CHAPTER III :

PRODUCTIVITY OF LABOUR AND FUEL

1. LABOUR PRODUCTIVITY

Concept of Labour Productivity

The most popular method of measuring labour productivity is to estimate the output per man-hour. This is the traditional average physical productivity of labour. This measure of labour productivity suffers from a serious limitation as observed by Salter, that, "it does not measure anything peculiar to labour; and that increased capital or materials may raise labour productivity while labour itself remains passive."[1] The ratio of output to labour input gives us the average productivity of labour, while the ratio of labour input to output gives us the labour requirements per unit of output. In other words, one ratio is the inverse of the other ratio. These ratios cannot be used to indicate the efficiency of labour. As Salter writes, "They (i.e. the above mentioned ratios) are not a measure of efficiency,

1 Salter W.E.G., Productivity and Technical Change, p.2. Cambridge University Press, 1966, (2nd ed.)

for a high output per man-hour can be produced as inefficiently as a low one."[2] Further, "The only significance that can be given to such figures is that they are indications of what may be termed 'growth in depth' as distinct from 'extensive growth' - growth which merely reproduces a given situation."[3] While analysing the partial productivity we have to be very careful in interpreting the results. We have to bear in mind that the observed gain in productivity of an input is the result of interaction of many factors operating at the same time; and these gains should never be attributed to any single factor. Bearing this fact in mind we estimate the productivity of labour and fuel and see whether these partial productivities show any sign of acceleration or retardation over a period of time.

Estimates of Labour Input

First we try to analyse the productivity of labour and then go over to the discussion of productivity of fuel input. The data regarding employment of labour in electricity are not available from Public Electricity - All India Statistics; so the data used here are from Employment Review, published by Directorate General of Employment and Training, Government of India. The data from the Employment

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2 Ibid, p.3.
3 Ibid, p.3.

Review are available from 1963 upto 1973. The data published in the Employment Review are for the fiscal year. This review collects information about the employment in organised sector only and does not cover unorganised sector. The 'unorganised'* sector consists of (a) Agriculture, (b) Self-employed, (c) House-hold establishments, and (d) Establishments in the private sector; employing less than 10 workers; over and above this employment in defence forces is also not covered by this Review.

The normal degree of non-response by the establishments in submitting returns is to the tune of 7 to 8 %. Thus, "the estimates of employment which failed to submit returns may be subject to some degree of error"[4]; so far as Electricity utility is concerned, it is all in the organized sector. The employment data in this publication are available, separately, for employment for Generation & Transmission as well as for distribution of electricity. These data are available for public sector and private sector separately.

The data for 1956-57 and for 1958-59 are taken from Employment in Public Sector published by National Employment

4 Employment Review, 1969-70, Directorate General of Employment & Training, Ministry of Labour, Employment & Rehabilitation, New Delhi, p.7.

Service. The Employment in Public Sector "confines itself solely to employment in every establishment in the public sector irrespective of its size."[5] These data include the employment of civilians only and does not give information about the Armed Forces. The study identified nearly 28,000 separate establishments and it received the information from 23,600 of them. Thus, it has a coverage of about 85%. This type of information is thought to be collected at quarterly intervals. These data are available for generation & transmission as well as for distribution separately. But these are available only for the public sector; and they are not available for either private sector or for total employment in generation & transmission and distribution of electricity.

On account of the non-availability of required data we could not estimate the employment in public electricity either for generation and transmission or for distribution or the total employment in electricity before 1956. In short, the employment figures are from 1956 onwards only and no data are available before 1956. For 1956-57 the data

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5 Employment in the Public Sector, National Employment Service, Ministry of Labour and Employment, New Delhi, November, 1959, Preface, p.(i).

are available only for public sector. According to the data reported in Employment in Public Sector, the average daily employment in public sector for generation and transmission of electricity was 21,198; and for distribution of electricity it was 33,554. The data for 1957-58 are again not available for public sector or for private sector or for the total employment. The data for 1958-59 are available only for the public sector. Again no data are available for 1959-60, 1960-61 and 1962-63. For 1961-62 only the total employment in electricity is available, no separate data for employment in generation and transmission and distribution of electricity are available. The detailed data are available only from 1963 onwards. As a result of non-availability of data most of the data before 1963 had to be estimated. The figures for the employment in generation and transmission and distribution of electricity, in public sector and private sector are estimated as follows :

First of all we have calculated the percentage increase in employment in public sector, for generation and transmission, in 1963-64 over 1956-57. Then the percentage increase in electricity generated by public sector, for the same period, is calculated. The employment in public sector for generation & transmission of electricity increased by 232.6 per cent over a period oof seven years i.e. from 1956-57 to 1963-64. Against this the electricity generated by public sector increased by 258.3 per cent over the same period. The ratio of percentage increase in employment for generation & transmission of electricity to the percentage increase in generation of electricity by public sector turns out to be 0.90044 (i.e. $\frac{232.6}{258.3}$). Assuming this ratio to remain the same for the private sector, the employment in generation & transmission of electricity for the private sector is estimated. It is further assumed that this ratio, viz., 0.90044, remains the same for all the years for which the employment figures are estimated. In order to estimate the percentage change in employment for generation & transmission of electricity for any given year, the percentage change in generation of electricity by that sector (i.e. either public or private sector) in 1963-64 over that particular year is multiplied by 0.90044. This gives us the percentage change in employment in generation and transmission in 1963-64 over that given year for which the employment figure is to be estimated. To illustrate, take 1957-58 as the year for which employment in public sector for generation and transmission of electricity is to be estimated. Electricity generated by public sector increased by 177.7 per cent from 1957-58 to 1963-64. Multiplying this percentage increasein electricity generated by public sector by 0.90044, we get the percentage increase in employment in public sector for generation and transmission of electricity over the same period. This percentage increase in employment in public sector for generation & transmission comes to be 160.1 per cent in 1963-64 over 1957-58. In other words, an increase of 177.8 per cent in generation of electricity by public sector would lead to an increase of 160.1 per cent in employment in public sector for generation & transmission of electricity, over the same period of time. Taking the 1963-64 employment figure of public sector for generation & transmission to be an increase of 160.1 per cent over 1957 employment figure, we work backwards and estimate the employment in public sector for generation and transmission of electricity for the year 1957-58. With the help of this method we estimate the employment in public sector for generation and transmission to be 27,110 in 1957-58.

The same method is used to estimate the employment in public sector for generation and transmission of electricity for the years 1959-60 and 1960-61. Again, the above discussed method is used for estimating the employment in private sector for generation and transmission of electricity for the years 1956-57, 1957-58, 1958-59, 1959-60 and 1960-61. Having estimated the employment in public sector and private sector for generation & transmission of electricity, we have summed them up together and estimated the total employment for generation and transmission of electricity for the above mentioned years.

For the year 1961-62 total employment in electricity is available, it is 208,000. In order to segregate this employment figure for private sector and public sector, we have assumed that the percentage share of public sector in total employment in electricity is the same as its share in total employment in electricity, gas, water and sanitary services. The Economic Survey, 1971-72, published by the Government of India gives the employment in public sector in electricity, gas, water etc. to be 2.24 lakhs, out of the total employment, in this category, of 2.64 lakhs. In terms of relative share, the public sector has a share of 84.8 per-cent in the employment in electricity gas, water, etc. Assuming this relative share of public sector to remain the same in the total employment in electricity, we have estimated the total employment in public sector in electricity to be 176,467. In other words, 176,467 is 84.8 per cent of 208,000. The residual is the total employment in private sector. After having segregated the employment in public sector from the total employment in electricity, we have to further segregate the employment in public sector for employment for generation & transmission of electricity and for employment in distribution of electricity in public sector. In order to estimate the employment in public sector for generation & transmission of electricity, we have estimated the ratio of employment for generation & transmission to employment in distribution of electricity in public sector in 1963-64. This ratio comes to be 0.6046 (i.e. $\frac{70,506}{116,625}$). Thus out of the total employment in public sector in 1963-64, 60.5 per cent is contributed by employment in distribution of electricity and the remaining 39.5 per cent is contributed by the employment for generation & transmission of electricity in public sector. In other words, 106,692 is

60.5 per cent of 176,467 and 69,775 is 39.5 per cent of 176,467 in 1961, the assumption being that the ratio of employment in distribution to employment for generation & transmission in 1961-62 is the same as that of 1963-64, for public sector.

The ratio of employment for generation & transmission of electricity to employment in distribution of electricity comes to be very near to one (viz., 0.97) in 1963-64 for private sector. Thus assuming an equal share of employment in distribution and employment for generation and transmission of electricity in total employment in private sector, we segregate the figures of employment in distribution and employment for generation & transmission from total employment in private sector in 1961-62.

