A STUDY OF AGEING WITHIN AN INDUSTRIAL ORGANISATION: AGE STRUCTURE AND ITS BEHAVIOURAL IMPLICATIONS

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SUMMARY

This thesis forms part of an applied project for a multinational organisation. The aim is to determine the extent of ageing within the organisation and its performance implications. The thesis is divided into three parts, each containing three chapters. A glossary of notation and terminology is provided.

In Part One, both the role of age as a factor in employment, and the development of occupational age structures are discussed. The total manpower stock is classified into occupations and the age and length of service structures are analysed. A typology is developed and sampled, and a retrospective framework employed to study longitudinal change in age/service structures. A series of age/service behaviour patterns for different types of manpower movement is established.

In Part Two, a computer ageing simulation technique which models the established age/service behaviour patterns is developed. It is used to project occupational age/service structures into the future, and is found to be both reliable and valid. On the basis of both the projections and the retrospective study, the age-linked characteristics of occupations are diagnosed and classified.

In Part Three, evidence relating age to work performance is discussed, and a performance appraisal carried out on a job previously diagnosed as possibly showing such a relationship. The quality, efficiency and quantity of performance, and time worked are analysed across the variables of age, length of service, training experience and task complexity. An age/work performance relationship is established, but found to be mediated by both training experience and task complexity.

It is concluded that use of the simulation technique in conjunction with performance information would provide a useful human resource planning system. However, the previously neglected variable of training experience must be incorporated into both manpower models and performance appraisals when considering the implications of ageing.

KEY WORDS: AGE STRUCTURE
MANPOWER
WORK PERFORMANCE

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CHAPTER ONE

AGE AS A FACTOR IN EMPLOYMENT: THE DEVELOPMENT OF OCCUPATIONAL AGE STRUCTURES

1.1: DEMOGRAPHIC TRENDS AND CHANGES IN EMPLOYMENT PATTERNS

> "Age becomes a significant factor in a worker's life when, simply because of advancing years, he begins to find difficulty either in doing his work, or in finding or keeping a job. It is at this stage of his career that he becomes an 'older worker' from the standpoint of the world of work."
>
> Director-General of the I.L.O. in 1962
> (International Labour Office, 1962, p.14)

1.1.1: Ageing populations

The decline in birth and death rates in industrialised countries has led to there being national populations which are significantly older than in any previous historical period. The United Kingdom has developed a 'pear-shaped' age structure, characteristic of all the industrialised nations. This age structure is illustrated in Figure 1.1 overleaf, and is in sharp contrast to the predominantly youthful age structures of developing countries (where sometimes over three-quarters of the population are aged below 30).

Table 1.1 shows that the proportion of the population aged 65 and over has increased over the period from 1951 to 1980 by, on average, about 3 per cent in several industrialised countries.

The consequence of this increase in the relative size of the elderly population has been an increase in the elderly dependency ratio (defined as the population of

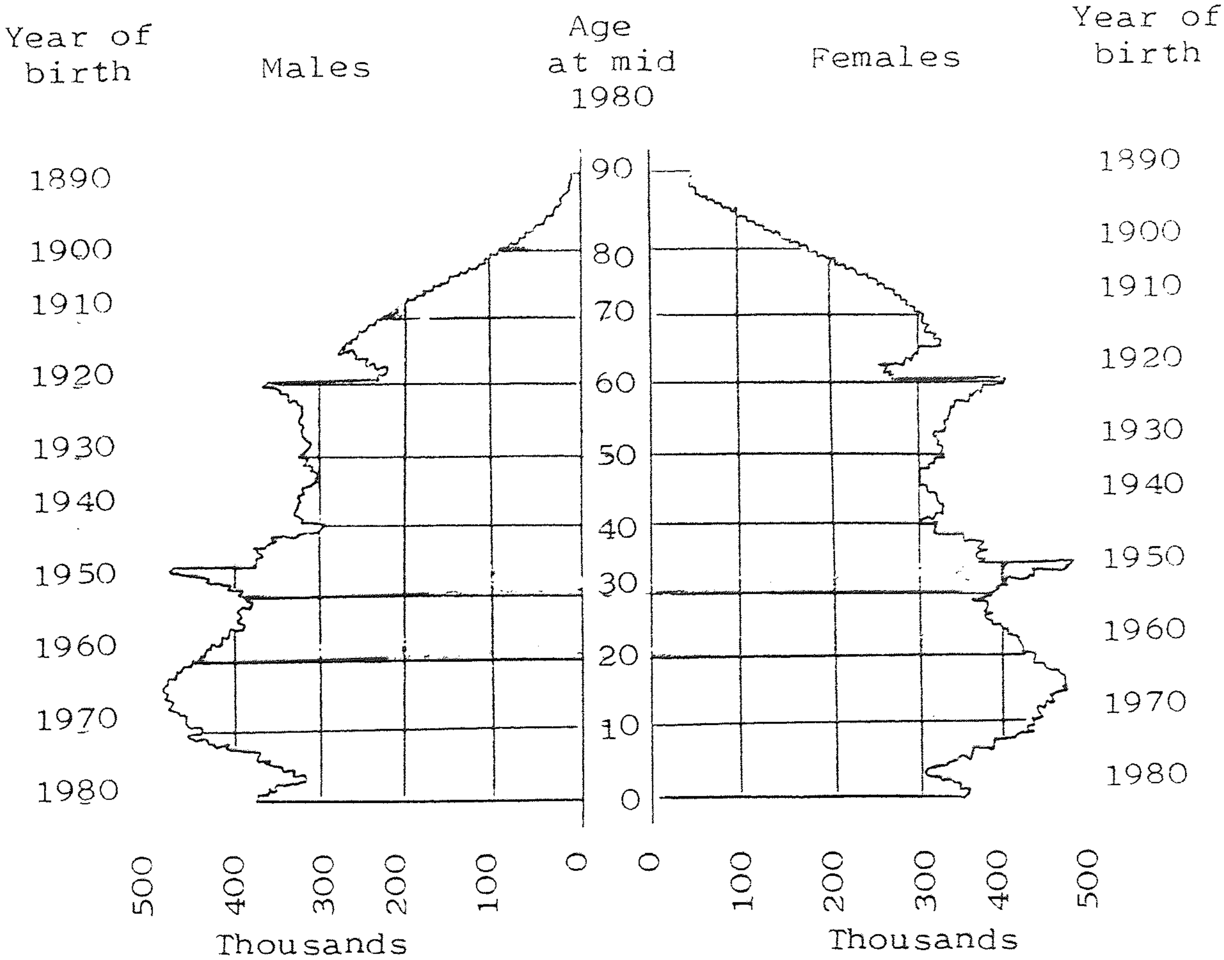
PERCENTAGE OF POPULATION AGED OVER 65

	1951	1956	1959	1965	1970	1975	1980
Belgium	11.1	11.6	11.7	12.5	13.3	14.2	[h] 14.2
Canada	-	-	-	7.6	7.8	8.0	9.5
Denmark	9.1	9.9	10.3	11.4	12.1	13.0	[j] 14.5
Finland	-	-	-	7.9	8.9	10.3	12.1
France	11.4	11.6	[b] 11.6	12.0	12.8	13.3	14.5
Germany	9.3	9.9	10.4	11.9	13.3	14.2	15.9
Ireland	10.7	10.9	[c] 10.8	[d] 11.2	[e] 11.2	[f] 11.3	[g] 10.5
Italy	8.1	8.7	[a] 8.8	9.7	10.6	11.7	12.7
Japan	-	-	-	6.3	7.0	7.9	9.1
Netherlands	7.8	8.4	8.8	9.5	10.1	10.6	11.5
Norway	9.6	10.2	10.6	11.9	12.8	13.4	[i] 14.6
Sweden	10.2	11.0	11.5	12.6	13.6	14.7	[i] 16.1
United Kingdom	10.9	11.3	[a] 11.5	12.0	12.8	13.5	14.9

[a] 1958 [b] 1960 [c] 1961 [d] 1966 [e] 1971 [f] 1976 [g] 1977 [h] 1978 [i] 1979 [j] 1981

After: Davies and Sparrow (1984)
Source: OECD (1975); International Labour Office (1981); United Nations (1982)

TABLE 1.1: PROPORTION OF POPULATION 65 AND OVER WITHIN THIRTEEN COUNTRIES



Source: Social Trends (1982)

FIGURE 1.1: UNITED KINGDOM POPULATION BY AGE AND SEX IN 1980

retirement age expressed as a proportion of the population of working age). In the United Kingdom, the elderly dependency ratio rose from 11.0 per cent in 1911 to 27.2 per cent in 1971. It is predicted to increase to 28.8 per cent by 1991. Considerable cost is incurred in the provision of the basic state pension together with supplementary benefit. In the United Kingdom (where the level of benefit is relatively low compared to many industrialised countries) the 1981 cost was £10.9 billion which represented 5 per cent of the Gross National Product.

Similar increases in the dependency ratio in the United States are predicted (for example, Sonnenfeld, 1978).

1.1.2: Labour force participation

The problems associated with an increasing dependency ratio are exacerbated by recent trends towards earlier withdrawal of men from the labour force. Table 1.2 overleaf presents economic participation rates for men in six industrial countries. There has been a substantial fall in the participation rate of men aged 65 and over, as well as for men aged 55 to 64. A continued fall in participation rates is estimated in the United States (Flaim & Fullerton, 1978; Fullerton, 1980). The participation rate for men aged 65 and over is estimated to fall from 20.1 per cent in 1977 to 15.0 per cent by 1990. The participation rate for men aged 55 to 64 is estimated to fall from 74.0 per cent in 1977 to 65.0 per cent in 1990, even though the number of men in this age group is projected to increase from 9.5 millions to 9.8 millions over the same period.

If this trend continues, then it has been suggested that it may create difficulties for any expansion of the United States economy over the next decade (see Gillaspy, 1980, for discussion).

The reduction in the labour force participation rates in industrialised countries appears to be due to several factors:-

	Actual				Projected
	1950	1960	1970	1980	1990
France	n.a.	75.0	71.3	67.3	53.9
West Germany	82.0	82.2	71.8	67.8	n.a.
Japan	n.a.	86.1	86.6	88.5	n.a.
Sweden	n.a.	87.8	85.4	n.a.	79.1
United Kingdom	n.a.	n.a.	91.2	83.8	n.a.
United States	86.4	84.7	80.8	69.9[a]	64.2

Men aged 55 to 64

	Actual				Projected
	1950	1960	1970	1980	1990
France	38.0	30.5	15.1	6.0	5.0
West Germany	26.6	22.6	19.9	7.4	n.a.
Japan	51.7	56.0	48.9	45.5	n.a.
Sweden	36.1	27.1	19.2	n.a.	7.9
United Kingdom	32.5	25.4	19.9	10.8	n.a.
United States	42.1	30.3	25.7	17.7[a]	14.4

Men aged 65 and over

[a]1981

TABLE 1.2: ECONOMIC PARTICIPATION RATES OF MEN AGED 55 TO 64, AND 65 AND OVER, FROM 1950 TO 1990 IN SIX INDUSTRIALISED COUNTRIES

1. Structural changes in the distribution of employment led industrialised economies away from a society in which the majority of the labour force was employed in agriculture and the extraction industries. Initially, a large proportion of the labour force was involved in manufacturing industries. More recently, the service sector has become the primary economic sector, and it has been argued that we are now seeing the development of an information sector as the major economic sector (e.g. Bell, 1980; Gershuny & Miles, 1983). Whilst this economic transition has been more marked in some countries than in others, common to all countries has been a progressive reduction in the labour force participation rates of elderly people (Belbin & Clarke, 1971).

2. The age of mandatory retirement has been, or is about to be lowered in many countries; examples include Ireland, Norway, Sweden and France. In recent years, only the United States has raised the mandatory retirement age from 65 to 70 in the private sector (although there are some exceptions).

3. However, whilst there has been a shift away from compulsory retirement in the United States, incentives to withdraw voluntarily from the

labour force have been expanded (Work in America, 1980). Brousseau (1981) noted the following incentives in the United States:-

a) that the proportion of the labour force covered by Social Security benefits rose from 58 per cent in 1940 to 95 per cent in 1975;

b) the number of people covered by private pension plans rose from 10 millions in 1950 to 30 millions in 1975;

c) there has been growth in real terms in the magnitude of Social Security benefits;

d) regulations have changed so that it is easier to retire earlier, albeit with some reduction in retirement benefit. In Belgium for example, although the retirement age for men is 65, it has been possible to retire at age 64 without financial penalty since 1977. In the United Kingdom, the Job Release Scheme and recent changes to unemployment registration regulations have, similarly, encouraged earlier withdrawal from the labour force;

e) a number of private companies have lowered the minimum age at which full benefits can be taken. Early retirement has also been encouraged by 'topping up' benefit provisions where necessary.

4. Personal reasons for retiring early have been studied by surveys in both the United Kingdom and the United States.

Surveys of early retirement fall into two categories of either selected groups of early retirees or cross-sections of the whole early retiring population.

a) McGoldrick and Cooper (1980) interviewed and surveyed 120 male early retirees and their wives from companies based in the North West of England. Health accounted for only 10 per cent of the reasons given (but early retirements through complete disability or ill-health were generally excluded from the sample). The main reasons given for retiring were that the finances were right, they had worked long enough or deserved retirement, and they wanted more free time.

b) Parker (1980) carried out a national survey in Britain in 1977. It was clear that many male early retirees were forced to give up work against their wishes for reasons of ill-health (76 per cent had some handicap and 50 per cent gave ill-health as their main reason for leaving). 44 per cent of the sample were sorry that they had retired.

Similar findings have come from the United

States. Reno (1971) concluded that many of the early retired employees did not want to retire, and their attitude was probably related to retirement income. About 70 per cent had lost their jobs through ill-health. Poor health is one of the reasons most frequently cited for early retirement by older workers (Barfield, 1972; Parnes & Meyer, 1972).

1.2: AGE DISCRIMINATION IN THE WORKPLACE

1.2.1: The extent of age discrimination

Another major factor which accounts for reduced participation rates for older workers is age discrimination (Sheppard, 1970; Slater, 1972). Haefner (1977) interviewed 585 employees within a wide range of occupations. Interviewees were presented with descriptions of sixteen hypothetical workmates (whose age, race and sex were experimentally controlled), and asked to rate the degree to which they would like to work with the (hypothetical) workmate. Discrimination on the grounds of age, sex and race was found, with the older, black and female employees being the least favoured workmates. Older employees in the sample did not, themselves, show any age discrimination. However, the effects of age discrimination are clearly felt.

Kasschau (1976, 1977) obtained data on reported discrimination for 273 employees aged over 45, in the aerospace industry. The sample represented a 30 per cent response rate to the questionnaire. Two separate forms of age discrimination were reported. These were situations where either personal discrimination was reported, or in which discrimination on the grounds of age was reported by a friend. The extent to which discrimination in these categories was reported is shown in Table 1.3 below:

Situation	Personal Discrimination	Discrimination reported by a friend	Total
In finding a job	33%	45%	78%
Promotional block	22%	22%	44%
Staying on in present job	10%	40%	50%
Forced retirement	20%	40%	60%

TABLE 1.3: PERCENTAGE OF OVER 45 YEAR OLD EMPLOYEES WHO HAVE PERCEIVED AGE DISCRIMINATION WITHIN VARIOUS CONTEXTS

(After Kasschau, 1976, 1977)

Age discrimination was most frequently reported in finding a job, where 78 per cent of the sample had either personally felt such discrimination, or had a friend who had been discriminated against. Forced retirement (60 per cent), staying on in the present job (50 per cent) and promotional blocks (44 per cent) also constituted situations in which discrimination was reported. Considerable difficulty, then, is found in gaining new employment, staying on in employment and in being forced to leave employment. Evidence covering age discrimination in these three aspects of the working life is now briefly discussed.

1.2.2: Age discrimination in recruitment

A recent analysis of age discrimination in the United Kingdom was carried out by Jolly, Creigh and Mingay (1980). In a survey of some 16000 national records from the Manpower Services Commission, 27.5 per cent of vacancies were qualified by an upper age limit. This figure differed across occupations. The highest proportions of age limits were found in the distributive trades (35.8 per cent) and manufacturing (30.2 per cent), and the lowest proportions in the service industries (22.9 per cent) and construction (17.9 per cent). Where age limits occurred, applicants were restricted to younger age groups. 44.9 per cent of restricted vacancies had an upper age limit of 30 years, reaching 65.3 per cent with an upper limit of 40 years. Little leniancy is practised as only 17 per cent of successful candidates were actually older than the official age limits. An analysis of the percentage of jobs open or closed to individuals seeking professional employment showed that 53 per cent of vacancies were closed to individuals aged over 45. This figure became 76 per cent by the age of 50, and 98 per cent by the age of 60.

1.2.3: Age discrimination at work

Rosen and Jerdee (1976b) found that the older worker is stereotyped as potentially less employable than a younger person (particularly for highly demanding and challenging positions). The older worker is expected to perform less well at creative, motivational and productive tasks, and is viewed as having a lower potential for development. Rosen and Jerdee (1976a, 1977) then tested the extent to which such stereotypes influenced managerial decisions. A sample of 142 undergraduate business students performed an in-basket simulation exercise of managerial decisions. A decision was required concerning a hypothetical individual about whom a complaint had been received. The individual in the incident was presented as being either older or younger, and six incidents were manipulated. The older manager was seen as being significantly more resistant to change, less promotable, less suitable for financial risk-taking decisions and less motivated to keep up to date. Raters were less prepared to allocate funds to retrain the older worker, or to allow attendance on refresher courses, than for the younger worker. When asked to choose between a talk to the manager or finding someone else for the job, it was decided that the younger manager should be given a talk, whilst the older manager should leave. Raters were also more willing to terminate the employment of the manager whose skills had become obsolete, and hire a fully qualified replacement, if the employee was older. Rosen and Jerdee (1977) argued that to the extent that such stereotypes influence managerial decisions, the potentially serious consequences for older workers include lowered motivation, career stagnation, and eventual career obsolescence.

Slightly different results were found by Schwab and Heneman (1978) with a more representative sample of 35 personnel specialists responsible for performance evaluation within their companies. In a disguised task, the age and length of company service of a hypothetical applicant for a secretarial post were experimentally manipulated. Six ratings of job performance were rated, based on a series of presented critical behaviour incidents. Job experience and age of the target secretary had no impact on the performance evaluations but there were significant interactions between the age of the rater, and age of the target secretary. Older raters provided lower ratings of older secretaries on job knowledge, responsibility and recommended salary increases. Two reasons were put forward for the lack of overall age effects:-

1. In line with previous findings (e.g. Reno, 1979) the personalisation of the older individual reduces age discrimination, making it more difficult to downgrade ratings of performance.
2. The target job (secretarial) is not as skill obsolescent as that of management, which was used in the studies by Rosen and Jerdee.

