

ENGINEERING MANPOWER

A SECTORAL STUDY OF ENGINEERING MANPOWER REQUIREMENTS
UPTO 1976, BASED ON OUTPUT, INVESTMENT
AND WORK-FORCE

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INSTITUTE OF APPLIED MANPOWER RESEARCH
INDRAPRASTHA ESTATE, RING ROAD
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The Institute of Applied Manpower Research was set up in 1962 by the Government of India to conduct research on problems of manpower planning. The main objects of the Institute are:-

- To advance knowledge about the nature, characteristics and utilisation of the human resources in India.
- To provide a broad perspective of requirements of trained manpower for economic development in different fields with due regard to the probable impact of technological changes on the pattern of employment.
- To develop improved methods and techniques for dealing with:-
 - training and development of the existing work force;
 - educational preparation for employment;
 - vocational guidance;
 - identifying and developing highly talented persons;
 - forecasting demand and supply of manpower and connected matters.

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REQUIREMENTS

FOREWORD

The work relating to the assessment of engineering manpower requirements for the Fourth and Fifth Plan periods was done, at different stages, by several organisations in the country including the IAMR. During the first half of the year 1966 a note on "Technical Education in the Fourth Plan - Approach and Tasks" was jointly prepared by the Planning Commission (Education Division), Ministry of Education, and Directorate of Manpower, Ministry of Home Affairs. This note was discussed at the Education Ministers' Conference held at Madras in June, 1966. Taking into account the views expressed by some of the State Education Ministers on the subject, and in view of the vital importance of estimates of demand for technical personnel for the Fifth and subsequent Plans, to the development of educational facilities during the Fourth Plan, it was decided to set up a high power committee to consider the matter in detail. Accordingly, a Technical Manpower Assessment Committee was set up under the chairmanship of Dr. V. K. R. V. Rao. The chairman of the committee felt that since the IAMR was already working on the methodological aspects of engineering manpower requirements, it would be appropriate if the Institute take up a study on the relationship between output, investment and employment of engineers in different sectors of the economy. The sectoral study was accordingly conducted by the Institute.

The objectives of the sectoral study were specified to be (i) to see how far a sectorwise approach to the estimation of requirements of engineering manpower is feasible in the context of the information available in the country and (ii) to see how far the results obtained by a sectorwise study differ from those obtained from global studies.

During the month of November, 1966, a preliminary paper on the relationship between output, investment and employment of engineers in different sectors of the economy was prepared by the IAMR and submitted to the Technical Manpower Assessment Committee. Results presented in the paper showed that while there are several difficulties and limitations in the way of carrying out a sectorwise study for the estimation of engineering manpower requirements, it is a worthwhile and feasible attempt. The analysis revealed that there exists a significant relationship between output, investment and employment of engineers in different sectors of the economy. On the basis of the relationship thus established, estimates of engineering manpower requirements for the years 1970-71 and 1975-76 were made by fitting regression lines to the observed data.

The Technical Manpower Assessment Committee used inter alia the results of the sectoral study of the IAMR in finalising its report on the estimates of demand and supply of engineering manpower for the Fourth and Fifth Plan periods.

In the paper submitted by the IAMR to the Technical Manpower Assessment Committee in November, 1966, the sectoral approach related employment of engineers with output and investment. Work was continued at the IAMR to establish a similar relationship between employment of engineers and work-force in different sectors of the economy.

The results of the sectoral study, in the extended form, are presented in this paper. The paper has been prepared by Dr. S. P. Agarwal, Head of the Manpower Economics and Statistics Division and Shri P. N. Mathur, Senior Research Officer with the assistance of Shri R. S. Sharma and Km. Lalita Grover. It is also intended to publish a condensed version of the paper in the Manpower Journal.

June 17, 1967

P. K. DAS
Director

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REQUIREMENTS UPTO 1976, BASED ON OUTPUT,
INVESTMENT AND WORK-FORCE

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SECTION I - INTRODUCTORY REMARKS:

A number of studies of engineering manpower requirements have been made in our country during the last eleven years. Special mention may be made in this connection of the studies made by the Engineering Personnel Committee, the Planning Commission and Working Groups thereof, the Manpower Directorate, the IAMR, the Indian Statistical Institute (ISI), the London School of Economics (LSE), the Education Commission and the Ministry of Education.* A careful study of the papers brought out by the different organisations reveals that the attempts made so far are conditioned by two main limitations. First, it is found that all the studies except one, are of a global nature, that is, they lump together all the sectors of the economy without making any distinction between them. The only instance where a sectoral study of engineering manpower requirement has been attempted is a memorandum entitled "Manpower and Educational Development in India, 1961-86" submitted to the Education Commission by a joint project team of the Indian Statistical Institute, the London School of Economics and the Perspective Planning Division (PPD) of the Planning Commission.

The second limitation of the studies made so far is that all the studies except one, have related engineering manpower requirement to estimates of mainly one factor, viz. output or investment, rather than considering simultaneously the three determining factors, viz. output, investment and work-force. The only instance where a relationship between engineering manpower requirement and the three factors is attempted is in the report of the Working Group on Technical Education and Vocational Training.

Need has been felt to conduct a study of engineering manpower requirement which does not suffer from the above mentioned limitations. It seems important to recognise that the various sectors of the economy differ considerably from one another in matters like output per engineer, investment needed per engineer and ratio of engineers to total work-force.

* A list of selected studies is appended to this paper.

Similarly, a simultaneous consideration of all the related factors, viz. output, investment, work-force and engineering manpower employment is necessary to ensure consistency and feasibility of the assumptions and results.

SECTION II - OBJECTIVE OF THE STUDY:

The present study seeks to overcome the two main limitations of the other studies of engineering manpower requirements made in our country. It is an attempt to see how far a sectorwise approach based simultaneously on three factors, viz. output, investment and work-force, is feasible for an estimation of engineering manpower requirement in the context of information available in our country. The results obtained by such a sectoral and three-pronged study would then be compared with those obtained from global studies on the one hand and from single factor studies on the other.

The present study is a pioneering attempt at the Institute of Applied Manpower Research, in the sense that a simultaneous use of the two main approaches indicated above has not yet been made in any study of engineering manpower requirement for our country. The ISI/LSE/PPD study did attempt a sectoral analysis but it was based mainly on output and to a certain extent on investment, ignoring work-force altogether. Similarly, the study made by the Working Group on Technical Education and Vocational Training did attempt a simultaneous consideration of the three factors, viz. output, investment and work-force, but this study was of a global nature and was not applied to different sectors of the economy.

SECTION III - CHOICE OF SECTORS:

Theoretically speaking, the Standard Industrial Classification should be regarded as an appropriate basis for determining the sectors in terms of which the study could be made. However, it is noticed that information on output, investment, work-force and employment of engineers has not yet been presented in our country in terms of the Standard Industrial Classification even at the divisional (one-digit) level. For example, the data on national income that are released by the Central Statistical Organisation do not contain separate figures for Construction which is one of the divisions in the Standard Industrial Classification and which is

a very important sector as far as employment of engineers is concerned.

While the adoption of the main divisions of the Standard Industrial Classification should generally be appropriate for the present study, there is reason to go into greater detail in respect of certain components of the 'services' division. We have sub-divided the 'services' division in terms of three sectors, viz. educational services, government administration other than educational services, and other services. This has been done since educational services and government administration deserve special consideration from the point of view of employment of engineering personnel. The number of engineers employed in government administration is quite large. In the case of educational services, not only is the number of engineering personnel sufficiently large, but even more important than that is the qualitative aspect since adequate arrangements must be made for the required number of teachers for technological institutions. It is, therefore, considered necessary that educational services and government administration should be taken as separate sectors for the present study and not merged with the broad 'services' group.