Again, no data are available for 1962-63. We have estimated the total employment in electricity in 1962-63 by taking it to be the simple arithmetic average of 1961-62 and 1963-64 total employment figures. From this estimated total employment in electricity, the employment in public sector and in private sector is segregated by the same method as discussed above. With the help of the method discussed above, we have further segregated the employment for generation & transmission and the employment in distribution of electricity for public sector and for private sector from the total employment in electricity for public sector & private sector. By estimating the employment for almost all the years before 1963 upto 1956 we have been able to have some idea about the employment in public electricity. These data are given in Table III.1.

In Table III.2, we have shown the electricity generated in public sector and private sector, as these figures were used for estimating the employment. In Table III.3, we present the weighted index of output and the index of labour input. Table III.4 shows gross value Added per worker at constant prices. Table III.5 shows the rates of acceleration/ retardation etc.

Table III.1

Employment in Electricity, 1956-57 to 1971-72

Year	Employment in Generation & Transmission of Electricity			Employment in Distribution of Electric Energy			Total Employment in Electricity		
	Public	Private	Total	Public	Private	Total	Public	Private	Total
1956-57	21,198	(11,610)	(32,808)	33,554	(11,610)	(45,164)	(54,752)	(23,220)	(77,972)
1957-58	(27,110)	(12,023)	(39,133)	(40,746)	(12,023)	(52,769)	(67,856)	(24,046)	(91,902)
1958-59	30,113	(13,176)	(43,289)	42,849	(13,176)	(56,025)	(72,962)	(26,352)	(99,314)
1969-60	(37,253)	(14,365)	(51,618)	(55,991)	(14,365)	(70,356)	(93,244)	(28,730)	(121,974)
1960-61	(42,723)	(15,351)	(58,074)	(70,663)	(15,351)	(86,014)	(113,386)	(30,702)	(144,088)
1961-62	(69,775)	(15,766)	(85,541)	(106,692)	(15,767)	(122,459)	(176,467)	(31,533)	208,000
1962-63	(72,315)	(15,633)	(87,948)	(110,576)	(15,634)	(126,210)	(182,891)	(31,267)	(214,158)
1963-64	70,506	16,762	87,268	116,625	16,263	132,888	187,131	33,025	220,156
1964-65	76,293	17,048	93,341	127,688	17,155	144,843	203,981	34,203	238,184
1965-66	88,276	15,916	104,192	147,886	16,809	164,695	236,162	32,725	268,887
1966-67	92,186	16,302	108,488	158,698	17,175	175,873	250,884	33,477	284,361
1967-68	91,798	18,116	109,914	174,138	18,276	192,414	265,936	36,392	302,328
1968-69	95,224	18,290	113,514	179,080	18,978	198,058	274,304	37,268	311,572
1969-70	94,963	17,314	112,277	198,771	18,375	217,146	293,734	35,689	329,423
1970-71	100,806	17,217	118,023	222,588	18,450	241,038	323,394	35,667	359,061
1971-72	101,600	17,900	119,500	247,300	19,000	266,300	348,900	36,900	385,800

Note: (1) Figures in the brackets indicate estimated employment as discussed in the text.
(2) Source: (a) For 1963-64 to 1971-72, Employment Review, Directorate* ~~Delhi~~. (b) For 1956-57 and 1958-59, Employment in Public Sector, National Employment Service, Ministry of Labour and Employment, New Delhi, November 1959.

* General of Employment and Training, Government of India, New Delhi.

Table III.2

Share of Public Sector and Private Sector in Electricity Generated

Year	Generation of Electricity				Total Electricity Generated (Mil.kwh)
	Public Sector		Private Sector		
	Electricity generated (mil.kwh)	%age share in total Elec.Gen. (%age)	Electricity generated (mil.kwh)	%age share in total Elec.Gen. (%age)	
1	2	3	4	5	6
1956-57	5294.61	54.80	4367.52	45.20	9662.13
1957-58	6830.00	60.07	4539.14	39.93	11369.14
1958-59	7982.86	61.44	5011.02	38.56	12993.89
1959-60	9527.35	63.38	5505.60	36.62	15032.95
1960-61	11015.86	65.04	5921.15	34.96	16937.01
1961-62	13728.28	69.79	5941.66	30.21	19669.94
1962-63	16070.36	71.86	6294.62	28.14	22364.97
1963-64	18971.90	74.41	6525.87	25.59	25497.77
1964-65	22663.57	76.66	6899.51	23.34	29563.08
1965-66	25798.27	78.86	6917.81	21.14	32716.08
1966-67	30673.88	84.33	5701.72	15.67	36375.60
1967-68	34653.64	84.12	6540.99	15.88	41194.64
1968-69	40390.88	85.15	7042.77	14.85	47433.65
1969-70	43141.49	85.18	7508.23	14.82	50649.72
1970-71	47144.43	88.27	6265.83	11.73	53410.26
1971-72	52801.38	88.39	6934.93	11.61	59736.31

Source : Public Electricity Supply - All India, General Review, op.cit.

Table III.3

Indexes of Weighted Output and Labour Input in Electricity: 1956-57 to 1970-71

(1956-57=100)

Year	Weighted Output Index	Index of employment in generation & Transmission	Index of employment in distribution	Index of total employment in electricity	Ratio of Index of weighted output to index of labour input
1	2	3	4	5	6
1956-57	100.00	100.00	100.00	100.00	1.000
1957-58	117.42	119.28	116.83	117.91	0.778
1958-59	133.30	131.94	124.04	127.42	1.046
1959-60	152.54	157.33	155.77	156.49	0.975
1960-61	169.06	177.01	190.43	184.86	0.915
1961-62	197.46	260.73	271.12	266.86	0.740
1962-63	224.87	268.07	279.43	274.76	0.818
1963-64	258.70	265.99	294.21	282.46	0.916
1964-65	287.06	284.50	320.68	305.59	0.939
1965-66	316.81	317.58	364.63	344.98	0.918
1966-67	348.61	330.67	389.38	364.84	0.956
1967-68	385.30	335.02	426.00	387.89	0.993
1968-69	441.04	345.99	438.50	399.75	1.103
1969-70	485.38	342.22	480.76	422.65	1.148
1970-71	523.62	359.73	533.66	460.68	1.137

Source : Based on Tables II.4 and III.1 of the present study.

Table III.4

Gross Value Added at 1970-71 Prices, Employment of Labour in Electricity and Gross Value Added per Worker

Year	Gross Value added at 1970-71 prices (Rs.lakhs)	Total Employment in Electricity	Gross Value Added per Worker (Rs.)
1	2	3	4
1956-57	6,761	77,972	8,671
1957-58	8,636	91,902	9,397
1958-59	9,612	99,314	9,678
1959-60	11,348	121,974	9,304
1960-61	12,389	144,088	8,598
1961-62	16,094	208,000	7,738
1962-63	17,160	214,158	8,013
1963-64	21,500	220,156	9,766
1964-65	26,284	238,184	11,035
1965-66	27,999	268,887	10,413
1966-67	31,465	284,361	11,065
1967-68	35,734	302,328	11,820
1968-69	41,009	311,572	13,162
1969-70	42,913	329,423	13,027
1970-71	52,141	359,061	14,572

Source : (1) Employment figures are taken from Table III.1 of this chapter.

(2) Gross Value Added at 1970-71 figures are from Table II.1, Chapter II, of the present study.

Analysis of Labour Productivity

Observing from Table III.3, columns 2 and 5, we note that the weighted output index and labour input index have grown almost by the same rate or sometime the labour input has grown even at a faster rate till 1961-62. Thus we get the ratio of weighted output index to labour input index to be almost one or less than one and declining till 1961-62. This indicates an increase in labour input that is larger than the increase in weighted output. This ratio of weighted output index to labour input index shows a trend in an upward direction especially from 1962-63 onwards.

Defining labour productivity, further, as the ratio of Gross Value Added (at constant prices) to labour input, we observe, from Table III.4, that the labour productivity tends to rise in electricity. This tendency for the productivity of labour to rise is more marked from 1962-63 onwards.

Some interesting observations can be made from the information given below :

Employment in :[6]

Year	Generation & Transmission	Distribution of Electricity	Total Employment in Electricity
1	2	3	4
1956-57	32808	45164	77972
1960-61	58074	86014	144088
1965-66	104192	164695	268887
1970-71	118023	241038	359061

From the information given above, we notice that the relative share of Generation and Transmission of Electricity in total employment in electricity, has gone down from 42% in 1956-57 to around 33% in 1970-71. In other words, the relative share of distribution of electricity, in total employment in electricity, has gone up from around 58% in 1956-57 to 67% in 1970-71. This seems to be the result of rural electrification. Thus, with increasing emphasis on rural electrification more and more labour would be employed in distributing electricity.

