.0319	0.010	0.0127
9. Constn.	0.013	0.063	0.031	0.002	0.0014	0.0021	0.018	0.0143	0.019	0.0268
10. Commn.	0.010	0.007	0.0001	0.0008	0.0007	0.0008	0.0110	0.0046	0.014	0.0107
11. Rail	0.036	0.040	0.073	0.002	0.0013	0.0020	0.0125	0.0098	0.011	0.0151
12. Other Tr. Ser.	0.009	0.007	0.007	0.009	0.0056	0.0099	0.0102	0.0566	0.078	0.0761
13. Mfg.	0.002	0.032	0.002	0.005	0.0056	0.0055	0.00006	0.0095	0.0002	0.0276
14. Other services	0.013	0.0065	0.002	0.006	0.00006	0.0062	0.0055	0.0019	0.008	0.0330
15. Equip- ment	0.101	0.0159	0.198	0.006	0.0583	0.0057	.042571	0.0054	0.444	0.0104