While the 'services' division of the Standard Industrial Classification has been sub-divided in terms of three sectors for the present study, three other divisions of the Standard Industrial Classification had to be merged into one. These three divisions are: mining and quarrying; manufacturing; and electricity, gas, water and sanitary services. The pooling together of these three sectors was considered necessary for a variety of reasons. First, the data on employment of engineers are not available in adequate detail so as to enable us to deal with each of these three sectors separately. Secondly, it is noticed that employment data of these three sectors are often merged. For example, engineers employed in the mining establishment of the steel industry are shown under the steel industry (i. e. manufacturing). Moreover, no appreciable disadvantages are likely to accrue in merging these three sectors for our study on India, as the developmental rates for these three sectors are likely to be in step with each other at the present stage of our economic development.

In view of the above, the sectors chosen for the present study are the following:

- (i) Mining, manufacturing and utilities*
- (ii) Construction
- (iii) Trade and Commerce
- (iv) Transport and communications
- (v) Educational services
- (vi) Government administration other than educational services
- (vii) Other services
- (viii) Agriculture

SECTION IV - COMPILATION OF BASIC DATA FOR THE CHOSEN SECTORS FOR DIFFERENT YEARS:

After having chosen the sectors for making the present study, we have to obtain figures of output, investment, work-force and employment of engineers in respect of each of them for as many years as possible. The data on net output from a number of sectors (in the national income terminology) are available for each year from 1948-49 to 1965-66, and therefore once a satisfactory method is evolved for obtaining separate estimates for sectors like construction and educational services, there would be no great difficulty in working out a complete series of output data needed for the study. Following the usual practice to ensure comparability over time, all figures of output used in this study are in terms of constant prices.

The position in respect of availability of data on sector-wise investment, work-force and employment of engineers is not so satisfactory. Investment data, for instance, are available for Plan periods as a whole and not for individual years. Even in the case of Plan periods, sector-wise data on investment for the first three Plans are not available in adequate detail. Therefore, approximate estimates of investment have to be worked out on the basis of sector-wise figures of outlay which are available in much greater detail than the figures of investment. There is also the problem of non-comparability over time of these estimates of investment. (This is discussed in greater detail in Section VI).

* The term 'utilities' denotes the industrial division 'electricity, gas, water and sanitary services'.

Sector-wise data on work-force for the country as a whole are available mainly from the decennial population census and the National Sample Survey (NSS). However, even the data given by the two latest censuses, one conducted in 1951 and the other in 1961, are not mutually consistent and the NSS data provide more or less a third set differing from the census. Following the normal practice, we have adopted the figures of the 1961 census as the basis of the sectoral employment data. Rather than relying on the NSS, we have made use of the data on employment generation in different Plan periods to work out estimates of total work-force in different years. This enables us to have a set of data on work-force for certain years which are more or less consistent with one another. Here also, there are certain difficulties in working out estimates of work-force in construction and educational services. Approximations have been made in such cases mainly based on the information contained in the Plan documents.

The greatest difficulty experienced is in estimating the number of engineers employed in different sectors of the economy. The earliest source of information on this subject is the studies made by the Perspective Planning Division of the Planning Commission relating to the year 1955-56. Estimates made by the IAMR for 1960-61, on the basis of information provided by the Census, the Directorate General of Employment and Training and the Council of Scientific and Industrial Research come next. From then on, the occupational returns received by the Directorate General of Employment and Training, from the public and private sectors in alternate years, provide some basis, for estimating the number of engineers employed in the reporting establishments. For the year 1964-65 the IAMR conducted a special study of electrical and mechanical engineers. Pooling all these sources together, the data on employment of engineers have been worked out for the sectors chosen for this study, in respect of the years 1955-56, 1960-61 and 1964-65*.

* The year 1965-66 being the final year of the Third Plan would be preferable to the year 1964-65 on certain grounds. However, engineering employment information was available more readily and in a better form for the year 1964-65 as compared to the year 1965-66. For purposes of output and investment also the year 1965-66 turned out to be abnormal. Therefore, the year 1964-65 has been used in this study instead of the year 1965-66.

Since the data on employment of engineers were worked out in a comparable form for only three years (viz. 1955-56, 1960-61 and 1964-65), the data on output were also taken for only these three years. Investment and work-force data in respect of the Second and the Third Plans (with some adjustment in the latter case) were taken in conjunction with these data of output and employment of engineers. The basic data are presented in Tables 1 to 4.

TABLE 1

Approximate distribution of net output among eight sectors for the years 1955-56, 1960-61 and 1964-65

Sector	(in abjas of ₹. at 1960-61 prices)		
	Net Output during		
	1955-56	1960-61	1964-65
1. Mining, manufacturing and utilities	19.5	23.0	28.0
2. Construction	2.2	3.0	3.9
3. Trade and commerce	14.1	17.3	20.7
4. Transport and communications	4.6	6.1	8.2
5. Educational services	1.2	2.3	3.0
6. Govt. administration	5.8	9.1	12.3
7. Other services	10.7	12.4	16.7
8. Agriculture	58.6	68.9	74.6
TOTAL	116.7	142.1	167.4

Sources: 1. Estimates of National Income, 1948-49 to 1962-63, Central Statistical Organization.

2. National Income by States, National Council of Applied Economic Research.

3. Notes on Perspective of Development, India, 1960-61 to 1975-76, Planning Commission, PP Division.

4. The Fourth Five Year Plan - A Draft Outline.

TABLE 2

Approximate distribution of investment among six sectors for the periods 1956-57 to 1960-61 and 1961-62 to 1964-65

(in crores of Rs. at current prices)

Sector	Investment during	
	1956-57 to 1960-61	1961-62 to 1964-65
1. Mining, manufacturing and utilities	2, 295	3, 244
2. Construction	982	908
3. Transport and communications	1, 410	1, 388
4. Educational services	216	240
5. Government administration, trade and commerce and other services	555	788
6. Agriculture	1, 292	1, 748
Total	6, 750	8, 316*

Source: Third Five Year Plan.

* Rough estimates.

TABLE 3

Approximate distribution of work-force among six sectors for the years 1955-56, 1960-61 and 1964-65

Sector	(in lakhs)		
	Work-force during		
	1955-56	1960-61	1964-65
1. Mining, manufacturing and utilities	196.5	209.0	223.8
2. Construction	14.8	20.0	24.8
3. Transport and communications	23.0	30.0	38.1
4. Educational services	13.2	17.8	23.0
5. Govt. administration, trade and commerce and other services	218.5	254.2	305.3
6. Agriculture	1,183.0	1,208.0	1,240.0
Total	1,649.0	1,739.0	1,855.0

Sources: 1. Notes on Perspective of Development, India, 1960-61 to 1975-76, Planning Commission, P.P. Division.

2. Second Five Year Plan.

3. Third Five Year Plan.

TABLE 4

Approximate employment of engineers (degree and diploma) by
sectors for the years 1955-56, 1960-61 and 1964-65

Sector	(in thousands)		
	Number of engineers employed during		
	1955-56	1960-61	1964-65
1. Mining, manufacturing and utilities	27	42	74
2. Construction	13	20	27
3. Trade and commerce	1.5	5	9
4. Transport and communications	5	10	14
5. Educational services	4	12	22.5
6. Government administration	24	32	40
7. Other services	4	11	17
8. Agriculture	0.5	1	1.5
Total	79	133	205

Sources: 1. Manpower Study No. 5 - Engineers in India, Number and Distribution, 1955 - Planning Commission, Perspective Planning Division;

2. IAMR Working Paper No. 6/1963 - Stocktaking of Engineering Personnel;

3. IAMR Working Paper No. 19/1965 - Employment of Mechanical and Electrical Engineering Manpower, 1964;

4. All India Quarterly Reports on Employment in the public and private sectors, Directorate General of Employment and Training; and

5. Information in respect of occupational pattern of workers in different sectors, available with the Directorate General of Employment and Training.