Further, defining labour productivity as the ratio of kwh generated to labour employed in generation and transmission and in distribution of electricity, we notice from the

6 Source: Table III.1

figures given below that the productivity of labour in generation of electricity has increased at a faster rate than the productivity of labour in distribution of electricity. Here, we assume that whatever energy is generated is distributed without any losses in transmission and distribution, of electricity.

Electricity Generated/Distributed per Worker in Generation & Transmission & Distribution Respectively[7]

Year	Generation & Transmission	Distribution
1956-57	294.5	213.9
1960-61	291.6	196.9
1965-66	314.0	198.6
1970-71	504.1	221.5

From the information given above we notice that the productivity of labour in generation and transmission of electricity has almost doubled over a period of 16 years. The productivity of labour in distribution of electricity, inspite of not accounting for the transmission losses, fails to register a perceptible increase over a period of 16 years.

7 Source : Derived on the basis of Tables III.1 and III.2.

This shows that there are economies of scale associated with generation of electricity. Whereas with distribution of electricity such economies are not perceptible.

Having seen the broad trend of the labour productivity to rise with the passage of time we may attempt to see whether there are any signs of retardation in the rate at which the labour productivity in electricity in India is increasing over a period of time. In order to see the existence, or otherwise, of retardation in the productivity of labour we have fitted the logarithmic parabola to the productivity estimates. The curve fitted, as discussed earlier in Chapter II, is of the form :

$$y = k\ a^{x}\ b^{x^2/2}$$

where y denotes productivity of labour and x is the time variable.

The rate at which productivity of labour increases is estimated by fitting the curve: $y = (e)^{gx}$; where y is the productivity of labour and x is the time factor. This gives us a rate of growth, of the productivity of labour, that is compounded continuously.

Table III.5

Rate of Acceleration/Retardation and Annual Average Rate, Compounded Continuously, of Growth in Productivity of Labour

Particulars	Annual Average Rate of Growth (%)	The Curve fitted is of the form $y = ce^{gx}$	Rate of Acceleration/ Retardation(%)	The Curve fitted is of the form $y = ka^{x} b^{x^2/2}$
1	2	3	4	5
I. Gross Value Added, at 1970-71 Prices, per worker	3.48	$y=(7.7553)(e)^{0.3477x}$	+2.05	$y=(9.4580)(0.92215)^{x}(1.0205)^{x^2/2}$
II. KWH generated per worker in generation & transmission	3.79	$y=(239.16)(e)^{.03793x}$	+2.52	$y=(314.55)(0.88349)^{x}(1.0252)^{x^2/2}$
III. Ratio of Weighted Output Index to Labour Input Index	1.53	$y=(0.84218)(e)^{.015258x}$	+1.74	$y=(1.0309)(0.89414)^{x}(1.0174)^{x^2/2}$

Observing the results of the fitted curves, given in Table III.5, we notice that there are no signs of retardation in the productivity of labour. Here, we have adopted three indicators of productivity of labour. One way of looking at the productivity of labour is to define it as a ratio of Gross Value Added, at constant prices, per worker. The productivity of labour, defined in this way, increased at an annual compound rate of 3.5%. This rate, though not a very high rate of growth, shows an acceleration, the value of the rate of acceleration being 2.05%. The highest rate of growth, as well as acceleration, is registered by the ratio of kwh generated to the employment in generation and transmission of electricity. The ratio of weighted output index to labour input index shows a very low rate of growth. This ratio also shows an acceleration, almost to the tune of 2%, in its rate of growth.

In short, labour productivity, defined in any way, shows no sign of retardation in its rate of growth. Thus, the rate at which labour productivity increases has a tendency to increase at an approximate rate of 2 to 3 % per annum. Similar is the experience of America as observed by Dr. Gould:

"A logarithmic parabola fitted to the index of electric light and power output per man 1902-42 reveals an acceleration of growth at an annual rate of 0.045 per cent, too high to be attributed to random causes".[8]

In our analysis we get a very high rate of acceleration in rate of growth of labour productivity. The time period analysed in this study is too short to enable us to reach any conclusion regarding the factors responsible for this acceleration.

2. PRODUCTIVITY OF FUEL INPUT

Types of Fuel Input

Due to the problem of aggregating all the inputs with appropriate weights assigned to them, we estimate only the partial productivity of fuel. The most important fuels used for the generation of electricity are coal and oil. The data regarding the fuel consumption, by all the types of plants, are available from The Public Electricity Supply: All India Statistics. The data pertaining to fuel consumption are

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8 Gould J.M., op.cit., p.139.

available from 1950-51 upto 1970-71, i.e. for a period of 21 years. The figures of coal consumption are given in terms of tons for the first three years, viz., for 1950, 1951 and 1953. For the years 1953-54, 1954-55, 1955-56, and 1956-57, the consumption of coal is measured in terms of tons as well as in terms of metric tonnes, and both these figures are readily available. From 1957-58 onwards all the figures of coal consumption are available in metric tonnes only. In order to compare the consumption of coal for different years, we have converted the consumption of coal from tons into metric tonnes by using the conversion ratio: 1 to = 1.01605 metric tonnes. From 1964-65 onwards more detailed data regarding consumption of fire wood, lignite are available separately. The 1964-65 onwards figures of coal consumption are available which include firewood, lignite etc. also. We have taken the figures of coal consumption inclusive of firewood etc. This is so because from 1964-65 onwards the heat-input data are also readily available which include heat input from firewood, coal, lignite, furnace oil, and natural and other gaseous fuels. Further, there is no specification for the earlier years regarding the figures of coal consumption, whether they are inclusive of firewood etc. or not.

Another important fuel, used for the generation of electricity, is oil. The data for furnace oil are not separately available, but the consumption of furnace oil is included in the consumption of coal. The furnace oil consumption is included in the figures of coal consumption after covering it into equivalent quantity of coal. The data for diesel oil are separately available. For the first three years, viz., 1950-51, 1951-52, and 1952-53, the consumption of diesel oil is measured in terms of tons. From 1953-54 upto 1964-65 the consumption of diesel oil is measured in terms of metric tonnes; and from 1964-65 onwards it is measured in terms of kilo-litres. The 1950-51, 1951-52 and 1952-53 figures are converted into metric tonnes by using the conversion ratio 1 ton = 1.01605 metric tonnes. Figures of diesel oil consumption for 1956-57, 1960-61 and 1965-66 are available in terms of metric tonnes as well as in terms of kilo-litres. Working out the ratio of K.L. to metric tonne we get 0.91743 metric tonne per K.L. This ratio is used to convert K.L. figures into metric tonne figures for the years 1966-67, 1967-68, 1968-69, 1969-70 and 1970-71; i.e. for the last five years. Thus, we have converted the consumption of coal and the consumption of diesel oil both in terms of metric tonnes only.

Equivalent of Heat Input

In order to have a clear idea about total consumption of energy, one has to aggregate the quantities of energy consumed from different sources. To aggregate the energy consumed from different sources it becomes necessary to express them in common units. Different common units can be used for this purpose. But the most commonly used aggregate measure is the coal equivalent tonne. Some of the developed countries use oil equivalent tonne. The United Nations still continues to use coal equivalent tonne as the measure of units. To quote from the Report of the Fuel Policy Committee, we have "Coal equivalent tonne expresses the heat content (Kilo Calories) of each fuel in terms of the heat content of an average tonne of indegenous coal." The calorific value of Indian coal ranges between 6700 KCal/Kg and 4000 KCal/Kg, depending on the variety of coal. We do not have the detailed data giving information about the consumpton of coal on the basis of different grades of coal used in generation of electricity. Therefore, we have taken 5000 KCal/Kg as the average heat content of the coal. This is the average heat content of coal that is used by the Fuel Policy Committee. The thermal value of oil product is, as given by the Fuel

Policy Committee, 10,000 KCal/Kg. Taking these values of the heat content for the two most important sources of energy we have estimated the total heat input, separately for coal and oil. This heat input is expressed as 10^9 KCal. Taking one metric tonne to be equal to 1000 Kg. We have the heat content per metric tonne of coal to be 5,000,000 kcal/metric tonne. Taking this value of heat content we have expressed the consumption of coal (measured in terms of metric tonne) in terms of heat input, (measured in terms of 10^9KCal). This estimates are calculated for the first 14 years, from 1950-51 to 1963-64. From 1964-65 onwards we get the data of heat input from coal, including firewood, furnace oil, natural and other gaseous fuels, readily available. Therefore, from 1964-65 onwards the figures of heat inputs are taken directly from the <u>Public Electricity Supply - All India Statistics</u>.

Similar method is followed to estimate the heat input from the consumption of oil. The data for diesel oil consumption are expressed in terms of metric tonnes, for all the 21 years. Again, taking 1 metric tonne to be equivalent to 1000 Kg., we get the heat content of oil to be 10,000,000 KCal/metric tonne. On the basis of this heat content of oil, we have expressed the consumption of diesel oil in terms of heat inputs (10^9 KCal).

