Report

MM-82

E

The supply of and demand for engineers in 1987

1981

Human Sciences Research Council

S.A. Institute for Manpower Research

RGN·HSRC

HUMAN SCIENCES RESEARCH COUNCIL
RAAD VIR GEESTESWETENSKAPLIKE NAVORSING

Private Bag X41
Pretoria
Republic of South Africa
0001
Telegrams RAGEN
Tel. (012) 28-3944
Telex 3-0893

Privaatsak X41
Pretoria
Republiek van Suid-Afrika
0001
Telegramme RAGEN
Tel. (012) 28-3944
Teleks 3-0893

Institutes

S.A. Institute for Communication Research (SAICR)
S.A. Institute for Educational Research (SAIER)
S.A. Institute for Historical Research (SAIHR)
S.A. Institute for Languages, Literature and Arts (SAILLA)
S.A. Institute for Manpower Research (SAIMAR)
S.A. Institute for Psychological and Psychometric Research (SAIPPR)
S.A. Institute for Research Development (SAIRD)
S.A. Institute for Sociological, Demographic and Criminological Research (SAISDCR)
S.A. Institute for Statistical Research (SAISR)

National Programmes

HSRC Sports Investigation
HSRC Investigation into Education

...istration

...Research Support
...SS)

...SRC

...nd co-ordinates research in
...rnment and other bodies
...nd disseminates infor-

Institute

S.A. Instituut vir Geskiedenisnavorsing (SAIGN)
S.A. Instituut vir Kommunikasienavorsing (SAIKN)
S.A. Instituut vir Mannekragnavorsing (SAIMAN)
S.A. Instituut vir Navorsingsontwikkeling (SAINO)
S.A. Instituut vir Opvoedkundige Navorsing (SAION)
S.A. Instituut vir Psigologiese en Psigometriese Navorsing (SAIPPN)
S.A. Instituut vir Sosiologiese, Demografiese en Kriminologiese Navorsing (SAISDKN)
S.A. Instituut vir Statistiese Navorsing (SAISN)
S.A. Instituut vir Taal, Lettere en Kuns (SAITALEK)

Nasionale Programme

RGN-Sportondersoek
RGN-Ondersoek na die Onderwys

Administrasie

Buro vir Ondersteunende Navorsingsdienste (BOND)

Funksie van die RGN

Die RGN onderneem, bevorder en koördineer navorsing op die gebied van die geesteswetenskappe, dien die Regering en ander instansies van advies insake die benutting van navorsingsbevindinge en versprei inligting betreffende die geesteswetenskappe.

HUMAN SCIENCES RESEARCH COUNCIL

THE SUPPLY OF AND DEMAND FOR ENGINEERS IN 1987

JOYCE VAN PLETZEN, B.Com. (Hons.)

Translated from Afrikaans by Mr C.P. Kleyn

SOUTH AFRICAN INSTITUTE FOR MANPOWER RESEARCH

ACTING DIRECTOR: S.S. TERBLANCHE

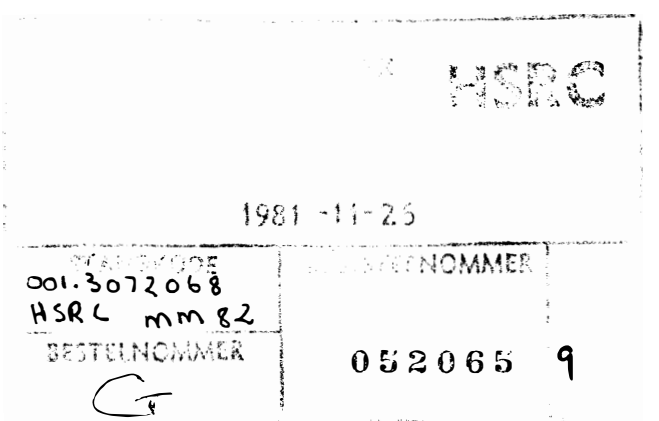
PRETORIA
1981

Report No. **MM-82**

Beskikbaar in Afrikaans

Price: R3,20
(GST included)

ISBN 0 86965 785 2
(Afrikaanse uitgawe ISBN 0 86965 784 4)



PREFACE

The engineer plays a unique role in the general development of any country, and the availability of sufficient engineers is of national importance. Consequently studies on the supply and demand situation in key professions (such as that of engineer) are important because problems that may develop in future in the supply situation, are anticipated and identified. In this way a contribution is made towards combatting the problem.

In a country where most people are free to choose their occupations within the limits of their abilities, manpower planning on national level is to a large extent based on the sensible choice of a well-informed citizenry. A large amount of informa= tion from a variety of sources is contained in the report, and a contribution is made towards manpower planning by the dissemination of information, whether the particular estimates presented are agreed with or not.

We thank the Bureau for Research Support Services for editing the report.

ACTING DIRECTOR
July 1981

CONTENTS

TABLES

FIGURES

SUMMARY

The estimates of demand are based on the economic growth target of the most recent Economic Development Programme for 1978-1987. The supply was determined by

(a) making an estimate of the section of the engineers of 1979 that will still be working as engineers in 1987, and

(b) by making projections of graduation tendencies.

The realism of these estimates as training-target is discussed on the basis of a number of exogenous variables.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND AND AIM

In his *Essay on the principle of population as it affects the future improvement of society* (1789) Thomas Malthus said that the population of the world was showing a geometrically rising growth tendency and that unless this tendency was kept in bounds by factors such as wars, diseases and birth control, the constant increase in food production would eventually be insufficient to feed the growing population. Malthus' prophecy of doom has not been realized mainly because of the far-reaching effect of the technological innovation which even in the 19th century caused rapid expansion of the boundaries of production potential in all fields. This innovation led to an improvement in the standard of living of many people despite the population increase resulting from the progress in the medical field (Samuelson, 1967, p. 31).

Technological advances have subsequently become increasingly important for the well-being of the industrialized world. Freeman (1972, p.35) stated that long-term economic growth depended almost entirely on the expansion of technological skill. Although extensive theoretical as well as empirical research points to a strong relation between technology and economic development (OECD, 1974), the precise nature and direction of this relation has not been finally established. There is even more uncertainty about the role of basic science in technological change and economic growth, especially with regard to the extent to which use should be made of imported technology, as opposed to the quantity of natural resources and energy that should be made available for local research and development.

Twentieth century technology is science-oriented to a very large degree and it is expected that important technological developments in the future will increasingly be the result of scientific breakthroughs. Developed and, more specifically, underdeveloped countries should therefore maintain a certain minimum level of education and training in a wide spectrum of scientific and technical fields. In this regard research is essential and an important role is played by natural scientists, as experts on basic scientific principles, and engineers - as those who fashion and use technology.

Although the precise nature and direction of the relation between technology and science cannot be determined, it is clear that the provision of sufficient trained engineers and natural scientists is an important factor in economic development. Supply and demand studies on engineers and other natural scientists can therefore contribute towards the early identification of problem areas concerning supply.

The aim of this study was to form an estimate of the expected supply of and demand for engineers for 1987. The methods and assumptions underlying the estimates in the report are explained fully in the course of the report. It is necessary, however, to state a general principle in this regard at this stage: The estimate of the demand for labour in the Economic Development Programme (EDP) (1978-1987) served as the basis for estimating the demand for engineers. This means that the implications of a 4,5 % growth in the Gross Domestic Product for the increase in the demand for engineers were investigated on the assumption that the tendencies of the past will continue. As it is assumed that the tendencies will continue, the estimates do not attempt to predict the actual position in 1987 but to obtain an idea of the situation towards which we are moving.

1.2 FORM OF THE REPORT

In Chapter 2 the demand for engineers in 1987 is estimated according to economic sector and engineering branch on the basis of the EDP (1978-1987) and by using data from the Manpower Surveys of the Department of Manpower Utilization as well as from the biennial HSRC salary surveys. Chapter 3 deals with the supply of engineers in 1987 on the basis of the estimated size of the engineering corps in 1979. The implications of these estimates of supply and demand for the training of engineers are discussed in Chapter 4 while Chapter 5 contains the conclusions and recommendations based on the analyses.

CHAPTER 2

THE DEMAND FOR ENGINEERS IN 1987

2.1 INTRODUCTION

The overall demand for manpower according to economic sector, as estimated by the EDP for 1987, serves as the basis for estimating the demand for engineers in 1987. This EDP differs from previous development programmes in its approach and the implications of this must be fully understood: "Instead of an investigation into the income and expenditure implications of alternative growth rates in the economy, the EDP approach now consists of an investigation of expected, actual economic prospects over the medium as well as the longer term, based on past experience as well as projections of the most likely development of certain economic magnitudes that will have an important effect on the actual course taken by the economy" (EDP, Volume I, p. 4) (Translation).

As far as the labour sector is concerned "an indication is given of the possible quantitative impact that macrofiscal and macromonetary policy measures will have on the supply of and demand for labour" (EDP, Volume 1, p. 5) (Translation).

In the development programme for 1987 the expected course of long-term economic growth is studied according to three possible policy strategies. The first (Scenario I) is a "control simulation" and represents the minimum level of economic growth. This simulation is based on the assumption that the existing economic structure and government policy will remain unchanged, except with regard to government expenditure where a growth rate lower than the increase in the available inland resources is presumed. An expected growth in the actual GDP of an average of 3,6 % per annum is implied by this policy.

Since the curtailed government expenditure according to Scenario I did not appear to ensure adequate growth, the possible effect of further policy measures had to be determined. As with Scenario I, the assumption with the implementation of the second (Scenario II) was that current expenditure as well as capital expenditure by the public sector would grow at an average rate of 3,5 and 1,5 %. Certain tax adjustments were also presumed. Assumptions were also made with regard to monetary, rate of exchange and trade policy (there were no additional measures to encourage import substitution). An expected growth rate of 4,5 % per annum is envisaged by this policy packet.

Further policy measures to stimulate exports were taken into account in the third strategy (Scenario III), with a consequent expected growth of 5 % in the real GDP.

The projections envisaged by the Scenario II, with an implied annual growth of 4,5 %, are further analyzed in the sectoral development programme as it was found that

the concurrent implementation of these (Scenario II) policy adjustments implied a growth rate that can be reasonably achieved in the economy (EDP, Volume I, p. 38). These projections form the basis for further analyses of the demand for engineers in 1987.

Table 2.1 shows the expected overall demand for labour in 1987 as estimated by the EDP and summarized according to eight economic sectors. Agricultural and domestic service workers are not included.

TABLE 2.1

THE OVERALL DEMAND FOR MANPOWER ACCORDING TO ECONOMIC SECTOR FOR 1987

Economic sector	Demand for manpower in 1987
Mining	787 900
Electricity, gas and water supply	94 600
Building and construction	746 800
Manufacturing	1 622 400
Commerce	1 192 900
Transport and communication	562 900
Services and finance	677 100
Government services	1 320 200
TOTAL	7 004 800

2.2 ESTIMATE OF THE SECTORAL DEMAND FOR MANPOWER ACCORDING TO OCCUPATIONAL GROUP

To form an estimate of the demand for manpower according to occupation, use is made mainly of the Manpower Surveys of the Department of Manpower Utilization. These surveys have been undertaken biennially since 1965 on a reasonably comparable sample basis. Employers in 38 sectors (into which the economy is divided for the purposes of the surveys) have to indicate the number of employees they have in their service in a particular occupation at a specific time (see Appendix A for a list of the 38 sectors).

For the purposes of this study the 38 sectors were grouped together to form 28 sector groups and the approximately 800 occupations for which provision is made in the surveys were classified into 22 occupational groups (see Appendix A and B). Information on the number of servants in private households and persons employed in agriculture and farming activities, is not supplied in the Manpower Surveys and is therefore not represented in these occupational groups. The numbers of hunters, fishermen and farmers mentioned in the Manpower Surveys as well as the persons employed in the fishing industry, were not taken into consideration for the purposes of this project. Figures

for 1979 do not include Transkei, Bophuthatswana and South West Africa but this will make little difference to the occupational structure.

The percentage composition according to occupational group of every economic sector for every survey (1965, 1967, 1969, ... 1977, 1979) was calculated so as to form a time series of eight points for each of the 22 occupational groups in each of the 28 sectors. In calculating the percentage component of every occupational group, men as well as women of all population groups were taken into account without a distinction being made between the sexes.

