THE INTERNATIONAL STATISTICAL INSTITUTE,
35TH SESSION, BELGRADE, SEPTEMBER 1965.

USE OF CAPITAL OUTPUT RATIOS IN PLANNING IN DEVELOPING COUNTRIES

By P. C. MAHALANOBIS

SOME GENERAL CONSIDERATIONS

1. The use of statistical information on capital and output for purposes of planning can be considered under three heads. Firstly, before any project is considered for inclusion in any plan, it is obviously necessary to know the capital cost of the project as well as the flow of annual output expected from it; such information is also required to choose between different projects or programmes. The aggregate investment and output for any draft plan, or exercises in preparing a plan, must be obtained by adding up respectively the capital costs of the projects and also the expected flow of annual outputs. In this very simple sense, capital and output data are being used and have always been used in every country by individual enterprises or at all higher levels of planning. Such use does not, however, involve the capital-output ratio as a parameter in any particular economic model.

2. Secondly, statistical information of a historical type on capital and output derived from administrative or census or survey data can be used in various ways as background knowledge for purposes of planning. Any historical approach would involve many social, institutional and environmental conditions. To transform such conditions into a quantitative form is difficult, even in principle, and usually not possible in practice. In spite of such difficulties statistical information on capital and output, as well as the ratio of the two, have considerable interest and value in a historical analysis of the economy of a country. A critical analysis of the success or otherwise of the implementation of plans in previous periods can be a guide to realistic decisions for the future and may be of help in exercises in estimating growth rates in future. A consideration of the use of such background type of knowledge has also been excluded from this paper.

3. The object of this note is to consider certain aspects, in a very preliminary and superficial way, of the use of a particular function of the two variables, namely, the capital-output ratio in economic planning with special reference to India. This capital-output ratio can be used in principle in many ways. At the most abstract level, multi-sector programming with sectoral capital-output ratios may be used to obtain sectoral targets on optimisation of a suitable "welfare" or some other

---

Invited paper for Section 8 : National Income and Wealth.

"value" function. The approach has been a stimulating tool for clarification of ideas and significant advances in the theory of planning. Some of the results have supplied valuable guidance in a qualitative way somewhat like the background knowledge of the economic-historical experience mentioned above. As far as I know, multi-sector programming has not been used so far in any country for making actual quantitative decisions.[1]

4. Simpler models using the capital-output ratio for the country as a whole or for some of its major sectors can be used to study the effect of different patterns of investment on the long term growth of the economy. So long as the sectors chosen are relatively independent, the procedure is valid and useful. This method was of help in the allocation of investments in the draft plan-frame for the Second Five Year Plan of India (1956–1961). Such simple models are likely to be useful in the initial stages of planning in under-developed countries when very little techno-economic or economic-historical information is available. But problems change continually as detailed planning is done more and more on the basis of projects. The simple aggregative models which were useful at the stage of the Second Five Year Plan of India are no longer relevant. It is, however, conceivable that other models, using capital-output ratios based on a small number of sectors which are to a large extent independent, can be of help in solving specific new problems.

5. A very simple way of using capital-output ratios is to make direct comparisons over time or for different conditions of operations, for example, single and double shift, or comparisons at micro-level, between different groups in the same branch of industry or even of different enterprises; such comparisons are sometimes quite useful. Aggregative values of the ratio for the same or similar branches of industry in different States or regions can supply valuable information on variations due to regional differences of an intrinsic kind or to differences in the efficiency of management. Comparisons of the rolling capital-output ratio can also be useful for particular purposes.