Thus having expressed the consumption of coal and oil in the common unit of heat input, we aggregate these heat inputs and get the total heat input (measured in 10^9 KCal given in Table III.6. The productivity of fuel input is defined as the ratio of kwh generated to the total heat inputs. In other words, the productivity of fuel input indicates the electricity generated per unit of heat input.

For estimating the productivity of fuel we exclude the electricity generated by hydro plants and by nuclear plants. Nuclear plants are of very recent origin. We exclude energy generated by hydro plants from the analysis of fuel productivity for the simple reason that these plants do not consume coal, oil or other fuels as prime movers. If we include energy generated by these plants in our analysis of fuel productivity then we would get an overestimate for the fuel productivity.[9] Therefore, we define fuel productivity as the ratio of kwh generated (excluding hydro plants) to total heat input. Thus, looking at the figures given in Table III.6 column 8, we notice a tendency for average heat input per kwh generated to decline over a period of 21 years. A fall

9 Percentage share of Hydro Plants in Total Electricity generated

1950-51	49.34
1960-61	46.27
1970-71	45.23

in the ratio of average heat input per kwh generated does indicate an improvement in the productivity of fuel input.

Further, defining fuel productivity as the ratio of index of unweighted output to the index of heat input, we observe a moderate improvement in fuel productivity. Unweighted output is defined here as kwh generated, excluding those generated by hydro plants. The trend shown by the ratio of unweighted output index to heat input index, rises upto 1959-60 and then falls for some time i.e. upto 1963-64. After 1963-64 this ratio continuously rises.

Table III.6

Fuel Consumption, Heat Input, Electricity Generated and Productivity of Fuel (Electricity Generated excludes that generated by Hydro and Nuclear Plants)

Year	Coal (metric tonnes)	Heat input 10^9 KCal of Coal+	Oil (metric tons)	Heat input 10^9 KCal of oil**	Total Heat input 10^9 KCal
1	2	3	4	5	6=3+5
1950-51	2,253,830	11,269.15	68,843	688.43	11,958
1951-52	2,521,919	12,609.60	74,322	743.22	13,353
1952-53	2,715,038	13,575.19	72,167	721.67	14,297
1953-54	3,107,426	15,537.13	71,209	712.09	16,249
1954-55	3,369,964	16,849.82	75,724	757.24	17,607
1955-56	3,739,552	18,697.76	76,751	767.51	19,465
1956-57	4,067,348	20,336.74	76,261	762.61	21,099
1957-58	4,593,761	22,968.81	83,341	833.41	23,802
1958-59	5,119,522	25,976.10	92,152	921.52	26,898
1959-60	5,759,000	28,795.00	101,483	1014.83	29,810
1960-61	6,699,590	33,497.95	111,974	1119.74	34,618
1961-62	7,236,361	36,181.81	118,194	1181.94	37,364
1962-63	7,995,689	39,978.45	119,470	1194.70	41,173
1963-64	8,759,461	47,797.31	113,089	1130.89	48,928
1964-65	10,566,625*	56,854***	125,011	1250.11	58,104
1965-66	12,471,946*	66,095***	170,521++	1705.21	67,800
1966-67	13,031,496*	71,833***	107,334	1073.34	72,906
1967-68	14,689,826*	79,898***	80,847	808.47	80,706
1968-69	16,559,864*	94,112***	63,006	630.06	94,742
1969-70	17,105,693	93,730***	41,125	411.25	94,141
1970-71	17,127,750	96,323***	36,365	363.65	96,687

cont...

Table III.6 (concluded)

Year	Total Electricity generated (excluding Hydro & Nuclear Plants)	Average Heat Input per kwh generated (i.e. KCal/KWH)	Index of Total Heat Input	Index of kwh generated	Ratio of Index of kwh generated to Index of heat input
	7	8	9	10	11
1950-51	2586.928	4622.47	89.69	86.27	0.96
1951-52	2998.705	4452.92	100.00	100.00	1.00
1952-53	3321.217	4304.75	107.23	110.75	1.03
1953-54	3782.332	4294.89	121.87	126.17	1.04
1954-55	4285.257	4108.74	132.05	142.90	1.08
1955-56	4850.213	4013.23	145.99	161.74	1.11
1956-57	5367.256	3931.06	158.24	178.99	1.13
1957-58	6296.901	3779.95	178.52	209.99	1.18
1958-59	7145.784	3764.18	201.74	238.30	1.18
1959-60	8005.529	3723.68	223.58	266.97	1.19
1960-61	9100.431	3804.00	259.64	303.48	1.17
1961-62	9855.569	3791.16	280.23	328.66	1.17
1962-63	10560.430	3898.80	308.80	352.17	1.14
1963-64	11541.071	4239.47	366.96	384.87	1.05
1964-65	14764.234	3935.46	435.78	492.35	1.13
1965-66	17765.154	3816.46	508.50	592.43	1.17
1966-67	19641.489	3711.84	546.80	655.00	1.20
1967-68	22536.59	3581.11	605.30	751.54	1.24
1968-69	26710.60	3546.98	710.57	890.74	1.25
1969-70	27603.67	3410.45	706.06	920.52	1.30
1970-71	28162.02	3433.24	725.15	939.14	1.30

Source:

(1) Public Electricity Supply - All India Statistics, for columns, 2, 4, and 7
(2) Columns, 3, 5, and 6 as explained in the text.
(3) Electricity generated excludes electricity generated by Hydro and Nuclear plants.

cont...

To observe the rate at which the productivity of fuel increases we have fitted the curve, discussed earlier, of the form $y = ce^{gx}$. For estimating the rate of acceleration/retardation in the rate of growth of fuel productivity we have fitted the logarithmic parabola, discussed earlier. The results of the two curves fitted to the fuel productivity data are given below :

Particular	Rate of growth, compounded continuously	The Curve fitted	Rate of Acceleration/Retardation (%)	The Curve fitted
Ratio of Index of Unweighted output to the Index of fuel input	1.12	$y=(1.0078) \cdot (e)^{.01121x}$	-0.12	$y=(.9881) \cdot (1.0385)^{x} \cdot (.9988)^{x^2/2}$

Note to Table III.6 (continued)

** The calorific value of oil is 10,000 KCal/Kg.
1 ton = 1.01605 metric tonnes.

* From 1964-65 onwards the figures of coal include the figures of firewood, lignite etc., which are given separately from 1964-65 onwards.

*** Heat inputs include coal, furnace oil, and natural and other gaseous fuels for which separate data are available from 1964-65.

✠ The calorific value of coal is taken as 5000 KCal/Kg.

++ Figures for 1965-66 and onwards are in terms of Kilo litres. For 1955-56, 1960-61, and 1965-66 it is possible to get the figures of oil consumption in metric tonnes as well as in kilo litres. Working out the ratio of K.L. to metric tonne we get 0.91743 metric tonne per K.L. This ratio is used to convert K.L. figures into metric tonnes for 1966-67 to 1970-71.

From the figures given above we notice that the rate at which the productivity of fuel increases is very low, viz., 1.12%. Not only that, but there are already signs of retardation in the rate of growth of productivity of fuel.

Thus, we observe that on the one hand the rate of growth in labour productivity shows an acceleration and on the other hand the rate of growth of fuel productivity shows a retardation. The significant fact still is that the fuel productivity has improved all along.

Factors Behind Fuel Productivity Improvement

The underlying reasons behind an improvement in the fuel productivity seem to be (a) a switch against gas and oil plants as compared to steam plants; and (b) within the steam plants the trend is towards bigger size plants. Table III.7 gives the information regarding generation of electricity by steamplants and by gas and diesel plants; and their relative share in total energy generated by all types of plants. Thus, we see that the relative share of gas and diesel plants in total energy generated declined from 3.75% in 1951-52 to 0.65% in 1970-71. As against this, the relative share of

Table III.7

Electricity Generated by Steam and Diesel and Gas Plants

Year		Electricity Generated (Mil.kwh)		
		by steam plants	by Diesel and Gas plants	Total
1		2	3	4
1951-52	(a) Mil.Kwh.	2779.059	219.646	5858.403
	(b) Percentage share in Total Electricity generated	47.44	3.75	100.00
1955-56	(a) Mil.Kwh.	4618.863	231.350	8592.451
	(b) Percentage share in total Ele-ctricity generated	53.75	2.69	100.00
1960-61	(a) Mil.Kwh.	8732.409	368.022	16973.012
	(b) Percentage share in total Electricity Generated	51.45	2.17	100.00
1965-66	(a) Mil.Kwh	17372.181	392.973	32990.125
	(b) Percentage share in total electricity Generated	52.66	1.19	100.00
1970-71	(a) Mil.Kwh.	27796.45	365.57	55827.64
	(b) Percentage share in total electricity Generated	49.79	0.65	100.00

Source: Public Electricity Supply:All India Statistics,op.cit.