In an attempt to eliminate the fluctuations in the percentages over time, use was made of a method based on the principle of moving averages. The percentages for the years in which no Manpower Surveys were conducted (the interim years) were first calculated as the arithmetic mean of the percentages in the preceding and succeeding base years. These percentages were then used in the same way to adjust the percentages in the base years (from the Manpower Surveys). In this way a time series of 15 points was built up for every occupational group in each of the economic sector groups.

A modified exponential curve ($y = ab^X + c$) was adapted to each of these calculated time series by means of the method of ordinary least squares, and by extrapolation projections were made for 1987 of the percentage component of each occupational group in each sector. The percentages for every economic sector were adjusted so that jointly they came to a total of one hundred. The projected percentage composition of every sector was subsequently applied to the EDP estimate of the overall demand for manpower in the specific sector and the demand for manpower calculated according to occupational group and economic sector for 1987. The estimates of the occupational structure changes made in this way are conservative, since all trends are levelled off.

2.3 ESTIMATE OF THE DEMAND FOR ENGINEERS AND METALLURGISTS ACCORDING TO ECONOMIC SECTOR

One of the occupational groups for which an estimate is made of the expected demand in 1987, is that of engineers/metallurgists.

The demand for engineers and metallurgists is shown according to eight main economic sectors: mining (Sectors 1 to 3 of the sector group classification for demand estimate - Appendix A); building and construction; electricity, gas and water supply; manufacturing (Sectors 5 to 23); commerce; transport and communication; diverse services and financing, and government services. The numbers of engineers and metallurgists employed in each of the eight economic sectors - expressed as percentages of the total labour force in the specific sectors - are shown in Table 2.2 for 1965 to 1979 with the projections for 1987. Figures for the manufacturing and mining sectors were calculated simply by adding together the specific subsectors (1 to 3 and 5 to 23 respectively) and

TABLE 2.2

THE DEMAND FOR ENGINEERS AND METALLURGISTS ACCORDING TO ECONOMIC SECTOR, 1965-1979, WITH PROJECTIONS FOR 1987

Economic sector		Base period								Target year
		1965	1967	1969	1971	1973	1975	1977	1979	1987
Mining	%	0,08	0,09	0,14	0,20	0,14	0,16	0,13	0,12	0,16
	N	460	524	838	1 365	927	1 011	840	848	1 253
Electricity, gas and water supply	%	2,17	1,93	1,61	1,20	1,21	1,47	1,23	1,11	1,11
	N	919	889	852	699	825	1 139	910	1 022	1 051
Building and construction	%	0,35	0,43	0,43	0,36	0,35	0,50	0,43	0,56	0,54
	N	646	1 146	1 357	1 458	1 407	2 248	1 983	2 360	4 047
Manufacturing	%	0,27	0,29	0,33	0,37	0,30	0,34	0,32	0,40	0,40
	N	2 489	2 926	3 584	4 512	3 882	4 695	4 770	5 524	6 484
Commerce	%	0,11	0,10	0,11	0,07	0,04	0,11	0,08	0,10	0,08
	N	588	516	593	444	282	768	608	712	961
Transport and communication	%	0,25	0,26	0,30	0,28	0,26	0,27	0,26	0,26	0,27
	N	842	905	1 056	1 130	1 047	1 152	1 232	1 275	1 500
Diverse services and finance	%	0,47	0,61	0,46	0,56	0,58	0,55	0,61	0,44	0,54
	N	1 566	2 168	1 825	3 122	3 026	3 197	3 695	2 749	3 658
Government services	%	0,28	0,23	0,23	0,26	0,21	0,22	0,24	0,25	0,23
	N	1 332	1 273	1 379	1 626	1 456	1 737	2 012	2 058	3 047
TOTAL	%	0,26	0,28	0,29	0,31	0,27	0,32	0,30	0,31	0,31
	N	8 842	10 347	11 484	14 356	12 852	15 947	16 050	16 548	22 001

calculating percentages for the different years. Table 2.2 is therefore a summary of the results obtained for engineers by applying the methods described in Paragraph 2.2.

The percentage demand for engineers in the eight economic sectors is graphically represented in Figure 2.1(a). Figure 2.1(b) shows the corresponding percentages for each year (1965 to 1979), calculated by applying the modified exponential curve to the time series and by making new estimates for the observed percentages with the parameters estimated in this way. The graphic representation therefore in fact indicates the form of the exponential curve and through that the general trend of the percentage demand for engineers according to economic sector.

Since 1973 it has been specified in the job titles of engineers in the Manpower Surveys that only professionally qualified engineers should be included in the specific categories. The effect of this additional requirement can be seen in the decrease in the percentages and numbers between 1971 and 1973, except in the mining and manufacturing sectors. Despite this requirement, however, there has been a marked increase in the number of engineers since 1975.

An analysis of the adjusted demand for engineers and metallurgists (Figure 2.1 (b)) shows that the projections for 1987 do not imply drastic structural changes in the occupational classification. The total percentage demand for engineers and metallurgists is in fact the same as for 1979, although the actual figures for 1979 and 1987 naturally differ.

The projected demand for engineers and metallurgists must be assessed against the background of the sectoral predictions of the EDP. Some comments are therefore made in this regard.

(a) According to projections the demand for engineers and metallurgists in the mining sector will grow at an annual rate of 4,1 % during the period 1977 to 1987. If it is taken into consideration that the EDP expects the downward trend in employment figures that has been experienced in this sector since the early seventies to continue, the growth in the demand for engineers is particularly high. This phenomenon can be ascribed to the increasing use of advanced technology which necessitates the employment of more engineers.

(b) Despite expectations that the demand for electricity will increase, the EDP envisages that this sector will not make any significant contribution towards alleviating the unemployment problem and consequently that employment will remain fairly constant. This trend is also reflected in the historical course and in the projection of the demand for engineers and metallurgists which shows an almost constant downward trend. The average annual growth in this sector for the period 1977 to 1987 (1,5 %) is

TABLE 2.1(a)

THE DEMAND FOR ENGINEERS AND METALLURGISTS AS A PERCENTAGE OF THE TOTAL LABOUR FORCE, IN EVERY ECONOMIC SECTOR, 1965-1979 (OBSERVED VALUES)

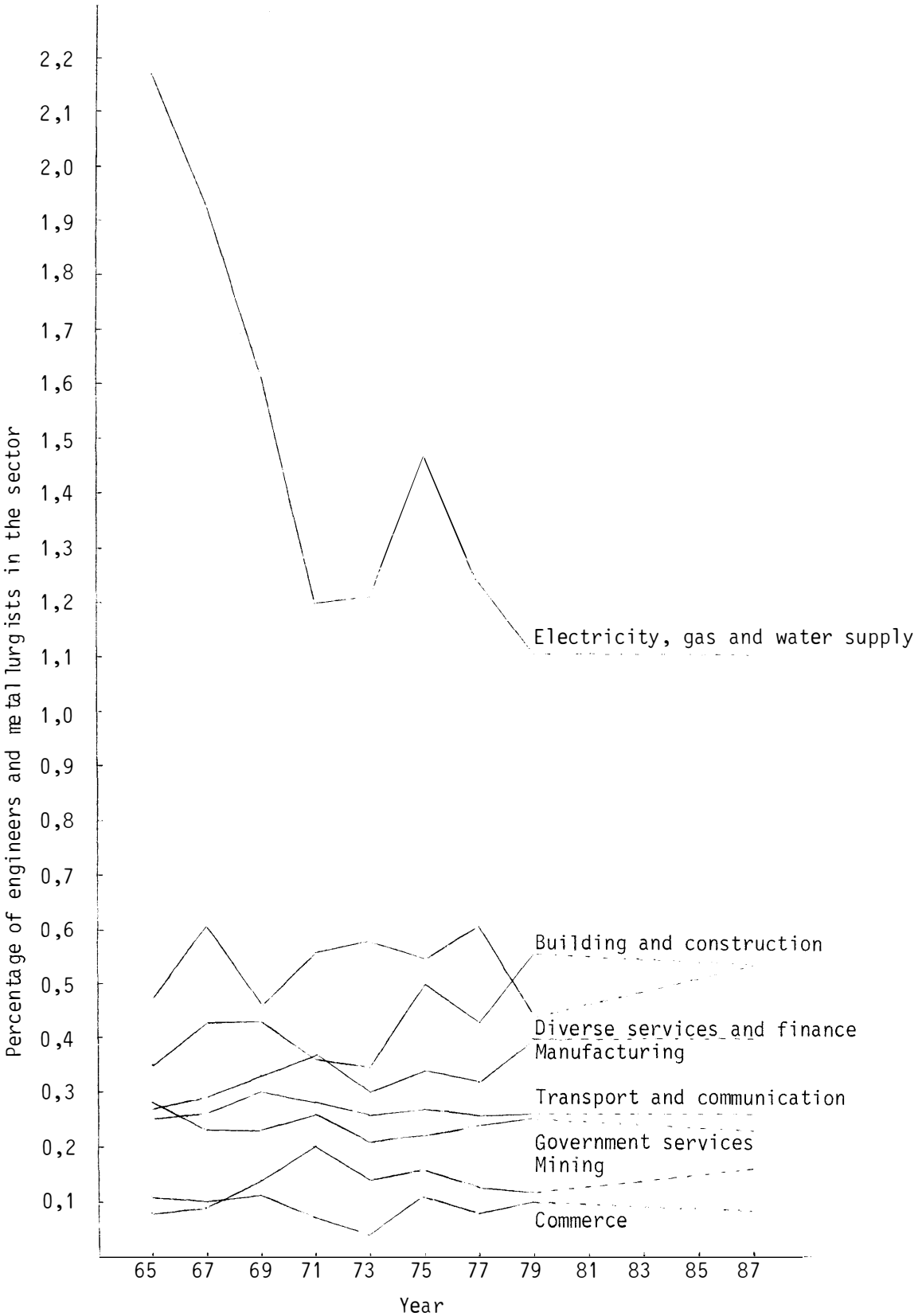
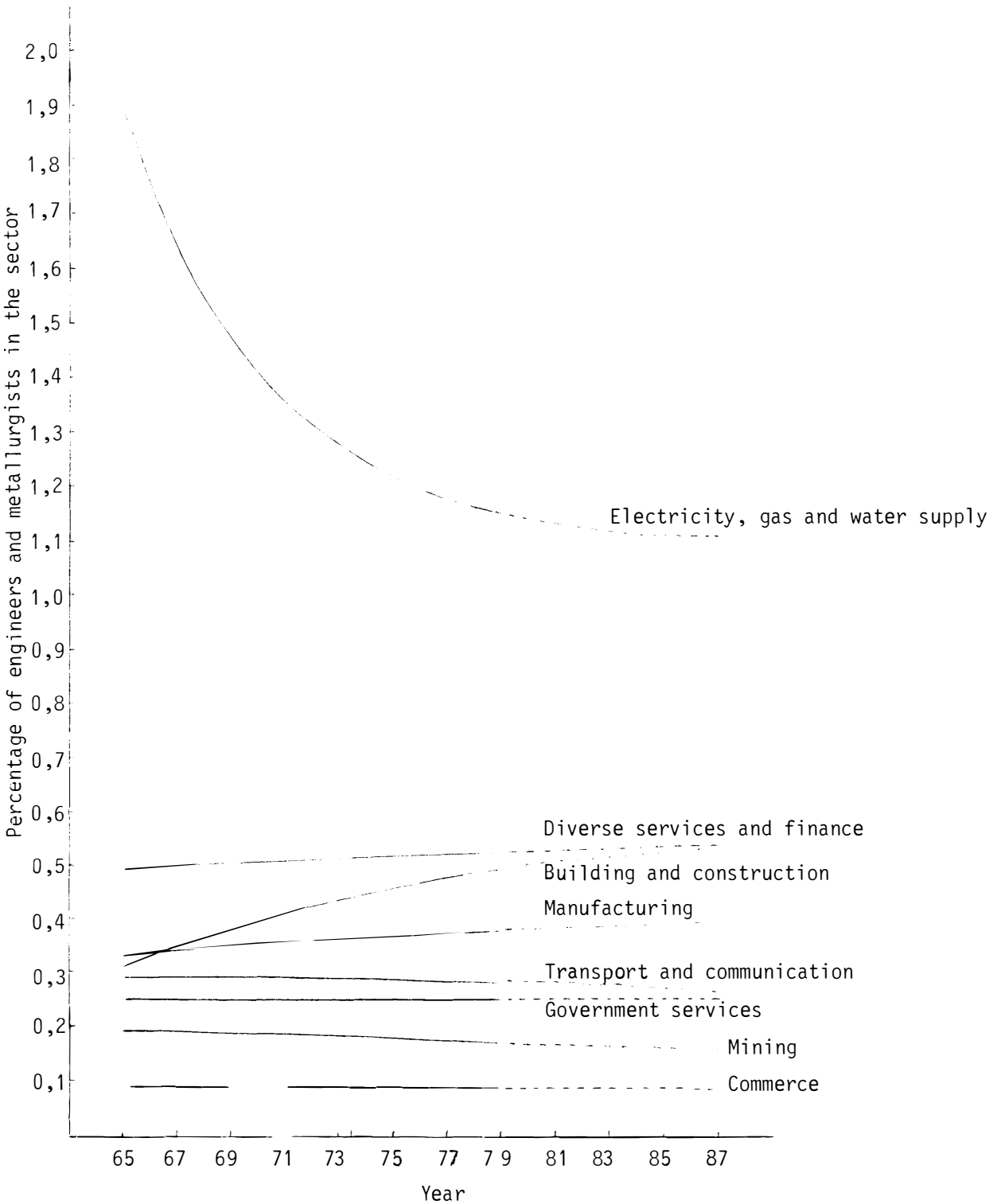


FIGURE 2.1(b)

THE DEMAND FOR ENGINEERS AND METALLURGISTS AS A PERCENTAGE OF THE TOTAL LABOUR FORCE, IN EVERY ECONOMIC SECTOR, 1965-1979, WITH PRO= JECTIONS FOR 1987 (CALCULATED VALUES)



also considerably lower than the average annual growth of 3,2 % in the overall demand for engineers.