1.2.4: Age and unemployment

Daniel (1974) analysed a 10 per cent national survey of the U.K. unemployed, and found that the percentage of unemployed due to redundancy rose from 17 per cent when aged under 25, to 42 per cent if over the age of 55. Daniel (1974) concluded that closures, shortages of work, and, particularly, reorganisations of work were more likely to affect older workers.

In another analysis, Daniel constructed a probability index for unemployment. He found a U relationship between age and probability of unemployment, but a positive linear relationship between age and duration of unemployment (as well as probability of redundancy). In 1973 the worker aged over 55 was slightly more likely to be unemployed than the worker aged under 25. Both these age groups were twice as likely to be unemployed than the 35 to 44 year olds. However, the over 55 year old was three times more likely to be made redundant than the under 25 year old, and the period of unemployment was twelve times as long.

The last decade has seen the "democratisation" of unemployment, as evidenced in Table 1.4 overleaf. This table shows both the numbers of registered unemployed and the proportions of long-term unemployed (over one year), by age bands. The number of registered unemployed increased from 660,606 to 2,221,050 from 1973 to 1983, and the proportion of this total who were long-term unemployed

	Total number of registered unemployed men	Total number of men registered as unemployed for over 52 weeks	Long-term unemployed men as a percentage of all unemployed men	Age Groups					
				Under 25	25-34	35-44	45-54	55-64	65+
January 1973	660,606	161,512	24.45%	1.94%	2.99%	3.70%	4.72%	11.03%	0.07%
October 1978	946,004	266,669	28.19%	3.55%	5.04%	4.38%	5.20%	9.89%	0.13%
April 1983	2,221,050	888,996	40,03%	9.10%	8.76%	6.40%	6.00%	9.70%	0.07%

TABLE 1.4: AGE AND LONG-TERM UNEMPLOYMENT: THE NUMBER OF MEN IN DIFFERENT AGE GROUPS IN GREAT BRITAIN REGISTERED AS BEING UNEMPLOYED FOR OVER 52 WEEKS EXPRESSED AS A PERCENTAGE OF THE TOTAL NUMBER OF UNEMPLOYED MEN FOR JANUARY 1973, OCTOBER 1978, AND APRIL 1983. THE TOTAL NUMBERS OF REGISTERED UNEMPLOYED MEN, THE TOTAL NUMBERS OF MEN UNEMPLOYED FOR OVER 52 WEEKS AND THE LATTER EXPRESSED AS A PERCENTAGE OF THE FORMER ARE ALSO SHOWN

SOURCES: EMPLOYMENT GAZETTE FOR FEBRUARY 1973, NOVEMBER 1978, AND JUNE 1983.

increased from 24.45 per cent to 40.03 per cent. The effect of this massive increase in unemployment differed across age bands. The long-term unemployed aged under 25 increased as a proportion of total unemployed from 1.94 per cent in 1973 to 9.10 per cent in 1983. The same proportion for 55 to 64 year olds fell from 11.03 per cent to 9.70 per cent. Long-term registered unemployment is probably underestimated by one third (Tyrrell & Shanks, 1981) because individuals have to re-register after prolonged illness. To the extent that such prolonged illness may increase with age, the figures might underestimate older long-term unemployment. Similarly, recent changes in regulations regarding registration have reduced the number of registered unemployed aged over 60 by an estimated 199,000 (Lipsey, 1983). Therefore, the 1983 figure is likely to have overestimated the decline in the proportion of unemployed represented by the 55 to 64 age band.

Redundancy "seems to slide into early retirement for a substantial number of men under pension age" (Parker, 1982). Two national surveys during 1976-77 in the United Kingdom showed that between 19-22 per cent of men who gave up work before the age of 65 did so because of redundancy (Hunt, 1978; Parker, 1980).

1.3: AGE AND WITHDRAWAL BEHAVIOURS

Evidence discussing age as a factor in employment has so far generally concerned aspects beyond the immediate control of the individual (such as mandatory retirement, age stereotypes and unemployment). Attention is now turned to the relationship between age and voluntary withdrawal behaviours. There are two types of withdrawal behaviour considered, i.e. absenteeism and unavoidable turnover. Both these behaviours form important aspects of accountable performance. The loss of productivity, wasted investment in training, and replacement costs associated with turnover are all accountable costs (Flamholtz, 1974). Similarly, an average 3.5 per cent of scheduled work hours are lost due to absenteeism in the United States (Taylor, 1979) accounting for a national loss of over $26 billions a year (Steers & Rhodes, 1978).

1.3.1: Absenteeism and age

Age and tenure represent two of the many correlates of absenteeism investigated. Reviews on absenteeism have been made by Brayfield and Crockett (1955), Herzberg, Mausner, Peterson and Capwell (1957), Muchinsky (1977), and Porter and Steers (1973), yet the lack of causal theory and appropriate taxonomies to classify those studies with age as a variable, have made the effect of age upon absenteeism difficult to interpret.

Several factors interact with age and tenure as explanatory variables of absenteeism (Nicholson, Brown & Chadwick-Jones, 1977), including the type of absence (whether paid or unpaid, and avoidable or unavoidable) and the methodology employed (longitudinal or cross-sectional). There is only limited information on the reliability of absence measures used (Muchinsky, 1977). Less than 9 per cent of studies computed the reliability of their measures, and estimates ranged from +0.16 to +0.74. Whilst frequency of absence was the most robust measure, estimates of reliability for even this measure were not consistent across studies.

Evidence indicating a positive correlation between age and absenteeism has come from two longitudinal studies on construction and skilled manual workers (Cooper & Payne, 1965; De La Mare & Sergean, 1961), and a cross-sectional study on clerical workers (Garrison & Muchinsky, 1977). Garrison and Muchinsky's (1977) study distinguished between paid and unpaid absence. Age correlated positively with paid absence and negatively with unpaid absence.

Negative correlations between age and absenteeism were obtained by Spencer and Steers (1980), Taylor (1967) and the U.S. Department of Labor (1956). These studies showed a negative correlation between age and frequency of absence, and a positive correlation between age and duration of absence.

Jackson (1944) found a U relationship between age and absence in a sample of machine shop workers, and two studies found no relationship in samples of female clerical workers and factory workers (Naylor & Vincent, 1959; Schenet, 1945).

Nicholson, Brown and Chadwick-Jones (1977) clarified these often contradictory findings by distinguishing between sex of sample and type of absence. They concluded that there is a distinct negative relationship between age and avoidable absence (casual, voluntary and unsanctioned frequency of absence) for males. This relationship for females is a less powerful negative relationship. There is no predominant relationship between age and unavoidable absence (sickness, involuntary, sanctioned and time-lost absence) for women, whilst for men, it appears that there are fewer unavoidable absences but, when they occur, the duration is longer than for younger men.

The link between tenure and absenteeism is more clear-cut. Whilst positive linear relationships between tenure and absence for female blue and white collar workers (Baumgartel & Sobol, 1959), and between tenure and paid absence for clerical workers (Garrison & Muchinsky, 1977) have been demonstrated, evidence for a negative linear relationship is far more predominant. A negative relationship has been found for male blue collar workers, machine shop workers, teachers, service workers and female clerical workers (Baumgartel & Sobol, 1959; Behrend, 1959; Jackson, 1944; Knox, 1961; Simpson, 1962; Spencer & Steers, 1980; Waters & Roach, 1971), and for clerical workers with unpaid absenteeism (Garrison & Muchinsky, 1977). No relationship was found in a longitudinal study of factory workers by Hill and Trist (1955).

1.3.2: Age and unavoidable turnover

Unavoidable turnover, defined as individual separations from a single plant excluding those leaving due to redundancy, mandatory retirement and death, represents an area of age behaviour discrete from forced withdrawal from work (see Section 1.2.4). The link between age and tenure (referred to as the age-tenure hypothesis) would seem apparent from the often observed high correlations between on the job service and age (e.g. O'Boyle (1969) found a correlation of +0.989 for men and +0.932 for women). Such observations, whilst ignoring the obvious limitation that young people have not had the time to accumulate service with an employer, are nevertheless supported by an overwhelming number of generally cross-sectional studies. These show a negative correlation between age and propensity to leave, and tenure and propensity to leave (Pettman, 1975; Price, 1977). Numerous reviews on turnover have supported this contention (e.g. Andrew, 1957; Porter & Steers, 1973).

The use of controls is relatively rare in studying the relationship between age and turnover, although four studies have shown that age and turnover continue to be negatively related when service is controlled for (Charters, 1970; Mackay, Boddy, Brack, Diack & Jones, 1971; Mangione, 1973; Van der Merwe & Miller, 1970). Using sex as a control, Archibald (1973) found the usual negative relationship between age and turnover although it was stronger for men than women.

Evidence for the importance of tenure is provided by a series of studies on clerical, production and sales workers, nurses' aides, ward attendants, bus drivers, long-haul lorry drivers and seasonal workers (Barrett & Lang, 1963; Black & Mackinney, 1963; Brown & Ghiselle, 1947; Buel, 1964; Cleland & Peck, 1959; Dunnette & Maetzold, 1955; Dunnette, Kirchner, Erickson & Banas, 1960; Fleishman & Berniger, 1960; Green, 1969; Kerr, 1947; Kirchner & Dunnette, 1957; Livingstone, 1955; MacKinney & Wolins, 1959; Mandel et al, 1956; Minor, 1958; Sowatsky, 1951; Shott, Albright & Glennan, 1963; Tiffin et al, 1947; Tiffin & Phelan, 1953; Wernimont, 1962; Wilson, 1959; and York, 1956). The variables considered included age, length of service, sex, skill level, marital status, number of children and method of recruitment. Pettman (1975), in his review, concluded that the two most reliable variables were length of service and the reasons given for leaving the previous job.

A recent study by Stumpf and Dawley (1981) used age, sex, tenure, education, absenteeism and three measures of performance to predict voluntary and involuntary turnover in a sample of bank tellers. Hierarchical multiple regressions provided significant predictions accounting for 27.2 per cent of the variance in voluntary turnover and 37.8 per cent of the variance in involuntary turnover. For voluntary turnover, the three performance measures accounted for 9.2 per cent of the variance followed by tenure (7.3 per cent), age (5.1 per cent), absenteeism (3.0 per cent) and sex (2.6 per cent). The relationship is different for involuntary turnover, with the performance measures producing the largest variance change (10.5 per cent), tenure (7.0 per cent), sex (3.3 per cent) and age (3.1 per cent). It can be concluded that age bears a strong negative relationship to propensity to leave voluntarily, but it is not as important as an individual's performance and tenure.

Reasons suggested for the negative link between age and propensity to leave include an increased importance of job security with age (Clarke, 1950) and of the benefits accruing to longer service, e.g. pension rights (Harris, 1964; Hatch, 1963).

1.4: THE DISTINCTIVE LABOUR MARKET EXPERIENCE OF OLDER WORKERS

In Section 1.2.4, it was pointed out that between 19-22 per cent of men who give up work before the age of 65 do so by retiring after a sustained period of unemployment. Another common strategy is to 'downgrade' their skill level, or move into 'part-time' employment in an attempt to find a job (Daniel, 1974, 1981). Those older workers who remain in employment therefore tend to be concentrated in relatively few industries. Makeham (1980) showed that, in the United Kingdom in 1977, 29 per cent of all males, but 55 per cent of men aged over 65 in employment, were employed in the four industries of agriculture, distribution, professional and scientific services, and miscellaneous services. Similarly, Nelson (1980) using 1970 census data in the United States, found a relative concentration of workers aged 65 and over in 'marginal occupations' (defined in terms of job security, number of weeks worked per year, rate of occupational growth or decline, and social status). Sobel (1970) pointed out that, since 1930 in the United States, older men were found in disproportionate numbers in many unskilled service occupations which required only low levels of skill and training. Such evidence, in conjunction with that describing recruitment, workplace discrimination, and unemployment, describes what Makeham (1980) called "the distinctive labour-market experience of older workers" (p.40).

1.5: OCCUPATIONAL AGE STRUCTURES

1.5.1: Theoretical value of occupational age structures

The distinctive labour market experience of older workers with differential age limits for vacancies across occupations, and increasing concentration with age of individuals into a narrow band of occupations, has led to the study of occupational age structures.

The assumption made is that the age distribution of workers in an occupation reflects the difficulty that the occupation poses for an age group. The matching process by which this assumption is achieved requires that individuals who are well-suited to the work will remain in the occupation. However, the individual who (because of age) is mismatched, will either be forced to leave (forced early retirement or compulsory redundancy), induced to leave voluntarily on the grounds of self-selection, or barred from joining (by age limits to recruitment).

There is evidence to show that the movement of manpower into and out of occupations is of a sufficient magnitude to make this matching process a valid assumption (Elliot, 1966; Harris & Clausen, 1966; Smith, 1967, 1974). However, local and national economic and demographic factors in the form of the age range of the labour force (past and present), recruitment and retirement policies, and unemployment, can also influence occupational choice (Butler, 1968; Carter, 1963; Welford, 1951), and might blur the age-linked matching process.

Smith (1974) points out that the theoretical value of occupational age structures rests primarily upon a negative case, in that the use of age structures is not prone to many of the methodological problems which affect experimental studies of age and performance indices. These methodological problems are dealt with later in Chapter Seven, when the topic of age and work performance is researched. At this point, Welford's (1951) conclusion that more valid results are found by considering the "incidence of older people on different occupations" as opposed to studying production indices is concurred with.

1.5.2: <u>Early studies of occupational age structure</u>

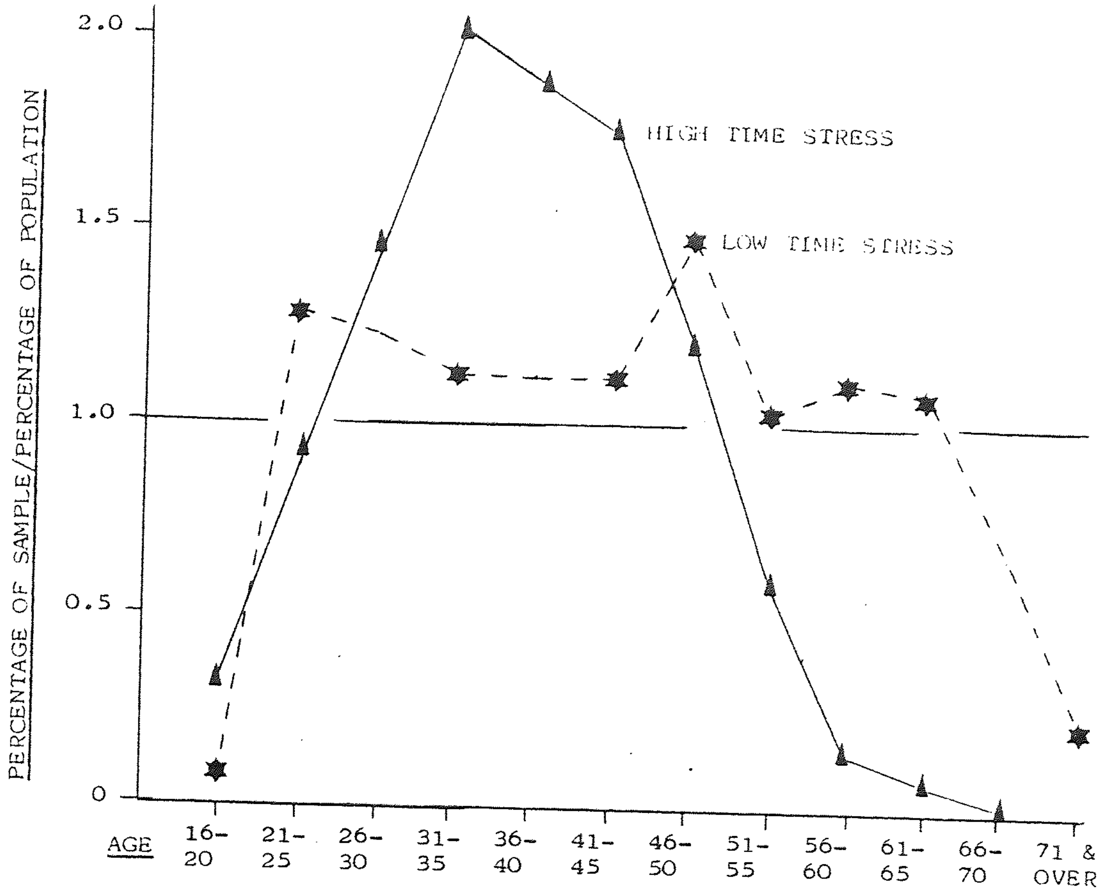
Barkin (1933) pioneered the use of occupational age structures in a study conducted in the United States during the Depression. He employed five categories of job description, and collected information on the type of industrial work on which individuals of different ages were engaged. Barkin found that the percentage of individuals engaged in "work which is performed by the application of bodily strength, or by the use of tools demanding bodily movements" (body work) increased considerably with age from the early thirties onwards. In the case of newly-hired workers, this phenomenon was even more marked.

Belbin (1955) conducted a similar study using a 1 per cent sample of the 1951 United Kingdom census. He examined the age distributions of jobs associated with heavy and light physical demands and found that, in industries such as steelmaking and bricklaying, proportionately more of the unskilled jobs requiring strenuous physical work were occupied by men aged over 45. Men of this age occupied proportionately fewer of the skilled jobs making minimal physical demands. However, no contrasts between the age structures of jobs associated with heavy and light work were observed in the plumbing and plating industries, and reductions in the number of men aged 55 and over employed as dock labourers, navvies, black-smiths and hand hewers were found.