Statistical information

6. I shall now try to give some idea of the type of information on capital-output ratios which are now available in India. There is an annual census of industrial establishments above certain limiting size, defined by a minimum of 50 workers on an average if using power and 100 workers on an average if not using power. An annual sample survey is used for establishments of a smaller size, with a cut-off point at a lower limiting size defined by 10 or more workers using power and 20 or more

---

[1] The following two recent papers illustrate this type of work: (1) An optimising planning model, by S. Chakravarty and Louis Lefeber, *Economic Weekly*, Annual Number, February 1965; (2) A consistency model of India's Fourth Plan, by Alan S. Manne and Ashok Rudra, *Sankhyā*, Series B, Vol. 27, Parts 1 & 2, 1965.

workers not using power. Table (1) presents the ratios based on the 1961 survey of industries for 17 selected industries.[2]

TABLE (1): CAPITAL-OUTPUT RATIO BASED ON SURVEY OF INDUSTRIES, 1961

industries	total capital/value of output			total capital/value added		
	census	sample	total	census	sample	total
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. electricity, gas	2.40	2.00	2.27	7.33	4.09	5.97
2. basic chemicals, fertilizer	1.46	0.59	1.39	4.74	2.61	4.62
3. cement	0.98	0.42	0.98	4.19	1.25	4.18
4. petroleum refineries	1.45	—	1.45	4.17	—	4.17
5. iron and steel, basic	1.03	0.52	0.99	3.92	2.56	3.84
6. non-ferrous metals, basic	1.09	0.47	0.92	3.99	2.46	3.68
7. paper and paper board	0.98	0.41	0.92	3.60	1.95	3.47
8. sugar	0.60	0.51	0.60	3.02	3.00	3.02
9. motor vehicles	0.48	—	0.48	2.38	—	2.38
10. metal prod. except machinery	0.58	0.54	0.57	2.21	2.03	2.15
11. non-electrical machinery	0.76	0.70	0.75	2.10	2.20	2.13
12. electrical machinery	0.69	0.38	0.66	2.14	1.22	2.07
13. miscellaneous food	0.36	0.24	0.32	2.45	1.16	1.98
14. rail road equipment	0.63	0.60	0.63	1.89	2.36	1.89
15. paints and chemicals	0.54	0.38	0.52	1.70	1.70	1.70
16. printing and publishing	0.65	0.52	0.62	1.58	1.09	1.44
17. cotton textiles	0.43	0.29	0.42	1.40	1.62	1.40
18. all industries	0.64	0.43	0.60	2.40	1.95	2.33

The census data, which are for larger enterprises, have larger capital-output ratios. Data of the above type, however, have well known limitations, for example, under-estimation of the value of fixed capital for older installations. In principle it is necessary to use the "replacement value" of the fixed capital. As there are great technical difficulties in estimating the replacement value, this method has not been used in India except in some occasional exercises.

[2] *Source :* Estimate of Total Capital, Employment and Output in Manufacturing Industries, 1961 (mimeo). Issued by Central Statistical Organization, India, 1965. Only industries having a total productive capital of Rs. 50 crores or more have been included. The industries in tables are generally arranged in descending order of total capital/value added ratio.

7. Data obtained from projects are more useful for purposes of detailed planning. Some estimates based on project data are given in Table (2) below[3]