Basic data on output, investment, work-force and employment of engineers in different sectors upto the year 1964-65 are summarised in Tables 1 to 4. For purposes of projecting the requirements of engineers for the Fourth and Fifth Plan periods, it is necessary to have some estimates of sector-wise investment for the Fourth and Fifth Plans and also of sector-wise output and work-force during the final years of the Fourth and Fifth Plans. Investment figures for the Fourth Plan are given sector-wise in the draft outline of the Fourth Plan. Targets of the total national income for 1970-71 are also given there, but their sector-wise break-up is not indicated. The draft outline similarly indicates targets of employment generation during the Fourth Plan without giving a sectoral break-up of the same. The information regarding the Fifth Plan period is still less specific. Under these circumstances, the sector-wise estimates of the three factors for the Fourth and Fifth Plan periods have been approximately worked out in the light of the papers brought out by the Perspective Planning Division. Since the earlier calculations of the P. P. Division were based on higher figures of investment, output and employment for the Fourth and Fifth Plan periods, appropriate adjustments have been made therein on the basis of the revised targets given in the draft outline of the Fourth Plan. Tables 5, 6 and 7 summarise the sector-wise estimates of output, investment and work-force made for the Fourth and Fifth Plan periods.

TABLE 5

An estimate of net output by sectors for the years
1970-71 and 1975-76

Sector	(in abjas of ₹. at 1960-61 prices)	
	Net output during	
	1970-71	1975-76
1. Mining, manufacturing and utilities	49.5	80.3
2. Construction	6.1	9.1
3. Trade and commerce	24.7	36.1
4. Transport and communications	15.4	24.4
5. Educational services	4.2	6.4
6. Government Administration	17.2	26.0
7. Other services	23.3	35.3
8. Agriculture	90.6	108.7
Total	231.0	326.3

Sources: 1. The Fourth Five Year Plan - A Draft Outline.

2. Notes on Perspective of Development, India, 1960-61 to 1975-76, Planning Commission, P. P. Division (Figures adjusted).

TABLE 6

An estimate of investment by sectors for the periods
1965-66 to 1970-71 and 1971-72 to 1975-76

Sector	(in crores of Rs.)	
	Investment during	
	1965-66 to 1970-71	1971-72 to 1975-76
1. Mining, manufacturing and utilities	9, 729	12, 708
2. Construction	2, 007	2, 800
3. Transport and communications	3, 988	5, 382
4. Educational services	710	970
5. Govt. administration, trade and commerce and other services	2, 905	3, 729
6. Agriculture	4, 095	4, 411
Total	23, 434	30, 000

Sources: 1. The Fourth Five Year Plan - A Draft Outline.

2. Notes on Perspective of Development, India,
1960-61 to 1975-76, Planning Commission,
P. P. Division (Figures adjusted).

TABLE 7

Estimated distribution of work-force by sectors
for the years 1970-71 and 1975-76

Sector	(in lakhs)	
	Work-force during	
	1970-71	1975-76
1. Mining, manufacturing and utilities	269.0	320.0
2. Construction	33.0	41.0
3. Transport and communications	54.0	72.0
4. Educational services	31.5	43.0
5. Govt. administration, trade and commerce, and other services	388.5	470.0
6. Agriculture	1,293.0	1,346.0
Total	2,069.0	2,292.0

Sources: 1. The Fourth Five Year Plan -
A Draft Outline.

2. Notes on Perspective of Development, India,
1960-61 to 1975-76, Planning Commission,
P. P. Division (Figures adjusted).

SECTION V - RELATIONSHIP BETWEEN SECTOR-WISE OUTPUT AND EMPLOYMENT OF ENGINEERS:

As shown in Table 4, sector-wise data on employment of engineers have been worked out for three years, viz. 1955-56, 1960-61 and 1964-65. Sector-wise output figures at constant prices have also been worked out for the same years in Table 1. There are two possible methods for studying the relationship between sector-wise employment of engineers and sector-wise output in the light of the available data. We shall refer to these two methods as (i) the ratio method and (ii) the regression method.

The ratio method focusses attention on the change over time in the average value of output-engineer ratio (at constant prices) in different sectors. Before discussing several important aspects of this ratio we may mention that this ratio is not equivalent to what may be called the productivity per engineer, since the output of each sector which figures in the numerator of the ratio is to be attributed to the total work-force of that sector including non-engineering personnel also. Secondly, since the output data that we have used in this paper relate to net output as distinguished from gross output, the output-engineer ratio as calculated by us is lower than if the data were to relate to gross output. From the point of view of studying the relationship between sector-wise output and employment of engineers, the main consideration is that the data for all the years should relate uniformly to either net output or gross output. In this paper we have used the data for net output for all the years.

We may now discuss the important factors which have to be taken into account while studying the output-engineer ratio. The time-lag between employment of an engineer and the starting of the productive activity for which he has been employed is one of the factors. Another factor is under-utilisation of the productive capacity of the undertaking, for the strength of the engineering staff is generally related to the total installed capacity. Thirdly, even within the same activity sector, not all establishments have the same value of output-engineer ratio. For example in the manufacturing sector, there are certain industries which are engineer-intensive, while in certain other industries the number of engineers employed is very small, with the result that output per engineer is quite different from one type of industry to another.

Still another factor which enters into a study of the average value of output engineer ratio is productivity. In fact, productivity considerations would suggest that output per engineer should go up over time. However, the data contained in our basic tables present quite a different picture, and the output-engineer ratio is seen to be going down in most of the sectors including the mining, manufacturing and utilities sector. For the economy as a whole also, since the number of engineers has grown faster than the domestic product, the average value of output-engineer ratio has steadily gone down from 1955-56 to 1964-65.

A steady decline in the average value of output-engineer ratio (at constant prices) over time in most of the sectors including the mining, manufacturing and utilities sector may look surprising, but it is not so strange after all. The reasons for this decline may lie in increasing engineer-intensiveness in some of our industries particularly with the shift from small and medium scale industries to large scale industries, and the possible replacement of foreign engineers by Indian engineers. It may also indicate that initially engineers were in short supply and gradually this shortfall is not only being bridged but in some cases may also be pending towards over-employment.

In the absence of detailed information on the above-mentioned factors, it is difficult to say how the average value of output-engineer ratio (at constant prices) would change over time for the different sectors of the economy. It may be mentioned here that the ISI/LSE/PPD memorandum referred to in the opening paragraph of this paper assumed a constant value of output per engineer (at constant prices) over time for each of the sectors. We shall give further consideration to this ratio, calculated on the basis of our own results, in Section X.

The second method, viz. the regression method for studying the relationship between sector-wise output and employment of engineers is somewhat simpler than the ratio method. In the regression method, we may regard the number of engineers employed in a sector as the dependent variable and the output from that sector (at constant prices) as the independent variable and then establish a regression equation between these two variables. Of course, the output of a sector during a certain year is itself the result of having employed a certain number of engineers in the preceding years in that sector. Therefore, theoretically speaking, a more intricate relationship between sector-wise

output and employment of engineers should be considered by introducing refinements based on time lags, demand curves, supply curves, etc. For the present, a simple regression between output and employment of engineers for the various sectors has been attempted. Here also, since the data are available for only three years, the best that can be done is to fit a linear regression equation. It is found, however, that although the number of degrees of freedom available to us for each sector is extremely small, the fit is surprisingly good because we have witnessed a steady growth in the employment of engineers as well as output in each of the non-agricultural sectors. Even in agriculture where output fluctuates from year to year, we have a rising trend over time and therefore the fit is quite good.

The results obtained by applying the regression method to the sector-wise data on engineers and output are summarised in Table 8. It is observed that the total requirement of degree and diploma engineers (whose number rose from 79,000 in 1955-56 to 205,000 in 1964-65) is expected to go up to 403,000 by 1970-71 and to 703,000 by 1975-76. If we add to these figures the number of engineering practicals, then the total requirement of all engineers including graduates, diploma-holders and practicals (who numbered 102,000 in 1955-56 and 246,000 in 1964-65) is expected to go up to 456,000 by 1970-71 and to 766,000 by 1975-76, on the basis of the output data.