Note: Total in column 4 includes Electricity generated by Hydro and Nuclear plants which are not shown separately in the table.

steam plants in total electricity generated increased from 47.44% in 1951-52 to 49.79% in 1970-71. This shows that the gas and diesel plants are being replaced by bigger and more efficient steam and hydro plants. Since the gas and diesel plants are basically of a smaller size as compared to steam and hydro plants, the replacement of gas and diesel plants by the other two types of plants does improve the productivity of fuel input.

Another factor that accounts for improved fuel productivity is the shift, within steam plants, in favour of bigger size of the plants. Observing from Table III.8, we notice that in 1951-52, steam plants with installed plant capacity of over 50,000 kw accounted for 53.7% of the energy generated by steam plants. The share of these plants has been consistently going up and in 1970-71 they account for almost 93% of the energy generated by steam plants. As against this relative share of small sized plants with installed capacity of upto 1000 kw has gone down from 1.01% in 1951-52 to 0.002% in 1970-71. For all practical purposes we can say that the plants of very small size have disappeared from the picture. Thus, we see that the relative share of all the small size of steam plants has been consistently going down. And we reach a

Table III.8

Electricity Generated by Steam Plants (Size-wise)

Year/particulars	Size of Installed Plant Capacity (KW)				
	Upto 1000	1001-10000	10001-50000	Over 50,000	Total
1	2	3	4	5	6
1951-52					
(a) Million kwh generated.	28.200	267.302	991.406	1492.151	2779.059
(b) Percentage share in total kwh generated by steam plants	1.01	9.62	35.67	53.69	100.00
(c) Average Overall Thermal Efficiency (%age)	3.65	9.18	14.6	19.9	16.3
1955-56					
(a) Million kwh generated.	20.72	253.334	1470.120	2852.065	4618.863
(b) Percentage share in total kwh generated by Steam plants.	0.45	5.48	31.83	61.75	100.00
(c) Average overall Thermal Efficiency (%age)	3.35	9.38	16.35	21.4	17.6
1960-61					
(a) Million kwh generated.	4.762	270.726	1753.831	6703.090	8732.409
(b) Percentage share in total kwh generated by steam plants.	0.05	3.10	20.08	76.76	100.00
(c) Average Overall Thermal Efficiency (%age)	5.0	9.6	16.2	22.9	19.9
1965-66					
(a) Million kwh generated.	0.627	433.549	2584.243	14353.76	17372.181
(b) Percentage share in total kwh generated by steam plants.	0.004	2.50	14.88	82.62	100.00
(c) Average Overall Thermal Efficiency (%age)	2.5	11.9	15.6	24.5	22.6
1970-71					
(a) Million kwh generated.	0.56	298.26	1801.91	25752.24	27796.45*
(b) Percentage share in total kwh generated by steam plants.	0.002	1.07	6.48	92.65	100.00
(c) Average Overall Thermal Efficiency (%age)	2.62	11.41	15.62	25.69	24.87

Source: Public Electricity Supply: All India Statistics, op.cit.

* Total kwh generated was 27852.97 which included 56.52 million kwh generated by Gas Turbine at Dhuvaran.

situation in 1970-71 where almost whole of the electricity generated by steam plants is accounted by the big plants only. The benefit of shifting from small plants to big plants can be seen by looking at the figures of thermal efficiency. The thermal efficiency of big plants is considerably higher than the thermal efficiency of small plants. In 1951-52 the thermal efficiency of small plants was 3.65% and that of big plants was 19.9%. With the shift in favour of big plants the thermal efficiency of big plants itself improves from 19.9% in 1951-52 to 25.69% in 1970-71. Not only this, but, the shift in favour of big plants improves the thermal efficiency of all the steam plants taken together. Thus, the average overall thermal efficiency, for all the plants taken together, improves from 16.3% in 1951-52 to 24.87% in 1970-71. Therefore, we can say that part of the improvement in fuel productivity is accounted for by the shift in favour of bigger steam plants.

CHAPTER IV :

CAPITAL PRODUCTIVITY

1. PROBLEMS OF CONCEPT AND MEASUREMENT

Concept of Capital :

The concept of capital can have two meanings associated with it. One of the meanings is that it represents an individual's command over financial resources. The second meaning of the term capital is that it represents one of the most important factors of production. In any analysis of growth, whether for the economy as a whole or for a particular industry, the concept of capital always represents a factor of production. In our analysis also, by capital we mean a factor of production that is produced by the economic system and used by the economic system for further production. The problem primarily arises because it is extremely difficult to measure the capital. This is so, because all the units of capital are not homogeneous and so one cannot aggregate different types of capital equipment in order to get a clear idea of the stock of capital. As a result of this difficulty of measuring capital in physical terms one has to measure the stock of capital and the additions to the capital stock in value terms. The reasons why we face the problems of defining and measuring capital are clearly summarised by Hashim and Dadi. Thus, according to them there are five basic reasons for facing these problems.

"(a) Capital is a "composite Commodity" made up of different types of capital goods - each with its own characteristics and durability;

(b) The composition of this "composite commodity" keeps on changing over time....

(c) The future productivity of a capital asset is not exactly measurable, since a capital asset is productive over a considerable period of time and future is unpredictable...

(d) The capital stock existing at any time has no limkage with current market valuations...

(e) The productivity of a capital asset might not remain the same over its life time."[1]

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1 Hashim S.R. and Dadi M.M.: Capital-Output Relations in Indian Manufacturing (1946-1964), The M.S.University of Baroda, Baroda, 1973,pp.6-7.

Measurement of Capital :

As observed earlier the only way of measuring capital is to measure it in value terms.The problem associated with the measurement of capital is which value of capital should we accept? Should we accept the net value of capital asset? Or should we accept the gross value of capital asset? That is to say, should we take capital as gross of depreciation or net of depreciation; depreciation as shown in the account books. The idea underlying the concept of net stock of capital is to capture the changes in the services of capital that take place over a period of time. Most of the analysists favour the gross stock of capital to the net stock of capital on the grounds that the net value of capital asset falls much more rapidly as compared to its ability to contribute to production. This is because the accounting depreciation does not necessarily represent the true technical decline in the efficiency of capital. Denison does not agree fully with the idea of using gross capital in one's analysis. Thus, for Denison, "the use of gross stock would imply that this ability is constant throughout the service life of a capital good", and that, "the gross stock assumption of constant services through out the life of an asset is extreme".[2] He then reaches the

2 E.F.Denison, Why Growth Rates Differ: Post-War Experience in Nine Western Countries; Washington; The Brookings Institution, 1967, p.140.

conclusion that a "correct index of capital services would fall somewhere between indexes of the gross and net stock but I believe it would lie much closer to a gross stock index..."[3] According to Prof. Leontief "Use of depreciated coefficient implies that capital stocks decrease in efficiency in exact relation to depreciation charge", but, "most available evidence indicates that this is not a reliable assumption."[4] This is due to the fact that most firms undertake large repairs and maintenance expenses, which maintain the technical efficiency of the plant and equipment at the same level or sometimes even increase it, as maintained by Leontief. Thus, so long as a capital asset is used, it continues to render services at a uniform efficiency. As a result of this objection against the use of net stock of capital, this analysis uses only the gross stock of capital, that is undepreciated stock.

Alternative Methods of Measurement :

Having decided to use the gross stock of capital, we face the problem of measuring this stock of capital. One

3 Ibid, p.141.

4. Harvard Economic Research Project; Estimates of the Capital Stock of American Industries, 1947; Cambridge Mass., 1953, pp.21-22.

cannot take the Book Value of capital assets as the Book values represent the written down values of capital purchased at different points of time at different prices.

Alternatively, one can adopt a Forward-Looking concept of capital by defining the value of capital assets "as the discounted future income stream to be derived from it."[5]. However, this is only a theoretical possibility as the stream of future income and the rate of discount to be adopted give rise to a host of problems.

Finally, there is the Backward-Looking concept of capital by defining it as the labour time spent in the past in producing the capital asset. This cost approach also has a problem that what we get is the cost of new machine when it was installed, but we cannot know the cost of old machine that was already installed a few years back. If we accept that the productivity of capital asset falls as the time passes then in order to know the worth of an old capital asset we have to know its 'earning power'. Thus, we go back to the forwarding looking concept of capital; the concept that we have already discarded. On account of these problems

5 Hashim S.R. and Dadi M.M., op.cit., p.7.

the cost approach of measuring capital is not free from objections. A slightly variant concept of value of capital is the 'Replacement Cost'. The Replacement Cost concept may either refer to the 'Replacement Cost New' or to the Replacement Cost written down. By replacement cost new we imply the cost of replacing the existing machine by a new machine of similar type.As against this, the replacement cost written down incorporates the idea of declining capital productivity with the passage of time. We cannot leave the determination of the value of old capital assets to the market forces. This is so because we do not have a well developed and an organised market for second hand goods. Therefore, we are left with only one concept of capital viz., undepreciated original cost of the asset.