(c) The EDP expects, with regard to employment in the manufacturing sector, that employment growth for the programming period (2,3 % per annum for 1977 to 1987) will be slower than for the previous period (3,3 % per annum for the period 1967 to 1977). Although the demand for engineers and metallurgists as a percentage component and in numbers is increasing consistently, the expected growth in this demand during the projection period (3,1 % per annum) is also lower than the growth rate of 5,1 % per annum achieved during the period 1967 to 1977.

(d) The building and construction industry is to a large extent dependent on real government expenditure. After an upsurge in this industry during the early seventies, the drastic curtailment of government expenditure had a negative effect on building and construction activities. It is unlikely that government expenditure on the building and construction industry will in the near future reach the same level as before and the EDP consequently predicts a decline in this industry's contribution to the GDP. The ten-year average percentage component of the construction industry in the secondary sector with regard to contribution to the GDP will drop - according to the EDP - from 14,7 % for 1967 - 1977 to a projected 13,2 % for 1977 - 1987 (EDP, Volume I, p. 52). A decreasing percentage component from 31,5 % to 30,5 % is also projected with regard to total employment for the same periods. According to Table 2.2 a growth of 7,4 % in the demand for engineers and metallurgists in the construction industry is projected for 1977 - 1987, after the demand had increased at 5,6 % between 1967 and 1977.

(e) An average increase of 3,2 % per annum in the overall demand for engineers and metallurgists is projected for the period 1977 to 1987. This is higher than the expected increase of 2,7 % per annum in the overall demand for manpower for the same period and can be ascribed to the growing importance of the role of engineers and metallurgists in technological and thus economic development.

In the manufacturing industry mainly electrical, mechanical and chemical engineers are involved in the manufacture of pharmaceutical, chemical and petroleum products, non-metalliferous mineral products and basic and processed metal products, while civil engineers are employed mainly in the building and construction industry. A further analysis according to engineering branch is undertaken to provide a clearer picture of the demand for engineers.

2.4 ESTIMATE OF THE DEMAND FOR ENGINEERS ACCORDING TO ENGINEERING BRANCH AND ECONOMIC SECTOR

The method for estimating the demand for engineers in 1987 according to engineering branch has two stages. First, the demand for metallurgists in 1987 is estimated and subtracted from the total sectoral demand for engineers and metallurgists esti-

mated in Paragraph 2.3. Secondly, the expected demand for engineers according to economic sector is subdivided according to engineering branch. This subdivision is based on information obtained from an HSRC survey among engineers in 1979.

As an approximation of the demand for metallurgists in 1987 the percentage of metallurgists in the engineers-metallurgists occupational group of every sector - as indicated in the 1979 Manpower Survey - is accepted as valid for 1987. Table 2.3 shows the expected demand for metallurgists as well as the total demand for engineers in 1987 according to economic sector.

A method other than the mere extrapolation of the time series compiled from the various manpower surveys had to be found for classifying the demand for engineers according to engineering branch.

The classification of engineers according to engineering branch of the 1979 Manpower Survey was unacceptable. This survey shows for example that civil engineers constitute 32,5 % of all engineers. In the transport and communication sector job opportunities are shown for only 37 civil engineers. As this number was so low enquiries were made to the SAR & H (the largest single employer in the transport sector) and according to the personnel manager the SAR & H employs more than 200 civil engineers. The most suitable alternative was to use the information in the 1979 salary survey of the South African Institute for Manpower Research.

A brief overview is subsequently given of the aim and nature of the 1979 salary survey.

Since 1971 the HSRC has been conducting biennial investigations into the salary structure of the country's high-level manpower. The method used during the most recent investigation is explained in the report The wage structure of graduate White men in 1979.

Of the group who took part in the investigation 7 165 White men were identified as having at least a B. degree (or similar qualification) in engineering, and the information supplied by them was used to estimate the composition of the 1987 demand for engineers by assuming that the 1979 composition would still be valid in 1987. References in this report to the salary survey investigation group have a bearing on this group of engineers.

Table 2.4 shows the classification according to economic sector and engineering branch of 4 919 of the 5 026 qualified engineers who were still in the engineering profession in 1979 and who took part in the salary survey. The 21 men older than 74 who are still practising as engineers and the 32 engineers in the agricultural sector were not taken into account, while the 54 engineers who did not state the economic sector in

TABLE 2.3

THE EXPECTED DEMAND FOR ENGINEERS AND METALLURGISTS (SEPARATELY) IN 1987 ACCORDING TO ECONOMIC SECTOR

Economic Sector	1987 Demand for metallurgists		1987 Demand for engineers		1987 TOTAL	
	% of group of engineers/ metallurgists	N	% of group of engi-neers/metallurgists	N	%	N
Mining	13,80	173	86,20	1 080	100	1 253
Electricity, gas and water supply	-	-	100,00	1 051	100	1 051
Building and construction	-	-	100,00	4 047	100	4 047
Manufacturing	5,00	324	95,00	6 160	100	6 484
Commerce	-	-	100.00	961	100	961
Transport and communication	0,78	12	99,22	1 488	100	1 500
Services and finance	2,08	140	97,92	6 565	100	6 705
TOTAL	2,95	649	97,05	21 352	100	22 001

TABLE 2.4

WHITE MALE ENGINEERS IN THE 1979 SALARY SURVEY ACCORDING TO ENGINEERING BRANCH AND ECONOMIC SECTOR

Engineering branch	Economic sector										Total	
	Mining		Electricity, gas and water		Building and construction		Manufacturing and commerce		Transport and communication		Services and finance			
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Civil engineering	27	7,16	32	15,31	421	85,57	42	4,54	141	35,16	1 527	60,69	2 190	44,52
Electrical engineering	47	12,47	108	51,67	12	2,44	176	19,05	160	39,90	373	14,82	876	17,81
Mechanical engineering	65	17,24	24	11,48	23	4,68	263	28,46	59	14,71	206	8,19	640	13,01
Chemical engineering	18	4,78	8	3,83	4	0,81	186	20,13	-	-	58	2,31	274	5,57
Mining/Metallurgical engineering	130	34,48	2	0,96	1	0,20	23	2,49	-	-	33	1,31	189	3,84
Industrial engineering	4	1,06	1	0,48	-	-	43	4,65	1	0,25	13	0,52	62	1,26
Agricultural engineering	-	-	-	-	-	-	3	0,33	-	-	31	1,23	34	0,69
Systems engineering	1	0,26	-	-	-	-	7	0,76	1	0,25	4	0,16	13	0,27
Bioengineering	-	-	-	-	-	-	-	-	-	-	2	0,08	2	0,04
Other engineering branches	85	22,55	34	16,27	31	6,30	181	19,59	39	9,73	269	10,69	639	12,99
TOTAL	377	100	209	100	492	100	924	100	401	100	2 516	100	4 919	100
%	7,66		4,25		10,00		18,78		8,16		51,15		100	

which they were employed were also excluded. The designation "civil engineer" also covers structural engineers, while "other engineers" include a number of rock mechanical engineers, irrigation and maintenance engineers as well as electrical and mechanical engineers and the engineers who did not state their branch of engineering.

The services sector accommodates the entire spectrum of engineering and more than half of the engineers who took part in the investigation were employed in this sector. The civil engineering component was high in most sectors, especially in the services sector, transport and communication and the building and construction industry.

These sectors are concerned with the provision of the country's infrastructure and the information in Table 2.4 once again emphasizes the important role of engineers in the economic development of a country. The relatively high percentage of chemical engineers in the manufacturing and commerce sector is in line with the general expectation that the manufacturing of chemical, petrochemical, metal and pharmaceutical products will increase, especially in view of the developments at Sasol and Iscor.

Table 2.5 shows a further classification of the engineers who took part in the 1979 salary survey according to professional status.

Table 2.6 shows the number and percentage composition according to engineering branch of the engineers (corporate members, professional engineers and engineers in training) registered with the South African Council for Professional Engineers (SACPE) at 31 May 1980.

There is a reasonable degree of correspondence between the data of Tables 2.5 and 2.6, especially with regard to the main branches of engineering. Differences can be expected between the SACPE data and those of the salary survey. The salary survey does not include only professional engineers or corporate members of SACPE and the classification according to branches is made on the basis of job title. Thus there are engineers calling themselves "electro-mechanical engineers" who are probably registered with SACPE in only one field. Persons with degrees in engineering who have advanced to managerial level and who, according to their job title, are no longer known as "engineers" were also excluded from the classification according to engineering branch. Of the 7 165 persons originally involved in the salary survey, 939 (13,1 %) were classified under managerial and administrative occupations.

On the basis of its correspondence to the SACPE information, the salary survey classification is considered to be more realistic than the Manpower Survey classification and is used to estimate the demand for engineers in 1987 in each economic sector according to branch of engineering. This is done by applying the percentages for each economic sector (Table 2.4) to the corresponding estimate of the demand for engineers (Table 2.3).

TABLE 2.5

ENGINEERS IN THE 1979 SALARY SURVEY ACCORDING TO ENGINEERING BRANCH AND PROFESSIONAL STATUS

Engineering branch	Professional status									
	Professional engineer		Engineer in training		Non-registered		Did not answer question		TOTAL	
	N	%	N	%	N	%	N	%	N	%
Civil engineering	1 537	48,7	534	49,6	110	16,4	9	50,0	2 190	44,5
Electrical engineering	527	16,7	212	19,7	134	20,0	3	16,7	876	17,8
Mechanical engineering	389	12,3	128	11,9	121	18,1	2	11,1	640	13,0
Chemical engineering	91	2,9	66	6,1	116	17,3	1	5,6	274	5,6
Mining engineering	102	3,2	20	1,9	66	9,9	1	5,6	189	3,8
Industrial engineering	29	0,9	24	2,2	9	1,4	-	-	62	1,3
Agricultural engineering	25	0,8	9	0,8	-	-	-	-	34	0,7
Systems engineering	3	0,1	5	0,5	5	0,8	-	-	13	0,3
Bioengineering	1	0,1	1	0,1	-	-	-	-	2	0,0
Other branches	451	14,3	78	7,2	108	16,1	2	11,1	639	13,0
TOTAL	3 155	100	1 077	100	669	100	18	100	4 919	100

TABLE 2.6

THE NUMBER OF CORPORATE MEMBERS, PROFESSIONAL ENGINEERS AND ENGINEERS-IN-TRAINING REGISTERED WITH SACPE, 31 MAY 1980, ACCORDING TO ENGINEERING BRANCH

Engineering branch	Corporate members		Professional engineers		Engineers in training	
	N	%	N	%	N	%
Civil engineers	3 701	43,0	3 544	50,5	1 376	66,7
Electrical engineers	1 573	18,3	1 420	20,2	330	16,0
Mechanical and industrial engineers	1 520	17,6	997	14,2	183	8,9
Chemical engineers	381	4,4	413	5,9	78	3,8
Mining engineers	1 312	15,2	514	7,3	65	3,2
Agricultural engineers	129	1,5	135	1,9	30	1,4
TOTAL	8 616	100	7 023	100	2 062	100

Table 2.7 shows the expected demand for engineers in 1987 according to economic sector and engineering branch.