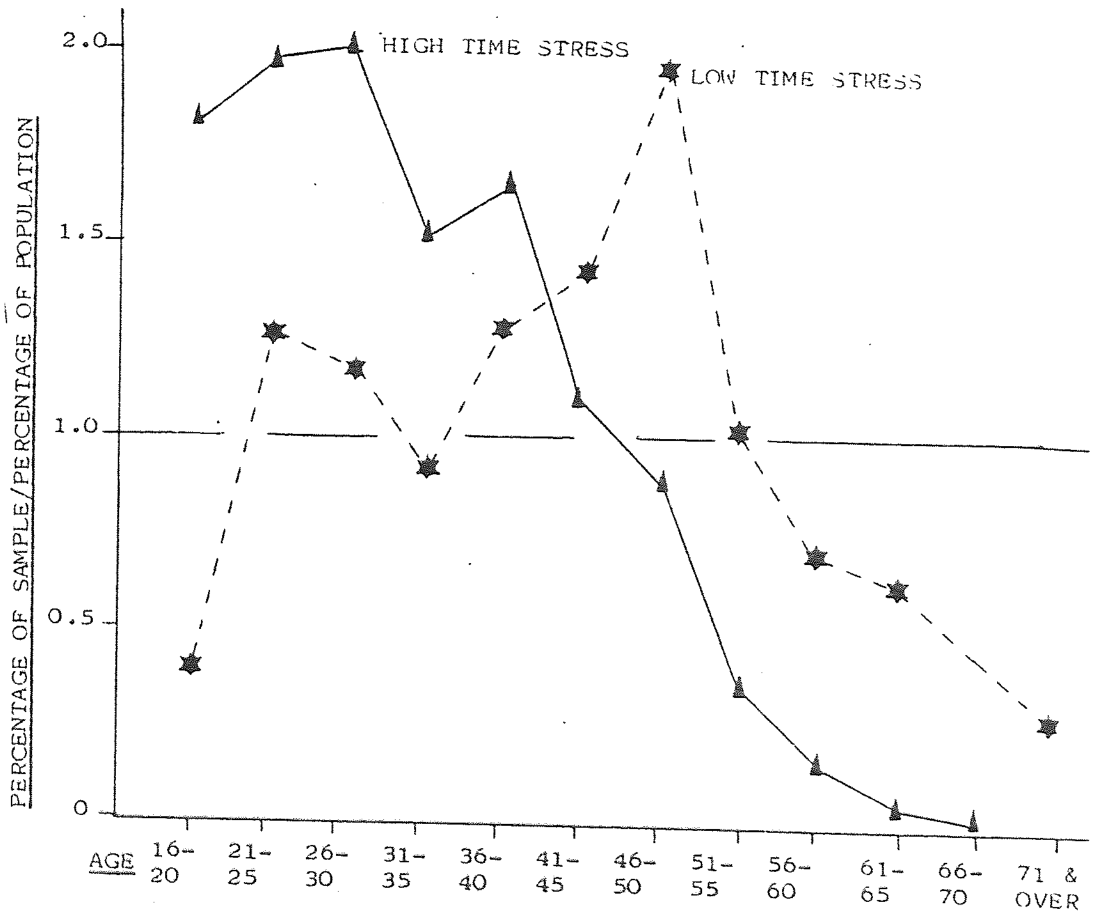
As age increases, so do transfers to lighter work (Belbin, 1955; Richardson, 1953) suggesting that, in some jobs, heavy work may pose greater difficulties for older workers than for younger ones. Richardson (1953) found a positive relationship between age and frequency of transfers to lighter work which was particularly marked in unskilled and semi-skilled workers aged over 40 years. Whilst over half the transfers were due to illness or injury, depth interviews and medical records revealed that, in many cases, the transfer followed a minor illness or injury. The recovery from such minor illnesses was both rapid and complete, but it appeared to act as a 'trigger-factor'. The final move to lighter work was often preceded by a period of weeks or months in which the individual became aware of the difficulties associated with heavy work. By far the most important difficulty reported was the speed of the work required, such that even when older men remained in jobs requiring heavy work, they transferred to jobs associated with a slower pace of working.

The finding that pace of work may pose a problem for older workers is consistent with the results of another study by Belbin (1953). Workshop operations in 32 firms were surveyed and the characteristics of each operation where difficulties were experienced by older workers (either in skill acquisition or continued performance) were analysed. The common features of operations in which age difficulties occurred were compared to a control group of operations where these difficulties were not apparent. Figure 1.2 overleaf compares the age distribution of workers in jobs where time stress was either present or not. It can be seen that, for both men and women, there was a steadily declining percentage of workers from the age of 35 onwards, in those occupations which involved time stress, whilst in those that did not, there was, if anything, an increasing percentage of workers above this age. Training differences were also experienced from the twenties onwards in jobs demanding a high degree of sensorimotor skill, and some tendency was observed for older workers to move away from "operations requiring continuous bodily movement and activity" especially when pacing was also a feature of the job.

An extensive series of examinations of the age structures of jobs and their possible relation to work difficulties



Men



Women

FIGURE 1.2: AGE DISTRIBUTION OF MEN AND WOMEN IN HIGH AND LOW TIME STRESS OCCUPATIONS (Source: Belbin, 1953)

was carried out by Murrell and his co-workers (Griew & Tucker, 1958; Murrell, 1962; Murrell & Griew, 1958; Murrell & Tucker, 1960; Murrell, Griew & Tucker, 1957). These studies looked at the median ages of representative jobs in the light engineering industry in the South West of England, and found that they were highly consistent across a number of firms over a period of several years. The median age of workers in the industry was 43.2 years. Jobs were classified as old or young around this median age. The 'old' jobs were mainly physical, and involved minimal time stress (e.g. storekeepers, median age 49.5 years; packers, median age 53.0 years; labourers, median age 55.0 years; and factory service workers, median age 56.5 years). Jobs associated with the lowest mean ages appeared to be those which made relatively high perceptual demands. They included pattern makers (median age 31.0 years), electricians (34.2 years), millers (35.1 years) and grinders (38.0 years). The factors in the work situation which were sources of difficulty for the older worker were revealed by job analyses to involve dial reading, a high degree of tolerance to be worked to, small detail to be attended to, and complex instructions to be followed. These factors all involve high perceptual demands. Fewer problems for older workers were posed by large amounts of physical activity or heavy loads to be lifted.

A higher proportion of reportable accidents than would be expected (if there were no interaction between age and job demands) was noted for older workers working in 'young' occupations (Griew, 1958). For example, men aged over 44 working as millers and grinders ('young' jobs) sustained about twice the expected number of accidents, whilst men over 44 working as storekeepers and labourers ('old' jobs) had about the same number of accidents as would be expected.

1.5.3: A clarification of the concept and measurement of occupational age structures

There are two concepts within occupational age structures which Smith (1974) clarified.

1.5.3.1: The level of measurement

The level of measurement revolves around the definition and validity of the term 'occupation'. Depending upon the aims of the study, age structures can be measured for jobs, industries or occupations. More immediate solutions may be afforded by study at the lower levels (job and industry), but the level of occupation is best when general issues are under study. Smith (1974) argues the following three advantages of considering occupations:-

1. Once data at the industrial level are subdivided by sex, age and occupation, then frequencies within single categories become small, and subject to dramatic change year by year. The industrial level could be said to be over discriminating.
2. Data at the industrial level are more vulnerable

to highly specific factors which might be affecting that industry at that time. This effect is less apparent in occupational data which can cross industries. The industrial level could be subject to greater 'background noise'.

3. Industrial data may ignore considerable inter-industry mobility.

To these arguments should be added a fourth which is concerned with the underlying psychological requirements of work:-

4. There are definitive occupational profiles across the constructs of aptitudes (Stewart, 1947), interests (Cardall, 1942) and personality (Cattell, Day & Meeland, 1956), such that significant differences exist between occupations on scores on these constructs. More recently, evidence points towards core skills underlying occupational families. Such distinct differences in psychological attributes allow for easier generalisation from occupational age structure differences than from industrial age structures, where the psychological underpinning is not as definitive.

Therefore, studies which use a definition of occupation which is both nationally standardised and has a psychologically meaningful structure may be of considerable value. The study of occupational age structures has been applied in such diverse areas as accident investigations (e.g. McFarland, 1959; King & Speakman, 1953); vocational guidance (e.g. Griew & Tucker, 1958); manpower planning (Air Transport & Travel I.T.B., 1972; Road Tranport I.T.B., 1972); performance appraisal (e.g. Kutscher & Walker, 1960); prediction of future events and national policy making (e.g. Le Gros, Clarke & Dunne, 1955).

1.5.3.2: <u>The statistical basis of measurement</u>

An occupational age structure needs to efficiently summarise the ages of workers in a manner which removes the influence of other factors such as the size of the occupation. A series of measures have been used in the study of occupational age structures (Smith, 1974) including:-

a) simple frequency distributions
b) percentage distributions (or proportions)
c) ratios of frequency in one age group divided by frequency in another (standard) age group
d) transformation of frequencies in age groups to a proportion of 100 per cent which is attributed to the largest frequency
e) ratio of proportion in each age group as a proportion of all workers in that age group
f) standardisation of frequencies in age groups as a ratio of 1.0

Smith (1968a, 1968b, 1969, 1970, 1973) favoured the use of measure (f). This was calculated as follows. The total frequencies of active males or females in all the age bands are calculated. Each age band frequency is then expressed as a percentage of all economically active males or females. An identical procedure is carried out for the occupation, deriving the percentage of all males in the occupation within each age band. A ratio is then calculated for each age band of the occupation by dividing the percentage of males in the occupation by the percentage of all economically active males. The resultant ratio measures the relative representation of each age band in the occupation. A ratio of more than 1.0 shows that there is an over-representation of people of that age in the occupation in proportion to the total working population of the same age.

1.5.4: A classification of occupational age structures

Smith (1969, 1970, 1975) classified occupational age structures derived from British Census data by using distance measures on seven non-orthogonal dimensions which were then cluster-analysed. 137 occupations were classified into four broad groups of age structures, which were then sub-divided into six characteristic age structures. These six characteristic age structures are illustrated overleaf in Figure 1.3.

1.5.5: Change in occupational age structures: Hypotheses H and A

Smith (1973) attempted to answer the question of what causes an occupation's age structure by studying

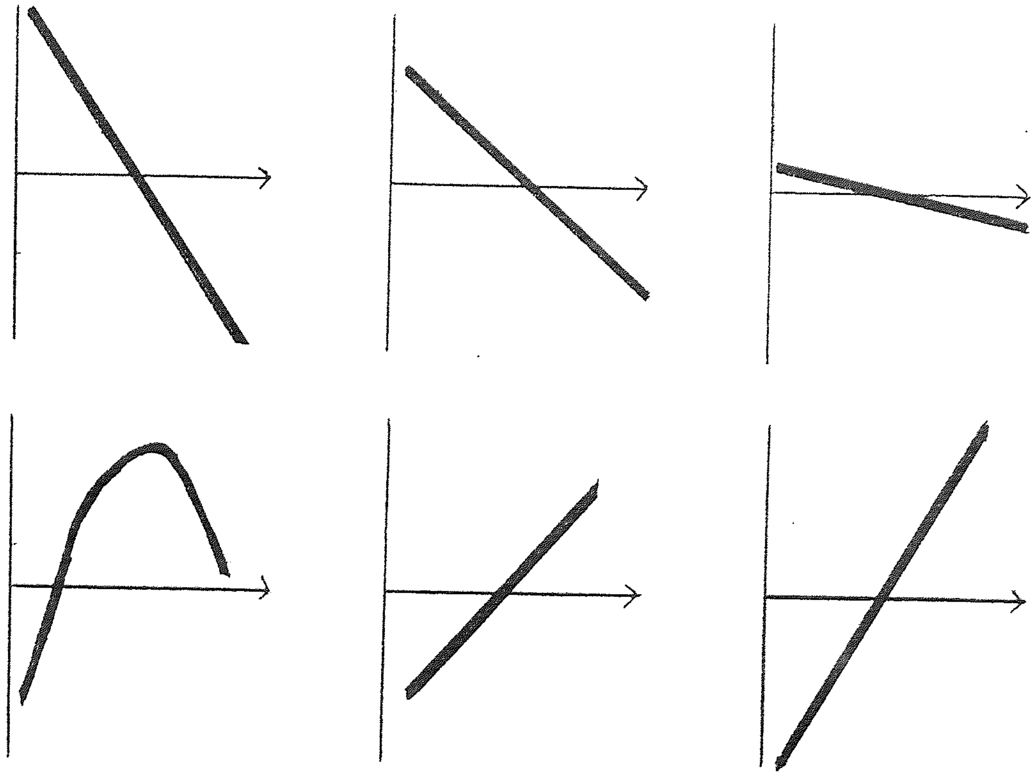


FIGURE 1.3: SIX CHARACTERISTIC AGE STRUCTURES CLASSIFIED BY SMITH (1969, 1970)

longitudinal changes in British Census data from 1961 to 1966. Two hypotheses were advanced: Hypothesis H maintained that an occupation's age structure is merely a blurred picture of the history of that occupation, caused by historical and economic factors. The temporal consequences in this case would show that the peaks and troughs of the age structure would move across the age bands in direct relation with time passed. Hypothesis A, however, maintains that the age structure reflects difficulties experienced in the job demands by different age groups. A trough in the proportion of over 50 year olds would mean that, on average, those over the age of 50 cannot perform the work adequately. Consequently, changes in the shape of the age structure over time would be minimal.

Smith (1973) developed a suitable measure of occupational age structures (described in Section 1.5.3.2) which was not confounded by external demographic influences such as fluctuations in birth rates. Occupational age structures were derived from 1961 Census data. These were then 'projected' forward five years under the two Hypotheses A and H. A Hypothesis H projection involved 'moving' the proportions of the age structure forward into the next five year age bands, and a Hypothesis A projection meant keeping the same age structure. These two hypothetical future age structures were then compared with the age structure that actually occurred (based on 1966 Census data).

The results clearly showed that 133 occupations most clearly conformed to Hypothesis A (age-linked change), and 50 occupations conformed to Hypothesis H. Conformity was calculated using a D^2 test, and the two proportions were significantly different using a sign test ($p < .001$). Smith (1973) concluded that those occupations which adhered to Hypothesis H "contain a higher proportion of jobs that involve a definite career structure or training" (p.489). Excluding those occupations which showed a relatively flat age structure (type 3 in

Figure 1.3), there was a high correlation between the proportion of occupations accounted for by Hypothesis H and the "agedness" of the age distribution. The Kendall's Tau rank order correlation was +0.80 ($p < .05$), showing that the 'older' the occupational age structure, the more likely that future change will be historical as opposed to age-linked.

1.6: CONCLUSIONS

The research discussed in this chapter has provided the following findings and conclusions:-

1. National populations in industrialised countries are ageing and are now significantly older than at any previous historical time. However, the economic activity of the increasing number of older people is in decline, particularly in men.

2. The reasons which underlie this potentially damaging drop in economic activity with age include economic structural change; reductions in the age of mandatory retirement; increased incentives for voluntary withdrawal from the workplace; poor health; and age discriminatory attitudes and personnel policies.

3. Age discrimination is clearly represented in recruitment age limits, stereotypes of older workers, and age-bias in redundancy. The over 55 year old in 1973 was three times more likely to be made redundant, and would be unemployed for a period twelve times as long as his under 25 year old counterpart.

4. The positive correlation between age and involuntary withdrawal from the labour force is in stark contrast to the link between age and voluntary withdrawal behaviours. Older men are avoidably absent significantly less often than are younger men. To a lesser extent, the same is true for older women. Unavoidable absenteeism occurs less frequently for older men, but when it does, it lasts for a longer period. Age and turnover are also significantly negatively related. The reduced turnover and absenteeism with age constitute a cost-saving which deserves consideration alongside direct measures of productivity.

5. The combination of distinguishable age patterns in both voluntary and involuntary withdrawal from work, along with age discriminatory attitudes constitute a distinctive labour market experience for older workers.

6. This distinctive experience is reflected in distinguishable age structures between occupations. Proportionately lower proportions of older men are found in such occupations as pattern-making, electrician, miller and grinder. These occupations tend to involve high perceptual demands, or time stress.

7. There are six characteristic occupational age structures, each showing a different relationship between age and the relative representation of workers.

8. Occupational age structures can be distinguished in terms of showing either historical longitudinal change, or age-linked longitudinal change. The majority of occupations are age-linked. Those which are not, generally represent jobs which involve a definite career structure or training, and have an initially 'older' age structure.

The following points arise from this review of research and form the basis of the initial research:-

1. Does the incorporation of length of service as well as age into occupational structures allow for meaningful comparison?

2. Of what practical use are occupational age/ service structures measured at the organisational as opposed to national level? Do they conform to findings shown for national structures?

3. Can organisational occupational age/service structures be classified?

4. Do they show longitudinal change, and if so, can this change be categorised as either historical or age-linked?

5. Is such change linked to the initial "agedness" of the structure, or is it due to other factors?

6. To what extent might such change be controllable within organisations?

CHAPTER TWO

THE STUDY OF OCCUPATIONAL AGE/SERVICE STRUCTURES WITHIN AN ORGANISATION

2.1: INTRODUCTION TO STUDY ONE

The research discussed in Chapter One clearly showed that there are occupational differences in age structures at a national level. However, it was apparent that local labour market factors can cause geographical variation; and there are some marked sex differences in age structures. Smith (1974) has detailed some of the major personnel implications of age structures. If these personnel implications are to have any validity for organisations, then it should first be demonstrated that occupational differences in age structure exist not only at a national level, but also within the personnel of an organisation. The first study is designed to analyse age structures at this organisational level, and specifically, it will test for differences across occupations, geographical locations, and sex.

2.2: AGE STRUCTURE OF THE TOTAL ORGANISATION

The organisation under study is a large multi-national company concerned with the production, and provision of maintenance services for office equipment. The organisation has over 12000 employees in the United Kingdom.

Data relating to pension scheme membership were gathered at three sample time points - June 1978; May 1979; and January 1980. The age structures of the total organisation as revealed by these data are shown overleaf in Table 2.1.

	AGE BAND										
Date of Sample	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	Over 60	Total Number Employ	Mean Age
June 1978	654 5.17	1753 13.85	2490 19.68	2462 19.45	1521 12.02	1176 9.29	932 7.37	832 6.58	612 4.84	220 1.74	12652	35.34
May 1979	660 5.30	1617 12.99	2196 17.65	2487 19.98	1578 12.68	1238 9.95	957 7.69	851 6.84	636 5.11	225 1.81	12445	36.48
January 1980	495 3.90	1738 13.80	2186 17.40	2559 20.30	1684 13.40	1274 10.10	1011 8.00	831 6.60	637 5.10	172 1.40	12587	36.04

KEY The figure in the top of each box is the frequency of workforce in the age band

The figure in the bottom of each box is the precentage of the sample this frequency represents

TABLE 2.1: AGE BAND ANALYSIS OF THE COMPANY FROM JUNE 1978 TO JANUARY 1980

Five-year age bands are used. The mean age of the organisation is calculated, and it changed over the three time points.