Undepreciated replacement cost new is the measure of capital which we adopt. Undepreciated because we have argued that a capital asset continues to render services at uniform efficiency so long as it continues to be used. This is because repairs and maintenance particularly in a public utility like Electricity effectively take care of wear and tear. Replacement cost new because we wish to put all capital assets on par with each other. How much would it cost to replace an old machine with a similar new one? Capital assets in existence in any given year were purchased at different earlier points of time at different prices prevailing then. If we know the purchase price of the capital asset (not merely written down Book value) and the change in prices during the period in question, we can convert the historical purchase prices into current replacement costs. Fortunately, the data relating to capital assets at cost (purchase prices) are available for Electricity Utility, something which is not available for manufacturing industries. We have this distinct advantage in case of Electricity Utility.

It may be noted that while we do not take depreciation into account, we would permit discarding due to obsolescene and aging. The Public Electricity Supply themselves do take discarding into account.

Capital at Purchase Prices :

The data pertaining to the values of capital at purchase prices are readily available from the consolidated capital account published in the Public Electricity Supply - All India Statistics. These data give the value of capital assets at cost, that is at purchase prices. The data on capital expenditure are available from 1947-48 onwards upto 1970-71. Some of the capital assets given in 1947-48 must be acquired before 1947-48. But no data on capital are available before 1947-48. The 1947-48 assets represent the stock of capital assets acquired at different times since the inception of electricity till 1947-48. One can only speculate about the assets prior to 1947-48. In 1947-48 the installed capacity was only 1.36 million kw as can be seen from Table IV.1. This may be compared with 4.65 million kw in 1960-61 and 14.71 million kw in 1970-71. We have data regarding installed capacity in 1939 available in 1971-72 issue of Public Electricity Supply. In 1939 the installed capacity was 1.07 million kw. In Venkataraman's book[6], for the year 1921-22, the installed capacity is given as 0.13 million kw. Thus, we can say that assets in existence in 1947-48, were acquired during 1921-22 to 1947-48.

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6 K.Venkataraman, Power Development in India - The Financial Aspects, Wiley Eastern Private Limited, New Delhi, 1972, p.29.

2. CAPITAL IN ELECTRICITY

Age Profile of Fixed Assets :

In Table IV.1 we have the data relating to installed capacity and total fixed capital at purchase prices. Age profile of fixed assets is required to make adjustments for price variations over time. Figures given for capital assets are the figures given for capital assets over a period of time. Thus the capital assets in use in any given year would be equal to the assets in existence in the earlier year, plus the assets added minus the assets discarded due to aging. In order, therefore, to know the amount of fixed capital added each year, we must know the age profile of the capital assets. Ideally, we need data for every type of capital assets purchased by public electricity. However, it was possible to segregate only two categories of capital assets. The two categories of capital assets taken are (i) buildings and civil works, and (ii) machinery and equipment, general assets and special items. Thus, from the total capital expenditure we deducted land and intangible assets to arrive at the figure of Fixed Capital Assets.

For the earlier three years, viz., 1947-48, 1948-49 and 1949-50, we do not get a detailed capital account. We get the total capital expenditure for these years from the 1951 issue of the Public Electricity Supply. The total capital expenditure for 1947-48, 1948-49 and 1949-50 is given to be Rs.115.5 crores, Rs.118.6 crores and Rs.131.0 crores, respectively. In order to arrive at the figure of total fixed capital for these years we apply the ratio of total capital expenditure to total fixed capital that prevailed in 1950-51 to these figures of capital expenditure. (The ratio of total fixed capital to total capital expenditure was 0.953. This is because a part of the capital expenditure is on land and intangible assets, which are excluded here, as we are concerned with reproducible capital only). Thus, we first estimate the total fixed capital assets for 1947-48, 1948-49, and 1949-50.

Having estimated the total fixed capital for 1947-48, 1948-49 and 1949-50, we try to estimate the figures for buildings and civil works on the one hand and machinery and equipment on the other. This has been done as follows :

For segregating the expenditure on buildings and civil works and plants and machinery from total fixed capital, for 1947-48, 1948-49 and 1949-50, we have applied the proportion of buildings and civil works in total fixed capital that prevailed in 1950-51. In 1950-51 buildings and civil works constituted 23.12% of total fixed capital. Assuming this proportion to remain the same, we have applied it to the figures of total fixed capital for 1947-48, 1948-49 and 1949-50. Thus, we get the expenditure on buildings and civil works for these years. The expenditure on plants and machinery is the residual. Thus, we have separate data for buildings and civil works on the one hand and plants and machinery on the other, for all the 24 years.

Once we have the complete series for buildings and civil works and machinery and equipment separately for all the years, then we can prepare the matrix of age profile, first, for buildings and civil works and then for plants and machinery at purchase prices.

Table IV.1

Installed Plant Capacity, Fixed Capital Assets, Buildings and Civil Works; and Plants and Machinery.

Year	Installed plant capacity (MW)	Total Fixed Capital (Rs.lakhs)	Buildings & Civil works (Rs. lakhs)	Plants & Machinery (Rs.lakhs)
1	2	3	4	5
1947-48	1363.3	11008	2545	8463
1948-49	1411.0	11303	2613	8690
1949-50	1537.2	12484	2886	9598
1950-51	1712.5	14077	3254	10823
1951-52	1835.4	16288	3224	13064
1952-53	2061.8	18739	3609	15130
1953-54	2305.2	21662	3874	17788
1954-55	2494.8	26075	4135	21940
1955-56	2694.8	31701	4956	26746
1956-57	2886.1	50369	7599	42770
1957-58	3223.1	54400	7942	46458
1958-59	3511.6	63918	9171	54747
1959-60	3873.2	69631	9935	59696
1960-61	4653.1	74103	10479	63626
1961-62	5218.8	90007	14183	75824
1962-63	5801.2	100342	15664	84678
1963-64	6575.9	113103	16099	97004
1964-65	7396.7	124254	12992	111261
1965-66	9027.0	161268	16244	145025
1966-67	10092.2	198742	22322	176419
1967-68	11883.2	225106	24244	200862
1968-69	12957.3	259807	22571	237237
1969-70	14102.5	281767	22999	258768
1970-71	14709.0	312164	24918	287246

Notes to Table IV.1

1. Source: Public Electricity Supply: All India Statistics, op.cit.
2. For 1947-48, 1948-49 and 1949-50 total capital expenditure is given to be 115.5, 118.6 and 131.0 crores of Rs. respectively. For getting total fixed capital for these years we have applied the ratio of total fixed capital to capital expenditure in 1950-51, the ratio was 0.953.
3. For segregating the expenditure on buildings and civil works and plants & machinery for 1947-48, 1948-49 and 1949-50 from total fixed capital we have applied the proportion of buildings and civil works in total fixed capital that prevailed in 1950-51. The buildings and civil works constituted 23.12% of total fixed capital in 1950-51. Applying this proportion we have estimated the figures for buildings and civil works for the above mentioned three years. Plants and machinery are residual.
4. On account of non submission of returns by the Assam and Andhra Pradesh Electricity Boards and Jammu & Kashmir Government Electricity Departments in 1957-58 their data were not included in the All India Statistics. We have added the figures of 1956-57 of these boards and departments to the 1957-58 All India data. Applying the ratio of buildings and civil works to total fixed capital, for All India, prevalent in 1957-58 to these figures we segregate the figures of buildings and civil works, (plants and machinery is the residual). Then,

cont....

Notes to Table IV.1(contd.)

we add these figures to the figures of All India for 1957-58. It may be noted that for other years the Public Electricity Supply have adopted the practice of taking the figures for capital for the prior year in case of non-response. However, the percentage of non-response is on the whole small.

5. From the total Expenditure given in the Reports, investment in land and value of intangibles are excluded.

6. The total capital expenditure for Andhra Pradesh, Assam, Orissa and Jammu & Kashmir comes to be Rs.4797 lakhs. for 1956-57. Applying the ratio of total fixed capital to total capital expenditure, (i.e. 0.976) for 1957-58 to Rs.4797 lakhs we get total fixed capital for these boards and government to be Rs.4682 lakhs for 1956-57. Then, Rs.4682 lakhs are added to the 1957-58 figure of total fixed capital for All India.

