Structural Change in the Indian Economy with Reference to Renewable and Non-renewable Resources

By
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Abstract

The production of material goods and services increasingly involves the depletion of non-renewable resources like coal, oil, minerals, etc. This undesirable situation has led to the development of efficient technologies ensuring non-renewable resource conservation, and also the development of renewable resource based technologies ensuring the substitution of non-renewable resources by renewable resources. The adoption of these new technologies in production processes, however, decreases their dependence on non-renewable resources and, at the same time, increases the threat from overexploitation of resources which are apparently renewable. The purpose of this paper is to capture this new structural change in the Indian economy. Input-output techniques have been employed to examine the structural changes from 1973–74 to 1983–84.

1. Introduction

With rising prices and shrinking reserves of non-renewable resources, renewable resources like sun, wind, water, plants, etc. are increasingly used in both industrial production processes, and public and private consumption. For example, in power industry, water resources, wind power and solar energy are gaining importance as inputs in electricity generation. In the gas sector, a considerable proportion of the total gas output now consists of biogas. Agro-based renewable alcohol are now substituting more and more oil feedstocks in the plastics industry.

But in doing so, there is a continuous threat from overexploitation of resources which are apparently renewable. It has been emphasized (The World Bank 1992) that the economic practices need to be modified so as to increase the efficiency in the use of renewable resources. Otherwise, renewable resources may become scarce in the near future. In fact, much of the concern today about resource exhaustion appears to involve renewable resources, the depletion of resources ranging from forest to marine fishes (Fisher 1991). Therefore, not only the substitution of non-renewable by renewable resources, but also the conservation of renewable resources along with non-renewable resources is one of the keys for survival.

In this context, it will be interesting to study the changes in direct and indirect, i.e., the total intermediate resource input requirements of both types over time by different industries. It will reveal, to some extent, the substitution and the conservation measures taken by industries. Such an attempt has been made in the following study. In order to carry out the study, we have considered the decade 1973–74 to 1983–84 and the data from the input-output tables of India are used. Linkages of the resource sectors with the economy are also studied in this paper.

2. Input-Output Framework

The input-output framework can be explained by considering a simple hypothetical economy consisting of N sectors. These N sectors would be interdependent in so far as they would

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purchase inputs from and sell outputs to each other. Among these N sectors, some are renewable resource producing sectors, some are non-renewable resource producing sectors and the rest are resource-using sectors. In this total input-output framework, the input-output of resources typically determine the resources required to deliver a product to final demand, both directly as resources consumed by an industry's production process and indirectly as resources embodied in that industry's inputs. (It is to be mentioned here that these resources should not be confused with resources like machineries, capital or labour. These are natural resources and are extracted from nature by man.) The input-output of resources can be stated formally as (Carter 1970)

$$({}_g\sum_k)_t = I_k Q_t I_g Y_T - I_g Y_T$$

where

$({}_g\sum_k)_t$	=	subvector k (say, renewable) of resource inputs required to deliver the final demand for sector g (say, construction) 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	=	the Leontief inverse matrix for the year t;
Y_T	=	final demand at time T.

In the present study, renewable resources consist of those resources which are produced and continuously regenerated by nature with or without human intervention and are extracted by man, viz. rice, wheat, marine fish, cow milk, water, animal leather, etc. On the other hand, non-renewable resources consist of those resources which are produced by nature, but are not renewable even with human intervention within the specific period of time and they are extracted by man, viz. coal, oil, iron ore, etc. Sectors that have been aggregated as renewable and non-renewable are listed in Table 1. The remaining sectors have been aggregated into 25 resource-using sectors (Table 2).

The above model has been applied to study the changes in intermediate resource input requirements over the period 1973–1983. The final demand has been fixed at the 1983–84 level and the intermediate resource input requirements to produce the same final demand with the input-output structures of 1973–74 and 1983–84 at constant prices (base year = 1973–74) are examined.

3. Empirical Results

Results of the above model concerning the changes in intermediate resource input requirements are presented in Table 3. On the basis of thses results, the percentage share of each type of resources in the intermediate resource input requirements in 1983–84 has been calculated (Table 4). In Table 4, sectors are described under three general categories:

1. Resources, i.e., renewable and non-renewable resource producing sectors;
2. Renewable resource based industries, i.e., resource using sectors which use more renewable resources as intermediate input than non-renewable resources and
3. Non-renewable resource based industries, i.e., resource using sectors which use more non-renewable resources as intermediate input than renewable resources.