Much of the age data in this thesis are summarised by a metric termed the Rate of Ageing Index (RAI). The RAI is calculated as the difference in the mean ages for samples year (x) and year (y), divided by the time difference between (x) and (y) in years. This metric establishes a ratio metric which describes either a positive or negative rate of mean age change per year.

From the data in Table 2.1, the RAI for the total organisation is +0.316 years per year (over the 1.58 year period sampled). Whilst this figure is based on a very limited time period, it illustrates that the organisation is ageing at a rate of one year in every three years that pass. If occupational differences can be shown within the organisation, then it is apparent that the personnel implications of age structures would have considerable relevance in this ageing organisation.

2.3: DATA COLLECTION TO ESTABLISH A LARGE SAMPLE OF EMPLOYEES FROM THE ORGANISATION

The first study tests three questions concerning the employees from the organisation; which are:-

1. Are there sex differences in age and length of service?

2. Are there geographical differences in age and length of service?

3. Are there occupational differences in age and length of service?

A cross-sectional sampling methodology was employed to establish the present age structure of employees. Data were collected for 9090 of the 12587 employees in April 1980. The following was recorded for each individual:-

(i) age in years (to the nearest whole integer)

(ii) length of company service in years (to the nearest whole integer)

(iii) job title

(iv) sex

(v) geographical location.

The 9090 employees studied represent a 72.22 per cent sample. Data were unfortunately unobtainable for 3497 employees who worked either in the research establishment or in small units spread over the United Kingdom. A check to establish the mean age of those unsampled employees can be made by inference. The mean age of the sample of 9090 employees in April 1980 was 36.03 years. By extrapolation from the organisational mean age, the 3497 employees not sampled have an estimated mean age of 36.06 years. It is inferred from this that the mean age of the sample is representative of the population mean age (the total organisation).

2.4: OPERATIONALISATION OF INDEPENDENT VARIABLES FOR OCCUPATION AND GEOGRAPHICAL LOCATION

2.4.1: National Occupational Classification

A suitable occupational classification is required for the sample in order to test the third question. This classification must allow for both generalisations to previous research at the national level; and useful psychological and personnel distinctions. The Office of Population Censuses and Surveys Classification of Occupations (Great Britain, 1980a) satisfies both of these criteria. The system classifies occupational titles based on the Classification of Occupations and Directory of Occupational Titles (CODOT) into a two-factor framework. The two factors are social class and socio-economic group.

The social class categories were drawn from the 1911 Census, and consist of:-

- I Professional, etc. occupations
- II Intermediate occupations
- III Skilled occupations
  - (N) Non-Manual
  - (M) Manual
- IV Partly skilled occupations
- V Unskilled occupations.

The socio-economic groups are classified under twenty sub-headings:-

(1) Employers and managers in central and local government, industry, commerce, etc. - large establishments (N>25)

1.1 Employers in industry, commerce, etc.

1.2 Managers in central and local government, industry, commerce, etc.

(2) Employers and managers in industry, commerce, etc. - small establishments (N<25)

2.1 Employers

2.2 Managers

(3) Professional workers - self-employed

(4) Professional workers - employees

(5) Intermediate non-manual workers

5.1 Ancillary workers and artists

5.2 Foremen and supervisors - non-manual

(6) Junior non-manual workers

(7) Personal service workers

(8) Foremen and supervisors - manual

(9) Skilled manual workers

(10) Semi-skilled manual workers

(11) Unskilled manual workers

(12) Own account workers

(13) Farmers - employers and managers

(14) Farmers - own account

(15) Agricultural workers

(16) Members of armed forces

(17) Inadequately described occupations

The advantage of using this classificatory system is that information about the sample may be compared to the spectrum of occupation within each social class/socio-economic group sector sampled. Clearly, the two axes of social class and socio-economic group are not independent, and the vast majority of industrial occupations fall within the 'Social Class III(M)/Socio-economic Group 9' sector. Similarly, the majority of individuals work as employees in non-agricultural or non-military organisations, thereby restricting the range of socio-economic groups to eleven, i.e. 1.2, 2.2, 4, 5.1, 5.2, 6, 7, 8, 9, 10 and 11.

The job title recorded for each individual was recoded into the appropriate occupational sector under this classificatory system. Table 2.2 overleaf shows those sectors covered by the sample under study. As the organisation is a non-agricultural, non-military employer, only those eleven previously-listed relevant socio-economic groups are considered. The sampling frame covers seven of the eleven possible socio-economic groups. Only professional employees, non-manual supervisors, personal service workers and unskilled manual workers are not represented. The sample also covers four out of the six social classes. Only professional and unskilled occupations are not represented.

The majority of the sample are ancillary, non-manual, junior non-manual, and skilled manual workers.

Socio-Economic Group	SOCIAL CLASS					
	I	II	III(Nm)	III(M)	IV	V
1.2		598 (6.58%)				
2.2		1006 (11.07%)				
4						
5.1		2307 (25.38%)				
5.2						
6			2618 (28.80%)			
7						
8				464 (5.10%)		
9				2011 (22.12%)		
10					86 (0.95%)	
11						

KEY Top figure = number of sample in each sector
Bottom figure = percentage of total sample in each sector

TABLE 2.2: SAMPLED NUMBERS WITHIN THE OFFICE OF POPULATION CENSUSES AND SURVEYS OCCUPATIONAL CLASSIFICATION

2.4.2: Organisational occupational classification

The sample has been classified into seven social class/ socio-economic group sectors of occupations under the Census Classification of Occupations. This allows for generalisation to national occupational age structures. The sample is now further sub-divided into ten 'occupational functions'. These occupational functions incorporate the organisational role performed by each individual, thereby adding the psychological and personnel validity which has been specified as necessary for the study. Appendix 1 contains a list of all job titles within each of the ten occupational functions.

Table 2.3 below shows the ten occupational functions, the parent social class/socio-economic group sector; and the final sample sizes for each occupational function.

Occupational Function	Parent Census Classification	Sample Size
Higher Management	1.2 II	265
Middle Management	2.2 II	542
Lower Management	2.2 II	464
Supervisory/Line Management	8 III(M)	464
Skilled Manual	9 III(M)	2011
Semi-Skilled Manual	10 IV	86
Technical	5.1 II	2307
Clerical	6 III(Nm)	1716
Sales Management	1.2 II	333
Sales Executives/Trainees	6 III(Nm)	902

TABLE 2.3: ORGANISATIONAL CLASSIFICATION OF THE SAMPLE INTO TEN OCCUPATIONAL FUNCTIONS

From Table 2.3, it can be seen that for four of the seven initial Census sectors, all the employees within that sector in fact performed just one occupational function within the organisation, e.g. all employees within sector

5.1 II performed a technical function. However, three of the Census sectors contained employees performing two discrete functions. For example, employees in sector 1.2 II were either performing high general management, or performing sales management. On the basis of personnel discussions within the organisation, it was decided that the nature of these functions was sufficiently different to justify the division of this census sector into two functions. Similarly, sector 6 III(Nm) was divided into the two discrete functions of clerical employees, and sales executives/trainees. Finally, sector 2.2 II was divided into two intermediate levels of management - middle and lower. This was done according to the individual's job grade which, within the organisation, is used to categorise lower and middle management.

The ten occupational functions used to classify the sample fall into a clear organisational hierarchy. This is shown overleaf in Figure 2.1.

2.4.3: Geographical location

At a national level, occupational age structures can be influenced by local labour market factors such as the distribution of occupational skills, unemployment rate, and population age structure. Such factors clearly bear upon organisations, and an operationalisation of geographical location is needed in order to test the second question. The location of workplace was used to classify the sample into nine geographical locations. These locations

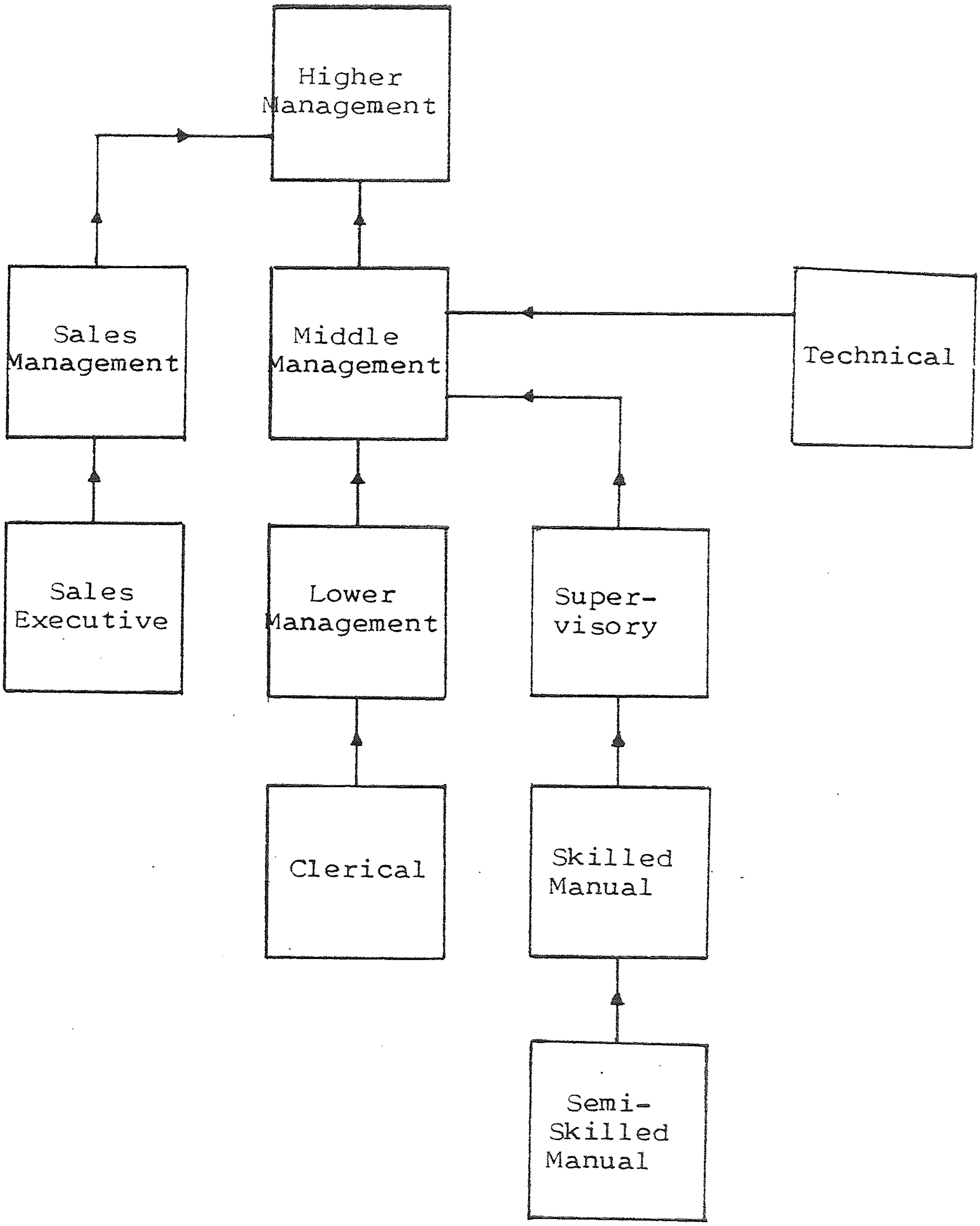


FIGURE 2.1: THE TEN OCCUPATIONAL FUNCTIONS WITHIN THE ORGANISATIONAL HIERARCHY

are illustrated in Figure 2.2 overleaf. The choice of areas was bound by operational regions within the organisation, but the classification in fact matches that employed by the Central Statistical Office (Great Britain, 1980b).

2.5: SEX DIFFERENCES IN AGE AND LENGTH OF SERVICE WITHIN OCCUPATIONAL FUNCTIONS

2.5.1: Relationship between age and length of service

In this analysis, age and length of company service are treated as two dependent variables. Previous research has shown that, in reality, the two are invariably related. For example, O. Boyle (1969) reported a median correlation of +0.989 for men and +0.932 for women. The degree of association between age and service in the ten sample occupational functions was tested using two-tailed Pearson Product Moment Correlations. An alpha level of one per cent was adopted, and the results are detailed in Table 2.4 overleaf.

The correlations between age and length of service are significant for all ten occupational functions. They range between +0.3184 to +0.6488 with a median correlation of +0.5663. This median accounts for 32.07 per cent of the variance between age and service. It is therefore considered that subsequent analysis of the occupational functions should appreciate that age and length of service are related, but that there is sufficiently high

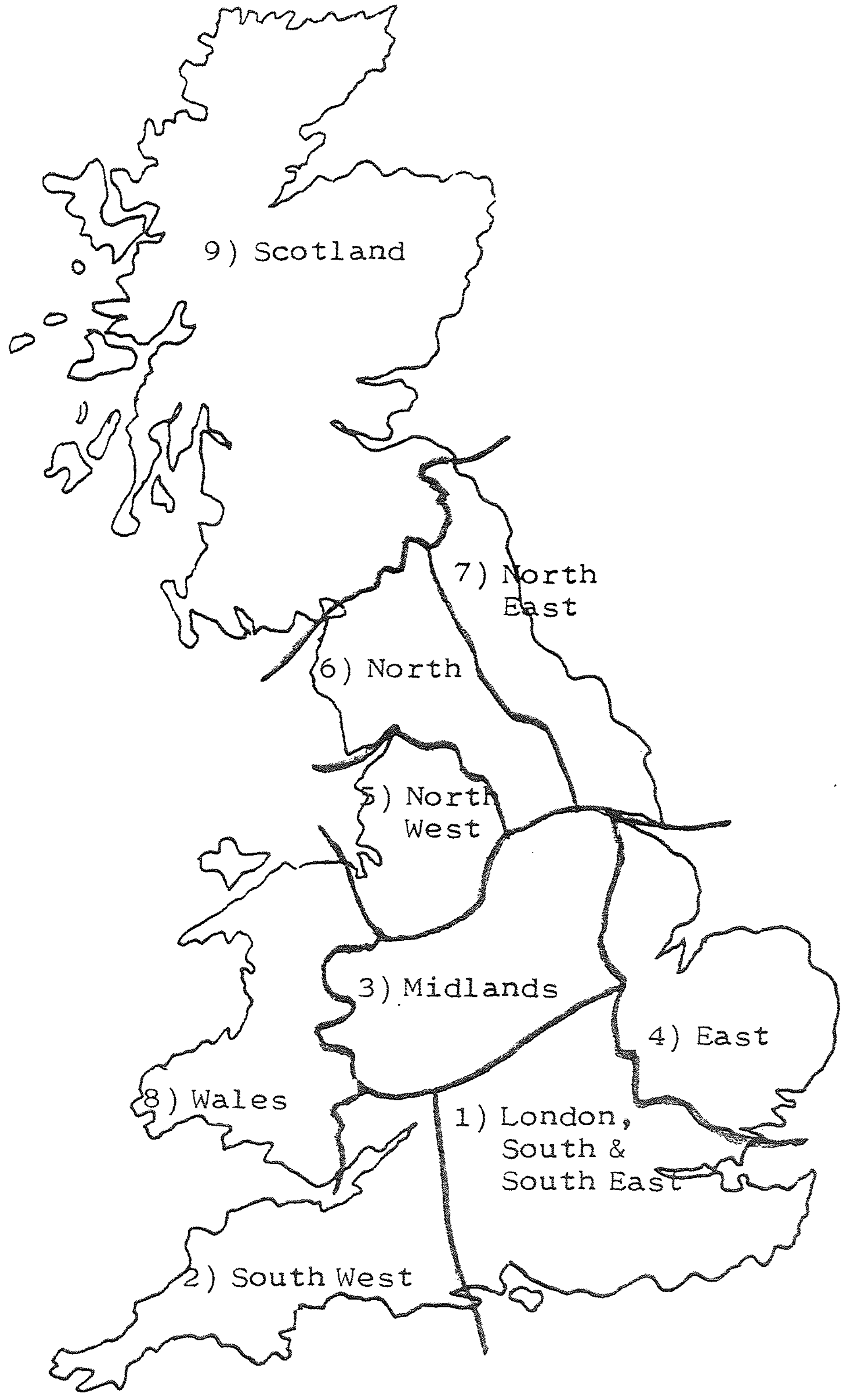


FIGURE 2.2: GEOGRAPHICAL LOCATIONS IMPOSED UPON AGE DATA

unshared variance (median of 67.93 per cent) to necessitate the use of both variables as controls.

2.5.2: Sex differences in the frequency of individuals in one-year age and service bands

The frequency of males versus females within each one-year age or service band was tested using Chi-Squared Tests of Significant Differences as applied by the S.P.S.S. Version 5 Package. The results are shown in Table 2.4.overleaf.

To aid interpretation of the results, seventeen descriptive statistics were calculated for each of the ten occupational functions. The seventeen descriptive measures are:-

(i) mean age of the total sample
(ii) standard deviation of age
(iii) age range in years
(iv) mean service of total sample
(v) standard deviation of service
(vi) service range in years
(vii) percentage of workforce - male
(viii) mean age of male employees
(ix) standard deviation of age of male employees
(x) mean service of male employees
(xi) standard deviation of service of male employees
(xii) percentage of workforce - female
(xiii) mean age of female employees

OCCUPATIONAL FUNCTION	x^2 RESULTS FOR SEX vs AGE BANDS	x^2 RESULTS FOR SEX vs SERVICE BANDS	CORRELATION BETWEEN AGE AND SERVICE	SAMPLE SIZE
SUPERVISORY	x^2=122.44 Df= 42 $p<.001$	x^2= 54.62 Df= 24 $p<.001$	r=.3814 $p<.001$	463
HIGHER MANAGEMENT	x^2= 81.71 Df= 36 $p<.001$	x^2= 39.16 Df= 27 N.S.	r=.5237 $p<.001$	265
SKILLED MANUAL	x^2=251.13 Df= 48 $p<.001$	x^2=156.24 Df= 23 p .001	r=.4494 $p<.001$	2011
MIDDLE MANAGEMENT	x^2= 73.31 Df= 38 $p<.001$	x^2= 15.50 Df= 26 N.S.	r=.5728 $p<.001$	542
LOWER MANAGEMENT	x^2=131.66 Df= 44 $p<.001$	x^2= 71.25 Df= 21 $p<.001$	r=.6399 $p<.001$	464
SEMI-SKILLED MANUAL	x^2= 25.87 Df= 35 N.S.	x^2= 6.42 Df= 13 N.S.	r=.6488 $p<.001$	86
TECHNICAL	x^2=243.21 Df= 43 $p<.001$	x^2=252.46 Df= 27 $p<.001$	r=.5598 $p<.001$	2307
SALES MANAGEMENT	x^2=111.74 Df= 36 $p<.001$	x^2= 46.93 Df= 18 $p<.001$	r=.5733 $p<.001$	333
CLERICAL	x^2=210.85 Df= 46 $p<.001$	x^2=137.57 Df= 22 $p<.001$	r=.5353 $p<.001$	1716
SALES EXECUTIVE & TRAINEE	x^2= 69.59 Df= 40 N.S.	x^2=27.10 Df= 20 N.S.	r=.5981 $p<.001$	901

TABLE 2.4: RESULTS OF STATISTICAL TESTS FOR AGE AND SERVICE DIFFERENCES BETWEEN MALES AND FEMALES WITHIN OCCUPATIONAL FUNCTIONS

(xiv) standard deviation of age of female employees

(xv) mean service of female employees

(xvi) standard deviation of service of female employees

(xvii) sample size of occupational function

These data are presented in Table 2.5. In this table, occupational functions are ordered by their mean age, and split into two groups of above average organisation age, and below average organisation age.