The figures in Table 2.7 represent the demand for engineers irrespective of race or sex. Some comments on population group and sex are therefore justified. The predominance of Whites in engineering is evident from the percentage composition of the total number of engineers in the labour force according to population group (Table 2.8). Secondly, traditionally engineering has been practised by men, as can be seen from Table 2.8.

On the basis of the data in Table 2.8 estimates were formed of the total demand for engineers and metallurgists according to population group and sex in 1987 by adjusting a modified exponential curve to the interpolated data according to the method discussed in Paragraph 2.2. The projected percentages and numbers are also shown in Table 2.8 and they evidently continue the historic trends. If these trends should continue, 99 % of the engineers in 1987 will still be male Whites.

TABLE 2.7

THE DEMAND FOR ENGINEERS IN 1987 ACCORDING TO ENGINEERING BRANCH AND ECONOMIC SECTOR

Engineering branch	Economic sector						
	Mining	Electricity, gas and water	Building and construction	Commerce and manufacturing	Transport and communication	Services and finance	TOTAL
Civil engineering	117	139	1 827	182	613	6 629	9 507
Electrical engineering	204	469	52	764	695	1 619	3 803
Mechanical engineering	282	104	100	1 141	256	894	2 777
Chemical engineering	78	35	17	807	-	252	1 189
Mining engineering	564	9	4	100	-	143	820
Industrial engineering	17	4	-	186	4	57	268
Agricultural engineering	-	-	-	13	-	134	147
Systems engineering	4	-	-	31	4	17	56
Bioengineering	-	-	-	-	-	9	9
Other branches	369	148	135	786	170	1 168	2 776
TOTAL	1 635	908	2 135	4 010	1 742	10 922	21 352

TABLE 2.8

PERCENTAGE COMPOSITION OF THE ENGINEERS AND METALLURGISTS ACCORDING TO POPULATION GROUP AND SEX, 1965-1979, WITH THE PROJECTED CLASSIFICATION FOR 1987

Population group / Sex	Base period								1987	
	1965	1967	1969	1971	1973	1975	1977	1979	Percentage	Number
% Whites	99,97	99,82	99,91	99,22	99,69	99,71	99,67	99,29	99,35	21 859
% Men	99,91	99,80	99,90	99,78	99,86	99,83	99,61	99,57	99,55	21 761
% Women	0,09	0,20	0,10	0,22	0,14	0,17	0,39	0,43	0,45	98
% Coloureds	0,02	0	0	0,02	0,10	0,11	0,09	0,28	0,26	57
% Men	100	0	0	100	100	55,56	100	100	100	57
% Women	0	0	0	0	0	44,44	0	0	0	0
% Asians	0,01	0,17	0,09	0,72	0,20	0,11	0,20	0,39	0,32	71
% Men	100	100	100	100	100	100	100	100	100	71
% Women	0	0	0	0	0	0	0	0	0	0
% Blacks	0	0,01	0	0,03	0,01	0,07	0,04	0,05	0,07	14
% Men	0	100	0	100	100	100	100	100	100	14
% Women	0	0	0	0	0	0	0	0	0	0
TOTAL	100	100	100	100	100	100	100	100	100	22 001

CHAPTER 3

THE SUPPLY OF ENGINEERS IN 1987

3.1 INTRODUCTION

To estimate the supply of engineers it is assumed that the engineering corps of 1987 will consist of a core group of 1979 engineers that will still be economically active in 1987. The engineering corps is obviously not static and during the period 1979 to 1987 it will be continually affected by economic and political conditions, technological progress and innovation. Although it is not intended to provide an econometric model that incorporates external and internal factors and then determines mutual relations, some external and internal influences are taken into account since some eroding and some supplementing factors are taken into consideration.

There are three important eroding factors that have a negative effect on any labour force, namely death, retirement and transfer to other occupations. On the other hand the existing labour force is supplemented by people who have completed their studies at local universities, immigrants with the necessary qualifications and people entering the occupation from other occupations. These factors will subsequently be discussed in the estimate of the supply of engineers in 1987.

3.2 ESTIMATE OF THE SUPPLY OF ENGINEERS IN 1979

The latest figures on the number of engineers in the RSA are those that appear in Manpower Survey No. 13 for 1979 of the Department of Manpower Utilization. These figures show the number of economically active engineers in the RSA (excluding SWA, Transkei and Bophuthatswana) as at 27 April 1979. These figures are accepted as being valid for the whole of 1979 and they are used as a basis for determining the expected number of engineers in 1987. According to Manpower Survey No. 13 there were 15 851 White men, 59 White women, 44 Coloured men, 50 Asian men and 7 Black men employed as engineers in 1979. As the number of White women and Non-Whites is so small (approximately 1 % of the total number of engineers), it is assumed for the purposes of this project that the 1987 engineering corps will consist only of White men.

To make the supply of engineers comparable with the estimated demand for 1987 the structure of the 1979 salary survey is applied according to engineering branch (Table 2.4) to the 15 851 White male engineers. Table 3.1 shows this classification.

TABLE 3.1

ESTIMATE OF THE 1979 ENGINEERING CORPS ACCORDING TO ENGINEERING BRANCH

Engineering branch	1979 Engineering corps	
	N	%
Civil engineering	7 057	44,52
Electrical engineering	2 823	17,81
Mechanical engineering	2 062	13,01
Chemical engineering	883	5,57
Mining engineering + Metallurgical engineering	609	3,84
Industrial engineering	200	1,26
Agricultural engineering	109	0,69
Systems engineering	43	0,27
Bioengineering	6	0,04
Other branches	2 059	12,99
TOTAL	15 851	100

On the basis of the 1979 salary survey the above figures are further classified according to age (Table 3.2). Engineers in agriculture were once again excluded. The economically active age for engineers was assumed to be 20 to 74 years, with the result that the 21 engineers who took part in the 1979 salary survey who are older than 74 and who are still practising as engineers were also excluded.

3.2.1 *The effect of retirement and death on the 1979 engineering corps*

The engineering corps is affected by various demographic factors and this is why an attempt is made through the quantification of death and retirement trends, to give an indication of that part of the economically active 1979 engineers who will still be in the labour force in 1987. For this reason an analysis is made according to age and economic status of the number of persons with a qualification in engineering who took part in the 1979 salary survey.

(a) Retirement

It is assumed that the retirement trend that applied to the 1979 salary survey test group will be valid also for 1987. Of the 7 165 White men who took part in the survey 88 were older than 75. Data of these persons were not further analyzed as 74 years of age is assumed to be the age limit for economically active engineers.

TABLE 3.2

ESTIMATED SIZE AND AGE STRUCTURE OF THE 1979 ENGINEERING CORPS ACCORDING TO ENGINEERING BRANCH

Engineering branch		Age											
		20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	TOTAL
Civil engineering	N	115	1 674	1 296	842	886	582	630	628	237	109	58	7 057
	%	1,63	23,72	18,37	11,93	12,56	8,25	8,93	8,89	3,36	1,54	0,82	100
Electrical engineering	N	83	635	654	395	246	298	261	226	83	32	10	2 823
	%	2,94	22,49	23,16	14,01	8,70	7,01	9,26	8,02	2,94	1,13	0,34	100
Mechanical engineering	N	48	388	451	321	219	153	206	146	79	35	16	2 062
	%	2,31	18,80	21,88	15,56	10,63	7,40	10,01	7,09	3,85	1,68	0,77	100
Chemical engineering	N	22	238	254	164	71	29	48	29	13	12	3	883
	%	2,55	26,91	28,73	18,55	8,00	3,27	5,46	3,27	1,45	1,45	0,36	100
Mining and metallurgical engineering	N	3	81	98	81	49	81	69	59	65	13	10	609
	%	0,54	13,37	16,04	13,37	8,02	13,37	11,23	9,63	10,69	2,14	1,60	100
Industrial engineering	N	16	68	45	20	16	-	29	6	-	-	-	200
	%	8,06	33,87	22,58	9,68	8,06	-	14,52	3,23	-	-	-	100
Agricultural engineering	N	3	25	19	31	13	3	9	3	3	-	-	109
	%	2,86	22,86	17,14	28,57	11,43	2,86	8,57	2,86	2,86	-	-	100
Systems engineering	N	3	20	11	3	3	-	3	-	-	-	-	43
	%	7,69	46,15	23,08	7,69	7,69	-	7,69	-	-	-	-	100
Bioengineering	N	-	-	3	-	-	-	-	3	-	-	-	6
	%	-	-	50,00	-	-	-	-	50,00	-	-	-	100
Other branches	N	16	221	309	265	234	218	290	272	123	54	57	2 059
	%	0,77	10,74	15,03	12,88	11,35	10,58	14,11	13,19	5,98	2,61	2,76	100
TOTAL	N	309	3 350	3 140	2 122	1 737	1 264	1 545	1 372	603	255	154	15 851
	%	1,95	21,13	19,81	13,39	10,96	7,97	9,75	8,66	3,80	1,61	0,97	100

A retirement trend for the group with a qualification in engineering was obtained by making a distinction, according to age, between the persons who indicated that they were retired and those who were still economically active at the time of the survey. This trend is shown in Table 3.3.

The participation pattern of persons older than 54 years is clearly different. The decline in the participation figure (the percentage of economically active persons) of the persons in the higher age groups is in accordance with the general retirement trend. However, the reason for the 9 persons who retired at the age of 25 to 39 is not known but illness and injury always prevent full employment of qualified persons.

Eight years hence the 20-year-olds in the test group of 1979 will be 28, the 25-year-olds 33 and the 67-year-olds will have retired. An estimate of the economic status of this group in 1987 was made through interpolation of the participation figures and appears in Table 3.4.

The retirement index was subsequently determined by dividing the percentage of economically active persons in a specific age group in Table 3.4 by the percentage of economically active persons in the corresponding age group of eight years ago, as in Table 3.3. The retirement index according to age group is given in Table 3.5. The retirement indexes for the age groups 20-24 (28-32), 25 - 29 (33 - 37), 30-34 (38-42) and 35 - 39 (43 - 47) were all approximated to 1,000 as retirement plays almost no role in these age groups.

TABLE 3.5

RETIREMENT INDEXES FOR THE PERIOD 1979-1987

Age group		Retirement index	
20-24	28-32	0,9970	1,0000
25-29	33-37	0,9996	1,0000
30-34	38-42	1,0000	1,0000
35-39	43-47	0,9970	1,0000
40-44	48-52	0,9963	
45-49	53-57	0,9925	
50-54	58-62	0,9170	
55-59	63-67	0,5406	
60-64	68-72	0,5002	
65-69	73-77	0,7908	

TABLE 3.3

THE AGE STRUCTURE OF THE 1979 SALARY SURVEY, ENGINEERS ACCORDING TO ECONOMIC STATUS

Economic status		Age											
		20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	Total
Not economically active	N	0	3	4	2	2	4	3	18	81	162	88	367
	%	0	0,25	0,32	0,21	0,25	0,71	0,44	2,70	21,43	56,64	57,89	5,19
Economically active	N	142	1 216	1 241	949	783	561	684	649	297	124	64	6 710
	%	100	99,75	99,68	99,79	99,75	99,29	99,56	97,30	78,57	43,36	42,11	94,81
TOTAL	N	142	1 219	1 245	951	785	565	687	667	378	286	152	7 077
	%	100	100	100	100	100	100	100	100	100	100	100	100

TABLE 3.4

ESTIMATE OF THE AGE STRUCTURE OF THE 1979 SALARY SURVEY ENGINEERS IN 1987, ACCORDING TO ECONOMIC STATUS

Economic status	Age									
	28-32	33-37	38-42	43-47	48-52	53-57	58-62	63-67	68-72	73-77
% Retired	0,30	0,29	0,11	0,51	0,62	1,45	8,70	47,40	60,70	65,71
% Economically active	99,70	99,71	99,89	99,49	99,38	98,55	91,30	52,60	39,30	34,29
TOTAL	100	100	100	100	100	100	100	100	100	100

The retirement indexes for the older group are probably rather high. As was mentioned before, the indexes were determined on the basis of the salary survey data. Retired persons are less inclined to respond to questionnaires that are of no direct concern to them. The indexes will thus reflect a slight underestimation of the eroding effect of retirement.

