

## **The Changing Structure of the Indian Economy with Special Reference to Infrastructure and Energy Sectors: An Input-Output Analysis<sup>1</sup>**

By  
Joyashree Roy\* and Ranjana Mukhopadhyay\*

### **Abstract**

Present study makes an assessment of the changing structure of the Indian economy with reference to the primary energy (oil and coal) and infrastructure sectors (electricity, construction, communication, railways and other transport services) over a period of past two decades. Standard input-output technique have been used as a method of analysis. Findings show that the changing structure of the Indian economy has been towards increased specialization. Efficiency in utilization of infrastructural and primary energy inputs, increasing construction and communication intensity of the later technologies are noteworthy. In primary energy and electricity sectors specialization rather than substitution are the dominant features. Communication substituted transport demand in most of the sectors. Electricity and energy products sectors are among the important key sectors.

### **1. Introduction**

The importance of technological change in the context of the Indian economy cannot be overlooked. In the Five Year Plans and, recently, in the New Economic Policy and policies related to environmental issues (Government of India, 1997), special emphasis has been placed on “technological development” in shaping the growth pattern of the country. On the other hand, the infrastructure sector (which is the key to the development of industry, trade and economic growth) is gaining importance day by day. In the recent past, India has adopted a policy of economic liberalization and hopes to play its proper role by rightly focusing its attention on the physical infrastructure necessary for a modern economy; especially in areas of power, transportation, telecommunications and, above all, technological development.

The novelty of the present study lies in its explicit concern with the energy and infrastructure sectors, and in its analysis of the changing economic structure of the Indian Economy. The present study is based on the premise that an explicit analysis of changing intermediate input requirement provides a greater insight, particularly in the understanding of technological change. The study of changes in intermediate input

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Manuscript received November 7, 1997. Revised July 9, 1998.

\*Department of Economics, Jadavpur University, India

<sup>1</sup> Authors acknowledge with thanks the comments from anonymous referees.

requirements can be easily justified in its own right. Many practical problems of business and government require an understanding of how, and at what rate, use of, say, electricity or communication or primary energy in agriculture or production services is changing. Such an attempt has been made in this study. Section 2 deals with the changing intermediate input requirement in the context of the changing structure of the Indian economy; while Section 3 deals specifically with the changing infrastructure and primary energy requirements. Section 4 has been devoted to linkage analysis, followed by a number concluding remarks.

## 2. Change in Intermediate Input Requirements: Methodology and Results

In this paper the input-output framework has been used as a method of analysis. For empirical analysis the input-output matrix of India for 1983-84 and 1989-90 (at 1980-81 prices) has been used. The Indian economy has been divided into fifteen sectors. Since infrastructure is an umbrella term for many activities in the present analysis, we have followed in line with the World Development Report, which classifies the infrastructure sector as including Power (Electricity), Transport (Railways, Roads), Communication, Construction. Thus, to obtain a detailed breakdown of the infrastructure sector the economy has been defined in terms of fifteen sectors (descriptions of the sectors are given in Appendix).

As an input-output coefficient table includes a column of input-output coefficients for every sector, it gives a structural description of the entire economy for a particular year. If  $Q^t$  represent a Leontief inverse matrix for the year  $t$ , each element  $q_{ij}$  measures the amount of the product of industry  $i$  required directly, and indirectly, to deliver a rupee's worth of output of industry ( $j$ ) to final demand. Let  $Y^t$  be the final demand vector for year  $t$ ,  $X^t$  being the total output vector for year  $t$ . Now,  $Z^t = X^t - Y^t$ , where  $Z^t$  is a vector of intermediate output levels of year  $t$ , measured in rupee value of transactions. A measure of total direct, and indirect, interdependence between each pair of sectors of the economy can be derived from a direct coefficient table by computing the Leontief inverse matrix.