A word of explanation may be added here in respect of the estimated number of engineering practicals. The total number of engineering practicals who were gainfully employed during 1955-56 is indicated in the PP Division's study referred to earlier and the corresponding figure for 1960-61 is available in the IAMR paper on stock-taking of engineering manpower. However, neither of these studies gives a sector-wise distribution of the engineering practicals. It was not possible, therefore, to carry out detailed calculations for the different sectors for the total number of engineering personnel including engineering practicals. The sector-wise calculations attempted so far relate to engineering graduates and diploma holders only. However, since engineering practicals also form part of the total pool of engineering manpower in the country, the estimates obtained by adding the figures of the different sectors have been adjusted at the global level by including therein an estimate of the number of engineering practicals.

TABLE 8

Estimated total requirement of engineers on the basis of output
for the years 1970-71 and 1975-76*

Sector	(in thousands)	
	Estimated total requirement of engineers in 1970-71	1975-76
1. Mining, manufacturing and utilities	193	365
2. Construction	45	70
3. Trade and commerce	14	26
4. Transport and communications	32	54
5. Educational services	33	55
6. Government administration	52	74
7. Other services	31	55
8. Agriculture	3	4
<hr/>		
Total (Degree and Diploma holders)	403	703
<hr/>		
Total (including engineering practicals)	456	766

* The table shows the estimated total requirements of engineers for the final years of the Fourth and the Fifth Plans. The gross additional requirements of engineers during the Fifth Plan to be met by institutional outturn would exceed the difference between the two figures given in the table to the extent allowance has to be made for attrition to the stock of engineers.

According to the PP Division's study, the total number of engineering practicals in India in 1955-56 was about 23,000. This number seems to have gone up to 41,000 by 1964-65. The estimate for 1964-65 has been worked out partly on the basis of the data on mechanical and electrical engineering manpower collected by the IAMR and partly on the basis of other information. It appears that the total number of engineering practicals holding posts which normally require a degree or diploma in engineering has gone up at an average rate of about 2,000 per year during the period 1955-56 to 1964-65. We have assumed a similar trend of annual increase in the numerical strength of the engineering practicals in absolute terms upto 1975-76. This assumption, in fact, implies a declining rate of increase in relative terms, in the number of engineering practicals from 1964-65 onward. The comparative positions of engineering degree and diploma holders on the one hand and of engineering practicals on the other, at different points of time, are shown in Table 9. It is noticed that engineering practicals are assumed to constitute a steadily declining percentage of engineering degree and diploma holders between 1955-56 and 1975-76.

TABLE 9

Relative strength of engineering practicals and degree and diploma holders, 1955-56 to 1975-76

Year	Number of engineering degree and diploma holders (thousands)	Number of engineering practicals (thousands)	% age of col (3) to col (2)	Increase during the period		% age of col (6) to col (5)
				Degree and diploma holders (thousands)	Practicals (thousands)	
1	2	3	4	5	6	7
1955-56	79	23	29.1	-	-	-
1960-61	133	33	24.8	54	10	18.5
1964-65	205	41	20.0	72	8	11.1
1970-71	400 (rounded)	53	13.3	195	12	6.2
1975-76	700 (")	63	9.0	300	10	3.3

SECTION VI - RELATIONSHIP BETWEEN SECTOR-
WISE INVESTMENT AND EMPLOY-
MENT OF ENGINEERS:

We have mentioned two methods, called the ratio method and the regression method, for studying the relationship between engineers and output. The same two methods can be used for studying the relationship between sector-wise employment of engineers and sectorwise investment.

The ratio method in the present case would study the changes over time in the average investment needed per engineer in different sectors. Two important factors have to be taken into account while studying this ratio.

The first factor which influences the average value of investment-engineer ratio at different points of time relates to what may be called the price indices of investment goods. In the case of national income data, comparability over time is achieved by converting 'national income at current prices' into 'national income at constant prices'. This is done by making use of the price indices for the various types of goods produced in the country. However, similar information needed for achieving comparability of investment figures over time has not yet been developed in our country. The Reserve Bank of India attempted a study of this type and published the results in the January 1963 issue of its Bulletin. This study only related to the years 1950-51 to 1960-61. It appears from this study that the price indices for investment goods, with the pre-Plan year 1950-51 as base, are higher than the corresponding price indices for the totality of goods produced in the country which ultimately determine the price indices for national income purposes. However, no price indices for investment goods are available for any year following 1960-61. The devaluation of the Indian currency in June 1966 also affects the price of imported capital goods as expressed in Rupees. In view of all these, we are not in a position at this stage to ascertain the effect of prices on the average value of investment-engineer ratio at different points of time. *

* However, more detailed consideration is being given to this subject for the purpose of ascertaining the possibility of quantifying, approximately even, the effect of price changes.

The second factor which influences the average amount of investment needed per engineer relates to questions of technology and plant size. It is common knowledge that even for the same type of manufacturing activity, the average investment per engineer is different in the case of an old unit being expanded from what it would be if a new unit were set up. Similarly, technological considerations are very important since the degree of mechanisation and automation that is introduced in an industry determines the amount of investment needed per engineer.

In the absence of detailed information on the above mentioned factors, it is difficult to say how the average value of investment-engineer ratio would change over time for the different sectors of the economy. It may be mentioned here that the Working Group on Technical Education and Vocational Training referred to in Section I of this paper had assumed a fairly constant amount of additional investment per additional engineer. We shall give further consideration to this ratio, calculated on the basis of our own results, in Section X.

The regression method for studying the relationship between sector-wise investment and employment of engineers is somewhat simpler than the ratio method. Of course, the problem of non-comparability of investment figures over time exists here also. Before indicating essential details of this method, it would be appropriate to draw attention to one more point that is to be kept in mind while using investment data for estimating the requirements for engineers.

The important point to note is that the requirements of engineers calculated on the basis of investment do not include the special needs of the non-Plan activities, that is the needs which exceed the trend line. For purposes of the present study, the most important non-Plan activity, of which the special needs are not fully included in our estimates, is the defence effort of the country. We have not yet made any special study of the requirement of engineers for the defence effort of the country nor for other non-Plan items.

The fitting of the linear regression equations between investment and employment of engineers for each sector may now be discussed. The actual variables used by us are net additional investment and net additional number of engineers employed, between 1955-56 and 1960-61, and between 1960-61 and 1964-65, respectively, as per data of Tables 2 and 4. There are three assumptions involved in this procedure.

First, the use of net additional investment implies that replacement equipment is excluded from consideration because it does not require an increase in the number of engineers. This assumption may not be entirely correct in practice. Secondly, our procedure implies that all the engineers employed at the time of the completion of installation operations of a plant continue to be employed when the plant carries on regular production. In other words, the need of the maintenance operations for the plant is assumed to be met by reallocating the engineering personnel employed for installation as between production operations and maintenance operations. Thirdly, our procedure does not provide for additional engineers when a greater proportion of machinery and equipment gets manufactured in our own country and consequently the proportion of imports of machinery and equipment goes down over time.* This last aspect has been discussed in some detail by the joint project team of the ISI/LSE/PPD. However, since non-adjustment for the price factor tends to inflate our estimates of engineering manpower requirements based on investment, we have not made in this paper any special provision for the needs of engineering personnel arising out of a reduction in imports of machinery and equipment.**

The results obtained by applying the regression method to the sector-wise data on engineers and investment are summarised in Table 10. It is observed that the total requirement of degree and diploma engineers estimated on the basis of investment data may go up to 411,000 by 1970-71 and to 676,000 by 1975-76. If we add to these figures the number of engineering practicals, then the total requirement of all engineers, including graduates, diploma-holders and practicals, calculated on the basis of investment data, may go up to 464,000 by 1970-71 and to 739,000 by 1975-76. It may be added here that these figures are subject to the limitations specified in the preceding paragraphs viz. non-inclusion of special needs of

* This change involves more engineering design and development activities within the country which is not adequately represented in investment.