Table 1: Renewable and Non-renewable Resource Producing Sectors

Renewable Resource Producing Sectors		Non-renewable Resource Producing Sectors	
Sector Number	Name	Sector Number	Name
001	paddy	023	coal and lignite
002	wheat	024	crude petroleum and natural gas
003	jowar	025	iron ore
004	bajra	026	manganese ore
005	maize	027	bauxite
006	gram	028	copper ore
007	pulses	029	other metallic minerals
008	sugarcane	030	lime stone
009	ground nut	031	mica
010	jute	032	other non-metallic minerals
011	cotton		
012	tea		
013	coffee		
014	rubber		
015	coconut		
016	tobacco		
017	other crops		
018	milk and milk products		
019	animal services		
020	other livestock products		
021	forestry and logging		
022	fishing		
102	water supply		

Source: Input-Output Transaction Table, 1973-74, CSO, Govt. of India.

Table 2: Resource Producing Sectors and Resource Using Sectors

Sector	Name
RESOURCE PRODUCING SECTORS	
01	Renewable resource
02	Non-renewable resource
RESOURCE USING SECTORS	
03	Food
04	Beverages
05	Tobacco
06	Textile
07	Wood and wood products
08	Paper, printing and allied activities
09	Leather and leather products
10	Plastic and rubber products
11	Petroleum and coal products
12	Inorganic heavy chemicals
13	Fertilizers
14	Organic heavy chemicals
15	Paint, varnishes and other chemicals
16	Non-metallic minerals
17	Basic metal
18	Metal products
19	Machineries
20	Electrical machineries
21	Transport equipment
22	Miscellaneous manufacturing industries
23	Construction
24	Electricity
25	Gas
26	Transport
27	Services

Table 3: Intermediate Renewable and Non-renewable Resource Input Requirements to Deliver Specific Sectors of Final Demand (Lakh Rs.)

Sectors	Year 1973–74		Year 1983–84		Percentage change in requirements	
	Renewable	Non-renewable	Renewable	Non-renewable	Renewable	Non-renewable
01	505718	405822	680698	448002	34.60	10.39
02	2	72	17	545	750.00	657.00
03	34187	14128	75780	270	121.66	91.33
04	10	32	51	125	410.00	290.63
05	567	245	594	341	4.76	39.18
06	20805	21346	30579	54539	46.98	155.50
07*	50	55	134	36	168.00	-34.55
08	25	194	147	1276	488.00	557.73
09[c]	205	136	157	134	-23.41	-1.47
10	67	194	297	633	343.28	226.29
11	13	14053	73	38072	461.54	170.92
12	0.5	13	0.6	13	20.00	2.34
13[c]	3	201	0.4	22	-0.87	-89.06
14	0.3	12	3	101	900.00	741.67
15	554	2526	2371	8577	327.98	239.55
16	18	980	111	5235	516.67	434.18
17	30	2427	51	3396	70.00	39.93
18	38	1470	54	1991	42.11	35.44
19	200	5739	419	7979	109.50	39.03
20	164	3345	289	5142	76.22	53.72
21	217	3903	298	5859	37.33	50.12
22	190	1882	200	2143	5.26	13.87
23	14841	131218	21175	144454	42.68	10.09
24	21	2149	41	5172	95.24	140.67
25*	0.002	0.8	0.3	0.6	14900.00	-25.00
26#	2317	39173	2019	86192	-12.86	120.03
27	53285	128989	142964	357593	168.30	177.23

* substitution of non-renewable resources by renewable resources
\# substitution of renewable resources by non-renewable resources
[c] conservation of resources of both types

Table 4: Percentage Share of Renewable and Non-renewable Resources in the Total Resource Input Requirements in 1983–84