Our objective here is that, after fixing the gross national product at a given level of industrial composition, we examine the intermediate output requirements to produce this same final demand with the input-output structure of different years. Here, we have fixed the final demand at the year 1989-90. Now, a vector of total intermediate output requirements to produce 1989-90 final demand with 1983-84 input structures is given by

$$Z^{83-84,89-90} = Q^{83-84} Y^{89-90} - Y^{89-90}$$

Again, the 1989-90 intermediate output requirements consistent with the bill of final demand, is simply the difference between the final demand and actual output for the year 1989-90. Table 1 shows the intermediate output requirements for the years 1983-

**Table 1: Changing Intermediate Output Requirement (in millions of rupees)**

Sl.no	Sectors	1983-84	1989-90	% Change in Requirements
1	Agriculture	1800893.26	1119365.53	-37.84
2	Food	274897.94	1715270.43	523.96
3	Textile	265304.48	611095.11	130.33
4	Mining	73728.11	10062.30	-86.35
5	Primary Energy	181159.40	1807.27	-99.00
6	Energy	231061.02	40755.51	-82.36
7	Basic	694559.06	952483.29	37.13
	Infrastructure Aggregate	711822.30	684660.22	-3.81
8	Electricity	270223.54	28262.85	-89.54
9	Construction	103613.78	455373.75	339.50
10	Railways	118175.07	21497.29	-81.80
11	Other Transport Services	200976.72	47601.30	76.31
12	Communication	18833.19	131925.03	600.50
13	Manufacturing	941054.18	340560.24	-63.81
14	Other Services	1164225.18	1196824.40	2.80
15	Equipment	70375.77	51741.32	26.47
	Total	6409080.70	6724625.60	4.92

84 and 1989-90 in order to satisfy the final demand of 1989-90 for all the sectors. The column sums in Table 1 (leaving aside the aggregate infrastructure) measure the gross volume of intermediate inputs from all industries required in order to produce 1989-90 deliveries of final demand with 1983-84, 1989-90 input structures, respectively. We notice that the total rupee volume of intermediate input requirement in constant prices (1980-81 prices) increases over time. The total volume of inputs required to produce the same final product tends to be a little greater (4.92%) with newer, rather than with older techniques of production over this time period. At first glance, this may appear paradoxical. If technological change is to be considered as technological progress, then here we find that more input has been required to produce the same deliveries to final demand at a later date. Actually, an increased volume of intermediate inputs means an increase in specialization. It represents a change in the division of labor among establishments, but it does not, in itself, imply a deterioration of technology. The later technologies use slightly more intermediate inputs in total. However, sector-wise the picture varies from the broad economic picture. From Table 1, we find that the input requirement from certain industries, like food products, textiles, and basic metals are increasing over time. Again, the inputs from other industries (such as agriculture, mining, primary energy, infrastructure aggregate, energy products, manufacturing and other service sectors) are decreasing over time. This indicates an increasing efficiency of the more recent technology in the use of

these inputs. As for infrastructure sector inputs, most of the components have decreased over the years. Exceptions are the construction and communications sectors. Later technologies are significantly communication intensive. Another point to note is the modal shift in freight from railways to roads and other transport services due to their greater flexibility. The input from the electricity sector, to meet the final demand fixed at 1989-90, has decreased over the years under consideration. This may be an indication of the increasing efficiency of these new technologies.

### 3. Changing Requirement of Primary Energy and Infrastructure: Methodology and Results

The standard input-output framework of Section 2 can be further analyzed more specifically in terms of infrastructure and primary energy inputs (Carter 1970, Das et al. 1994), and can be presented as below:

$$(g\Sigma)_{kt} = I_k Q_t I_g Y_T - I_g Y_T$$

Where  $(g\Sigma)_{kt}$  subvector  $k$  (say, electricity) of infrastructure inputs required to deliver the final demand vector for sector  $g$  (say, agriculture), with the technology of time  $(t)$  prevailing in all industries;  $I_k, I_g =$  Identity matrices, with diagonal elements other than  $k$  and  $g$  respectively being zero.