(b) Death

The expected number of survivors out of every 100 000 of the population is given in single years according to age in the l_x tables of the Life Tables of the Department of Statistics for 1969 - 1971. The figures for White men were used to determine survival indexes which give an indication of the number of people in a specific age group who will still be living eight years from now (1979).

Survival indexes were calculated by dividing the expected number of survivors in a specific age group by the expected number of survivors eight years younger. The expected number of survivors (White men) according to the Life Tables and the survival indexes for the eight-year period appear in Table 3.6. A distinction is made between the survival index for one-year groups and that for five-year groups. The latter is the arithmetic mean of the one-year indexes.

It can now be estimated which part of the 1979 engineering corps will still be economically active in 1987 after the effect of death and retirement has been taken into account. The retention index - the product of the retirement index and the survival index - is calculated for this purpose (Table 3.7).

TABLE 3.7

RETENTION INDEXES FOR THE 1987 ENGINEERING CORPS ACCORDING TO AGE

Age		Retention index
20-24	28-32	0,9806
25-29	33-37	0,9802
30-34	38-42	0,9728
35-39	43-47	0,9574
40-44	48-52	0,9316
45-49	53-57	0,8959
50-54	58-62	0,7846
55-59	63-67	0,4264
60-64	68-72	0,3500
65-66	73-74	0,4941

TABLE 3.6

SURVIVAL INDEXES FOR WHITE MEN IN ONE-YEAR AND FIVE-YEAR GROUPS FOR THE AGES 20-66

Age	Number of survivors at end of year (0 years = 100000)	Survival index (eight year period)	
		Single years	Five-year average
20	95 698	0,9802	
21	95 463	0,9803	
22	95 218	0,9806	0,9806
23	94 970	0,9807	
24	94 724	0,9811	
25	94 482	0,9811	
26	94 247	0,9807	
27	94 020	0,9805	0,9802
28	93 799	0,9797	
29	93 585	0,9785	
30	93 372	0,9771	
31	93 155	0,9753	
32	92 932	0,9732	0,9728
33	92 698	0,9707	
34	92 449	0,9679	
35	92 182	0,9647	
36	91 893	0,9613	
37	91 578	0,9576	0,9574
38	91 234	0,9537	
39	90 856	0,9496	
40	90 439	0,9452	
41	89 981	0,9405	
42	89 479	0,9355	0,9351
43	88 931	0,9301	
44	88 337	0,9242	
45	87 697	0,9178	
46	87 010	0,9109	
47	86 273	0,9033	0,9027
48	85 481	0,8952	
49	84 629	0,8865	
50	83 710	0,8771	
51	82 716	0,8672	
52	81 644	0,8564	0,8556
53	80 491	0,8448	
54	79 254	0,8324	
55	77 932	0,8190	
56	76 522	0,8047	
57	75 022	0,7896	0,7887
58	73 426	0,7735	
59	71 728	0,7566	
60	69 921	0,7389	
61	68 002	0,7203	
62	65 970	0,7007	0,6997
63	63 828	0,6801	
64	61 581	0,6586	
65	59 235	0,6363	0,6248
66	56 797	0,6133	

3.2.2 *The extent of occupational transfer in the 1979 engineering corps*

The extent of occupational mobility among engineers has to be estimated before an estimate can be given of the size of the basic engineering corps for 1987.

Respondents in the 1979 salary survey had to indicate the occupation they had been practising four years earlier (1 March 1975). These job titles were compared with those for 1979 and an analysis was made of the number of White men (N = 1 822) who had left the engineering profession during a period of four years as well as the number who had entered the engineering profession from other occupations during the same period. Persons who left the engineering profession owing to retirement, were not taken into consideration as provision is made for them in the retirement index. Students who entered the profession during the four years from 1975 were also excluded from the analyses since attention will be devoted later to graduation trends and the possibility of double counting had to be avoided. The net effect of the occupational transfers that occurred in the salary survey group is shown in Table 3.8, in actual numbers and as a percentage of the number of engineers in a specific engineering branch and age group. A minus sign before a figure indicates a net flow away from the engineering profession and a plus sign indicates there had been a net flow to the occupation.

On the assumption that the pattern of occupational transfer that was determined from the 1979 salary survey for 1975 - 1979 will still be valid for the periods 1979-1983 and 1983 - 1987, an estimate was made of the part of the 1979 engineering corps that will still be practising as engineers in 1987 by first applying the retention index to the numbers in Table 3.2. The effect of occupational transfer was then taken into consideration by first doubling the percentages in Table 3.8 (to make them apply to the period of eight years) and then applying them to the numbers obtained after applying the retention index.

As persons over 74 are no longer regarded as economically active, the age group 65 - 69 (or 73 - 77 in 1987) had to be adjusted accordingly. This was done by subtracting 153 ($\frac{255}{5}$ x 3 = 153) from the 255 persons in the age group 65 - 69 (Table 3.2) and applying the engineering branch structure of the 1979 salary survey to the number obtained. According to this method there were 44 civil engineers, 13 electrical engineers, 14 mechanical engineers, 5 chemical and 5 mining engineers and 21 other engineers in the age group 65 - 66 (i.e. 73 - 74 for 1987). The retention index and the percentage occupational transfer were applied to these numbers in the normal manner.

Table 3.9 shows the remaining part of the 1979 engineering corps estimated to be still practising as engineers in 1987.

It was estimated for the period of eight years (1979 - 1987) that approximately 533 engineers will leave the profession (not including students and retired persons),

TABLE 3.8

NET EFFECT OF CHANGE OF OCCUPATION ON THE ENGINEERING CORPS, 1975-1979

Engineering branch		Age											Total
		20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	
Civil	N	-	+3	-13	- 6	-3	+1	+ 1	- 1	-1	- 1		-20
	*%	-	+0,57	- 3,21	- 2,28	-1,08	+0,55	+ 0,51	- 0,51	-1,35	- 2,94		- 0,91
Electrical	N	-	-4	- 7		+3	+2	+ 1	+ 4				- 1
	%	-	-2,01	- 3,41		+3,90	+3,23	+ 1,22	+ 5,63				- 0,11
Mechanical	N	-	+1	- 4	- 3	+1	+1		- 1		+ 2		- 3
	%	-	+0,82	- 2,82	- 2,97	+1,45	+2,08		- 2,17		+18,18		- 0,46
Chemical	N	-	-2	- 1	+ 1				- 2		+ 1		- 3
	%	-	-2,70	- 1,27	+ 1,96				-22,22		+25,00		- 1,09
Mining	N	-	+1	- 1	- 6	+1	+1				- 1		- 5
	%	-	+4,00	- 3,33	-24,00	+6,67	+4,00				-25,00		- 2,67
Industrial	N	-		- 4	+ 1			+ 1					- 1
	%	-		-28,57	+16,67			+11,11					- 1,61
Agricultural	N	-	-2	- 2									- 4
	%	-	-25,00	-33,33									-11,43
Other branches	N	-	-6	-20	-10	-2	-4	- 6	+ 1	+3	- 3	+ 2	-45
	%	-	-8,57	-20,41	-11,90	-2,70	-5,80	- 6,52	+ 1,16	+7,69	-17,65	+11,11	- 6,90
TOTAL	N	-	-9	-52	-23		+1	- 3	+ 1	+2	- 2	+ 2	-82
	%	-	-0,86	- 5,29	- 3,46		+0,50	- 0,62	+ 0,23	+1,06	- 2,50	+ 4,17	- 1,65

*As a percentage of the total group in the category.

TABLE 3.9

ESTIMATE OF THE REMAINING SECTION OF THE 1979 ENGINEERING CORPS IN 1987 ACCORDING TO ENGINEERING BRANCH

Engineering branch	Age										Total
	28-32	33-37	38-42	43-47	48-52	53-57	58-62	63-67	68-72	73-74	
Civil engineering	113	1 660	1 180	769	807	527	499	265	81	21	5 922
Electrical engineering	81	597	593	378	247	188	210	107	29	6	2 436
Mechanical engineering	47	386	414	289	210	143	162	59	28	9	1 747
Chemical engineering	22	220	241	163	66	26	38	7	4	5	792
Mining engineering	3	85	89	40	52	79	54	25	23	1	451
Industrial engineering	16	67	19	25	15		28	3			173
Agricultural engineering	3	12	6	30	12	3	7	1	1		75
Systems engineering	3	20	11	3	3		2				42
Bioengineering			3					1			4
Other branches	16	180	178	194	206	172	197	119	50	7	1 319
TOTAL	304	3 227	2 734	1 891	1 618	1 138	1 197	587	216	49	12 961

mainly for managerial positions. As a percentage of the 15 851 White male engineers who were economically active in 1979, this occupational transfer represents 3,4 % of the total.

3.3 ESTIMATE OF THE NUMBER OF ENGINEERS WHO HAVE TO BE TRAINED DURING THE PERIOD 1979 TO 1987

The estimated demand for engineers in 1987 can now be compared with the remainder of the 1979 engineering corps. A distinction is made according to engineering branch so that an indication can be obtained of the branch in which there will be the greatest demand.

The large number of engineers in the category "other engineers" hampers comparison with the number of degrees awarded according to engineering branch (see Table 4.1) where there is no classification for "other engineers". Analyses of the 1979 salary survey data for engineers revealed a high correlation between the branch of engineering and the qualifications of engineers. As the salary survey structure according to engineering branch was used to estimate the demand for and supply of engineers, this information was also used for the further classification of "other engineers".

The major subject or field of study at B. degree level of 534 engineers in the category "other engineers" could be determined from the salary survey data. The field of engineering of 106 of the 534 engineers was not known. The qualification structure of the remaining 428 engineers is shown in Table 3.10.

TABLE 3.10

THE CLASSIFICATION AT B. DEGREE LEVEL OF ENGINEERS IN THE CATEGORY "OTHER ENGINEERS" ACCORDING TO FIELD OF STUDY

Engineering branch/ field of study	N	%
Civil engineering	97	22,66
Electrical engineering	127	29,67
Mechanical engineering	149	34,81
Chemical engineering	18	4,21
Mining engineering	18	4,21
Industrial engineering	10	2,34
Agricultural engineering	9	2,10
TOTAL	428	100

There is little similarity in the percentage structures of Tables 3.1 and 3.10. Most of the "other engineers" are qualified in mechanical engineering while only 23 % are trained in civil engineering - the largest group according to Table 3.1.

On the assumption that the classification according to qualification of the group of "other engineers" is valid for 1979 and 1987, the percentages in Table 3.10 are applied to the estimated demand for 2 776 "other engineers" for 1987 (see Table 2.7) and to the 1 319 "other engineers" of 1979 who are estimated to be still economically active in 1987 (see Table 3.9). The numbers calculated in this way were added to the numbers in the various engineering branches (as in Tables 2.7 and 3.9). For purposes of comparison the relatively small number of bioengineers and systems engineers were added to the number of electrical engineers.

Table 3.11 is a summary of the estimated demand for engineers and the estimated remaining part of the 1979 engineering corps in 1987 as well as of the difference between these two estimates.

The difference between the estimated demand for engineers and the estimated remainder of the 1979 engineering corps means that approximately 1 050 persons have to join the engineering profession annually if a break-even point is to be reached.

Attention will subsequently be devoted to the possibility of an average annual increase of approximately 1 000 engineers in the ranks of the engineering corps.

TABLE 3.11

ESTIMATE OF THE NUMBER OF ENGINEERS WHO HAVE TO BE TRAINED DURING THE PERIOD 1979-1987 TO MEET THE DEMAND FOR ENGINEERS, ACCORDING TO ENGINEERING BRANCH

Engineering branch	Estimated demand for engineers in 1987		Estimated remainder of engineers in 1987		Number of engineers who have to be trained		
					1979-1987		Annually (average)
	N	%	N	%	N	%	
Civil engineering	10 136	47,5	6 221	48,0	3 915	46,7	489
Electrical engineering	4 692	22,0	2 873	22,2	1 819	21,7	227
Mechanical engineering	3 743	17,5	2 206	17,0	1 537	18,3	192
Chemical engineering	1 306	6,1	848	6,5	458	5,5	57
Mining engineering	937	4,4	506	3,9	431	5,1	54
Industrial engineering	333	1,6	204	1,6	129	1,5	16
Agricultural engineering	205	0,9	103	0,8	102	1,2	13
TOTAL	21 352	100	12 961	100	8 391	100	1 048

CHAPTER 4

TRAINING IMPLICATIONS OF THE ESTIMATE OF SUPPLY AND DEMAND

New graduates and immigrants are the main sources of recruits to the engineering profession. In the discussion of these two sources the effect of the eroding factors (death and retirement) and occupational transfer on the new additions is not taken into account.