TABLE (2): CAPITAL-OUTPUT RATIO BASED ON PROJECT DATA

	industries	shift	fixed capital/ value of output	total capital/ value of output	fixed capital/ value added	total capital/ value added
	(1)	(2)	(3)	(4)	(5)	(6)
1.	aluminium	3	3.16	3.86	12.64	15.44
2.	generators	1	3.00	3.64	7.50	9.10
3.	oil refinery equipment	1	2.75	3.08	6.88	7.70
4.	turbines	1	2.50	3.00	6.25	7.50
5.	heavy forging	1	2.20	2.50	5.50	6.25
6.	chem. ind. machinery	1	2.00	2.33	5.00	5.82
7.	finished steel	3	2.28	2.68	4.38	5.15
8.	nitrogenous fertilizer	3	1.61	2.01	4.02	5.02
9.	vegetable oil	1	0.15	0.29	2.50	4.83
10.	steel casting	1	1.43	1.73	3.58	4.32
11.	paper and paper board	3	1.33	1.69	3.09	3.03
12.	sugar	3	0.60	1.00	2.22	3.70
13.	artificial silk	1	1.00	1.43	2.56	3.67
14.	crude oil refining	3	1.10	1.50	2.44	3.55
15.	cement machinery	1	1.00	1.33	2.50	3.33
16.	coal mining machinery	1	1.00	1.33	2.50	3.32
17.	cotton yarn	2	0.73	1.06	2.28	3.31
18.	refrigerators	1	1.00	1.40	2.22	3.11
19.	steam locos	2	0.80	1.13	2.16	3.05
20.	metal cutting tools	1	0.80	1.13	2.00	2.82
21.	iron ore	–	2.27	2.47	2.52	2.74
22.	jute textiles	1	0.50	0.78	1.72	2.68
23.	coal	–	2.00	2.20	2.35	2.59
24.	cement	3	0.92	1.00	2.30	2.50
25.	copper	3	0.28	0.61	1.12	2.44
26.	sulphuric acid	3	0.64	1.03	1.45	2.34
27.	cotton cloth	2	0.50	0.85	1.35	2.30
28.	wagons	1	0.50	0.75	1.50	2.25
29.	superphosphate	3	0.48	0.88	1.20	2.20
30.	rubber footwear	1	0.50	0.82	1.28	2.10
31.	jute textile machinery	2	0.50	0.83	1.25	2.09
32.	agricultural implements	1	0.50	0.83	1.25	2.08
33.	automobiles	1	0.40	0.60	1.33	2.00
34.	leather	1	0.33	0.63	1.00	1.89
35.	radio sets	1	0.40	0.80	0.89	1.78
36.	cotton textile machinery	2	0.50	0.83	0.83	1.38
37.	dry batteries	1	0.20	0.60	0.44	1.33

Comparison between project and survey data is difficult. Projects refer usually to new units of production; survey data to the industry as a whole with production units of varying age. The difficulty in valuation of fixed capital has been

[3] *Source:* A Survey of Economic Co-efficients for Organized Industries in India, Perspective Planning Division, Planning Commission, April 1959 (mimeo.).

already mentioned; another difficulty arises from the fact that project data include a reasonable amount of inventory while the survey data supply the actual inventory holdings, which have been sometimes unnecessarily large in India.

8. That the value of the capital-output ratio would decrease when the number of shifts is increased is an elementary point which does not call for any comments. Some numerical information may, however, be of interest. Table (3) below shows that a total capital/value-added ratio of about 3 was reduced to about 2 when a single shift was changed to a double shift[4].

TABLE (3): FREQUENCY DISTRIBUTION OF CAPITAL-OUTPUT RATIO FOR SINGLE AND DOUBLE SHIFTS

range	single shift	double shift
(1)	(2)	(3)
0 — 0.90	0	1
1 — 1.99	20	47
2 — 2.99	29	18
3 — 3.99	12	9
4 — 4.99	9	2
5 — 5.99	3	0
6 — 6.99	2	0
7 — 7.99	2	0
total	77	77
average	2.98	2.03

9. Another important factor is the form of the new investment. It is possible either to set up new units or to make substantial extensions of old units. Extensions should normally lead to lower capital-output ratios in comparison with new units. In census and survey data it is not possible to distinguish between substantial extensions and new units. Some information is given in Table (4) below on the reduction of the ratio in the case of substantial extensions based on direct returns[5].

TABLE (4): CAPITAL-OUTPUT RATIO FOR NEW UNITS AND SUBSTANTIAL EXTENSIONS

industries	shifts	fixed capital/ value added	fixed capital/ value of output	lag between new unit and extension (month)
(1)	(2)	(3)	(4)	(5)
1. *Sugar*				
new unit	3	3.14	1.10	
substantial extension	3	2.23	0.78	11
2. *Cotton yarn*				
new unit	3	2.15	0.75	
substantial extension	3	1.82	0.60	6
3. *Cotton cloth*				
new unit	3	2.50	0.40	
substantial extension	3	0.94	0.15	6
4. *Cement*				
new unit	3	4.12	1.65	
substantial extension	3	2.50	1.00	10

[4] *Source:* See footnote 3.