$$Q_t = \text{the Leontief matrix for the year } t$$

$$Y_T = \text{final demand at time } T$$

The above model has been applied in order to study the changes in infrastructure and primary energy requirements across certain sectors during the period 1983-1990. The final demand has been fixed at the 1989-90 level, and the intermediate infrastructure and primary energy input requirements to produce the Individual sector's same final demand with input-output structures of 1983-84 and 1989-90 at constant prices (base year = 1980-81) are examined. Results are shown in Tables 2 and 3. On the basis of these results, the percentage share of each type of intermediate input requirement has been calculated. As we have disaggregated the infrastructure sector into five sectors (electricity, construction, communication, rail and other transport services), we have examined whether any substitution has occurred among these sectors. Further, we have tried to analyze whether any substitution has taken place between the primary energy producing sector and the electricity sector. In the case of most sectors (agriculture, food products, textile, mining, primary energy, energy products and manufacturing), both the consumption of primary energy and electricity has increased, which is not inconsistent for a growing economy like India. It can be said that in these sectors specialization is dominant rather than substitution. Exceptions are basic metal, other services sector and the equipment sector. An analysis of Tables 2 and 3 reveals that substitution has occurred between different intermediate inputs in

**Table 2: Intermediate Infrastructure and Primary Energy Input Requirements to Deliver Specific Sectors of Final Demand (million rupees)**

Sectors	Primary Energy		Electricity		Construction	
	1983-84	1989-90	1983-84	1989-90	1983-84	1989-90
1 Agriculture	4930.00	19431.01	6173.33	25598.62	17190.08	33381.36
2 Food Products	23591.19	53949.64	31846.29	63878.95	22243.04	45719.42
3 Textile	15256.24	25927.79	37469.12	48055.99	4864.94	12122.54
4 Mining	137.45	418.62	515.22	870.24	37.83	85.32
5 Primary	28.88	119.33	74.24	262.11	29.24	84.03
6 Energy	238.45	24185.83	547.35	3073.15	216.88	1024.40
7 Basic	83570.26	113494.61	106042.9	134813.71	20063.12	28039.43
8 Electricity	8583.98	5729.65	10954.04	10833.41	771.58	1179.05
9 Construction	12015.82	21447.96	20372.12	29146.11	464988.3	466714.4
10 Communication	891.99	904.51	2481.31	1881.82	4578.53	3184.96
11 Rail	1452.80	1960.28	2343.48	1999.52	2951.68	2439.84
12 Other Transport.	713.71	3895.23	1803.00	1448.92	1395.11	726.44
13 Manufacturing	12599.01	24530.16	8549.63	28670.10	3904.27	7369.39
14 Other Services	13073.86	11840.12	29126.22	18496.39	6464.47	28043.49
15 Equipment	4075.67	2301.62	11815.14	3311.21	14270.35	901.80

Sectors	Communication		Rail		Other Transport Services	
	1983-84	1989-90	1983-84	1989-90	1983-84	1989-90
1 Agriculture	14889.46	1904.04	7151.77	9246.19	825.61	23064.71
2 Food Products	46267.42	8029.49	16884.28	19582.94	3038.86	92956.05
3 Textile	18261.29	3680.99	6219.03	6879.12	1283.72	41274.18
4 Mining	131.49	32.63	72.02	84.36	11.40	244.82
5 Primary	17.56	9.35	29.73	71.85	1.95	66.14
6 Energy	718.14	160.20	856.13	1451.20	43.82	1743.00
7 Basic	36070.54	6606.01	47091.72	38364.92	3725.23	51877.80
8 Electricity	927.97	171.46	2318.77	1527.10	124.67	985.14
9 Construction	16204.27	2703.67	14124.08	11743.64	1451.72	24365.07
10 Communication	2694.86	103.45	1905.39	8481.46	67.59	2085.78
11 Rail	3213.40	148.82	893.15	475.25	396.54	925.86
12 Other Transport.	6543.11	453.48	1179.18	638.54	584.80	4847.25
13 Manufacturing	4923.72	3066.14	3610.51	7527.65	497.50	1988137.00
14 Other Services	17054.21	8891.87	10929.81	2783.31	2608.26	51207.73
15 Equipment	33059.20	524.42	4909.43	596.10	4151.46	2025.20