An indication on the graduation trends among engineers is obtained from the various annual reports of the Department of National Education which give information on the number of B. degrees in engineering that are annually awarded by universities for Whites. Table 4.1 shows the number of B. degrees in engineering awarded to White men and women during the period 1965 - 1978. (Very few degrees in engineering are awarded to women, an average of approximately four a year). Degrees in the field B. Eng. (Land Surveying) are not included. Degrees in aeronautical engineering were grouped with mechanical engineering, those in applied and industrial chemistry with chemical engineering, while degrees in metallurgical engineering, mining geology and mining engineering were grouped together under "mining".

The number of engineering degrees awarded in 1977 is almost twice as great as the number awarded in 1967, with an average annual growth rate of 6,9 %. (An average of 596 engineering degrees were awarded annually during the period 1965 to 1977).

A linear curve and a power curve (for civil, mechanical and electrical engineers) were fitted to these numbers (of degrees awarded 1965 - 1978) and through extrapolation estimates were made of the number of B. degrees in engineering that will be awarded during the period 1979 - 1987. The results of the curve fitting are shown in Table 4.1 and Figure 4.1. The totals in the table and the figure were not obtained through a curve fitting but by summation of the results of the different branches. According to this summation an average of 874 engineering degrees per annum is projected for the period 1979 - 1987, approximately 300 more than the average awarded during the period 1965 - 1977.

The projection shows that if past trends continue the demand for engineers will not be met. The average demand is approximately 1 000 per annum while the average supply, estimated on the basis of graduation trends, comes to approximately 875 - a shortfall of roughly 125 degrees a year. The only two branches in which no shortage is estimated are agricultural and industrial engineering. While immigration played a significant role in the supply of engineers up to 1976, there has been no real net inflow since 1977. Since the extent of immigration and emigration is difficult to predict, this aspect is not taken into account in the current report.

TABLE 4.1

THE NUMBER OF B. DEGREES IN ENGINEERING AWARDED DURING THE PERIOD 1965-1978 AND AN ESTIMATE OF THE NUMBER OF B. DEGREES IN ENGINEERING THAT WILL BE AWARDED AT SOUTH AFRICAN UNIVERSITIES FOR WHITES DURING THE PERIOD 1979-1987, ACCORDING TO ENGINEERING BRANCH

Year	Engineering Branch							
	Civil	Electrical	Mechanical	Chemical	Mining	Industrial	Agricultural	TOTAL
1965	98	90	85	67	27	12	7	386
1966	112	95	78	44	34	5	7	375
1967	112	104	98	57	32	15	3	421
1968	129	128	99	52	35	10	6	459
1969	180	142	116	88	28	13	4	571
1970	226	165	112	54	37	11	7	612
1971	245	159	119	71	29	7	10	640
1972	274	154	95	66	36	10	12	647
1973	309	154	98	42	28	13	9	653
1974	287	174	110	56	26	13	11	677
1975	366	193	107	33	21	17	6	743
1976	353	188	107	39	23	29	2	741
1977	390	195	113	49	29	31	14	821
1978	314	199	95	50	42	23	14	737
TOTAL 1965-1978	3 395	2 140	1 432	768	427	209	112	8 483
1979	378	201	111	44	29	25	11	799
1980	392	205	112	42	29	26	12	818
1981	407	209	112	41	29	28	12	838
1982	421	213	113	40	29	29	13	858
1983	435	217	113	38	29	30	13	875
1984	448	221	114	37	29	32	14	895
1985	461	225	114	35	28	33	14	910
1986	474	228	115	34	28	34	14	927
1987	487	232	115	32	28	36	15	945
TOTAL 1979-1987	3 903	1 951	1 019	343	258	273	118	7 865

FIGURE 4.1

THE NUMBER OF B.-DEGREES IN ENGINEERING AWARDED, 1965-1978, AND AN ESTIMATE OF THE NUMBER OF B.-DEGREES IN ENGINEERING THAT WILL BE AWARDED DURING THE PERIOD 1979-1987

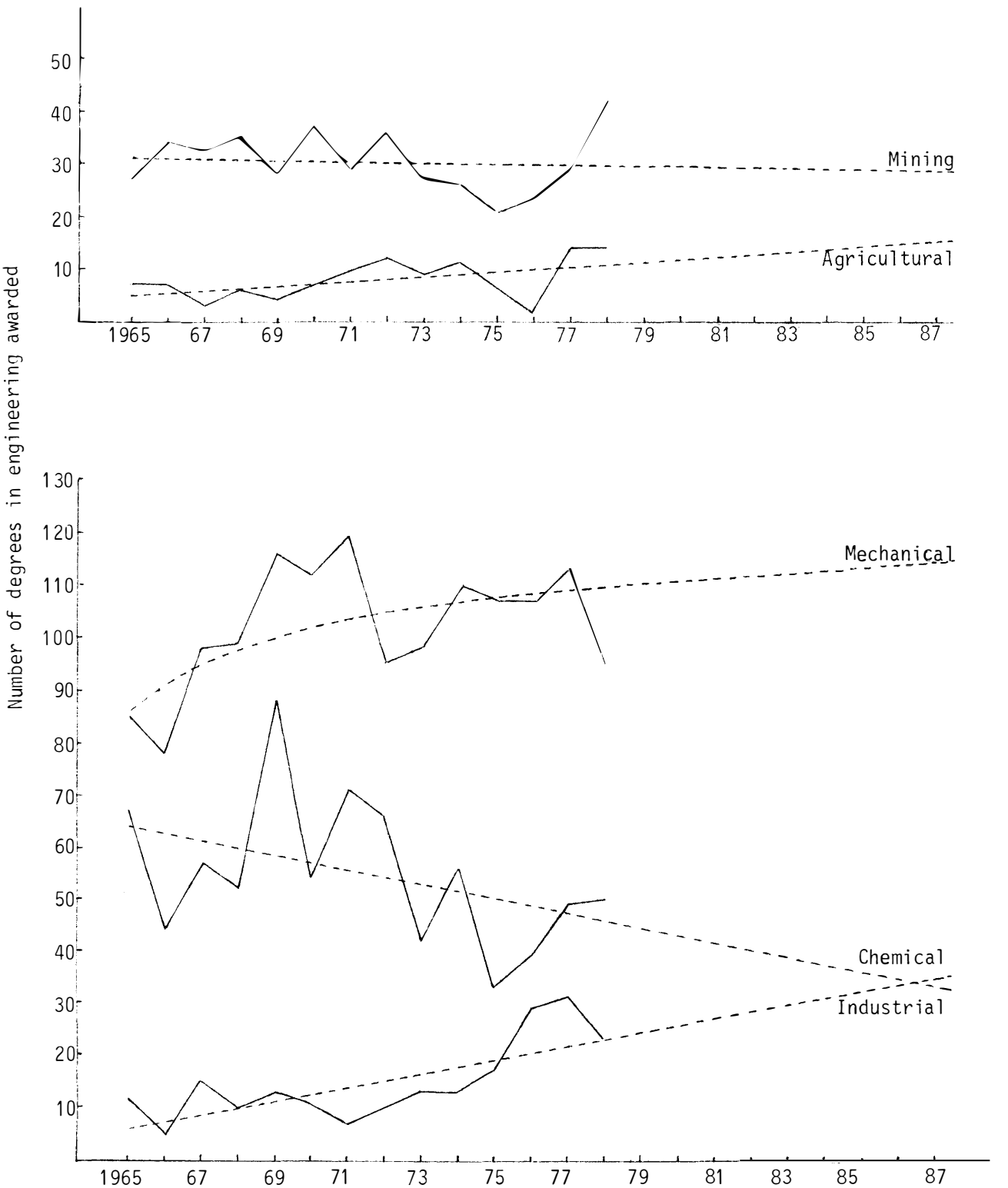
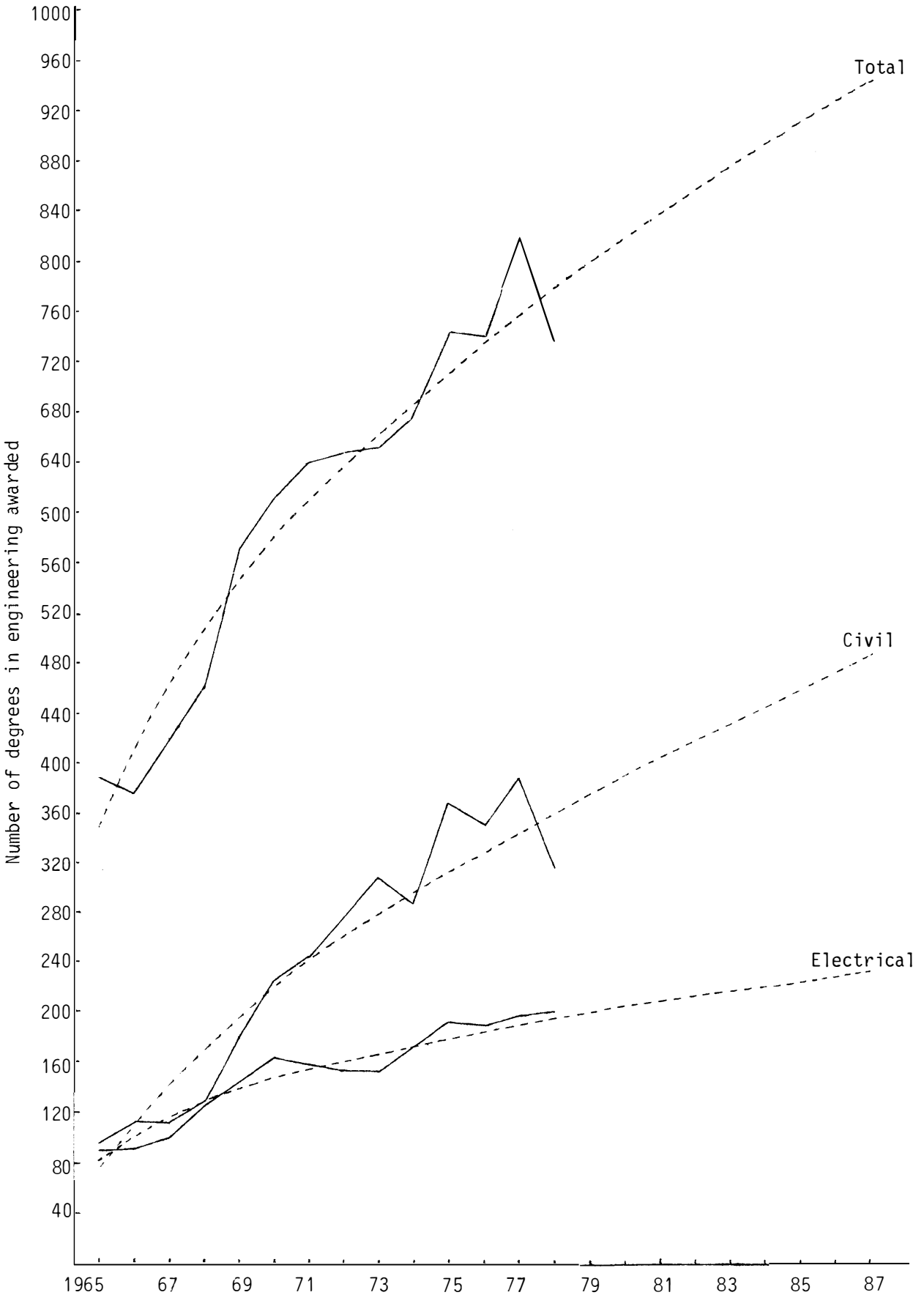


FIGURE 4.1 (CONTINUED)



It can now be asked how accurately the different projections reflect the actual position.