** These aspects are being considered for more detailed studies.

non-Plan activities on the one hand and an element of over-estimation because of non-availability of suitable price indices for conversion of investment figures, on the other. It is difficult to say as to how the figures given in Table 10 would be affected if adjustments for these two factors could be made.

TABLE 10

Estimated total requirement of engineers on the
basis of investment for the years 1970-71 and
1975-76

Sector	(in thousands)	
	Estimated total requirement of engineers in	
	1970-71	1975-76
1. Mining, manufacturing and utilities	163	279
2. Construction	42	63
3. Transport and Communications	27	44
4. Educational services	52	92
5. Govt. administration, trade and commerce and other services	124	193
6. Agriculture	3	5
Total (Degree and diploma holders)	411	676
Total (including engineering practicals)	464	739

SECTION VII - RELATIONSHIP BETWEEN SECTOR-WISE WORK-FORCE AND EMPLOYMENT OF ENGINEERS

Estimation of demand for engineers on the basis of relationship between engineers and other workers has been attempted more commonly in western countries than in India. A close relationship has been found to exist between the number of technical and scientific personnel in an industry to total employment in that industry at different points of time in countries like the USA. The explanation for such relationship is that the occupational composition of each industry reflects not only its technology but also a variety of institutional factors.

In India, however, there are very few studies on the estimation of demand for engineers which are based on figures of total employment. This is partly due to the fact that we do not have a consistent time-series of data on employment covering the entire period of our Plans. We have already referred to the problem of inconsistency between the estimates of work-force as given by the 1951 census, the 1961 census and the National Sample Survey. Regular returns on the strength of the work-force in different activities that are submitted by employers to official agencies like the Directorate General of Employment and Training cover only a small component of the total work-force of the country. A systematic and reliable set of figures on employment in different activities and sectors is thus not available in our country, for the period covered by our Plans.

While the work-force data for different years exclude those who are unemployed, the underemployed component deserves a special consideration. In utilising the figures of work-force for different years for purposes of the present study, we have to keep in mind the varying degree of underemployment in those years. In other words, what we really require is the number of persons who have more or less regular and full-time work of a productive nature in different years.

Similarly the data on engineers that should be used in conjunction with the data on regular and full-time workers need to be adjusted from the point of view of their utilisation. More specifically, since ours is a demand study, the data on the number of engineers in different years should more or less correspond to the demand curve for engineers. In a situation of shortage of engineers, as we had in 1955-56, the employment figures of engineers reflected mainly the supply position and not

so much the demand position, because there were a number of unfilled vacancies of engineers. A similar statement can be made for 1960-61 also, with the difference that the extent of shortage of engineering personnel was probably not so acute in that year as in 1955-56. On the other hand, the year 1964-65 perhaps saw the balancing of demand and supply of engineering personnel in our country and therefore the figures of employment of engineers in that year represent more or less the common point between the supply curve and the demand curve*.

The degree of accuracy of the estimates of engineering manpower requirement for future years based on projections of work-force would depend upon how accurately we can take into account the factor of overall underemployment on the one hand and shortage or surplus of engineering personnel on the other. In countries where future projections of work-force are considered more accurate than future projections of output and investment, the method of estimating demand for engineers on the basis of work-force has naturally been preferred to methods based on output or investment. No such special claim can, however, be made for this method under Indian conditions, since the requisite information base is lacking.

As in the case of estimating engineering manpower requirement based on output and investment, we again have a choice of two methods using employment data for purposes of estimation. The first method would consider the ratio between engineering manpower and total work-force in different sectors of the economy and see how it changes over time. It is noticed, for example, that the ratio of engineers to work-force in each sector of our economy has steadily gone up in our country since 1955-56. We shall discuss other aspects of this ratio in Section X.

The second method would be to establish a regression equation between the number of engineers employed in each sector and the total work-force of that sector at different points of time. Since the figures on employment of engineers in different sectors are available for three years, the only possibility is to fit a regression line to the available data. The results obtained by using this method are summarised in Table 11. It is observed that the total requirement of degree and diploma engineers estimated on the basis of work-force data may go up to 356,000 by 1970-71 and 521,000 by 1975-76.

*The limitations of engineering manpower data discussed in this paragraph, in fact, apply to all studies on demand estimation.

TABLE 11

Estimated total requirements of engineers on the
basis of work-force for the years 1970-71
and 1975-76

Sector	(in thousands)	
	Estimated total requirements of engineers in	
	1970-71	1975-76
1. Mining, manufacturing and utilities	150	239
2. Construction	39	50
3. Transport and communications	24	34
4. Educational services	38	60
5. Govt. administration, trade and commerce and other services	102	135
6. Agriculture	3	3
Total (Degree and diploma holders)	356	521
Total (including engineering practicals)	409	584

SECTION VIII - SECTORWISE COMPARISON OF ESTIMATES:

We have in the preceding sections worked out three sets of estimates of engineering manpower requirements for 1970-71 and 1975-76. The estimates are based on (i) output, (ii) investment and (iii) work-force. In each case we have first worked out the estimates for different sectors and then added them up to get a total figure of requirement of degree and diploma holders. We shall now undertake a comparison of the different estimates. As a first step in this direction, we shall compare the estimates sectorwise.

The three sets of estimates worked out in this paper constitute the only figures available sectorwise for 1970-71. However, for 1975-76 we have a fourth set of sectoral estimates made by the joint project team of the Indian Statistical Institute, the London School of Economics and the Perspective Planning Division of the Planning Commission, to which a reference was made in the opening paragraph of the paper. The specific sectors used in the ISI/LSE/PPD study are slightly different from the ones used in this paper. We have therefore grouped the sectors in such a way as to achieve comparability as far as possible.

A sectorwise comparison of estimates is presented in Table 12 (page 26). For 1970-71, the comparison is between the three estimates worked out in this paper while for 1975-76, the comparison is between four estimates, of which three have been worked out in this paper and the fourth is based on the ISI/LSE/PPD study.

It is noticed from Table 12 that the estimated requirements of engineering degree and diploma holders based on work-force are, for most of the sectors, lower than the corresponding estimates based on output or investment. For the mining, manufacturing and utilities sector, the estimates based on output are considerably higher than those based on investment, while for the educational services, government administration, trade and commerce and other services the estimates based on investment are higher than those based on output. For the remaining three sectors, viz., construction, transport and communications, and agriculture, the differences between the estimates of engineering manpower requirements based on output, investment and work-force are comparatively smaller.

TABLE 12

Sectorwise comparison of estimated requirements of engineering degree and diploma holders worked out on the basis of output, investment and work-force

Sector	(in thousands)						
	Estimated requirements of engineering degree and diploma holders in						
	1970-71 based on			1975-76 based on			
	Out-put	Invest-ment	Work-force	Out-put	Invest-ment	Work-force	ISI/LSE/PPD (regrouped)
1. Mining, manufacturing and utilities	193	163	150	365	279	239	415
2. Construction	45	42	39	70	63	50	125
3. Transport and communications	32	27	24	54	44	34	38
4. Educational services	33	52	38	55	92	60	128
5. Govt. admn., trade and commerce and other services	97	124	102	155	193	135	172
6. Agriculture	3	3	3	4	5	3	-
Total	403	411	356	703	676	521	878

The last column of Table 12 gives the estimates of engineering manpower requirements for the year 1975-76 as worked out by the joint project team of ISI/LSE/PPD and regrouped according to the sectors defined in this study. The specific sectorwise figures as shown in the tables have been calculated by us to make up the total figure of 878,000 engineering degree and diploma holders as given in their paper. These estimates are based on output. It is noticed that for all the sectors other than transport and communications and agriculture, the ISI/LSE/PPD figures are higher than the estimates worked out in this paper on the basis of output.