**Table 3: Percentage Change in Requirement of Intermediate Infrastructures and Primary Energy Inputs to Deliver Sectoral Final Demand**

Sectors	Primary Energy	Electricity	Construction	Communication	Rail	Other Transport
1 Agriculture	294.13	314.66	94.18	130.62	29.28	54.90
2 Food Products	128.68	100.58	105.54	164.22	15.98	100.90
3 Textile	69.95	28.25	149.18	186.74	10.61	126.00
4 Mining	204.56	68.90	125.53	186.22	17.13	86.18
5 Primary	3.23	253.05	187.38	379.50	141.67	276.65
6 Energy	10042.93	367.50	372.33	265.58	69.50	142.70
7 Basic	35.80	27.13	39.75	77.33	-18.53	43.82
8 Electricity	-33.25	-0.29	52.80	37.53	-34.17	6.16
9 Construction	78.50	43.00	0.37	86.23	-16.85	50.36
10 Communication	1.40	-24.11	-30.43	0.01	-55.50	-22.60
11 Rail	31.21	-14.60	-17.30	-62.47	-1.79	-71.18
12 Other Transport Services	445.77	-19.60	-48.00	-22.45	-45.80	-2.97
13 Manufacturing	94.70	235.30	88.75	516.30	108.49	303.78
14 Other Service Sector	-9.40	-36.50	333.80	240.90	-74.50	200.00
15 Equipment	-43.52	-71.97	-93.68	-87.36	-87.86	-93.80

these latter sectors. In the case of the communication sector, primary energy consumption has increased, while the consumption of electricity has declined in the year 1989-90, i.e., the former has replaced the latter. Similar substitution occurred in the case of rail and other transport services. Now, we have to find out whether any substitution has occurred between rail and other transport services. In the case of other service sectors, construction, electricity, basic metal industry-rail transport services has been substituted by other transport services in 1989-90, because in all these cases the use of other transport services has increased, while the use of rail transport services has declined in the year 1989-90. The use of rail and other transport services has both increased in the year 1989-90 for most of the sectors. However, the percentage increase in use of communication is way above the transportation need in all the sectors. This, in fact, reflects the Government policies, which favored telecommunication during this period. An exception is the equipment sector, where we can see a decline in the need for all the infrastructure inputs. For the aggregate economy, structural change (Table 1) over the period under study has led to more use of construction, communication and other transport, and less use of primary energy, electricity and railways. But this is not the picture across individual sectors (Tables 2 and 3). Construction requirement has declined in communication, rail, other transport and equipment sectors. Communication demand has declined for rail, other transport services and equipment sectors. The requirement from other transport has declined in communication, rail and equipment sectors. However, for all other sectors' the requirement of primary energy and infrastructure has increased. For the agriculture sector the need for primary energy, electricity and communication has risen quite

substantially. This reflects the modernization efforts in agriculture and improvements in rural life. We can expect this trend to continue over the coming years. We can assume that in the equipment sector technological development has been successful in reducing the need for all the individual infrastructure sectors and primary energy.