The availability of engineers is related to the demand and the composition of the White male population in particular (most engineers are men). Is the traditional source, in terms of numbers and skills, of such a nature that the graduation trends as projected in Table 4.1 can be realized? Before this question can be answered a study must be made of factors such as economic conditions, population growth, wage structures and level of education which all have an effect on the availability of engineers.

Cain, Hansen and Freeman (1973) point out, with regard to the effect of economic conditions on the availability of new graduate engineers, that the supply of engineers inevitably shows a reaction to economic conditions in the past because of the relatively long university training required from persons who have decided to take an engineering course on the basis of the state of the economy as reflected by salaries and job opportunities. The demand for engineers at a specific time is determined by the current economic conditions. It is clear therefore that the supply of and demand for engineers follow a type of cobweb dynamics, which implies that supply and demand are always out of step.

What aggravates the imbalance between supply and demand is that the number of bursaries made available for study in engineering fluctuates according to the economic situation. The relation between economic cycle and the number of engineering students is reflected in the number of enrolled second-year students during the period 1965-1979 (Table 4.2 and Figure 4.2).

Because of its close connection with the building and construction industry the civil engineering branch is particularly sensitive to economic trends. In 1974, 1975 and 1976, when the South African economy was facing a serious recession, the number of enrolled second-year civil engineering students was comparatively high. It was only in 1977 that the number of second-year students dropped by more than one hundred to reach the lowest level of 282 in 1979. In view of the above the projections of the number of engineering degrees (Table 4.1) are very optimistic and it can be expected that until 1982/1983 considerably fewer engineers, especially civil engineers, than reflected in the projections, will be provided. The increase in the demand caused by the present economic revival should - on the basis of the Freeman model - lead to an increase in student numbers.

The size of the population also has an effect on the availability of engineers in the sense that there should be sufficient people who can be trained in a specific field. The issue here is therefore whether the projections of the increasing number of new graduate engineers are realistic in terms of population growth. If a minimum period

TABLE 4.2

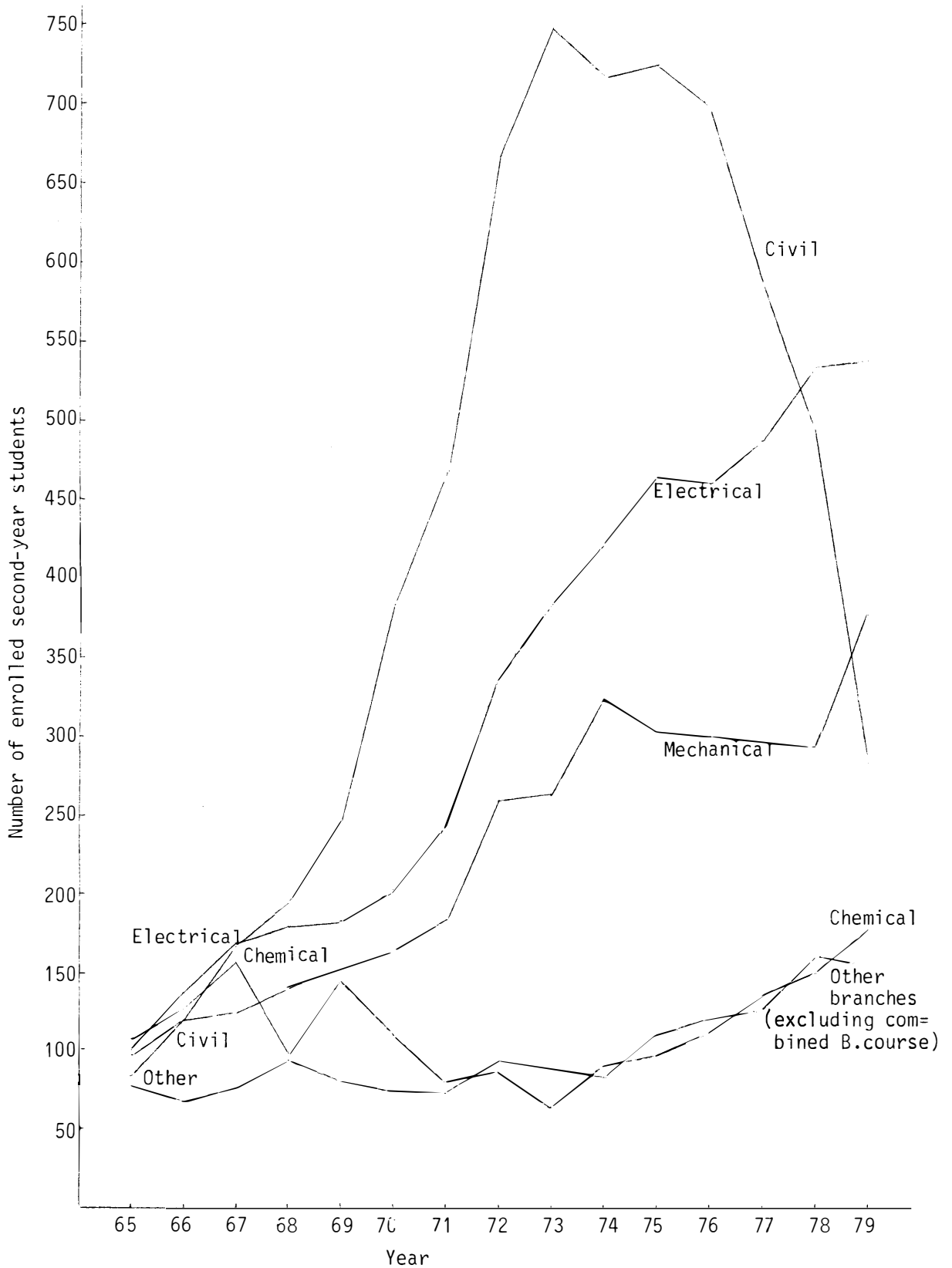
THE NUMBER OF WHITE ENROLLED SECOND-YEAR ENGINEERING STUDENTS, 1965-1979, ACCORDING TO ENGINEERING BRANCH

Year	Engineering branch								
	Civil	Electrical	Mechanical	Chemical	Mining	Industrial	Agricultural	Combined B. course before specialization	TOTAL
1965	84	99	99	107	56	17	5	249	716
1966	120	137	118	123	50	13	5	314	880
1967	171	170	122	156	57	14	7	410	1 107
1968	193	181	141	98	62	23	10	510	1 218
1969	243	183	153	143	60	13	8	496	1 299
*1970	384	203	164	108	51	12	9	157	1 088
*1971	466	244	185	80	41	15	17	8	1 056
1972	665	338	259	85	36	36	21	6	1 446
1973	746	383	264	65	31	35	20	19	1 563
1974	718	421	324	89	32	35	16	20	1 655
1975	723	463	304	97	50	40	21	27	1 725
1976	697	460	299	109	61	41	17	14	1 698
1977	584	488	298	136	57	48	21	13	1 645
1978	494	532	295	149	91	42	26	-	1 629
1979	282	535	376	176	84	34	35	-	1 522

*The figures for 1970 and 1971 do not include the second-year engineering students of the University of Stellenbosch as only a total figure for second, third and fourth-year engineering students at this University is available

FIGURE 4.2

THE NUMBER OF WHITE ENROLLED SECOND-YEAR ENGINEERING STUDENTS, 1965-1979, ACCORD= ING TO ENGINEERING BRANCH



of four years for obtaining a degree in engineering and the two years' military service that White men have to complete are taken into consideration, the 20 to 29-year-old group of White men can be regarded as the main source of new graduate engineers. Table 4.3 shows the projections of the number of 20 to 24 and 25 to 29-year-old White men in 1977 and 1987 as estimated by the South African Institute for Sociological, Demographic and Criminological Research.

TABLE 4.3

PROJECTIONS OF THE NUMBERS OF 20 TO 29-YEAR-OLD WHITE MEN IN THE RSA FOR 1977 AND 1987

Age group	Number of White men in		Average growth a year
	1977	1987	1977-1987
20-24	185 310	207 590	1,14
25-29	187 490	192 820	0,54
TOTAL: 20-29	372 800	400 410	0,72

The expected annual growth in the number of 20 to 29-year-old White men (0,7 % per annum) is considerably lower than the 1,4 % growth in the number of engineering degrees projected for 1977 - 1987.

Furthermore, the number of White boys who passed Mathematics and Physical Science with university exemption shows no noticeable trend in any direction (Table 4.4).

Since a relatively large percentage of the pupils with a superior IQ and high achievement in Mathematics and Physical Science already choose engineering as their field of occupation (see Table 4.5) it appears unlikely that a larger percentage of these pupils can be attracted to this profession.

Eighty three per cent of the White men who took part in Project Talent Survey and who obtained degrees in engineering had obtained more than 60 % in Mathematics in Standard Ten. This is approximately 15 % more than the percentage of White men who obtained degrees in medical and paramedical fields and who had obtained 60 %+ in Standard Ten Mathematics. Although a smaller percentage of the persons involved in the investigation (men as well as women) had taken Physical Science in Standard Ten, men as well as women generally had done better in Physical Science than in Mathematics. Also with regard to IQ the percentage of White men with a superior IQ was the highest in the engineering and medical fields.

TABLE 4.4

THE NUMBER OF WHITE MALES WHO PASSED MATRIC WITH EXEMPTION IN MATHEMATICS AND PHYSICAL SCIENCE, 1974-1978[1)]

Subject passed with exemption	1974		1975		1976		1977		1978	
	N	%[2)]	N	%	N	%	N	%	N	%
Mathematics	8 667	81,10	8 022	72,50	7 518	72,39	8 760	76,79	8 634	77,78
Physical Science	7 469	69,89	7 374	66,64	7 281	70,11	7 917	69,40	7 940	71,52
TOTAL (all boys with exemption)	10 687		11 065		10 385		11 407		11 101	

1. Figures provided by the South African Institute for Educational Research (SAIER).

2. As a percentage of the number of boys who passed with exemption.

According to Table 4.5 a larger percentage of White women than of men with degrees in pure and applied natural sciences, commerce and pure human sciences reached above average levels of achievement in Mathematics in Std. 10. If the larger percentage of women in all fields of study with a superior IQ (Table 4.5) is taken into consideration, it appears that there are sufficient women with the potential to be trained as engineers. Greater employment of female engineers, however, is influenced by factors such as the unique participation pattern of women in the labour force as well as their interests.

In addition to factors such as aptitude and interest, income is another factor that attracts people to a specific occupation and with that the possibility of being one's own master. Engineering does not lend itself as readily as other high-level occupations (cf. accountancy, law and medicine) to private entrepreneurship. Despite the relatively high median income of self-employed civil engineers (R25 050 per annum) according to the 1979 salary survey for White men (Kruger, 1979), there is only a small number of them (333) as against the 852 and 932 civil engineers who are employed in the private and public sectors (with median incomes of R13 000 and R12 830 per annum). According to the salary survey, mechanical and electrical engineers employed in the private or public sector earn a higher median income than the civil engineers in these sectors but considerably less than their self-employed colleagues (45 self-employed electrical engineers earn a median income of R20 500 per annum as against the R14 360 per annum of 345 electrical engineers employed in the private sector). The median income of persons with engineering degrees who have advanced to managerial level is not included under the designation "engineer" and the above figures consequently give only an indication of the median income of persons still practising as engineers. A direct comparison of the income of self-employed persons with that of employees cannot be made as the former includes entrepreneur's remuneration and a risk premium (Kruger, 1979, p. 6).

A further indication of the financial attraction of the engineering profession is obtained from a study of the profitability of the occupation in which cost factors such as study costs and forfeited income are taken into consideration. Such a study was made by the South African Institute for Manpower Research on the basis of the 1979 salary survey data (Kruger, 1980). The cash value of the expected income flow during an occupational lifetime stretching from 20 to 65 years of age for some occupations according to type of employer is shown in Table 4.6 at a discount rate of zero. Although the profitability of the occupation is high for self-employed graduate engineers, the cash value of expected income of graduates practising as engineers is fairly average.