[5] *Source:* The Investment—Output—Employment relationships, Phasing of Investment and Time lags in Organized Manufacturing Industries, (mimeo.) Perspective Planning Division, Planning Commission, March 1960.

A detailed study of investment and output is necessary to decide between a substantial extension and the setting up of a new unit at any particular stage of planning. A lower capital-output ratio is not, however, necessarily decisive. It is essential to keep in view the need of future expansion. A suitable new unit may be preferable, even if it is more capital intensive, because it would offer more scope for extensions in future.

10. The time lag between the investment and production is an important factor in the relation between capital and output. Table (5) below gives some estimates of time lags between the date of issue of Industries Act license and the date of realization of full production[6]. The data are given separately for new units and substantial extensions.

TABLE (5): LAG IN YEARS BETWEEN INVESTMENT AND GENERATION OF OUTPUT

industries	new unit		extension		combined	
	n	lag	*n*	lag	*n*	lag
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. wood, paper, etc.	1	5.42	2	3.37	3	4.05
2. industrial machinery	6	4.12	4	3.92	10	4.03
3. metallurgical industries	8	4.12	1	3.25	9	3.93
4. cement, glass, etc.	2	4.42	4	3.58	6	3.85
5. chemical industries	7	3.83	13	3.67	20	3 70
6. food industries	1	4.50	1	3.58	2	3.62
7. rubber products	1	3.58	1	3.42	2	3.54
8. textiles	4	3.58	2	3.33	6	3.50
9. transport equipment	5	4.08	3	2.42	8	3.46
10. electrical equipment	8	3.17	6	3.58	14	3.42
11. total	43	3.90	37	3.51	80	3.72

It is somewhat surprising but true that extensions do not have generally a smaller time lag in India. Their only advantage is in respect of smaller capital-output ratios.

11. Project data have to be used for purposes of the detailed planning of investments. Historical information on capital-output ratios based on census and survey data are not adequate for detailed planning but give some guidance in assessing likely performance in future. Census and survey data on capital-output ratios may therefore be quite useful for models for long range projections. Census and survey estimates may also be of considerable help in making detailed comparisons in individual industries.

[6] *Source:* See footnote 5.

Use of sample surveys

12. India is having an annual census of manufacturing industries. I am not sure that in developing countries, the usefulness of an annual census would be always commensurate with the cost. An annual sample survey, on the other hand, is likely to be quite useful from very early stages of industrialisation. In developing countries continuing attention must be given to the validity and margin of error of survey data. On the side of sampling techniques, the use of the design of inter-penetrating network of samples (IPNS) supplies a great deal of statistical control. Estimates of the capital-output ratios for fifteen selected industries, based on two inter-penetrating sub-samples as well as the pooled samples, are given in Table (6) in respect of the sample (that is, the small scale) sector of the 1959 survey of industries[7]. The sub-sample estimates are generally closer for the total capital/value-added and fixed capital/value added ratios, as could be expected. Also, differences in sub-sample estimate may, apart from technical errors (sampling or non-sampling), represent real physical differences between different units. The survey estimates may, therefore, be sufficiently reliable for many practical purposes.

Concluding observations

13. The capital/value-added ratio has the advantage that it is independent of industrial classification, and can be aggregated at all levels. The capital/value-of-output ratio for any level of aggregation depends on the composition or "mix" of types of industrial production; comparisons over time would be valid to the extent the industrial compositions of each sector remains the same over time. The relation between capital and full-capacity output is, in principle, of a physical or technical nature. However, the difference between the theoretical full-capacity output and the actual output may be large during periods of slack demand, or for lack of raw materials or other inputs or inefficiency of management.