#### 4. Linkage Analysis

The above analysis of sector-specific structural change, supplemented by linkage analysis, can help identify those sectors of the economy in such a way that, by concentrating resources on them it should be possible to stimulate a more rapid growth of production than with an alternative allocation of resources. At present a sector may induce growth because it stimulates other domestic sectors, in order to satisfy its intermediate requirements (backward linkages), or since it stimulates domestic production, because it may induce use of its output as input in new activities (forward linkages). Finally, the sum of the analytical expressions defining the types of linkages defines the total linkages exerted by this sector. The strength of these two linkages may be measured in different ways. However, for our present purposes, the following measures of total forward linkage and backward linkage have been adopted. They are:

$$\sum_{i=1}^N q_{ij}$$

for total forward linkages and

$$\sum_{j=1}^N q_{ij}$$

for total backward linkages, where  $q_{ij}$  are the elements of the Leontief Inverse Matrix  $Q'$ . Tables 4 and 5 present the total backward and forward linkages of the fifteen sectors and their relative ranks. The magnitude of linkages and ranks does not always move in the same directions. The relative ranking of a sector as buyer may remain unchanged (say, electricity sector, Table 4), but, in absolute terms, the sector may increase its purchase. It is interesting to note that sectors such as "other services", manufacturing, electricity and basic metal maintained their ranks in analyzing their positions as buyers. The agriculture sector slid down to fifth position in 1989-90, from its third position in 1983-84 in its relative position as a buyer. Its magnitude of purchase has also declined. The aggregate infrastructure sector will be instrumental in stimulating domestic production, as it will induce other sectors for its intermediate input requirements. On the other hand, the food production and textile industries and energy products sector were not good buyers, because they have maintained low ranks over the years. The "other services" sector has the highest magnitude for backward linkage in 1989-90, followed by manufacturing, primary energy, basic metal, food products and, textile industry, energy production industry, and so on.

**Table 4: Backward Linkages for the Years 1983-84, 1989-90**

Sectors	1983-84	Rank	1989-90	Rank
1 Agriculture	3.15	3	2.33	5
2 Food Products	1.22	13	1.2	14
3 Textile	1.44	11	1.49	10
4 Mining	1.13	14	1.26	13
5 Primary Energy	1.67	8	2.39	3
6 Energy Products	1.93	7	1.93	8
7 Basic Metal	2.47	4	2.34	4
Infrastructure Aggregate	2.19	n.a	2.68	n.a.
8 Electricity	2.12	6	2.24	6
9 Construction	1.58	10	1.43	11
10 Communication	1.41	12	1.66	9
11 Railways	2.13	5	1.08	5
12 Other Transport	1.13	15	1.29	12
13 Manufacturing	3.23	2	2.72	2
14 Other Services	3.55	1	3.2	1
15 Equipment	1.63	9	2.18	7

Note: n.a.= not applicable

While “other services”, manufacturing, basic metal and railways maintained their relative position as buyers, the magnitude of their purchasing from other sectors declined. However, electricity maintained its rank, despite, an increase in its backward linkage. This means that the importance of these sectors as buyers in the economy has been maintained, despite structural changes. So, as far as the forward linkages are concerned, along with structural changes, their sectoral position as seller in the economy has changed. None of the sectors could maintain its rank. The equipment sector lost its top position as seller in 1983-84, to basic metal industry in 1989-90. Comparing Tables 4 and 5, we find that the total backward linkages of the infrastructure sector has increased, while the total forward linkages of the infrastructure sector has decreased only slightly over the years (1983-84 to 1989-90). As such, its importance as a seller has decreased, while it has gained importance as a buyer over the years. An increase in the value of backward linkage of the infrastructure sector over the years indicates that this sector will be instrumental in stimulating domestic production, as it may induce use of other sectors output as an input. The rise in the value of total backward linkage over the years for the infrastructure sector might have resulted from the electricity, other transport and communication sectors. The sectors responsible for the decline of forward linkage are construction, communication and electricity. Structural changes in the Indian economy over this period can be seen from the shifting positions of the industries in terms of the total linkages. In 1983-84 manufacturing and equipment had the highest value for total linkages in the economy, followed by other services, basic metal,