A further comment on the estimates of engineering manpower requirements for educational services may be made here. Besides calculating these estimates on the basis of output, investment and work-force, we can also use a method based on enrolment of students and pupil-teacher ratio in engineering educational institutions. Accordingly an independent estimate of requirement of engineering teachers has been worked out by us in the light of the programmes for expansion of engineering educational facilities during the Fourth and Fifth Plan periods. In terms of concrete figures, this independent estimate puts the requirements of engineering teachers as 37,000 for the year 1970-71 and 56,000 for the year 1975-76. These estimates are fairly close to the ones based on work-force or output. The estimated requirements of engineering teachers calculated on the basis of investment are higher than these and those calculated in the ISI/LSE/PPD study are still higher.

SECTION IX - GLOBAL LEVEL COMPARISON OF ESTIMATES:

After having compared the estimates sectorwise, we shall now look at the different figures at the global level. The number of estimates available for a global level comparison is quite large; for example, we already have referred to the following in this paper:-

- (i) Totals of the three sets of sectoral estimates worked out in this paper, for 1970-71 as well as 1975-76.
- (ii) Total of the sectoral estimates worked out by the ISI/LSE/PPD for 1975-76.

- (iii) Global estimates worked out by the Working Group on Technical Education and Vocational Training for 1970-71.

It should be added here that the most important global study of engineering manpower requirements for the Fourth and the Fifth Plan periods has been made in a paper prepared jointly by the Planning Commission, the Manpower Directorate and the Ministry of Education. Estimates for 1970-71 and 1975-76 have been made in this paper on the basis of output and investment.

Speaking of global studies we may further say that, following the methodology of sectoral estimates, we have ourselves attempted global estimates based on output, investment and work-force. More specifically, we have applied the regression method at the global level to work out another set of estimates. The regression equations fitted by us at the global level between engineering manpower on the one hand and output or work-force on the other are based on data for each of the ten years, 1955-56 to 1964-65. However, the relationship between engineering manpower and investment had to be calculated on the basis of global level figures for only three years, viz., 1955-56, 1960-61 and 1964-65.

Before making a global level comparison of the various estimates, we may also mention that one more set of estimates has been worked out by us by considering only two broad sectors, viz., agricultural activities and non-agricultural activities. The employment of engineering manpower in agriculture is seen to be less than one per cent of the total. A lumping together of all the non-agricultural sectors into one is, therefore, very much like a global approach. The methodology adopted by us for the non-agricultural field as a whole is similar to the one followed for the other approaches used in this paper, viz., fitting of regression equations. The estimates worked out by us by adding up the figures for the agricultural and the non-agricultural activities may be designated as two-sector estimates to distinguish them from the global estimates on the one hand and multi-sector estimates on the other.

A summary statement of global level comparison of the estimates mentioned in the preceding four paragraphs is presented in Table 13. The statement indicates whether estimates under consideration, sectoral as well as global and worked out by the different organisations, are based on output, investment or work-force. Further, the comparison in the table is made not only for degree and diploma holders but also for the total pool of engineering manpower including engineering practicals.

TABLE 13

Global level comparison of estimated requirements of
engineers worked out by different organisations and
approaches

		(in thousands)					
		Estimated requirements of engineers					
Approach/Organisation	Degree and diploma holders based on			Total (including practicals) based on			
	Out-put	Invest-ment	Work-force	Out-put	Invest-ment	Work-force	
1	2	3	4	5	6	7	
(A. <u>Sectoral</u>							
(Present Paper	403	411	356	456	464	409	
(B. <u>Two-Sector approach</u>							
(Present Paper	395	354	341	448	407	394	
(C. <u>Global</u>							
(1. Present Paper	371	325	333	424	378	386	
(2. Planning Com-							
1970-71 (mission, Directo-							
(rate of Manpower							
(and Ministry of							
(Education	420	422	N. A.	434	436	N. A.	
(3. Working Group	Not	440	450	N. A.	N. A.	N. A.	
(on Technical	worked						
(Education and	out for						
(Vocational	1970-71						
(Training							
(A. <u>Sectoral</u>							
((i) Present Paper	703	676	521	766	739	584	
((ii) ISI/LSE/PPD	878	N. A.	N. A.	N. A.	N. A.	N. A.	
(B. <u>Two-Sector approach</u>							
(Present Paper	694	650	486	757	713	549	
(C. <u>Global</u>							
((i) Present Paper	615	581	470	678	644	533	
((ii) Planning Com-							
1975-76 (mission, Directo-							
(rate of Manpower							
(and Ministry of							
(Education	720	N. A.	N. A.	732	N. A.	N. A.	

We notice from Table 13 that for the year 1970-71, the estimated requirements of engineering degree and diploma holders, as worked out in this paper on the basis of various approaches, are lower than those worked out in the joint paper of the Planning Commission, the Manpower Directorate and the Ministry of Education and also lower than the estimates contained in the report of the Working Group on Technical Education and Vocational Training. Similarly, for the year 1975-76 the estimated requirements of engineering degree and diploma holders, as worked out in this paper on the basis of various approaches, are lower than those worked out in the joint paper of the Planning Commission, the Manpower Directorate and the Ministry of Education and also lower than the estimates given in the ISI/LSE/PPD study.

We may add a few words about the relative magnitudes of the estimates worked out in this paper through (i) the multi-sector approach, (ii) the two-sector approach and (iii) the global approach as based on the projected figures of output, investment and work-force. The estimates worked out through the global approach on the basis of any of the three factors are lower than the estimates worked out through the two-sector approach on the basis of the same factor and these in turn are lower than the corresponding estimates based on the multi-sector approach. Of course, even the multi-sector estimates are lower than all the estimates made by other organisations. In particular, the estimates made in the ISI/LSE/PPD study for 1975-76 are far higher than all the other estimates which are shown in Table 13.

So much about a global level comparison of estimates of engineering degree and diploma holders. Let us now look at the relative magnitudes of the estimated requirements of total engineering manpower, including engineering practicals, as shown in the last three columns of Table 13. The first point to note in this connection is that, besides the estimates of total engineering manpower as worked out in this paper, the only other estimates for the total pool of engineers including practicals, are those contained in the joint paper of the Planning Commission, the Manpower Directorate and the Ministry of Education. The Working Group on Technical Education and Vocational Training and the joint project team of the ISI/LSE/PPD have not given any estimates for engineering practicals.

The second point to note is that the estimates of engineering practicals as used in this paper are higher than those used in the joint paper of the Planning Commission, the Manpower Directorate and the Ministry

of Education. The figures of engineering practicals as used in this paper have already been shown in Table 9 and the position relating thereto is discussed in Section V. As against these, the joint paper of the Planning Commission, the Manpower Directorate and the Ministry of Education has assumed a very small and declining number of engineering practicals for the years covered by our study. Consequently, although the estimated requirements of engineering degree and diploma holders as worked out in this paper are lower than those worked out in the joint paper of the Planning Commission, the Manpower Directorate and the Ministry of Education, the two papers do not show any significant differences in the estimated requirements of the total pool of engineering manpower including engineering practicals.

SECTION X - COMPARISON BETWEEN SINGLE FACTOR AND THREE-FACTOR APPROACHES

We have in the preceding two sections compared a number of estimates, first at the sectoral level and then at the global level. We shall now complete the process of comparison by considering the difference between estimates based on a single factor, say output or investment or work-force, and estimates based on all these three factors.

The main advantage in the three-pronged approach is that it can ensure consistency of important ratios that are basic to the structure of our economy. Considering engineering manpower employment in relation to the three factors, viz., output, investment and work-force, we have a set of six important ratios, viz., (i) output-engineer ratio, (ii) investment-engineer ratio, (iii) engineer-work force ratio, (iv) output per worker, (v) investment per worker, and (vi) investment-output ratio. These six ratios are inter-dependent and each of them can be expressed as a multiplication or division of two other ratios out of the remaining five. The projection of engineering manpower requirement should in fact be viewed as a part of the over-all development of our economic activities. It is necessary, therefore, to ensure that our estimates for the future do not result in giving such values to the factors under consideration as may imply inconsistent ratios.