Sectors	Name	Percentage share of		Rank
		Renewable	Non-renewable	
RESOURCES				
01	Renewable	60.30	39.70	
02	Non-renewable	3.02	96.98	
RENEWABLE RESOURCE BASE INDUSTRIES				
07	Wood and wood products	78.82	21.18	1
03	Food	73.70	22.30	2
05	Tobacco	63.53	36.47	3
09	Leather and leather products	53.95	46.05	4
NON-RENEWABLE RESOURCE BASED INDUSTRIES				
11	Petroleum and coal products	0.002	99.99	1
24	Electricity	0.80	99.20	2
17	Basic metal	1.48	98.52	3
13	Fertilizers	1.80	98.20	4
16	Non-metallic minerals	2.07	97.93	5
26	Transport	2.29	97.71	6
18	Metal products	2.64	97.36	7
14	Organic heavy chemicals	2.95	97.05	8
12	Inorganic heavy chemicals	4.41	95.59	9
21	Transport equipment	4.84	95.16	10
19	Machineries	4.99	95.01	11
20	Electrical machineries	5.32	94.68	12
22	Miscellaneous manufacturing industries	9.65	90.35	13
08	Paper, printing and allied activities	10.33	89.67	14
23	Construction	14.50	85.50	15
15	Paint, varnishes and other chemicals	21.66	78.34	16
27	Services	28.56	71.44	17
04	Beverages	28.98	71.02	18
10	Plastic and rubber products	31.93	68.07	19
25	Gas	33.33	66.67	20
06	Textile	35.92	64.08	21

Renewable resource based industries are then ranked among themselves. It is found that wood and wood products (sector 7) is the most important renewable resource based industry and leather and leather products (sector 9) ranked lowest. The next important industry is food (sector 3), followed by tobacco (sector 5).

Non-renewable resource based industries are also ranked among themselves. It is observed that petroleum and coal products (sector 11) is the most important non-renewable resource based industry, followed by electricity, basic metals and fertilizers. Although textile industry belongs to this group, it ranked lowest in the group, preceded by gas, plastic and rubber products, and beverages. These four are near renewable resource based industries.

Turning back to Table 3, we notice that in 1983–84 most of the industries used resources of both types more inefficiently than in the year 1973–74. Exceptions are sectors 9 and 13, i.e., leather and leather products, and fertilizers. These two sectors used resources of both types more efficiently in the year 1983–84 than in 1973–74. Some other exceptions are sectors 7 and 25, i.e., wood and wood products, and gas. These two sectors experienced the substitution of non-renewable by renewable resources. (The enormous growth of renewable resource input in the case of gas is due to the introduction of bio-gas (Gobar gas) technology during this period, which was practically absent in 1973–74.) The reverse case is sector 26, i.e., transport. Substitution of renewable by non-renewable resources occurred in the transport sector.

Thus the overall situation is not very encouraging. It is observed that not only non-renewable resource based industries but also renewable resource based industries used both types of resources more inefficiently in the latter year than in the former year. Therefore, for survival, this trend is to be reversed as in sectors 9 and 13. In the next section, we shall try to reveal the linkages of the resource producing sectors and the resource using sectors within the economy.

4. Linkage Measures

In the input-output framework, the linkage of any particular sector with other sectors may be defined in two ways (Miller and Blair 1985), viz. the forward linkage (i.e., as a seller) and the backward linkage (i.e., as a purchaser). The strength of these two linkages may be measured in different ways. However, for the present purpose, the measures of total forward and total backward linkages have been adopted. They are

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

for total forward linkage and

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

for total backward linkage, where q_{ij}'s are the elements of the Leontief inverse matrix Q.

Total forward linkages of 27 sectors in 1973–74 and 1983–84 and their ranks are presented in Table 5. It is interesting to note that both the non-renewable resource and the non-renewable resource based industries are among the first ten sectors except the renewable resource based industry wood and wood products having rank 9 in the year 1983–84. However, in general, renewable resource and renewable resource based industries were not good sellers during that period.