14. Capital/output ratios at the national level can be obtained as the weighted average of ratios for individual units and would supply meaningful information for the capital/value-added ratio at the national, or at any level of aggregation. The capital/capacity-output ratio at the national level could give only a hypothetical asymptotic upper limit which can be never realised in practice due to management inefficiencies, shortages of materials, or of man-power etc., even in a fully planned economy, and, in addition, due to fluctuations of demand in a mixed economy. The capital/value-added ratio appears to be more useful for use in aggregative models.

15. Wherever the national economy is partitioned into more than one sector, the sectoral capital/output ratios would be necessarily inter-dependent; and in general increasingly so as the number of sectors is increased. The sectoral capital/output ratio would be more directly meaningful, the greater is the independence of the sectors under consideration.

---

[7] *Source :* Tables with notes on the Annual Survey of Industries, 1959 : Sample Sector : Summary Results, National Sample Survey No. 91, Cabinet Secretariat, Government of India, 1964. Units in completely enumerated strata occur in both sub-samples.

TABLE (6): CAPITAL-OUTPUT RATIO BY SUB-SAMPLES BASED ON SURVEY OF INDUSTRIES, 1959: SAMPLE SECTOR

selected industries	n			fixed capital/ value of output			total capital/ value of output			fixed capital/ value added			total capital/ value added		
	s.s.1	s.s.2	pooled	s.s.1	s.s.2	pooled	s.s.1	s.s.2	pooled	s.s.1	s.s.2	pooled	s.s.1	s.s.2	pooled
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1. electric light and power	53	50	100	2.47	1.90	2.20	2.57	2.05	2.32	4.88	4.79	4.79	5.08	4.97	5.05
2. water supply station	41	40	52	1.55	1.82	1.69	1.60	1.88	1.74	4.62	4.85	4.85	4.77	5.22	5.00
3. sugar factories	32	23	48	0.29	0.29	0.29	0.38	0.42	0.41	2.37	2.91	2.70	3.08	4.25	3.77
4. ginning and pressing	151	135	283	0.54	0.29	0.36	0.64	0.39	0.45	2.64	2.68	2.66	3.12	3.52	3.36
5. paper and paper board	37	36	63	0.27	0.21	0.24	0.54	0.50	0.52	1.19	0.92	1.06	2.38	2.15	2.27
6. basic chemicals	39	38	68	0.19	0.16	0.17	0.40	0.48	0.45	1.01	0.78	0.87	2.13	2.36	2.27
7. non-electrical machinery	166	155	320	0.25	0.25	0.25	0.42	0.75	0.58	0.80	0.80	0.80	1.31	2.39	1.83
8. non-ferrous metals	46	44	84	0.06	0.08	0.07	0.23	0.23	0.23	0.45	0.65	0.54	1.67	1.98	1.80
9. rubber and rubber products	35	34	64	0.18	0.16	0.17	0.26	0.68	0.43	0.81	0.53	0.67	1.18	2.31	1.71
10. glass and glass products	28	27	49	0.15	0.27	0.23	0.40	0.49	0.45	0.52	1.03	0.83	1.33	1.85	1.65
11. ferrous metals	64	62	113	0.19	0.12	0.14	0.35	0.30	0.32	0.77	0.65	0.70	1.42	1.63	1.54
12. electrical machinery	42	43	78	0.17	0.20	0.18	0.33	0.39	0.35	0.73	0.73	0.73	1.45	1.43	1.44
13. cotton textiles	226	206	412	0.13	0.12	0.13	0.20	0.30	0.31	0.63	0.50	0.56	0.94	1.22	1.36
14. tobacco manufacture	233	223	452	0.04	0.03	0.04	0.19	0.23	0.21	0.20	0.14	0.17	0.87	1.11	1.00
15. boots and shoes	25	22	41	0.04	0.06	0.05	0.14	0.18	0.16	0.16	0.22	0.18	0.49	0.66	0.56