The study of engineering manpower requirement based on a single factor, say output, will only use one ratio, viz., output-engineer ratio. The same ratio in a study based on three factors, is expressible as a sort of second order ratio, that is a ratio of two of the above-mentioned

ratios. For example, output per worker divided by engineer-work force ratio gives us the output-engineer ratio. Also investment-engineer ratio divided by investment-output ratio gives us the output-engineer ratio. The changes over time that we envisage in the ratio of output to engineer can, therefore, be tested for consistency by looking at values of as many as four other ratios in a study based on three factors.

The use of six ratios referred to above in conjunction with the sectoral approach would be important if values of these ratios differ significantly from sector to sector. With a view to throwing light on this and certain related aspects, the values of these ratios for different time periods are presented in Tables 14 to 19. Figures of engineering manpower used in these tables refer to degree and diploma holders only, and thus exclude engineering practicals. Ratios in which investment is one of the factors have been calculated by considering incremental values over the base year, viz., 1955-56.

We notice from Tables 14 to 16 that the output-engineer ratio, the investment-engineer ratio and the engineer-work-force ratio, differ significantly from sector to sector. Leaving aside agriculture which is a special case as far as engineering manpower employment is concerned, the average value of output-engineer ratio is quite low in construction and educational services and is considerably higher in mining, manufacturing and utilities, transport and communications, and government administration, trade, commerce and other services. The overall trend is quite clear, viz., that output-engineer ratio has gone down in almost every sector between 1955-56 and 1975-76. This was briefly commented on in Section V.

The engineer-work force ratio is higher in construction and educational services than in the remaining sectors. These are the same sectors in which the output-engineer ratio is low as we noticed in the preceding paragraph. This type of inverse relationship is not surprising since the product of the two ratios, viz., output-engineer ratio and engineer-work-force ratio gives us the output per member of the work-force, which according to Table 17 does not show the same degree of differences from sector to sector as the two component ratios show separately. The inverse relationship between the output-engineer ratio and the engineer-work-force ratio is noticed at the global level also. While the output-engineer ratio is seen to decline steadily over time, the engineer-work-force ratio is seen to steadily increase over time. The engineer-work force ratio was briefly commented on in Section VII.

TABLE 14

Output-engineer ratio by sectors, 1955-56 to 1975-76

Sector	(in ten thousands of Rs.)					
	Output-engineer ratio for the year					
	1955-56	1960-61	1964-65	*	1970-71	1975-76
1	2	3	4	5	6	7
1. Mining, manufacturing and utilities	72	55	38	I	26	22
				II	30	29
				III	33	33
2. Construction	17	15	14	I	14	13
				II	15	14
				III	16	18
3. Transport and communications	92	61	59	I	48	45
				II	57	55
				III	64	72
4. Educational services	30	19	13	I	13	12
				II	8	7
				III	11	11
5. Govt. administration, trade and commerce and other services	104	81	75	I	67	63
				II	53	50
				III	64	72
6. Agriculture	11,720	6,890	4,973	I	3,020	2,718
				II	3,020	2,174
				III	3,020	3,623
Total	148	107	82	I	57	46
				II	56	48
				III	65	63

Source: Tables 1, 4 5 and 12.

*I- Refers to the estimated requirements of engineering degree and diploma holders on the basis of output.

II- Refers to the estimated requirements of engineering degree and diploma holders on the basis of investment.

III- Refers to the estimated requirements of engineering degree and diploma holders on the basis of work-force.

TABLE 15

Investment-engineer ratio by sectors, 1960-61 to 1975-76*

Sector	(in ten thousands of Rs.)				
	Investment-engineer ratio for the period between 1955-56 and				
	1960-61	1964-65	**	1970-71	1975-76
1	2	3	4	5	6
1. Mining, manufacturing and utilities	153	118	I	92	83
			II	112	111
			III	124	132
2. Construction	140	135	I	122	117
			II	134	134
			III	150	181
3. Transport and communications	282	311	I	251	248
			II	308	312
			III	357	420
4. Educational services	27	25	I	40	42
			II	24	24
			III	34	38
5. Govt. administration, trade and commerce and other services	30	37	I	63	90
			II	45	63
			III	59	76
6. Agriculture	2,584	3,040	I	2,854	3,299
			II	2,854	2,566
			III	2,854	4,618
Total	125	120	I	119	110
			II	116	115
			III	139	155

Source: Tables 2, 4, 6 and 12.

* The average values of investment-engineer ratio have been calculated by considering increments over the base year, viz., 1955-56.

** I - Refers to the estimated requirements of engineering degree and diploma holders on the basis of output.

II - Refers to the estimated requirements of engineering degree and diploma holders on the basis of investment.

III - Refers to the estimated requirements of engineering degree and diploma holders on the basis of work-force.

TABLE 16

Engineer-workforce ratio in different sectors of the economy,
1955-56 to 1975-76

Sector	Engineers per 10,000 workers in					
	1955-56	1960-61	1964-65	*	1970-71	1975-76
1	2	3	4	5	6	7
1. Mining, manufacturing and utilities	13.74	20.10	33.06	I	71.75	114.06
				II	60.59	87.19
				III	55.76	74.69
2. Construction	87.84	100.00	108.87	I	136.36	170.73
				II	127.27	153.66
				III	118.18	121.95
3. Transport and Communications	21.74	33.33	36.79	I	59.26	75.00
				II	50.00	61.11
				III	44.44	47.22
4. Educational services	30.30	67.61	97.83	I	104.76	127.91
				II	165.08	213.95
				III	120.64	139.53
5. Govt. administration, trade and commerce and other services	13.50	18.88	21.62	I	25.00	32.98
				II	31.92	41.06
				III	26.25	28.72
6. Agriculture	0.04	0.08	0.12	I	0.23	0.30
				II	0.23	0.37
				III	0.23	0.22
Total	4.79	7.65	11.05	I	19.48	30.67
				II	19.86	29.49
				III	17.21	22.73

Source: Tables 3, 4, 7 and 12.

*I - Refers to the estimated requirements of engineering degree and diploma holders on the basis of output.

II - Refers to the estimated requirements of engineering degree and diploma holders on the basis of investment.

III - Refers to the estimated requirements of engineering degree and diploma holders on the basis of work-force.

TABLE 17

Output per worker by sectors, 1955-56 to 1975-76

Sector	(in Rupees)				
	Output per worker in				
	1955-56	1960-61	1964-65	1970-71	1975-76
1	2	3	4	5	6
1. Mining, manufacturing and utilities	992	1,100	1,251	1,840	2,509
2. Construction	1,486	1,500	1,573	1,878	2,241
3. Transport and communications	2,000	2,033	2,155	2,852	3,389
4. Educational services	773	1,296	1,304	1,333	1,488
5. Govt. administration, trade and commerce and other services	1,350	1,526	1,628	1,678	2,072
6. Agriculture	493	570	602	701	808
Total	707	817	902	1,116	1,423

Source: Tables 1, 3, 5 and 7.

TABLE 18

Investment per worker by sectors, 1960-61 to 1975-76*

Sector	(in Rupees)			
	Investment per worker for the period between 1955-56 and			
	1960-61	1964-65	1970-71	1975-76
1	2	3	4	5
1. Mining, manufacturing and utilities	18,345	20,267	21,056	22,651
2. Construction	18,885	18,900	21,412	25,561
3. Transport and communications	21,429	18,591	21,890	24,833
4. Educational services	4,747	4,653	6,372	7,168
5. Govt. administration, trade and commerce and other services	1,553	1,547	2,499	3,172
6. Agriculture	5,168	5,333	6,486	7,083
Total	7,500	7,314	9,167	10,653

Source: Tables 2, 3, 6 and 7.

* The average values of investment per worker have been calculated by considering increments over the base year, viz., 1955-56.