Table 5: Total Forward Linkages in the Year 1973–74 and 1983–84

Sectors	Name	Total forward linkages		Rank	
		73–74	83–84	73–74	83–84
RESOURCES					
01	Renewable	1.49	1.53	16	18
02	Non-renewable	2.90	3.00	3	2
RENEWABLE RESOURCE BASE INDUSTRIES					
07	Wood and wood products	2.10	2.30	13	9
03	Food	1.32	1.31	21	22
05	Tobacco	1.09	1.03	27	27
09	Leather and leather products	1.27	1.30	23	23
NON-RENEWABLE RESOURCE BASED INDUSTRIES					
11	Petroleum and coal products	2.18	2.40	9	7
24	Electricity	2.59	2.97	5	3
17	Basic metal	2.65	2.80	4	5
13	Fertilizers	2.36	2.61	7	6
16	Non-metallic minerals	2.14	1.91	12	13
26	Transport	1.71	1.92	14	12
18	Metal products	2.18	2.21	10	10
14	Organic heavy chemicals	2.93	2.85	2	4
12	Inorganic heavy chemicals	2.94	3.25	1	1
21	Transport equipment	1.61	1.76	15	15
19	Machineries	1.43	1.48	19	20
20	Electrical machineries	1.46	1.52	17	19
22	Miscellaneous manufacturing industries	1.30	1.56	22	17
08	Paper, printing and allied activities	2.53	2.30	6	8
23	Construction	1.17	1.24	24	24
15	Paint, varnishes and other chemicals	2.23	2.13	8	11
27	Services	1.45	1.58	18	16
04	Beverages	1.11	1.07	26	25
10	Plastic and rubber products	2.17	1.83	11	14
25	Gas	1.12	1.03	25	26
06	Textile	1.39	1.47	20	21

Table 6: Total Backward Linkages in the Year 1973–74 and 1983–84

Sectors	Name	Total backward linkages		Rank	
		73–74	83–84	73–74	83–84
RESOURCES					
01	Renewable	4.09	4.28	1	2
02	Non-renewable	1.09	1.22	24	22
RENEWABLE RESOURCE BASE INDUSTRIES					
07	Wood and wood products	1.17	1.16	23	24
03	Food	2.00	2.14	8	8
05	Tobacco	1.21	1.11	22	25
09	Leather and leather products	1.40	1.37	18	20
NON-RENEWABLE RESOURCE BASED INDUSTRIES					
11	Petroleum and coal products	1.73	1.96	12	9
24	Electricity	1.56	1.86	15	10
17	Basic metal	2.09	2.39	7	7
13	Fertilizers	1.25	1.65	20	13
16	Non-metallic minerals	1.38	1.43	19	17
26	Transport	2.82	2.80	4	4
18	Metal products	1.61	1.41	14	18
14	Organic heavy chemicals	1.09	1.20	25	23
12	Inorganic heavy chemicals	1.22	1.28	21	21
21	Transport equipment	1.97	1.77	9	11
19	Machineries	1.77	1.67	11	12
20	Electrical machineries	1.85	1.63	10	15
22	Miscellaneous manufacturing industries	1.62	1.38	13	19
08	Paper, printing and allied activities	1.56	1.65	16	14
23	Construction	3.62	3.83	3	3
15	Paint, varnishes and other chemicals	2.75	2.69	5	5
27	Services	3.95	4.36	2	1
04	Beverages	1.08	1.07	26	26
10	Plastic and rubber products	1.43	1.44	17	16
25	Gas	1.00	1.00	27	27
06	Textile	2.52	2.61	6	6

This picture is slightly different when the total backward linkages are measured (Table 6). It is found that the rank of renewable resource was 1 in 1973–74 and 2 in 1983–84. Thus, it was a good purchaser during that period. But the ranks of renewable resource based industries are more or less the same as in Table 5. One interesting point is that the sectors which were less important, like the non-renewable resource based industries were generally good purchasers. The rank of construction was 3, rank of other chemicals was 5, rank of services was 2 and that of textiles was 6 in the year 1973–74. In the year 1983–84, only the rank of services was upgraded to 1.

5. Conclusion

Empirical results (Table 4) reveal that the renewable resource itself is a good (direct and indirect) user of non-renewable resources. But the non-renewable resource sector uses only a negligible amount of renewable resources in comparison with its use of non-renewable resources. Therefore, with the depletion of non-renewable resources, it may be said that renewable resource itself will be affected to some extent. But the reverse is not true for non-renewable sector, i.e., it will be little affected by the exhaustion of renewable resources.

Again, in the light of conservation (Table 3), it is observed that the usage pattern of resources by the renewable resource producing sector changed less inefficiently over time than the non-renewable resource producing sector. This is also true for other renewable resource based industries.

Finally, by observing the backward linkages (Table 6), it may be concluded that if the renewable resource sector increases its output, there will be more increased demand for inputs than that created by the increased output in other sectors except services. Thus it will enhance the activities of the economy with increased output. But the total forward linkage of this sector (Table 5) shows that the increased output in other sectors will not cause any remarkable change in its output as it is not a good seller. This scenario is supposed to be changed with more direct and indirect substitutions of non-renewable resources by renewable resources.

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