The majority of the sample are male (78 per cent), and women only outnumber males in the clerical occupational function. The observed sex differences in age and service distribution (see Table 2.4) fall into five patterns which are detailed in Table 2.6 overleaf.

Women are only older, on average, than men in the supervisory and skilled manual occupational functions, although they have lower service. In all other functions, the men are older than the women, or there are no differences. Differences in the career pattern become apparent. For example, in the higher and middle management grades, there are no differences in the average length of company service between men and women, although the men are older. This suggests that women enter these management grades (from lower management mainly) at a younger age than do the men. The function from which they come - lower

OCCUPATIONAL FUNCTION	COMPLETE SAMPLE							MALES					FEMALES				
	Sample Size	Mean Age	S.D. Age	Age Range	Mean Serv.	S.D. Serv.	Serv. Range	%Total W-Force	Mean Age	S.D. Age	Mean Serv.	S.D. Serv	%Total W-Force	Mean Age	S.D. Age	Mean Serv	S.D. Serv
SUPERVISORY	463	43.25	10.27	44	10.87	6.23	31	84.4	42.67	10.20	11.10	6.08	15.6	46.38	10.16	9.58	6.86
HIGHER MANAGEMENT	265	39.56	8.42	42	10.40	6.30	36	87.9	40.45	8.14	10.87	6.40	12.1	33.09	7.65	6.97	4.24
SKILLED MANUAL	2011	39.55	12.26	61	8.45	5.64	36	89.8	39.52	12.26	8.45	5.55	10.2	39.78	12.25	8.39	6.35
MIDDLE MANAGEMENT	542	38.44	8.66	44	9.87	6.50	31	96.5	38.56	8.62	9.95	6.53	3.5	35.32	9.43	7.74	5.41
LOWER MANAGEMENT	464	35.99	9.62	46	8.68	5.48	27	73.7	37.53	8.62	9.88	5.36	26.3	31.68	10.94	5.31	4.31
SEMI-SKILLED MANUAL	86	35.94	13.08	44	5.07	4.33	16	95.3	36.67	12.96	5.27	4.34	4.7	21.00	1.16	1.00	0.00
TECHNICAL	2307	35.29	8.53	56	8.17	5.01	37	88.1	35.47	8.47	8.28	4.97	1.9	26.40	3.55	2.72	3.74
SALES MANAGEMENT	333	34.65	7.39	40	6.63	4.26	18	72.4	36.57	7.07	7.39	4.18	27.6	29.64	5.70	4.65	3.83
CLERICAL	1716	32.41	12.49	46	5.04	4.25	26	38.6	35.62	13.51	5.82	4.51	61.4	30.40	11.35	4.55	4.01
SALES EXECUTIVE & TRAINEE	901	31.34	7.04	42	3.71	3.71	20	82.5	32.09	7.24	3.89	3.86	17.5	27.81	4.58	2.86	2.83
TOTAL	9090	36.03															

TABLE 2.5: DESCRIPTIVE STATISTICS FOR THE TEN OCCUPATIONAL FUNCTIONS

management - has a slightly different pattern. Here the men have higher mean service as well as age. Women have generally not been members of the lower management function for as long as men - and this likely accounts for their younger mean age.

Pattern Number	Description of Pattern	Occupational Functions
1.	Males with higher age and higher service	Lower Management Technical Sales Management
2.	Males with higher age and no difference in service	Higher Management Middle Management
3.	Males with lower age and higher service	Supervisory (Line Management) Skilled Manual
4.	Males with higher age and lower service	Clerical
5.	No differences between age and service	Sales Executives and Trainees

TABLE 2.6: FIVE PATTERNS OF AGE AND SERVICE DIFFERENCES BETWEEN MALES AND FEMALES WITHIN OCCUPATIONAL FUNCTIONS

It can be concluded that there are sex differences in both the distribution of age and service, and that these differences form five discrete patterns. From these patterns of sex differences, it is inferred that there are probably sex differences in career paths and recruitment patterns, and these are the main causes of the age and service differences.

2.6: GEOGRAPHICAL DIFFERENCES IN AGE AND SEX

2.6.1: Statistical methodology employed

The distinction between the nine geographical regions has been drawn in Section 2.4.3. An Analysis of Variance framework was used to test for geographical differences. There were three aspects of the analysis:-

1. To test if there was an overall effect for geographical regions, ten One-Way Analyses of Variance Between Subjects Designs (Winer, 1971) with age as the dependent variable, and a further ten with service as the dependent variable were calculated. The number of levels for the independent variables (number of regions) depended on the number of geographical locations in which employees in the occupational function operated. Since twenty tests were employed, an alpha level of $p < .01$ was adopted.
2. In contrast to the significance level associated with the F Tests, a statement can be made about the actual Strength of Effect which is observed, or what Keppel (1973) defines as the "proportion of total variability in the data set accounted for by the independent variable". The design employed is a Randomised Group, and the Strength of Effect (w^2) was calculated for each of the

twenty F Tests using Keppel's (1973) formula.

3. A significant ANOVA shows that differences exist across the independent variable, but does not isolate at which levels of the independent variable those differences exist. Such statements can be made by using a Multiple Comparison of the Means (M.C.M.). The unequal sample size in each level requires that Scheffe's Method for M.C.M.s be used, and the M.C.M.s are only calculated for those analyses of variance which show significant geographical location effects. The statistical detail for this analysis (summary analysis of variance tables and summary M.C.M. tables for the twenty tests) are detailed in Appendix 2.

2.6.2: Discussion of the effects of geographical region upon age and service for the sample

Table 2.7 overleaf shows the F values, associated degrees of freedom, and levels of significance obtained in the twenty One-Way ANOVAs. The results are mixed. There are significant age and service differences between regions in the higher management, technical and clerical occupational functions. Significant differences for age alone are found in the skilled manual function. Significant service differences are found in the supervisory function. The actual means, number of cases, and associated strength of effects are detailed in Table 2.8 (for age data) and Table 2.9 (for service data).

OCCUPATIONAL FUNCTION	AGE RESULTS	SERVICE RESULTS
HIGHER MANAGEMENT	F= 2.9 DF(6,258) p<.01	F= 3.5 DF(6,258) p<.01
SALES MANAGEMENT	F= 1.4 DF(8,324) N.S.	F= 1.3 DF(8,324) N.S.
MIDDLE MANAGEMENT	F= 1.8 DF(8,533) N.S.	F= 2.0 DF(8,533) N.S.
LOWER MANAGEMENT	F= 0.8 DF(8,455) N.S.	F= 1.4 DF(8,455) N.S.
TECHNICAL	F=15.4 DF(8,2298) p<.001	F=28.8 DF(8,2298) p<.001
SALES EXECUTIVE & TRAINEE	F= 2.1 DF(8,893) N.S.	F= 1.7 DF(8,893) N.S.
CLERICAL	F= 9.1 DF(8,1707) p<.001	F=23.2 DF(8,1707) p<.001
SUPERVISORY	F= 2.4 DF(4,449) N.S.	F=10.0 DF(4,449) p<.001
SKILLED MANUAL	F= 3.8 DF(4,2003) p<.01	F= 1.4 DF(4,2003) N.S.
SEMI-SKILLED & UNSKILLED MANUAL	F= 3.8 DF(3,75) N.S.	F= 2.5 DF(3,75) N.S.

TABLE 2.7: RESULTS OF F TESTS FOR GEOGRAPHICAL VARIATION IN AGE AND SERVICE WITHIN OCCUPATIONAL FUNCTIONS

OCCUPATIONAL FUNCTION	GEOGRAPHICAL REGION									STRENGTH OF EFFECT (per cent)
	1	2	3	4	5	6	7	8	9	
HIGHER MANAGEMENT	37.7 (114)	41.8 (122)	37.2 (5)	39.7 (8)	—	36.0 (4)	—	35.8 (4)	36.9 (8)	4.06% (p<.01)
SALES MANAGEMENT	35.4 (197)	34.0 (11)	32.2 (35)	33.3 (31)	33.3 (10)	3.43 (27)	29.8 (6)	36.8 (15)	—	1.00% N.S.
MIDDLE MANAGEMENT	36.2 (112)	39.1 (395)	41.5 (6)	38.9 (10)	—	36.2 (6)	—	—	39.9 (7)	1.17% N.S.
LOWER MANAGEMENT	35.7 (321)	39.4 (18)	34.3 (36)	37.2 (36)	34.0 (4)	36.4 (21)	35.4 (5)	37,6 (15)	39.7 (8)	0.41% N.S.
TECHNICAL	33.3 (901)	37.8 (687)	35.5 (175)	36.0 (201)	33.9 (65)	34.5 (155)	37.4 (40)	35.2 (82)	—	4.77% (p<.001)
SALES EXECUTIVE AND TRAINEE	30.5 (440)	32.5 (50)	31.0 (118)	32.1 (107)	33.3 (34)	31.9 (80)	32.3 (23)	33.5 (45)	33.4 (5)	0.98% N.S.
CLERICAL	30.2 (469)	34.4 (963)	28.3 (65)	28.7 (76)	38.5 (12)	29.2 (50)	39.9 (7)	27.2 (36)	29.1 (38)	3.66% (p<.001)
SUPERVISORY	38.5 (35)	43.7 (359+	41.2 (12)	43.7 (31)	—	41.1 (17)	—	—	—	1.22% N.S.
SKILLED MANUAL	42.6 (76)	39.3 (1872)	40.6 (7)	45.1 (43)	—	—	—	—	36.3 (10)	0.55% (p<.01)
SEMI-SKILLED MANUAL	34.3 (61)	—	38.8 (5)	49.6 (8)	—	41.8 (5)	—	—	—	9.56% N.S.
AVERAGE TOTAL	33.4 (2726)	38.3 (4477)	33.4 (464)	35.6 (551)	34.1 (125)	33.8 (365)	38.9 (81)	33.7 (197)	33.3 (76)	= (9002)

TABLE 2.8: MEANS, NUMBER OF CASES AND STRENGTH OF EFFECT FOR AGE DIFFERENCES ACROSS GEOGRAPHICAL REGIONS

OCCUPATIONAL FUNCTION	GEOGRAPHICAL REGION									STRENGTH OF EFFECT (per cent)
	1	2	3	4	5	6	7	8	9	
HIGHER MANAGEMENT	8.8 (114)	12.2 (122)	6.8 (5)	11.0 (8)	—	9.0 (4)	—	10.0 (4)	8.0 (8)	5.29% ($p<.01$)
SALES MANAGEMENT	6.9 (197)	6.0 (11)	5.0 (35)	6.3 (31)	6.7 (10)	7.5 (27)	4.2 (6)	7.2 (15)	—	0.68% N.S.
MIDDLE MANAGEMENT	7.8 (112)	10.4 (395)	10.7 (6)	10.9 (10)	—	10.2 (6)	—	—	11.4 (7)	1.52% N.S.
LOWER MANAGEMENT	8.3 (321)	8.6 (18)	9.2 (36)	10.6 (36)	9.7 (4)	10.8 (21)	9.0 (5)	8.9 (15)	6.4 (8)	0.70% N.S.
TECHNICAL	6.9 (901)	10.4 (687)	7.8 (175)	8.1 (201)	7.4 (65)	7.0 (155)	8.4 (40)	7.8 (82)	—	8.80% ($p<.001$)
SALES EXECUTIVE AND TRAINEE	3.4 (440)	4.0 (50)	3.4 (118)	4.0 (107)	5.3 (34)	4.3 (80)	3.5 (23)	4.2 (45)	3.4 (5)	0.63% N.S.
CLERICAL	3.8 (469)	6.1 (963)	3.0 (65)	4.0 (76)	6.7 (12)	3.2 (50)	8.3 (7)	2.6 (36)	2.3 (38)	9.37% ($p<.001$)
SUPERVISORY	7.0 (35)	11.8 (359)	8.0 (12)	7.0 (31)	—	8.2 (17)	—	—	—	7.36% ($p<.001$)
SKILLED MANUAL	8.1 (76)	8.5 (1872)	6.7 (7)	7.9 (43)	—	—	—	—	4.8 (10)	0.08% N.S.
SEMI-SKILLED MANUAL	4.3 (61)	—	7.4 (5)	8.6 (8)	—	5.4 (5)	—	—	—	5.26% N.S.
AVERAGE TOTAL	6.1 (2726)	8.8 (4477)	5.9 (464)	6.8 (551)	6.8 (125)	6.3 (365)	6.7 (81)	9.4 (197)	4.6 (76)	

TABLE 2.9: MEANS, NUMBER OF CASES AND STRENGTH OF EFFECT FOR SERVICE DIFFERENCES ACROSS GEOGRAPHICAL REGIONS

The overall ranks associated with the age data for both the total sample, and individual functions are contained in Table 2.10. Over three-quarters of the sample are drawn from the two regions of South West England and London and the South East (49.40 per cent and 30.08 per cent respectively). The remaining regions contain relatively small proportions of the sample, with North East England (0.89 per cent) and Scotland (0.84 per cent) being very poorly represented. Over the whole sample, North East England, South West England and East England represent the older regions; whilst Scotland, the Midlands, and London and the South East are the youngest regions. A Spearman's Rho Correlation Coefficient between the regional rank orders for age and service for the whole sample (columns 2 and 3 in Table 2.10) was calculated. A correlation of +0.6417 ($p < .001$) was obtained suggesting that those geographical differences in age and service detailed in Table 2.7 are linked.

The second set of data in Table 2.10 (columns 4 to 13) shows the order of geographical regions (ranked by mean age) within each of the ten occupational functions. The rank order of regional age is not constant across the occupational functions, suggesting an interaction between regional age and occupational function. This possible interaction can be revealed from an analysis of the M.C.M.s established for the ten occupational functions. The detailed findings of the M.C.M. analyses are given in Table 2.11 overleaf.

GEOGRAPHICAL REGION	TOTAL SAMPLE			OCCUPATIONAL FUNCTIONS									
	% of Sample	Rank Order of Age	Rank Order of Service	Higher Man.	Sales Man.	Middle Man.	Lower Man.	Tech.	Sales Exec. & Trainee	Cler.	Super.	Skilled Manual	Semi-Skilled Manual
North East England	0.89	1	5	—	8	—	7	2	5	1	—	—	—
South West England	49.40	2	2	1	4	3	2	1	4	3	1.5	4	—
East England	6.08	3	3.5	2	5.5	4	4	3	6	7	1.5	1	1
North West England	1.38	4	3.5	—	5.5	—	9	7	3	2	—	—	—
North England	4.03	5	6	6	3	5.5	5	6	7	5	4	—	2
Wales	2.17	6	1	7	1	—	3	5	1	9	—	—	—
London & South East England	30.08	7.5	7	3	2	5.5	6	8	9	4	5	2	4
Midlands	5.12	7.5	8	4	7	1	8	4	8	8	3	3	3
Scotland	0.84	9	9	5	—	2	1	—	2	6	—	5	—

TABLE 2.10: RANK ORDER OF GEOGRAPHICAL AGE DIFFERENCES IN TOTAL SAMPLE AND OCCUPATIONAL FUNCTIONS

FUNCTION	AGE OR SERVICE	REGION(S) 'HIGHER THAN'	REGION(S) 'LOWER THAN'
HIGHER MANAGEMENT	Age	South West	London & South East
	Service	South West	London & South East
CLERICAL	Age	South West	London & South East
	Service	South West	(Midlands (Wales
TECHNICAL	Age	South West	(London & (South East (North Eng- (land
	Service		(London & (South East (Midlands (East/North ~~(North West~~
SUPERVISORY	Age		
	Service	South West	(London & (South East (East
SKILLED MANUAL	Age	East	South West
	Service		

TABLE 2.11: SIGNIFICANT RESULTS FROM M.C.M. ANALYSES FOR REGIONAL DIFFERENCES WITHIN OCCUPATIONAL FUNCTIONS

Seven out of the eight significant differences established show that the mixed regional differences in age and service shown in Table 2.7 may be reduced to one essential difference. The South West as a region contains employees in certain occupations with significantly higher age or service than those employees working in the same occupations in other regions (notably London and the South East). This one specific regional difference is most probably due to the existence of the Manufacturing Plant in this location. 94.88 per cent of all employees in the South West are located at this plant. Unlike all other locations across the United Kingdom which come under the control of a central Operating Company, with inherent mobility between them, the Manufacturing Plant is autonomous, recruiting its own staff and having remarkably little transfer of staff to and from the Operating Company. The observed regional differences in the occupational age structures are due solely to local market factors affecting the Manufacturing Plant.

2.7: DIFFERENCES BETWEEN THE AGE/SERVICE STRUCTURES OF THE TEN ORGANISATIONAL LEVEL OCCUPATIONAL FUNCTIONS

The aim of the first study is to analyse occupational age structures at the organisational level, establishing differences due to sex, geographical location and occupational function. A 72.22 per cent cross-sectional sample has been shown to be representative (in terms of age data) of the total company population (Section 2.3.2). The sample itself has been shown to cover a range of occupations within a representative national framework of social class and socio-economic group sectors (Section 2.4.1), and has been subdivided into ten occupational functions based upon the superimposition of specific organisational roles on to the national sectors previously described in Section 2.4.2. Within these occupational functions, clear sex differences between age and service have been shown (Section 2.5). Geographical variation in age and service has also been established (Section 2.6.2), but has been isolated to local labour market forces and practices surrounding the Manufacturing Plant in the South West of England. The third question of differences in age and service between occupational functions is now examined.