Looking at the figures given in Appendix Table IV.1, we notice that the value of buildings and civil works, at purchase prices, for 1951-52 is lower than that for the previous year. This gives us a negative addition to the existing stock of buildings & civil works. There is no explanation provided for this sudden fall in the value of buildings and civil works in 1951-52. Here, the problem that one faces is how to interprete this negative value. We have taken this to be the result of exceptionally large discarding of old assets. Therefore, in the cell of 1951-52 we have put the addition to be zero and then we have subtracted the difference from the figure of 1947-48 which is carried forward- upto 1951-52. Thus, the value of stock of buildings & civil works in 1947-48 was Rs.2545 lakhs carried forward upto 1950-51 and from 1951-52 this value becomes Rs.2515 lakhs and the addition in 1951-52 becomes zero. We have adopted the same method of extraordinary discarding whenever the addition to the stock of buildings and machinery turns out to be negative. These years are exceptional years and we fail to find any explanation for this negative addition. In our matrix we have in all three such exceptional years, viz., 1951-52, 1964-65 and 1968-69.

Similar method for constructing the matrix of age profile for plants and machinery, at purchase prices, is adopted. Unlike buildings and civil works we do not get any negative additions to the stock of plants and machinery. This age structure of plants andmachinery is given in Appendix Table IV.2.

Age Profile at Current Prices :

In order to have some idea about the value of buildings and civil works and plants and machinery at current prices, we have to know the age structure, as discussed above, of these capital assets. We need to express the value of fixed capital assets at current prices because the inventories are at current prices. In order to have some idea about the total capital of electricity utility we must be in a position to add up the inventories and the fixed capital assets together. Therefore, the expression of fixed capital assets at current prices becomes inevitable. To express buildings and civil works and machinery and equipment at current prices we have to multiply the addition made in each year with appropriate price indices for the respective years. Appendix Table IV.3 gives the matrix of age profile of buildings and civil works at current prices. The figures given in the second row and second column (and written in the brackets) give the price indices that are used. For buildings and civil works we have applied the construction cost[7] indices for 23 years viz., from 1948-49 to 1970-71. As we could not get the construction cost index for 1947-48 we have used the price index of manufactures for that year.[8]

Thus, we have to multiply each and every cell of the matrix showing the age profile of buildings and civil works at purchase prices, with the relevant price indices. The two above mentioned price indices are converted to the 1951-52 base and written in a continuous manner from 1947-48 to 1970-71. This implies an assumption that the construction cost index in 1947-48 moved in the same manner as the price index of manufactures. In absence of any other alternative, we assume that the price index of manufactures in 1947-48 can be taken as a proxy for price index of buildings and civil works. This same assumption we make for the price index of machinery and equipment.

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7 Dholakia, B.H.: op.cit., p.196.

8 M.Mukerjee, National Income of India: trends and Structure, Calcutta, Statistical Publishing Society, 1969, p.94.

Thus, we arrive at the matrix of age profile for buildings and civil works and plants and machinery by multiplying each and every cell of the matrices at purchase prices with the relevant price indices; and thereby estimate each and every cell for the matrices showing age profiles at current prices. For plants and machinery we use the price indices of machinery and equipment[9]; for 23 years i.e. from 1948-49 to 1970-71. For 1947-48 we use the above mentioned price index of manufactures.

To put the method symbolically, we have,[10]

$$K_t = \sum_{i=1}^{24} A_i \left(\frac{P_t}{P_i} \right);$$

where, K_t represents the value of accumulated capital assets in t^{th} year in t^{th} year's prices. A_i is the addition to capital stock in i^{th} year; Pt and P_i are the price indices in t^{th} year and in i^{th} year, respectively.

Thus, we build up two matrices for the two categories of capital. Appendix Table IV.3 gives the matrix of age profile for buildings and civil works at current prices. The age profile of plants and machinery at current prices is

9 Dholakia, B.H.: op.cit., p.196.

10 Hashim S.R. and Dadi M.M., op.cit., p.20.

given in Table IV.4. Having estimated capital assets at current prices we apply relevant price indices and express the stock of buildings and civil works and plants and machinery at 1970-71 prices.

In this manner, we have constructed the value of gross fixed capital at purchase prices, at current prices and at constant prices. The matrix of age profile at purchase prices becomes inevitable if one wants to measure fixed capital at current prices. The need for measuring fixed capital at current prices arises because inventories are expressed at current prices. In order to minimize the price factor one has to express capital at constant prices. And so, the expression of value of stock of capital at constant prices becomes useful.

It may be mentioned that the above method takes care of converting the additions made to capital during each of the year between 1947-48 to 1970-71, into current prices appropriate to each year. But the capital that existed in 1947-48, that is the year of starting of our series itself remains unconverted. However, on a closer consideration, we find that though, the capital in existence in 1947-48 was mostly acquired during 1921-22 to 1946-47, in terms of the price level if it does not seem to have been acquired at a price level very different from that prevailing 1947-48. Thus in 1947-48 total fixed capital as seen in Table IV.1 was Rs.11008 lakhs and installed capacity was 1363.3 MW. Thus capital per 1 kw installed capacity in 1947-48 was Rs.807. In 1948-49 the capital increased by Rs.295 lakhs and capacity by 47.3 MW. Thus the capital cost of additional capacity was Rs.624 per 1 kw in 1948-49. Similarly in 1949-50 this came to Rs.936. It will thus be observed that the capital assets acquired before 1947-48, were acquired at a price not very different from that prevailing in 1947-48 etc. Therefore, one single price adjustment as done in appendix Tables IV.3 and IV.4 for 1947-48 is enough.

Inventories

Having discussed the method adopted for measuring fixed capital, we discuss the inventories. The data regarding inventories are readily available from Public Electricity Supply - All India Statistics. These data are available from 1950-51 onwards only. The current assets, used here to indicate inventories, include works in progress and stores and materials at hand. From our analysis we exclude the works in progress for the simple reason that it must have been included in fixed capital in the following years. In order to avoid this double counting we do not include works in progress in the current assets. Thus, our current assets include stores and materials at hand. Since the value of stores and materials is at current prices, and the stores and materials are not accumulated over a period of time, as fixed capital is, we do not have to make any adjustments in order to represent them at current prices. In other words, we have taken the value of stores and materials at current prices as they are given. Thus, our total capital at current prices includes fixed capital at current prices and stores and materials at current prices.

For expressing the value of stores and materials at constant prices we have to apply a suitable price index. Stores and materials in hand include, (a) Fuel coal and/or oil at cost; and (b) General stores at a below cost. Since we have no idea about the proportion of fuel coal and oil, as well as about the items included in general stores, we cannot apply different price indices to each item. As a result of this, we have applied the price index of coal, as a proxy, to the stores and materials at hand. Thus the value of stores and materials at 1970-71 prices is estimated by applying the price indices of coal, with 1951-52 as the base year. Our total capital at 1970-71 prices is the summation of gross fixed capital, (as discussed above) and the current assets, both at 1970-71 prices.

Composition of Capital

However, it may be observed from the information given below, that the composition of capital in electricity utility has undergone a change over a period of time. The composition of capital has changed in favour of plants and machinery and against buildings and civil works and inventories.

Relative Share of Types of Capital in Total Capital (per cent)

Year	Building & Civil work	Plants & Machinery	Inventories
1950-51	27	66	26
1955-56	18	76	6
1960-61	15	77	8
1965-66	10	82	9
1970-71	8	85	7

Thus, having estimated the total capital of public electricity, we now estimate the productivity. The productivity of capital is measured by the output: capital ratio, i.e. the inverse of capital: output ratio.

<u>Capital : Output Ratio</u> :

Capital output ratio can be defined as the ratio of total capital to gross value added. This, of course, is the average capital output ratio. Capital: output ratio can be either at current prices or at constant prices. While estimating the capital: output ratio at current prices we use capital and gross value added both at current prices and for constant prices we use capital and gross value added both at 1970-71 prices.

Further, one can observe the ratio of gross fixed capital to gross value added at current and at constant prices. Similarly, one can observe the ratio of inventories to gross value added both at current as well as at constant prices.