TABLE 4.5

PERCENTAGE OF WHITE GRADUATES AND DIPLOMATES WHO OBTAINED HIGH MARKS IN MATHEMATICS AND PHYSICAL SCIENCE AT STANDARD 10 LEVEL (1969)

(a) Men

Nature of B. degree	N	% with Mathematics in Std. 10	% with Physical Science in Std. 10	% with 60 %+ in Mathematics	% with 60 %+ in Physical Science	% with more than 60 % in total Std. 10 examination	% with superior IQ (120 +)
Engineering	553	100	90	83	87	77	57
Medical and paramedical	455	100	92	67	83	75	49
Pure natural sciences	362	100	89	48	64	49	46
Applied natural sciences	435	100	86	39	49	37	36
Law	343	95	79	29	43	43	40
Commerce and administration	784	99	84	36	41	37	39
Pure human sciences	516	86	73	24	35	32	35
Applied human sciences	237	83	75	34	43	41	40

(b) Women

Medical and paramedical	217	96	74	63	78	76	58
Pure natural sciences	247	98	80	72	79	79	73
Applied natural sciences	60	91	73	45	57	68	61
Commerce and administration	98	95	53	63	60	71	55
Pure human sciences	684	72	37	33	44	59	50
Applied human sciences	317	73	41	29	38	46	41
Diplomas							
Diplomas in engineering and Natural sciences (NDT)	499	97	91	16	26	15	25
Teacher's diplomas (Men)	531	64	52	5	13	11	11
(Non-degree) (Women)	2328	40	19	15	20	28	23

Source of information: HSRC, SAIMAR, Project Talent Survey

TABLE 4.6

CASH VALUE OF THE EXPECTED INCOME (RANDS) OF SELF-EMPLOYED PERSONS AND EMPLOYEES IN SOME OCCUPATIONS (DISCOUNT RATE 0 %)

Occupation	Employer			
	Self-employed		Employee	
	N	Cash value (Rands)	N	Cash value
Accountant (registered)	1 101	702 234	506	536 101
Medical specialist	444	689 896	205	549 106
Graduate engineer	590	644 038	4 490	503 196
Quantity surveyor	194	628 143	239	450 996
Gen. Med. practitioner	854	622 396	896	506 929
Lawyer	1 160	617 254	175	429 349
Dentist	310	601 000	61	537 900
Architect	463	544 433	263	427 255
Pharmacist	610	539 748	356	398 284
Vet. surgeon	120	514 768	119	442 764
Land surveyor	124	490 956	119	428 805

From what was said earlier it appears that the occupation of engineer is one that makes high demands on the intellectual abilities of the persons joining it (Table 4.5) and there is little indication that the traditional source of engineers, White Standard Ten boys who do well in Mathematics, will increase drastically.

CHAPTER 5

SUMMARY AND CONCLUSION

With the Economic Development Programme for 1978 - 1987 as starting point it was estimated that the demand for engineers in 1987 will be 21 352 of which 44,5 % will be for civil engineers, 17,8 % for electrical engineers, 13 % for mechanical engineers, 5,6 % for chemical engineers, 3,8 % for mining and metallurgical engineers and 1,3 % for industrial engineers; the rest of the demand will be for bioengineers, agricultural engineers, systems engineers, etc. Approximately 70 % of the demand for engineers is expected in the services sector and the manufacturing industry.

It is expected that 12 961 of the 1979 engineering corps (according to Manpower Survey No. 13 there were 15 851 White male professional engineers) will still be practising as engineers in 1987 - i.e. after provision has been made for the effect of eroding factors. This means that approximately 1 050 persons will have to enter the engineering profession annually to meet the demand.

Projections of the number of engineering degrees awarded in 1965 - 1978 indicate an average annual addition of 874 White new graduates to the engineering corps during the period 1979 - 1987. Structural factors such as the number of 20 to 29-year-old White men, the number of White boys who pass matric with exemption in Mathematics and Physical Science, salary structures and the economic trend indicate, however, that in the short or the long term White men alone will be unable to meet the demand for engineers.

We have seen that the engineering profession relies heavily on the high achievers (intellectually as well as in terms of scholastic achievement) but that there is little indication that the traditional source of engineers (male White high achievers) is going to increase noticeably. The stated training objective can thus only be achieved if a larger proportion of these students can be attracted to engineering. In view of the competition from other professions in respect of their profitability (see Table 4.6), it is most unlikely that larger members will be attracted. Shortages of high-level manpower are fairly common in most fields with the result that competition for the traditional source of high-level manpower is very severe. A study of the job situation of new graduates (Terblanche and Ebersohn, 1980) showed that, unlike in Western countries, new graduates in this country experience few problems in obtaining employment even in times of recession.

It is an open question whether it is in the national interest that the engineering profession should rely even more heavily on the limited supply of high-level manpower. Persons with an above average intellect and achievement are of vital impor-

tance also in other fields of the national economy, and as the public sector's competitive position cannot be compared financially with that of the private sector and is in fact falling even further behind, the public sector will suffer most from a large-scale shift to engineering as this sector also requires its quota of the limited supply of manpower for effective functioning. Without an efficient public service to provide and maintain the social infrastructure and a defence force and police force to protect the structure, an adequate technological labour force is of academic interest only.

The question now arises as to what can be done to improve the situation concerning the provision of engineers. Some ideas in this regard, each with its concomitant problems, can be mentioned.

(a) Immigration

In the past immigrants played an important role in supplementing the trained technological labour force and although the political situation and foreign pressure have had an adverse effect on recruitment, this source should still be kept in mind, because the recession in Europe should, on the other hand, facilitate recruitment. Technology is used internationally and this is why imported technological manpower unlike the manpower in other fields, can almost immediately be fully utilized.

(b) Improved utilization of the traditional sources of manpower

Research conducted in 1973 (Ebersohn, 1975, p. 56) revealed that the existing corps of engineers is not fully utilized and that many functions performed by engineers can be carried out just as efficiently by technicians. This means there must be an adequate number of technicians, but indications are that the shortage of technicians is becoming quite serious. Despite this employers should try to ensure better job distribution since it is easier to train technicians than engineers.

At the request of the South African Institute for Civil Engineers SAIMAR is now researching the extent of possible incorrect utilization of civil engineers.

(c) Utilization of sources other than the traditional one

(i) White women obviously have the potential to be trained as engineers (see Table 4.5). The small number of female engineers is probably due to a lack of interest in engineering among women. If this lack of interest is based on a misunderstanding of the engineering profession, it should be rectified at school level, especially by the guidance teachers.

(ii) Although the available source of Non-Whites, i.e. high achievers in Mathematics, appears to be limited, everything possible should be done to develop and utilize

this source.

(d) Economic situation and the supply of and demand for technological manpower

Students and employers should be less influenced by economic cycles. They should realize that the long-term demand for all kinds of engineers will be high under all circumstances that can be called "normal". Short-term reactions to economic conditions should be avoided and all employers in a position to do so should not in times of recession curtail the number of bursaries they make available. New graduates may not be able during a recession to obtain the level of employment they expected, but their chances of being employed are still good and the low level of economic activity is normally of a temporary nature. This has been confirmed by research in overseas countries where competition is much stronger than in the RSA.

APPENDIX A

ECONOMIC SECTOR CLASSIFICATION USED IN THE MANPOWER SURVEYS (DEPT. OF MANPOWER UTILIZATION) AND SECTOR GROUP CLASSIFICATION USED TO ESTIMATE THE TOTAL DEMAND FOR MANPOWER

Manpower Survey classification	Sector group classification for estimating demand
1. Fishing industry	
2. Gold mining industry	1. Gold mining industry
3. Coal mines	2. Coal mines
4. Other mines	3. Other mines
5. Building and construction industry	4. Building and construction industry
6. Food industry	5. Food industry
7. Beverage and tobacco industry	6. Beverage and tobacco industry
8. Textile industry	7. Textile industry
9. Clothing industry	8. Clothing industry
10. Wood processing	9. Wood processing (wood and wood products)
11. Furniture industry	10. Furniture industry
12. Paper manufacturing	11. Paper manufacturing (paper and paper products)
13. Printing industry	12. Printing industry (printing, publishing and other related industries)
14. Chemical industry	13. Pharmaceutical, chemical, plastic and petroleum products
15. Petro-chemical	
16. Rubber products manufacturing	14. Rubber products manufacturing
17. Leather industry	15. Leather industry (leather and leather products)
18. Shoe industry	16. Shoe industry
19. Non-metalliferous mineral products	17. Non-metalliferous mineral products
20. Basic metal industry	18. Basic metal industry (basic iron and steel products)
21. Manufacturing of metal products	19. Manufacturing of metal products
22. Manufacturing of machinery	20. Manufacturing of machinery (except electrical)
23. Manufacturing of electrical machinery	21. Manufacturing of electrical machinery
24. Miscellaneous manufacturing	22. Miscellaneous manufacturing
25. Manufacturing of transport equipment	23. Manufacturing of transport equipment
26. Commerce	24. Commerce
27. Motor trade	
28. Electricity, gas and water supply	25. Electricity, gas and water supply
29. Transport and communication	26. Transport, storage and communication
30. SA Railways and Harbours	
31. Postal services	
32. Financial organizations	27. Miscellaneous services and financial organizations
33. Personal services	
34. Sport and recreation	
35. Professional, medical and other services	
36. Local authorities	28. Public services
37. Government and provincial administrations	
38. National states governments	

APPENDIX B

OCCUPATIONAL GROUP CLASSIFICATION USED IN THE OVERALL DEMAND ESTIMATE

1-13. Persons practising professional occupations

1. Architects, quantity surveyors, town and regional planners
2. Engineers and metallurgists
3. Land surveyors, mining surveyors and topographical surveyors
4. Natural and life scientists
5. Medical doctors, dentists and veterinary surgeons
6. Paramedical practitioners, nurses, midwives and nursing assistants
7. Other paramedical practitioners
8. Technicians: engineers and draughtsmen
9. Other technicians and technical assistants
10. Lawyers, advocates, etc.
11. Teachers, lecturers, etc.
12. Clergymen, etc.
13. Other professional practitioners

14. Managerial, executive and administrative workers
15. Clerical workers
16. Sales workers
17. Transport and communication workers
18. Service workers
19. Production workers
20. Foremen and supervisors
21. Artisans and apprentices
22. Labourers

BIBLIOGRAPHY

1. CAIN, G.G., FREEMAN, R.B., HANSEN, W.L. *Labor market analysis of engineers and technical workers.* Baltimore, The Johns Hopkins University Press, 1973.

2. EBERSOHN, D. *Die ingenieurs in die RSA.* Pretoria, RGN, 1975, Verslag MM-55.

3. FREEMAN, R.B. *Labor Economics.* Englewood Cliffs, Prentice-Hall Inc., 1972.

4. KRUGER, A. *Die loonstruktuur van gegradueerde Blanke mans in 1979.* Pretoria, RGN, 1979. Navorsingsbevinding M-N-66.

5. KRUGER, A. *The profitability of occupations and fields of study pursued by graduates in 1979,* Pretoria, HSRC, 1980. Report No. M-R-76.

6. OECD. *The conditions for success in technological innovation.* Paris, OECD, 1974.

7. SAMUELSON, P.A. *Economics.* New York, McGraw-Hill Book Company, 1967.

8. SUID-AFRIKA (REPUBLIEK). DEPARTEMENT VAN MANNEKRAGBENUTTING. *Mannekragopnames* Nr. 6-13. Pretoria, Departement van Mannekragbenutting, 1965-1979 (elke twee jaar).

9. SUID-AFRIKA (REPUBLIEK). DEPARTEMENT VAN NASIONALE OPVOEDING. *Jaarverslag 1966-1979.* Pretoria, Staatsdrukker, 1966-1979.

10. SUID-AFRIKA (REPUBLIEK). DEPARTEMENT VAN STATISTIEK. *Suid-Afrikaanse Lewenstabelle 1969-1971.* Pretoria, Staatsdrukker, 1976. Verslag Nr. 02-06-02.

11. SUID-AFRIKA (REPUBLIEK). KANTOOR VAN DIE EKONOMIESE RAADGEWER VAN DIE EERSTE MINISTER. *Ekonomiese Ontwikkelingsprogram vir die Republiek van Suid-Afrika, 1978-1987, Volume I en II.* Pretoria, Staatsdrukker. 1980.

12. TERBLANCHE, S.S. and EBERSOHN, D. *The job situation of the new graduate.* Pretoria, HSRC, 1980. Research finding M-R-81.

HSRC PUBLICATION LIST

A complete list of HSRC publications or a list of publications of a particular institute of the HSRC can be obtained from the President of the Council.

Original title

Die vraag na en aanbod van ingenieurs in 1987

ISBN 0 86965 785 2
(Afrikaanse uitgawe ISBN 0 86965 784 4)

V&R Pta.