A biographical analysis of age and service within the ten occupational functions has already been carried out (see Section 2.5; Table 2.5). In this analysis, the functions were partitioned into above and below company mean age groups. From this table, it can be seen that the supervisory, higher management, skilled manual and middle management functions represent the older occupational functions within the company. Lower management and semi-skilled manual functions have almost identical mean ages to the company as a whole. Technical, sales management, clerical and sales executives and trainees represent the younger occupational functions within the company. The occupational function mean ages range from 31.34 years to 43.25 years, and the Spearman's Rho Correlation Coefficient between the mean age and mean service of the ten occupational functions is +0.9273 ($p < .001$).

In order to test for significant differences between the occupational age/service structures, a measure has to be devised to represent these structures. Two measures are used, the first for statistical analysis, and the second for graphical drawing of the shape.

2.7.1: The measure used to test for statistical differences in occupational age/service structures

It has been previously stated that, in analysing the occupational age/service structures (henceforth referred to as OA/S structures because of extensive use), the effects of both age and service shall be considered. The frequency of individuals within a series of age and service bands was recorded for each occupational function. The most appropriate range for these service bands is always a matter for debate, and differs considerably across the literature (Smith, 1974). Too large ranges reduce the amount of information which may be of use, and too small ranges may obscure what would otherwise be clear trends in the data. It was decided to use five-year age bands for both age and service since sample sizes were high enough to provide sufficient numbers of data within such a range to make statistical analysis appropriate. A two-dimensional matrix with ten age bands was drawn (see Figure 2.3) with the appropriate age and

AGE IN YEARS

LENGTH OF SERVICE IN YEARS.	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65
0-5	1	2	3	4	5	6	7	8	9	10
6-10		11	12	13	14	15	16	17	18	19
11-15			20	21	22	23	24	25	26	27
16-20				28	29	30	31	32	33	34
20+					35	36	37	38	39	40

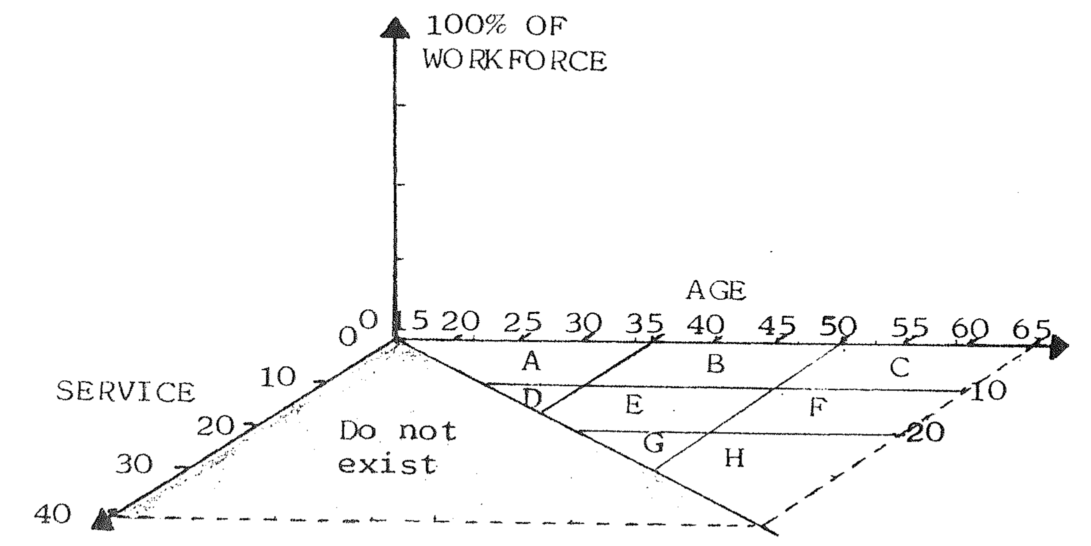
Figure in each cell is the one-dimensional array position

FIGURE 2.3: TWO-DIMENSIONAL AGE/SERVICE MATRIX USED TO RECORD THE OCCUPATIONAL AGE/SERVICE STRUCTURES

service values. The fifth service band of 20+ years was used to record the small number of individuals with such high service. It can be seen from Figure 2.3 that there are in fact only forty age/service cells in which data may exist since it is impossible for someone, for example, who is 30 years old to have more than 15 years of service (the company does not recruit below the age of 16 years). Having obtained the frequency in each of the forty possible age/service cells, it is divided by the total sample size resulting in a probability or percentage. The sum of these percentages will equal 100 per cent for all ten occupational functions thereby reducing the confounding effect of elevation upon the OA/S structures. All that differs between the OA/S structures is the relative magnitude within each cell (representing a commensurate measurement with a hypothetical limit of 100). Such changes represent essential differences in shape and can be protrayed graphically.

2.7.2: Graphical illustration of the occupational age/service structures

The OA/S structures are three-dimensional, varying along the dimensions of age, service and magnitude within each age/service cell. This is illustrated in Figure 2.4 overleaf. The base area (age and service dimensions) has been divided into eight diagnostic regions which are detailed in Figure 2.4. What varies between OA/S structures using the measure detailed in Section 2.7.1 is the relative height within these eight age/service regions.



KEY	
	DIAGNOSTIC AREAS
A	Low Age, Low Service
B	Medium Age, Low Service
C	High Age, Low Service
D	Low Age, Medium Service
E	Medium Age, Medium Service
F	High Age, Medium Service
G	Medium Age, High Service
H	High Age, High Service

FIGURE 2.4: FIGURE TO ILLUSTRATE THE THREE-DIMENSIONAL NATURE OF THE OCCUPATIONAL AGE/SERVICE STRUCTURES, AND DIAGNOSTIC AREAS WITHIN THE STRUCTURES

To display the OA/S structures, a graphical computer program using the GINO Graphics Library at Aston University was written. The graphs drawn plot single year age and service bands so that complete detail may be seen. The relevant data for the ten occupational functions is now described.

2.7.3: The occupational age/service structures for the ten occupational functions

Data for the ten occupational functions under study are contained in Appendix 3 and shown in two formats. The first is a table detailing the frequency and percentage within the forty age/service cells (Tables 'a' to 'j'), and the second is the three-dimensional graphical representation of each occupational function using the GINO drawings (Figures 'a' to 'e'). The tables also order the eight diagnostic regions in order of magnitude.

A brief study of the data presented in Appendix 3 leads to two conclusions:-

1. There are differences in shape between occupational functions.

2. These differences, however, do seem to pattern.

Two examples may be given to illustrate these points. The clerical/commercial function (Table 'h'; Figure 'd') markedly differs in shape from the supervisory function (Table 'd'; Figure 'b'). The diagnostic orders of the age/service regions are ABCFEDHG versus EABFCDHG respectively. The clerical function consists of a very large (64.88 per cent) low age, low service sector compared to a quota of only 20.04 per cent in the supervisory function. Similarly, the medium age, medium service sectors differ markedly, with quotas of 3.73 per cent and 22.63 per cent respectively for the clerical and supervisory functions.

Similarities between functions, however, do appear to exist. For example, the three management functions all have diagnostic orders beginning with AEB; with F and D as either fourth or fifth order; with C and G as either sixth or seventh order; and ending with H. Equally, the sales management and sales executive and trainee functions have a nearly identical diagnostic order, with only the fifth and sixth characters being reversed. Such evidence suggests that the third hypothesis of occupational differences in the age/service structures whould be supplemented by a fourth - that of establishing a statistical pattern within the OA/S structures.

2.7.4: Statistical test for significant differences between occupational age/service structures

A Chi-Squares Test for Significant Differences (Siegel, 1956) with forty rows (the forty age/service cells detailed in Figure 2.3) and ten columns (the ten occupational functions) was calculated using the data presented in Appendix 3. A χ^2 of 2985.71 (df=351, $p < .001$) resulted showing that the noted differences between the OA/S structures are significant. The final hypothesis of patterning within these differences is now considered.

2.8: OCCUPATIONAL PATTERNING OF AGE/SERVICE STRUCTURES

It was concluded towards the end of Section 2.7.3 that, although the OA/S structures clearly differ, there are patterns or groups of OA/S structures. It would be useful to classify the ten sampled OA/S structures into a series of groups within which the structures resemble each other more that they do those in other groups. There are two main statistical techniques which can reduce large sets of data into such "archetypal groups". These are Factor Analysis and the Cluster Analysis techniques. Cluster analysis was chosen because:-

1. The non-parametric nature of the frequency data would violate the statistical assumptions inherent in factor analysis, which really requires data of at least interval level. Cluster analysis can be performed on ordinal data.
2. Cluster analysis allows for an hierarchical combination of members such that statements about relative similarity can be made at different levels of an hierarchy.

Ward and Hook (1963) explain the purpose of cluster analysis as grouping "large numbers of persons, jobs or objects into smaller numbers of mutually exclusive classes in which the members have similar characteristics".

It is essentially a technique to reduce data, whilst at the same time, increasing the information it represents by providing a classificatory framework over it. There is, however, a vast variety of clustering techniques (Bijnen, 1973; Everitt, 1974) and three aspects of the analysis need to be detailed. These are:-

(i) The measure of similarity used

(ii) The type of clustering to be used

(iii) The criterion for clusters.

2.8.1: Spearman Rho Correlations between the ten occupational functions as a measure of similarity

The UACLUSTAN statistical package was used to perform the cluster analysis, and a Spearman's Rho Correlation Matrix was used as the measure of similarity. The correlation matrix is included overleaf in Table 2.12. It can be seen that the majority of the correlations are significant (a criterion of $p < .001$ has been imposed due to the large number of tests performed), suggesting that an hierarchical combination of the ten OA/S structures in terms of their relative similarity is justified. For example, at a glance it can be seen that higher management is related to all other management functions and the technical function, but nothing else. The clerical function relates to the two manual support functions (skilled and semi-skilled), and to lower management and sales executives, but not to others. A similar matrix to this is used in the cluster analysis. It differs in that the data set are standardised to counter for any

	Sales Management	Middle Management	Lower Management	Technical	Sales Executive & Trainee	Clerical	Supervisory	Skilled Manual	Semi-Skilled Manual
Higher Management	.8160 $p < .001$	.6705 $p < .001$	.5527 $p < .001$	.8059 $p < .001$	.3635	.0158	.6819 $p < .001$	.4849	.3287
Sales Management		.7256 $p < .001$	.7161 $p < .001$	.9399 $p < .001$	.7470 $p < .001$	.4256	.5725 $p < .001$	.6170 $p < .001$	.6672 $p < .001$
Middle Management			.5948 $p < .001$	.7291 $p < .001$	.6552 $p < .001$	.1565	.5358 $p < .001$	.5477 $p < .001$	.3965
Lower Management				.8337 $p < .001$	.6880 $p < .001$	.6247 $p < .001$	.5322 $p < .001$	.6394 $p < .001$	.7000 $p < .001$
Technical					.6703 $p < .001$	.4234	.6241 $p < .001$	.6699 $p < .001$	.6535 $p < .001$
Sales Executive & Trainee						.7476 $p < .001$	.2793	.5633 $p < .001$	.7944 $p < .001$
Clerical							.1401	.5083 $p < .001$	.8399 $p < .001$
Supervisory								.7801 $p < .001$	.3532
Skilled Manual									.7053 $p < .001$

KEY

[ ] denotes significant at $p < .001$

TABLE 2.12: CORRELATION MATRIX BETWEEN THE TEN OCCUPATIONAL AGE/SERVICE STRUCTURES

elevation effects.

2.8.2: Hierarchical clustering by the Furthest Neighbour technique

All agglomerative hierarchical techniques of data combination ultimately reduce the data to a single cluster containing all the original samples, and consequently great importance is attached to the decision providing the criteria to stop combination. The basic procedure of all agglomerative techniques is similar. They begin by computing a similarity or distance matrix (for this analysis, the correlation matrix from Section 2.8.2) between samples (or entities). The end product is the production of a dendogram showing the successive fusions of entities, culminating at the stage where all entities are in one group. At any particular stage, all methods fuse entities or groups of entities which are closest (or most similar). Differences between methods arise because of different ways of defining distance (or similarity) between an entity and a group containing several entities, or between two groups of entities.

The Furthest Neighbour method of clustering was used in the analysis. The following hypothetical example illustrates how members or entities are clustered. Table 2.13 shows a hypothetical correlation matrix between five members. Groups initially consisting of single members are fused according to the least 'distance' between their furthest member (i.e. the highest correlation). Each fusion decreases by one the number of groups. In the example given, members 2 and 5 would be fused first since 0.92 is the highest correlation.

		1	2	3	4	5
	1	1.00	0.51	0.83	0.67	0.21
	2	0.51	1.00	0.65	0.34	0.92
S_1	3	0.83	0.65	1.00	0.82	0.22
	4	0.67	0.34	0.82	1.00	0.12
	5	0.21	0.92	0.22	0.12	1.00

TABLE 2.13: HYPOTHETICAL CORRELATION SIMILARITY MATRIX AT LEVEL ONE TO ILLUSTRATE FURTHEST NEIGHBOUR CLUSTERING

The similarity between this new group or member (2+5), and the three other groups (1, 3 and 4) are shown in Table 2.14. For the Furthest Neighbour method, similarity (2+5, 3) would become 0.22, which, from Table 2.13 can be seen to be the smallest similarity (furthest neighbour) of the original 2 to 3 (0.65) and 5 to 3 (0.22) comparisons.

		1	2+5	3	4
	1	1.00	0.21	0.83	0.67
	2+5	0.21	1.00	0.22	0.12
S_2	3	0.83	0.22	1.00	0.82
	4	0.67	0.12	0.82	1.00

TABLE 2.14: HYPOTHETICAL CORRELATION SIMILARITY MATRIX AT LEVEL TWO TO ILLUSTRATE FURTHEST NEIGHBOUR CLUSTERING

The next fusion would join members 1 and 3 since 0.83 shows the greatest similarity at level two. The process could continue until all members were successively fused into one group. The next section describes the criterion used to end the clustering process.

2.8.3: Criterion for number of clusters and statistical detail

The Furthest Neighbour method of hierarchical clustering has been chosen to fuse the OA/S structures for the ten functions. The structures will be successively fused until all belong to one cluster - making a total of nine fusions. Each successive fusion occurs at a point where increasingly dissimilar clusters are being combined. A coefficient of similarity is calculated which has a value of +1.0 when cluster members are identical (each containing only one age structure in this analysis), with smaller values representing increased dissimilarity. Clearly, fusion will continue until the ten OA/S structures have been reduced to one, so a criterion for the most appropriate number of clusters is required. In other words, a decision has to be made as to the point at which to stop 'forcing' combinations. Such a criterion is, by the very nature of the statistical technique, and by the purpose for which it is being used (for mere classification as opposed to quantitative interpretation) arbitrary. Nevertheless, a sensible limit to the degree of fusion may be established from the calculated coefficients of similarity, which are presented in Table 2.15. Each successive fusion is at a point of decreasing similarity, and as a consequence, fusion is stopped before the point which would create the greatest change in similarity once fusion has begun.

Number of resultant clusters	Coefficient of similarity	Change in similarity	End point of fusion
(10)	(1.0000)		
9	0.5985		
8	0.4771	0.1214	
7	0.3836	0.0935	
6	0.2372	0.1464	
5	0.1968	0.0404	
4	0.1473	0.0496	______
3	-0.2005	*0.3478	
2	-0.4091	0.2013	
1	-0.5714	0.1696	

* denotes largest change in similarity

TABLE 2.15: COEFFICIENTS OF SIMILARITY DERIVED FROM FURTHEST NEIGHBOUR FUSION OF THE TEN OA/S STRUCTURES

It can be seen from Table 2.15 that the largest change in similarity would be caused by the creation of only three clusters from the point where there are four. This fusion is stopped, and the cut off occurs when there are four clusters. The dendogram showing the successive fusions and cluster members is illustrated in Figure 2.5 overleaf.