Table IV.2

Buildings & Civil Works, Plants & Machinery, Total Gross Fixed Capital, Inventories, and Gross Value Added, at Current Prices and at 1970-71 Prices

(Rs. lakhs)

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Year	At current prices (Rs.lakhs)					At 1970-71 prices (Rs. lakhs)					Gross Value added(Rs.lakhs)	
	Bldgs.& Civil works	Plants & Machinery	Total Fixed capital	Inventories	Total Capital	Bldgs.& Civil works	Plants & Machinery	Total Fixed capital	Inventories	Total capital	At current prices	At 1970-71 prices
1	2	3	4	5	6	7	8	9	10	11	12	13
1950-51	5436	13229	18665	1336	20001	10699	26625	37324	3185	40509	2380	3560
1951-52	5376	17412	22788	1400	24188	10612	30558	41170	3338	44508	2678	4440
1952-53	5816	20748	26564	1556	28120	11367	33935	45320	3710	49012	2746	4600
1953-54	6108	22980	29088	1808	30896	11879	38373	50252	4311	54563	3095	4799
1954-55	6375	26891	33266	2082	35348	14214	45379	59593	4964	64557	3394	5304
1955-56	7316	31829	39145	2640	41785	13953	53454	67407	6232	73639	3933	6109
1956-57	10340	48369	58709	4437	63146	18743	79932	98675	9120	107795	4148	6761
1957-58	11223	53426	64649	6282	70931	19332	85863	105195	11701	116896	5747	8636
1958-59	12923	62839	75762	6902	82664	21365	98908	120273	12372	132645	7015	9612
1959-60	13632	69252	82884	7200	90084	22632	106518	129150	12716	141866	8136	11348
1960-61	14877	76764	91641	7723	99364	23494	112267	135761	13059	148820	9415	12389
1961-62	19345	90625	109970	8244	118214	29062	129728	158790	13842	172632	10936	16094
1962-63	21339	102361	123700	10611	134311	31225	142011	173236	16754	189990	12428	17160
1963-64	22312	120029	142341	14059	156400	31847	158265	190112	20691	210803	15150	21500
1964-65	17199	138073	155272	16569	171841	23398	176488	199886	23375	223261	17804	26284
1965-66	21803	180284	202087	19103	221190	27501	217157	244658	25878	270536	20397	2799~~4~~9
1966-67	29260	230116	259376	21515	280891	34711	251465	286176	27728	313904	25356	31465
1967-68	33224	262438	295662	24345	320007	36845	277290	314135	26383	340518	29168	35734
1968-69	31364	303397	334761	23391	358152	33593	315066	348659	23035	371694	34761	41009
1969-70	32897	331210	364107	24177	388284	34035	336970	371005	24646	395651	39611	42913
1970-71	35954	365448	401402	29002	430404	35954	365448	401402	29002	430404	52141	52141

Notes: (1) Columns 2 and 3 derived from Appendix Tables IV.3 and IV.4. (2) Column 5 from Public Electricity Supply; All India Statistics, op.cit. (3) Columns 7 and 8 derived by applying the price indexes of construction & machinery and equipment to columns 2 and 3, respectively. (4) Column 10 derived by applying the price index of coal, 1951-52=100, given in Table II.12. (5) Columns 12 and 13 are taken from Tables II.10 and II.11.

Table IV.3

Fixed Capital to Output Ratio, Inventories to Output Ratio, Total Capital to Output Ratio and Incremental Capital Output Ratio, at Current and at Constant Prices.

Year	At Current Prices				At 1970-71 prices			
	Fixed capital to output ratio	Inventories to output Ratio	Total capital to output ratio	Incremental capital to output ratio	Fixed capital to output ratio	Inventories to output Ratio	Total capital to output ratio	Incremental capital to output ratio
1	2	3	4	5	6	7	8	9
1950-51	7.84	0.56	8.40	-	10.48	0.89	11.38	-
1951-52	8.51	0.52	9.03	14.05	9.27	0.75	10.02	4.54
1952-53	9.67	0.57	10.24	57.82	9.84	0.81	10.65	28.15
1953-54	9.40	0.58	9.98	7.95	10.47	0.90	11.37	27.89
1954-55	9.80	0.61	10.41	14.89	11.24	0.94	12.17	19.79
1955-56	9.95	0.67	10.62	11.94	11.03	1.02	12.05	11.28
1956-57	14.15	1.07	15.22	99.35	14.59	1.35	15.94	52.39
1957-58	11.25	1.09	12.34	4.87	12.18	1.35	13.54	4.85
1958-59	10.80	0.98	11.78	9.25	12.51	1.29	13.80	16.14
1959-60	10.19	0.88	11.07	6.62	11.38	1.12	12.50	5.31
1960-61	9.73	0.82	10.55	7.26	10.96	1.05	12.01	6.68
1961-62	10.06	0.75	10.81	12.39	9.87	0.86	10.73	6.43
1962-63	9.95	0.85	10.81	10.78	10.10	1.21	12.28	16.28
1963-64	9.40	0.93	10.32	8.11	8.84	0.96	9.80	4.80
1964-65	8.72	0.93	9.65	5.82	7.60	0.89	8.49	2.60
1965-66	9.91	0.94	10.84	19.03	8.74	0.99	11.21	27.57
1966-67	10.23	0.85	11.08	12.04	9.10	0.88	9.98	12.51
1967-68	10.14	0.83	10.97	10.26	8.79	0.74	9.53	6.23
1968-69	9.63	0.67	10.30	6.82	8.50	0.56	9.06	5.91
1969-70	9.19	0.61	9.80	6.21	8.65	0.57	9.22	12.58
1970-71	7.70	0.56	8.25	3.36	7.70	0.56	8.25	3.77

Observing Table IV.3 we note that inventories to output ratio remained more or less stable and very low. It is the fixed capital; output ratio that influences the overall capital: output ratio. The capital:output ratio, barring the first year, shows a continuously rising trend upto 1956-57 where it reaches the highest value of 15.94, (at constant prices). From 1957-58 upto 1961-62 capital:output ratio shows a declining trend.Then it rises and falls, showing irregular movement. From 1966-67 onwards there is a decline. Looking to the capital:output ratios for all the 21 years one notices a tendency for capital:output ratio to fall, though the tendency is not consistent. Over a period of time the average capital:output ratio has fallen from the maximum of 15.94 in 1956-57 to 8.25 in 1970-71. As compared to other manufacturing industries the capital:output ratio in electricity is definitely much higher. The capital:output ratio for manufacturing industries in 1964 was 5.20.[11] As against this the capital:output ratio in electricity in 1963-64 was 9.80. Thus, we notice that as compared to other industries electricity industry requires a larger amount of capital per unit of output. Not only this,

11 Hashim S.R. and Dadi M.M., op.cit., p.39.

but in the initial stages the capital:output ratio tends to be much higher; viz., 15.94 in 1956-57.As the electricity industry grows and the output increases the capital output-ratio tends to fall.A declining tendency on the part of capital:output ratio indicates a rising trend for the productivity of capital. Thus, we see a rising tendency on the part of capital productivity.

Similar is the experience of America as observed by Dr. Ulmer.[12] The capital: product ratio, at 1929 Dollars, increased from 4.42 in 1887 to 18.40 in 1893. From 1894 onwards the capital: output ratio for electricity and power utility in America shows a downward trend. Thus, for America, the capital: output ratio in electricity falls from a maximum of 18.40 in 1893 to 1.30 in 1950.

The fall in the capital: output ratio in electricity in India is not as marked as in America. This is mainly because our findings are based on the time series data for 21 years only. Dr. Ulmer's findings are based on the data for more than 60 years.

In summary, we conclude that the capital output ratio

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12 Ulmer M.J., op.cit., pp.476-7.

shows a declining trend in electricity in India. Over a period of time, we have seen that the productivity of all the three inputs, taken separately, has a tendency to rise. These partial productivities do explain the growth in the output of electricity, but fail to show the contribution of inputs, taken jointly, in the growth of this industry. Therefore, we have to take up the analysis of joint productivity.

Rate of Growth of Capital Productivity :

Productivity of capital is nothing else but the inverse of capital: output rato. Thus, productivity of capital is defined as the ratio of gross value added to total capital, both at constant prices. Since the capital:output ratio does not show a consistent trend, we will not get a consistent trend for output capital ratio also. Therefore, in order to know whether the productivity of capital has increased over a period of time, we have fitted the curve, discussed earlier, $y = ce^{gx}$, where y stands for output: capital ratio and x is the time variable. By fitting this curve we get an annual rate of growth, compounded continuously, of 1.57 per cent for the productivity of capital. This is arather slow rate of growth. Thus, the curve that we get is :

$$y = (0.07642)(e)^{0.0157\cancel{(}5x}$$

Having seen that the productivity of capital increases at a very slow rate, we would like to know whether there are any signs of retardation in the rate of growth of capital productivity. As already discussed earlier, we have fitted a logarithmic parabola of the form:

$$y = k\ a^{x}\ b^{x^2/2}\ ,$$

where y is the output: capital ratio and x, is the time variable. The curve we get is :

$$y = (.09523)(0.90886)^{x}\ (1.0121)^{x^2/2}$$

Since the value is 'b' is greater than unity, we get acceleration in the rate of growth of capital productivity. The rate of acceleration in the rate of growth of capital productivity is 1.21 per cent.

Thus, we see that neither labour productivity nor capital productivity shows any sign of retardation in the rate of growth of productivity.