TABLE 19

Investment-output ratio by sectors, 1960-61 to 1975-76*

Sector	(in Rupees)			
	Investment per unit of output for the period between 1955-56 and			
	1960-61	1964-65	1970-71	1975-76
1	2	3	4	5
1. Mining, manufacturing and utilities	6.5571	6,5165	5.0893	4.6013
2. Construction	12.2750	11,1176	9,9923	9.7058
3. Transport and communications	9,4000	7.7722	6.2833	6.1455
4. Educational services	1,9636	2.6333	3.8867	4.1077
5. Govt. administration, trade and commerce and other services	0.6768	0.7031	1.2277	1.1942
6. Agriculture	1.2544	1.9000	2.2297	2.3046
Total	2.6575	2.9716	3.3683	3.2681

Source: Tables 1, 2, 5 and 6.

* The average values of investment per unit of output have been calculated by considering increments over the base year, viz., 1955-56.

The investment-engineer ratio is seen to be quite low in educational services, government administration, trade, commerce and other services. Considerably higher values of this ratio are noticed in the remaining sectors. Agriculture again is a special case. A point which distinguishes the values of investment-engineer ratio from those of the other two ratios (viz., output-engineer ratio and engineer-work force ratio) is that while the other two ratios have a clear trend over time, either upward or downward, the investment-engineer ratio does not have such a clear trend over time. Reference may be made to Section VI in this connection.

So much about the ratios in which engineering manpower is one of the variables. Tables 17 to 19 give values of ratios which involve output, investment and work-force but not engineering manpower. We have already commented briefly on the average values of output per worker in different sectors. We shall make only three more comments here. First, there is an affinity in the way the two ratios, viz., investment per worker and investment-output ratio differ from sector to sector. The values of these two ratios are quite low in educational services, government administration, trade, commerce and other services and agriculture. Considerably higher values of both these ratios are noticed in construction, transport and communications, and mining, manufacturing and utilities. Secondly, the investment-output ratio as worked out by us is fairly close to the normally accepted value of 3.0 at the global level although it differs considerably from sector to sector. Thirdly, the average values of investment per worker, as per our calculations, show a rising trend over time in almost all the sectors, although the rate of growth differs considerably from sector to sector.

SECTION XI - CONCLUDING REMARKS:

The objectives of the present study, as set out in Section II, can be expressed as seeking answers to three questions, viz., (i) How far is a sectoral study for estimating requirement of engineering manpower feasible in the context of the information available in our country? (ii) If a sectoral study is feasible, how do the results obtained by such a study compare with those obtained from global studies? (iii) How do the results obtained from a three-pronged approach based simultaneously on output, investment and work-force compare with those based on a single factor approach? We shall summarise in this section the answers that can be given to these questions on the basis of the study made in this paper.

First, we observe in the light of the results presented in this paper that while there are various difficulties and limitations in the way of carrying out a sector-wise study for the estimation of requirement of engineering manpower, it is a worthwhile and feasible attempt. The main problem in the sectoral study arose from the paucity of data, since engineering employment figures in respect of different sectors were available for only selected years during the period 1955-56 to 1964-65. In the course of the next few years, when further data on engineering manpower employment will be available for different sectors, a definite improvement over the results of the present study should be expected, since the relationship would then depend on a larger number of points as compared to only three points in the present study. Of course, an element of caution would still be necessary because data for all these years will have to be on a comparable basis.

Secondly, a comparison of the results obtained from sectoral and global studies has brought to light the relative strength and weakness of the two approaches, indicating the need of checking the findings of the one with the help of the other. Conceptually, the superiority of the sectoral approach over the global approach is unquestionable, since the various sectors of the economy have widely different characteristics as far as engineering manpower employment and related factors are concerned. Not only do important ratios like output-engineer, ratio, investment-engineer ratio and engineer-work force ratio differ significantly from sector to sector, the rates of growth of various sectors over time, as measured in several possible ways, are also quite different. However, the statistical problems that the sectoral approach faces are more difficult than the ones encountered in the global approach. This is mainly because global level estimates of engineering manpower employment are available for a larger number of years than sector-wise figures. In view of this it seems advisable to carry out both the global and the sectoral studies and not to depend solely on only one of them.

Thirdly, the present study points out the importance of basing estimates of engineering manpower requirements on output, investment and work-force rather than on any one of these factors. The use of three factors in conjunction with engineering manpower employment makes it possible to consider values of six important ratios and thus to check the consistency of projections with the economic system as a whole. As against this, a single factor study would be based on only one of the six

ratios and hence involve the risk of making projections which are out of tune with development in the factors left out of consideration.

At this stage, we may raise a point that the use of the sectoral approach and of the three factors would bring out the full advantages only if the three factors occur in a single relation and not separately as in the ratios considered in this paper. This in fact suggests the importance of adopting the production function approach to our problem. The Cobb-Douglas formulation expressed output as a function of investment and work-force for manufacturing industries. The modification suggested therein by Prof. Solow introduces what is now commonly called as the residual factor. From the manpower angle, it is important to introduce one more generalisation in the production function by treating the work-force not as a homogeneous entity but as a combination of significant components. Such a generalised production function with manpower orientation is expected to make a significant contribution to an understanding of the relationship between engineering manpower, output, investment and work-force. We propose to present some results on these lines in a subsequent paper.

Finally, we may raise a question as to which of the various possible estimates of engineering manpower requirements is to be preferred for policy formulation. To answer this question in a more definitive way than has been done in this paper, it is necessary to make a deeper study of the various issues raised in the paper as also to consider the possibility of studying the problem with more precise data covering a longer period of time. This being the first attempt in our country to combine the sectoral approach with a three-factor analysis, a good deal of spade work had to be done to prepare the basic material and tools for the study.

While formulating manpower policies and programmes, the overall economic climate of the country is of great significance. Periodical surveys on shortages and surpluses indicate the type of imbalances that we have at particular points of time. The extent to which we utilise our engineering personnel in different occupations also imparts a degree of flexibility to estimates of demand and supply. The availability of engineering practicals other than the graduates and diploma holders is also a point for consideration.

At this stage we may be content with the observation that the estimated requirements of engineering manpower made through different sectoral approaches in this paper are lower than all the other estimates made so far by different organisations. This underlines the

need for caution and more studies in depth before any of the other estimates are accepted as a basis for any policy or programme regarding engineering manpower. It is true that even the sectoral approach based on output, investment and work-force has given estimates which differ from one another. Part of the difference is likely to be explained when more studies on the points raised in the paper are carried out and some of the shortcomings of existing data are overcome. The availability of additional data relating to the Fourth and the Fifth Plans would enable a further refinement of methodology and impart greater confidence to the results of the study.

APPENDIX

A list of selected studies of engineering manpower requirements made in India during 1956-66

1. Planning Commission : Report of the Engineering Personnel Committee, New Delhi, 1956.
2. Planning Commission : Report of the Working Group on Technical Education and Vocational Training, New Delhi, 1960.
3. Institute of Applied Manpower Research : Working Paper No. 7/1963 - Engineering Manpower : Analytical Review of Demand Forecast Methodology and Provisional Forecast of Growth (Parts I and II), New Delhi, 1963.
4. Institute of Applied Manpower Research : Report No. 2/1965 - Second Report on Engineering Manpower Survey - Demand and Supply of Engineering Manpower (1961-1975), New Delhi, 1965.
5. Indian Statistical Institute (Planning Unit), London School of Economics (Unit for Economic and Statistical Studies on Higher Education), Planning Commission (PPD) : Manpower and Educational Development in India (1961-1986) with Annexure - Memorandum from the Joint Project Team submitted to Education Commission, 1965.
6. Ministry of Education : Report of the Education Commission, 1964-66 - Education and National Development, New Delhi, 1966.
7. Planning Commission (Education Division), Ministry of Education and Directorate of Manpower, Ministry of Home Affairs : Technical Education in the Fourth Plan - Approach and Tasks (Discussed at the conference of Education Ministers at Madras in June, 1966).

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 - educational preparation for employment;
 - vocational guidance;
 - identifying and developing highly talented persons;
 - forecasting demand and supply of manpower and connected matters.