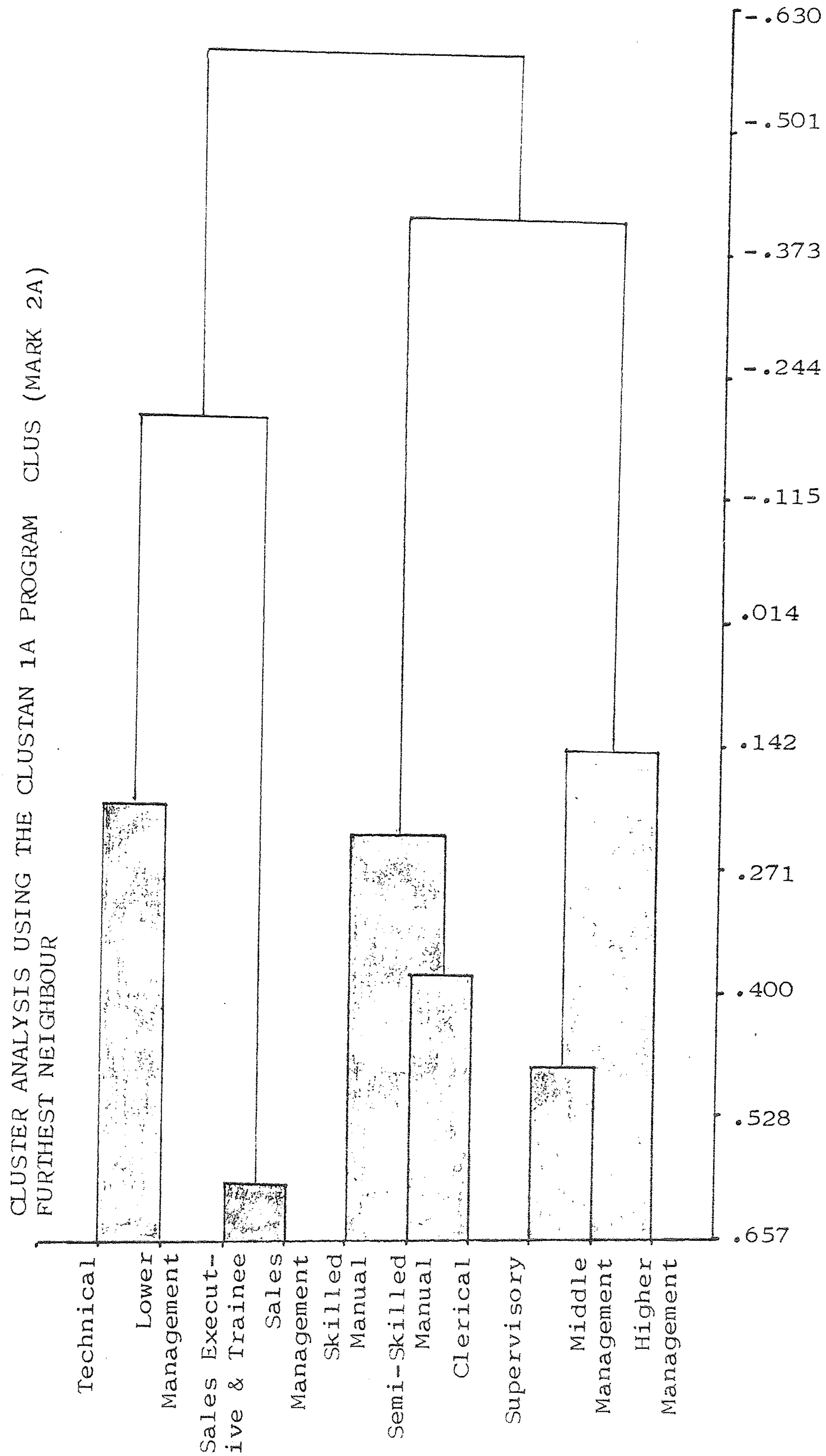


FIGURE 2.5: DENDOGRAM SHOWING CLUSTER ANALYSIS BY FURTHEST NEIGHBOUR OF THE TEN OCCUPATIONAL AGE/SERVICE STRUCTURES

2.8.4: Description of the four clusters of organisational level OA/S structures

The four clusters produced by the Furthest Neighbour method of combination can be ordered in terms of the coefficient of similarity of cluster members. The four clusters are described in this order, and Table 2.16 shows the cluster numbers, their coefficients of similarity, the constituent occupational functions (classified according to the framework shown in Table 2.3), and the name given to the clusters. To facilitate interpretation, the constituent occupational functions for each cluster were combined, and the combined OA/S structure calculated and graphically drawn as described in Section 2.7.2. The four cluster OA/S structures are displayed in Figures 2.6 and 2.7.

Cluster One is called the 'Sales' cluster since it contains both the sales-related functions which are non-manual, and cover social classes II and III. Figure 2.6 shows that the vast majority fall in the low age, low service region of the OA/S structure. There is also a fair proportion in the medium age, medium service region, and a notable absence of any high service or high age individuals.

Cluster Two, named 'Lower Skilled Support' contains both the manual support skilled and semi-skilled functions, and the non-manual clerical support function. 98.78 per cent of the individuals are social class III, and the

Cluster Number	Coefficient of Similarity of Members	Member OA/S Structures	Occupational Classifications	Cluster Name
1	0.5985	Sales Management Sales Executive & Trainee	1.2 II Nm 6 III Nm	Sales
2	0.2372	Clerical Skilled Manual Semi-Skilled Manual	6 III Nm 9 III M 10 IV M	Lower Skilled Support
3	0.1968	Lower Management Technical	2.2 II Nm 5.2 II M	Skilled Support
4	0.1473	Higher Management Middle Management Supervisory (Line Management)	1.2 II Nm 2.2 II Nm 8 III M	Management

TABLE 2.16: DESCRIPTION OF THE FOUR CLUSTERS WITH MEMBER DETAILS

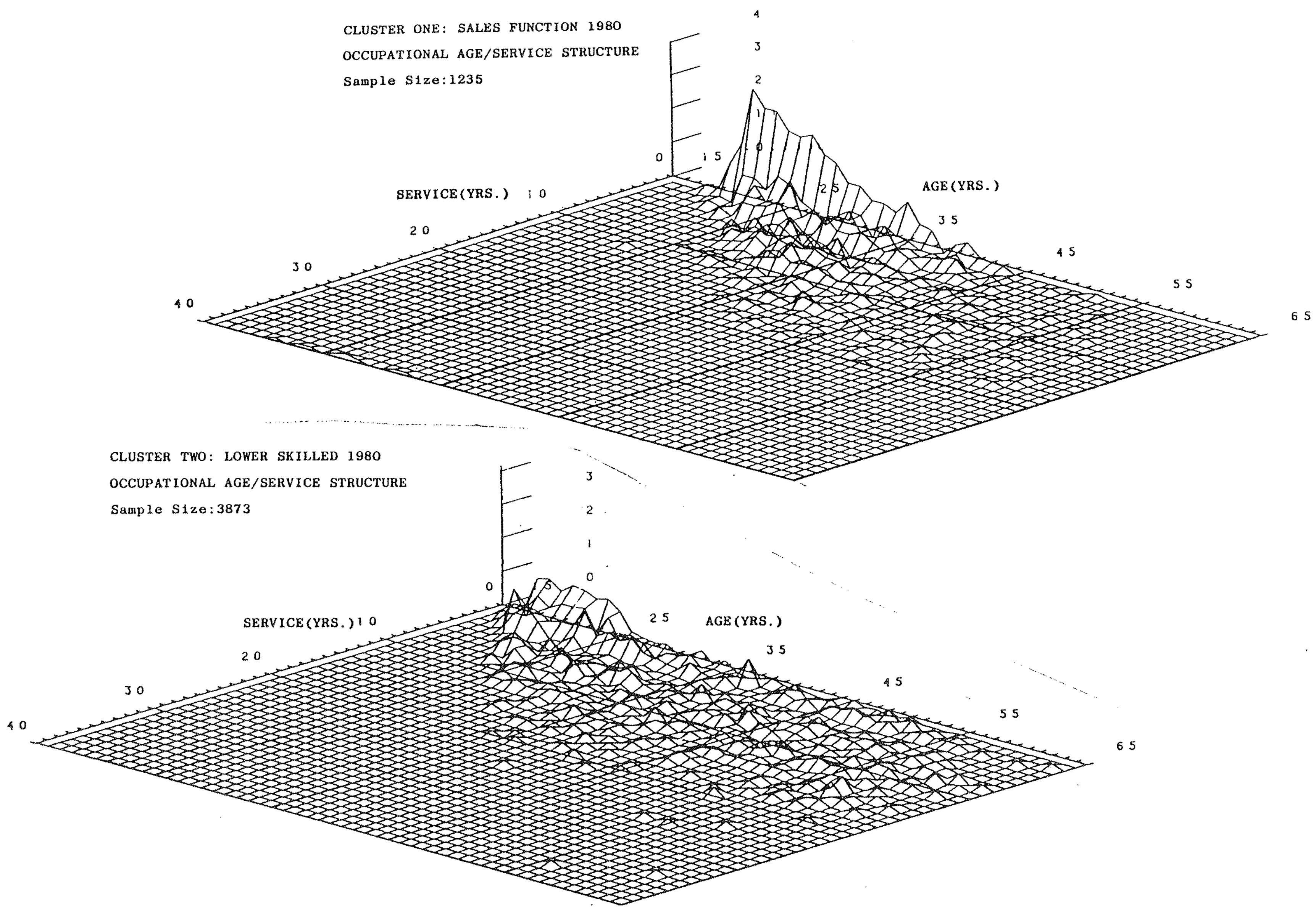
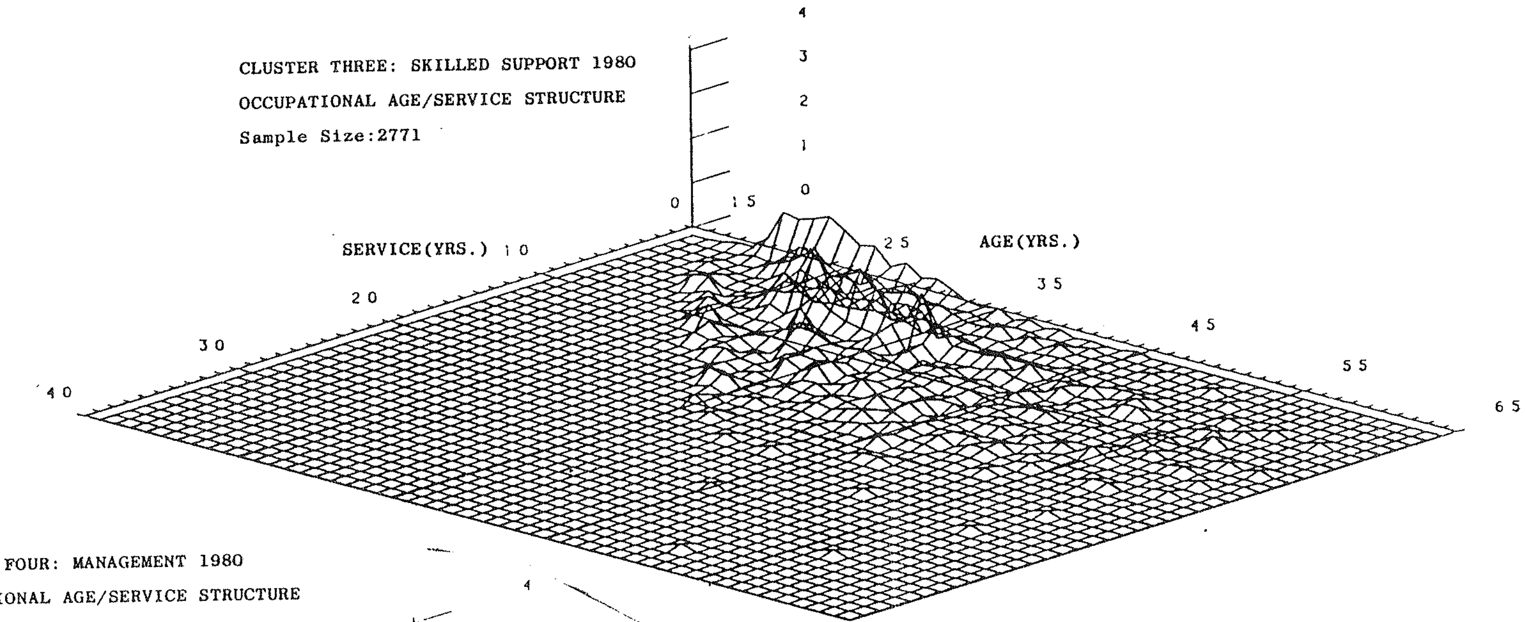


FIGURE 2.6: THREE-DIMENSIONAL GRAPHS SHOWING OCCUPATIONAL AGE/SERVICE STRUCTURES OF SALES CLUSTER AND LOWER SKILLED CLUSTER IN 1980



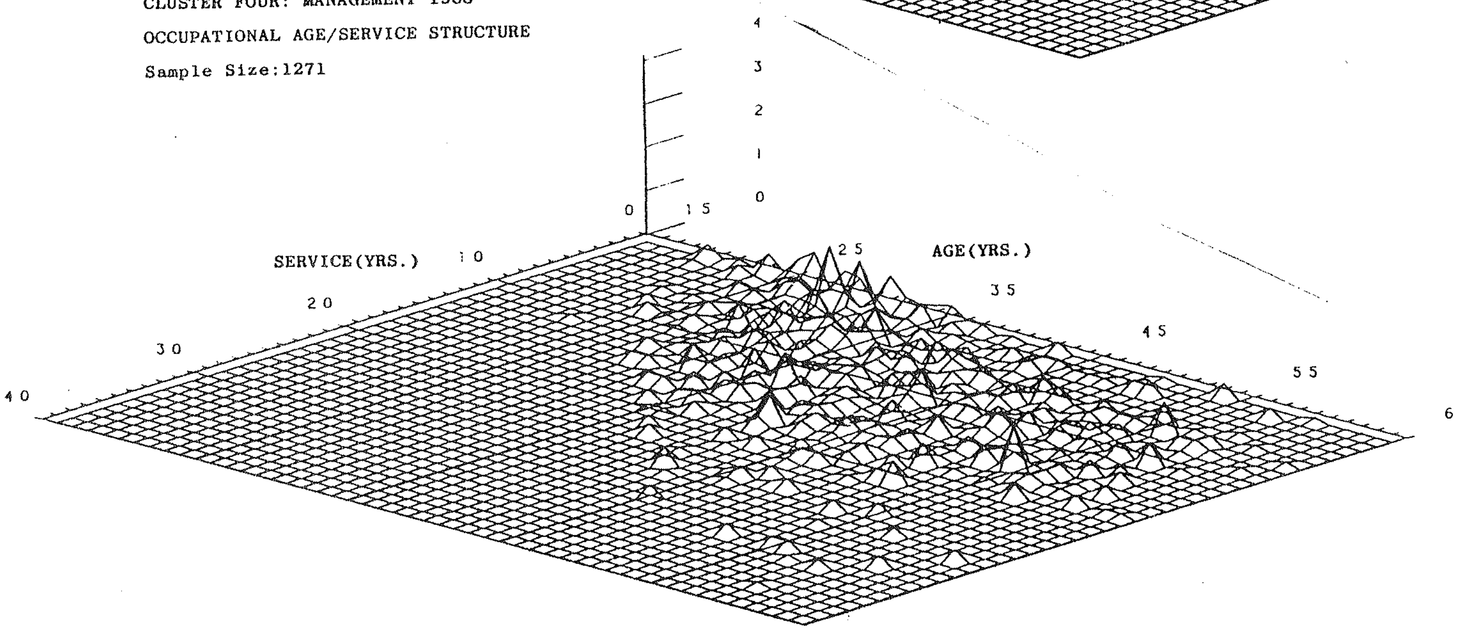


FIGURE 2.7: THREE-DIMENSIONAL GRAPHS SHOWING OCCUPATIONAL AGE/SERVICE STRUCTURES OF SKILLED CLUSTER AND MANAGEMENT CLUSTER IN 1980

lower socio-economic groups of 6, 9 and 10 are represented. Figure 2.6 shows that, whilst there are very few high service individuals, the high age, low service and high age, medium service regions are represented. The modal region is, once more, low age, low service.

Cluster Three is termed 'Skilled Support' since members cover socio-economic groups 2.2 and 5.2 suggesting a higher skill level than the previous cluster. Constituent functions are technical and lower management, both drawn from social class II. Figure 2.7 shows a fairly restricted range of age/service regions. The magnitude of the low age, low service region is not as large as the previous two clusters. There are very few high age or high service individuals, and the low age, medium service region is large compared to Clusters One and Two.

Finally, Cluster Four has been named the 'Management' cluster since it contains three out of the four management functions (higher, middle and supervisory). Figure 2.7 shows that the dominance of the low age, low service region seen in other clusters has disappeared. There is, conversely, a fair number of high service as well as high age individuals. This is undoubtedly the oldest function.

An interpretation of the four clusters or patterns of OA/S structures is difficult and has not been tested. However, it appears that the OA/S structures at the organisational level group not around job content factors specifically, but rather around the organisational hierarchy (which has an implicit career structure). The similarity between the four cluster members, and sections of the organisational hierarchy can be seen by referring to Figure 2.1.

2.9: CONCLUSIONS TO CHAPTER TWO

The following six major findings and conclusions have been made from Chapter Two:-

1. Whilst age and length of service show positive correlations from +0.3814 to +0.6488 across the ten occupational functions, the two variables are deemed to exhibit sufficient unexplained variance to justify their continued spearate use.

2. There are clear sex differences in the age and service of occupational functions. In the top management functions, men are generally older, but have the same length of service. This suggests that those few women who are promoted into upper management levels, are done so at a younger age than men. Other patterns are observed for different occupational functions e.g. in skilled manual and supervisory work, women are older but have lower service.

3. Geographical variation exists within occupational functions. All variation, however, revolves around employees in the South West of England, who are usually older than similar employees in London and the South East, or the North of England. 95 per cent of all employees in the South West of England are based within the organisation's manufacturing plant. Local labour market conditions relating to this manufacturing plant are concluded as accounting for the geographical variation in age and service.

4. Wide differences exist between the age and service of occupational functions. Supervisory, higher management, skilled manual and middle management represent the oldest functions. Sales executives and trainees, clerical and sales management represent the youngest functions.

5. A measure of the occupational age/service structure is developed which calculates the proportion of the total workforce within 40 age/service bands. Five-year intervals are used for the age service bands. Rank correlations between the ten occupational functions showed that, whilst the structures are

significantly different, there are some marked similarities in the essential shape of the age/service structures.

6. A cluster analysis was performed to group the ten occupational functions into 'parent families' according to the relative similarity of the age/service structures. Four such 'parent families' were established. These are:-

(i) Sales Cluster - which contains sales-related occupational functions which are non-manual. The vast majority of employees fall into the low age and low service regions of the OA/S structure.

(ii) Lower Skilled Support Cluster - which contains both skilled and semi-skilled manual functions, and the non-manual clerical function. All perform support activities. This cluster also has mainly low age and low service but other areas are clearly represented.

(iii) Skilled Support Cluster - which contains the technical and lower management functions, both of which offer skilled support to the central management group. This cluster of occupations is characterised by covering a fairly restricted range of age/service regions. The magnitude of the low age, low service region is not as marked as in the previous two clusters.

(iv) Management Cluster - which contains three of the four management functions. This cluster of occupations is characterised by a fair proportion of high service as well as high age individuals.

CHAPTER THREE

LONGITUDINAL CHANGE IN AGE/SERVICE STRUCTURES AND MANPOWER MOVEMENTS

3.1: INTRODUCTION TO THE HISTORICAL STUDY OF AGEING

The first study demonstrated that there are occupational differences in the age and service of employees, and sex differences within these occupations when measured at the organisational level. These findings are generally in line with research findings conducted on national occupational age structures. Previous research has shown that occupational age structures are not necessarily stable, and can change over time (Smith, 1973). Indeed, a preliminary analysis conducted in Section 2.2 showed that the organisation under study is ageing at a rate of roughly one year in every three that pass.

The second study is designed to answer the following three questions:-

1. Are there longitudinal changes in OA/S structures which exist within the organisation?
2. Is there differential longitudinal change between occupations?
3. What mechanisms are responsible for longitudinal change in age structures at the organisational level?