**Table 5: Forward Linkages for the Years 1983-84, 1989-90**

Sectors	1983-84	Rank	1989-90	Rank
1 Agriculture	1.51	10	1.60	12
2 Food Products	2.18	7	2.35	2
3 Textile	1.98	8	2.30	3
4 Mining	1.30	14	1.41	13
5 Primary Energy	1.24	15	1.64	11
6 Energy Products	1.38	12	2.29	4
7 Basic Metal	2.43	3	2.43	1
Infrastructure Aggregate	2.10	n.a.	1.95	n.a.
8 Electricity	2.26	5	2.05	8
9 Construction	2.21	6	2.06	7
10 Communication	2.47	2	1.20	15
11 Railways	1.97	9	2.21	5
12 Other Transport	1.30	13	1.72	10
13 Manufacturing	2.29	4	2.20	6
14 Other Services	1.39	11	1.30	14
15 Equipment	3.89	1	2.00	9

n.a. =not applicable

agriculture, electricity, railways, etc. In 1989-90 manufacturing continued, with the highest value of total linkage, but then the balance tilted towards basic metal, other services, electricity, energy products, equipment etc. The agriculture sector's total linkage has waned over time.

## 5. Conclusions

An analysis of structural change, especially in a country like India, is important in order to understand the changing national and global economic scenarios. It has been observed that use of primary energy and electricity are on the rise. But, over the years, technological change has led to increasing efficiency in their use. The increasing importance of communication is another important finding in this context, as it can serve as a substitute for the fossil fuel-based transport sector. It can be said that the infrastructure sector will be instrumental in stimulating domestic production with its high backward linkage.

## Appendix. Aggregation Scheme

1. Agriculture:
  - i) Food Crops
  - ii) Cash Crops
  - iii) Plantation Crops
  - iv) Other Crops
  - v) Animal Husbandry
  - vi) Forestry and Logging
  - vii) Fishing
2. Food Products:
  - i) Sugar
  - ii) Food Products (Excluding Sugar)
  - iii) Beverages
  - iv) Tobacco Products
3. Textiles:
  - i) Cotton Textiles
  - ii) Wool, Silk and Synthetic Textiles
  - iii) Jute, Hemp and Mesta Textiles
  - iv) Textile Products
4. Mining and Quarrying:
  - i) Iron Ore
  - ii) Other Minerals
5. Primary Energy:
  - i) Coal and Lignite
  - ii) Crude Petroleum and Natural Gas
6. Energy Products:
  - i) Petroleum Products
  - ii) Coal-Tar Products
7. Basic Metal:
  - i) Iron and Steel and Foundries
  - ii) Other Basic Metal Industries
8. Electricity
9. Construction
10. Railway Transport Services
11. Other Transport Services
12. Communication
13. Manufacturing:
  - i) Wood Products (Excluding Furniture)
  - ii) Furniture and Fixtures
  - iii) Paper and Paper Products
  - iv) Print, Publishing and allied activities
  - v) Leather and Leather Products
  - vi) Plastic and Rubber Products
  - vii) Fertilizers
  - viii) Paint, Varnishes and Lacquers
  - ix) Pesticides, Drugs and Other Chemicals
  - x) Cement
  - xi) Non-Metallic Mineral Product

- xii) Metal Production Exclusive Machinery
  - xiii) Agricultural Machinery
  - xiv) Machinery for Food and Textiles
  - xv) Other Machinery
  - xvi) Electronic and Electrical Machinery
  - xvii) Miscellaneous Manufacturing Industries
  - xviii) Inorganic Heavy Chemicals
  - xix) Organic Heavy Chemicals
  - xx) Other Chemical and Chemical Products
14. Other Services:
- i) Storage and Warehousing
  - ii) Trade
  - iii) Hotels and Restaurants
  - iv) Banking
  - v) Insurance
  - vi) Ownership of Dwelling
  - vii) Education and Research
  - viii) Medical and Health
  - ix) Other Services
  - x) Public Administration and Defence
15. Equipment:
- i) Railway Transport Equipment
  - ii) Other Transport Equipment

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