3.2: SELECTION OF A SAMPLE OF OCCUPATIONAL AGE/SERVICE STRUCTURES WITHIN THE ORGANISATION

Data have already been gathered for 9090 employees within a large organisation during April 1980. A suitable database which can be used to study age structures historically needs to be selected. There is a series of criteria which this database must satisfy:-

1. Local labour market forces and demographic factors can exert considerable influence upon the age structure of a workforce. Section 2.6.1 in the previous chapter showed that the vast majority of geographical variation established in the organisational OA/S structures surrounded the manufacturing plant in the South West of England. Employees in most occupations at the manufacturing plant had longer service and higher age than similar employees in other locations around the country. By selecting employees based in the manufacturing plant only, some control will be exerted over local labour market and demographic factors.

2. Clear differences have been shown between occupations in terms of their age/service structure. These differences, in fact, can be classified into four 'parent groups' or clusters. The sample should cover as large a spectrum of these clusters as possible.

Six of the original ten occupational functions defined in Section 2.4.2 of the previous chapter are represented within the manufacturing plant. During April 1980, there were 4295 employees based in the manufacturing plant. This represents 45.04 per cent of the total organisational

OCCUPATIONAL FUNCTION	SAMPLE SIZE	% OF POPULATION	MEAN AGE	MEAN SERVICE
HIGHER MANAGEMENT	117	100.0%	41.96	12.16
MIDDLE MANAGEMENT	130	33.3%	39.00	10.38
SKILLED MANUAL	374	20.0%	39.29	8.50
TECHNICAL	201	33.3%	37.96	10.67
SUPERVISORY	115	33.3%	43.84	12.04
CLERICAL	186	20.0%	34.63	6.25

TABLE 3.1: DESCRIPTIVE DATA FOR THE SIX OCCUPATIONAL FUNCTIONS WITHIN THE MANUFACTURING PLANT

sample studied in the previous chapter, and only the Sales Cluster is not represented. Table 3.1 above summarises the six occupational age/service structures drawn from the manufacturing plant.

3.3: METHODOLOGY FOR HISTORICAL STUDY

3.3.1: Retrospective framework

Within the limited time framework of this research, it would be impractical to start a longitudinal study of occupational age/service structures. A commonly used alternative to a longitudinal study is to impose a quasi-experimental design over retrospective data. Data were available in the personnel department of the manufacturing plant which allowed for a backdating of the OA/S structures over a period of six years (to April 1974). Fortunately, there were no major organisational changes over this period which altered the job classification.

3.3.2: The backdating of OA/S structures

Data were collated in the personnel department which recorded every individual who either left or joined a workforce. These data are called Manpower Movement Data, and record:-

1. the age of the individual;
2. length of service with the organisation (not job service);
3. the reason for leaving;
4. the job title.

Unfortunately, the sex of individuals was not recorded.

For each year - by adding all leavers, and subtracting all recruitees from the present workforce, and by subtracting one year from the age and length of service of those who did not move - the OA/S structure of the workforce can be backdated to its previous state one calendar year before. In essence, all movements into and out of the workforce are put into reverse, and a sample taken each calendar year that passes. This process was carried out on each of the six occupational functions sampled at the manufacturing plant over six calendar year periods.

3.3.3: Five types of Manpower Movement

The discussion of the link between age and various withdrawal behaviours in Chapter One showed that the relationship is different depending upon the type of withdrawal behaviour. Five separate types of manpower movement were recorded:-

1. Recruitment
2. Voluntary Turnover
3. Early Retirement
4. Voluntary Redundancy
5. Compulsory Redundancy

The constituent reasons for leaving within these five categories of manpower movement are listed in Appendix 4. The age and length of service for all movers, along with the type of manpower movement made and occupational function to which it relates, was recorded. The utility of recording the manpower movements will become apparent later.

3.3.4: The diagnosis of ageing within occupational functions: Smith's (1973) Hypothesis A and Hypothesis H

The first aim of the study is to establish whether or not there was any longitudinal change in the occupational functions. In order to study such change, each occupational function was sampled in April of each year. Data exist, then, for seven points in April of each year from 1974 to 1980 inclusive. The measure taken was the same as that described in Sections 2.7.1 and 2.7.2 in the previous chapter. As in the previous chapter, three-

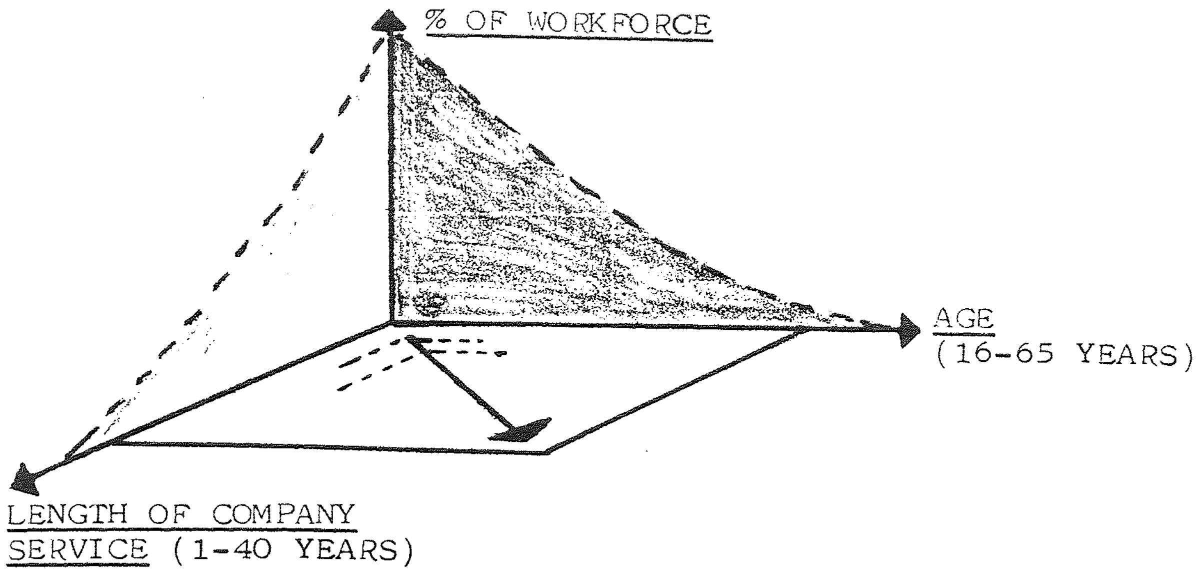


FIGURE 3.1: ILLUSTRATION OF PURE AGEING AS REPRESENTED ON COMPUTER-DRAWN DIAGRAMS

dimensional computer diagrams of the occupational age/service structures were drawn. Two diagrams are produced for each occupational function - one for April 1974 and the other for April 1980.

In the absence of all other factors, each year that passes would see a workforce age by one year, and increase in service by one year. Figure 3.1 above illustrates how this 'pure' ageing would appear on the computer diagrams. The right-angled feature in the centre of the diagram can be seen to move in the general direction of the viewer. Such a movement would occur when the centre spot of the right-angle is plotted at successive points with an additional year of age and service. If any feature within the six sampled OA/S structures is ageing in such an unrestricted fashion, then it will follow this direction across the floor of the diagram.

In the absence of any age-related factors, this form of unrestricted ageing would be observed. It relates to Smith's (1973) Hypothesis H, where the shape and movement of the age structure is purely historical. If, however, the age structure does not change in this fashion, but rather maintains its shape and does not move, then the change relates to Smith's Hypothesis A. For an occupational age/service structure not to age over time, the manpower movements would be age-linked. The older individuals would leave the workforce, compensated by an inflow of younger recruits. To the extent that such age-linked manpower movements can be attributed to an age-performance effect, the following characteristics would be inferred from the observed rate of ageing index or RAI (see Section 2.2 in the previous chapter). Theoretically, a RAI of +1.0 would be observed if no-one ever left or entered the workforce. The closer the observed RAI is to +1.0, the greater likelihood there is that ageing is due merely to historical factors, according to Smith's (1973) Hypothesis H. Of course, it is possible to achieve a RAI of greater than +1.0, if, for example, all leavers were of below average age, and all recruits were of above average age. The opposite theoretical state is a RAI of 0.0. This would be achieved if the occupational age/service structure never altered over time, in which case Smith's Hypothesis A would be inferred to apply to the workforce. Once more, it is possible to achieve a negative RAI, where the workforce actually gets younger. This would be seen where there was very high attrition and recruitment in a workforce which was used to drastically alter the age structure.

Practically, it would not be expected that the whole of an occupational age/service structure would be influenced by only one of Smith's (1973) hypotheses. If, for example, there was significant encouragement for individuals to withdraw from the workforce after the age of fifty (because of an assumed or proven age-performance effect), then features of the occupational age/service structure aged under fifty might be observed to age historically, whereas features over the age of fifty would be subject to the age-linked change. To this end, the longitudinal change observed in the six occupational functions under study shall be described by considering several notable features within each occupational age/service structure.

3.4: DESCRIPTIONS OF LONGITUDINAL CHANGE IN OCCUPATIONAL FUNCTIONS

3.4.1: Higher Mangement

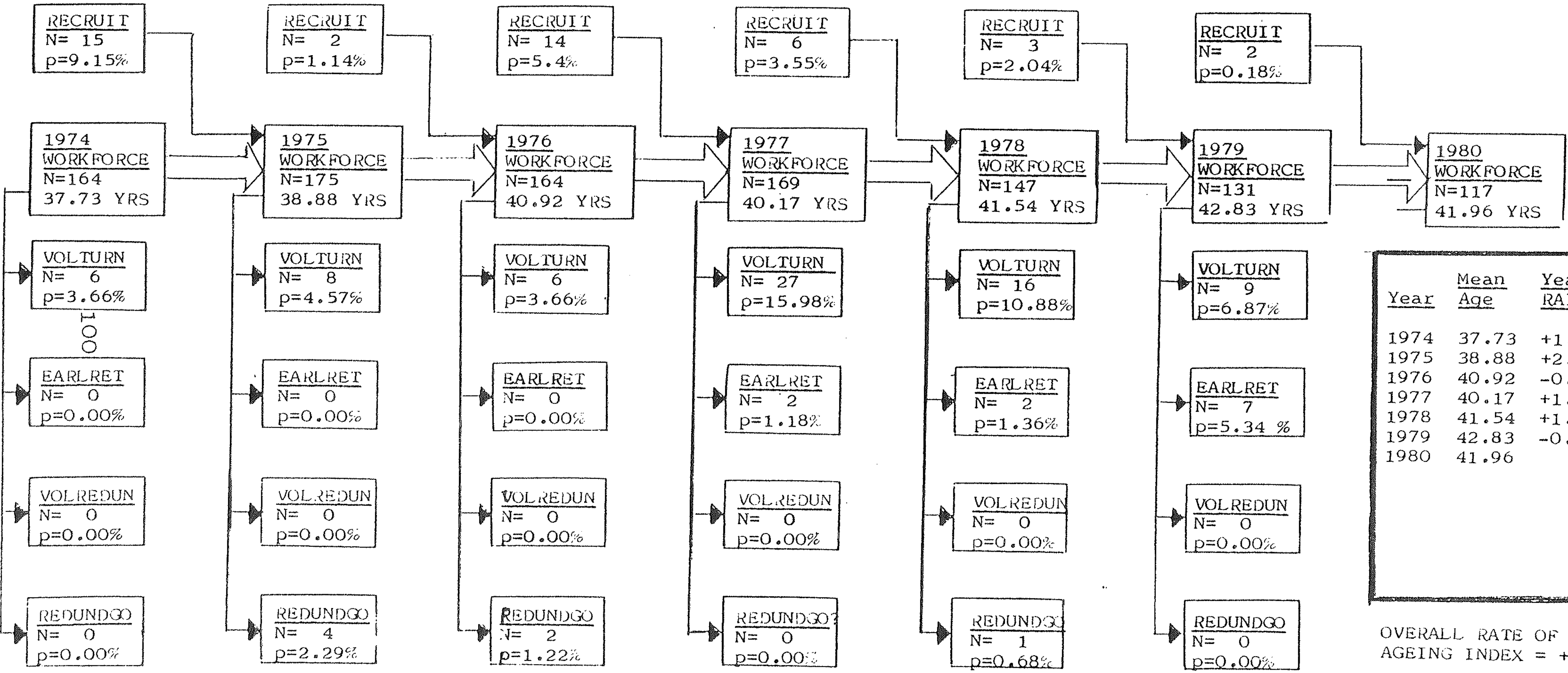
Figure 3.2 shows the size and mean age of the workforce from 1974 to 1980. The frequency and percentage rate of the five possible manpower movements for each year are also presented within the Markov Chain. The table shows the RAI for each year period, as well as the Ratioed RAI. The Ratioed RAI is an expression of the relative rate of ageing of the target workforce in comparison with that of the organisation as a whole:

$$\text{Ratioed RAI} = \frac{\text{Overall RAI for Occupational Function}}{\text{RAI for Organisation as a whole}}$$

The RAI for the organisation as a whole has been established at +0.316 years per year in Section 2.2.

Figure 3.2 shows that the higher management function positively aged with an overall RAI of +0.710 years per year. The Ratioed RAI shows that this rate was 2.33 times as fast as the organisation as a whole. The relevant OA/S structure for 1980 is included for reference in Appendix 5. The longitudinal change is illustrated in Figure 3.3. As noted in Section 3.3.4, four 'features', labelled A to D, were marked on the 1974 OA/S structure.

Feature A represented the modal point of the workforce covering ages 25-35 with a service of 3-9 years. Feature B was the forward end of this main structure, i.e. a group of older managers aged 38-50 with service of 3-12 years. Feature C represented a small group of managers aged in their late forties to early fifties, with 25-30 years of service. Feature D represented isolated groups of managers aged 55 years and over with 1-14 years of service. The characteristic features of historical change illustrated in Figure 3.1 become clear by following the



Year	Mean Age	Yearly RAI
1974	37.73	+1.15
1975	38.88	+2.04
1976	40.92	-0.75
1977	40.17	+1.37
1978	41.54	+1.29
1979	42.83	-0.87
1980	41.96	

OVERALL RATE OF AGEING INDEX = +0.708

RATIOED RATE OF AGEING INDEX = +2.230

FIGURE 3.2: MARKOV CHAIN SUMMARISING MANPOWER MOVEMENTS AND AGEING DATA FOR HIGHER MANAGEMENT FUNCTION FROM 1974 TO 1980

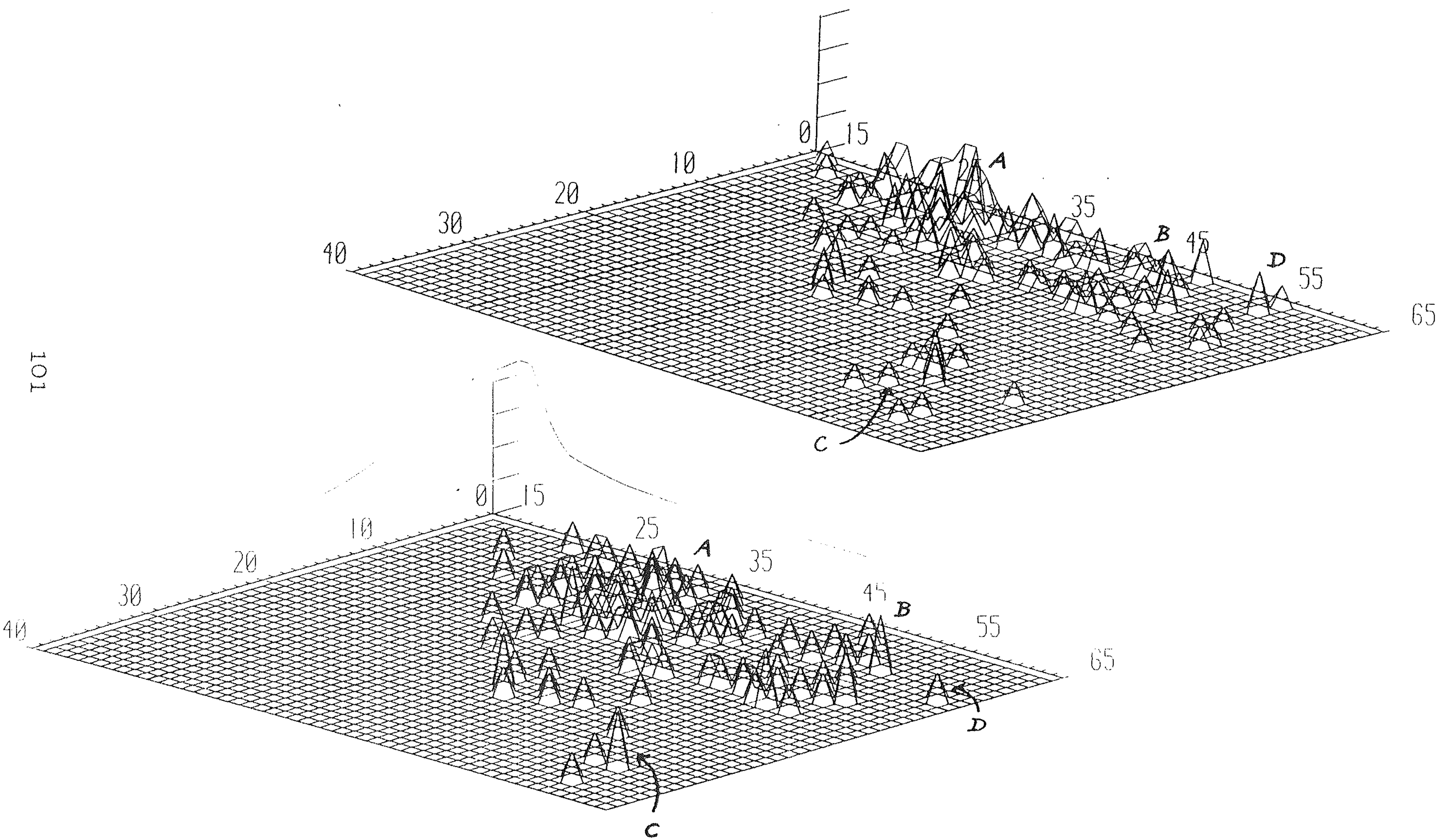


FIGURE 3.3: THREE-DIMENSIONAL GRAPHS SHOWING OCCUPATIONAL AGE/SERVICE STRUCTURE OF HIGHER MANAGEMENT FUNCTION AT THE MANUFACTURING PLANT IN 1974 (TOP) AND 1980 (BOTTOM)

progress of these four features from their 1974 positions to their 1980 positions (Figure 3.3).

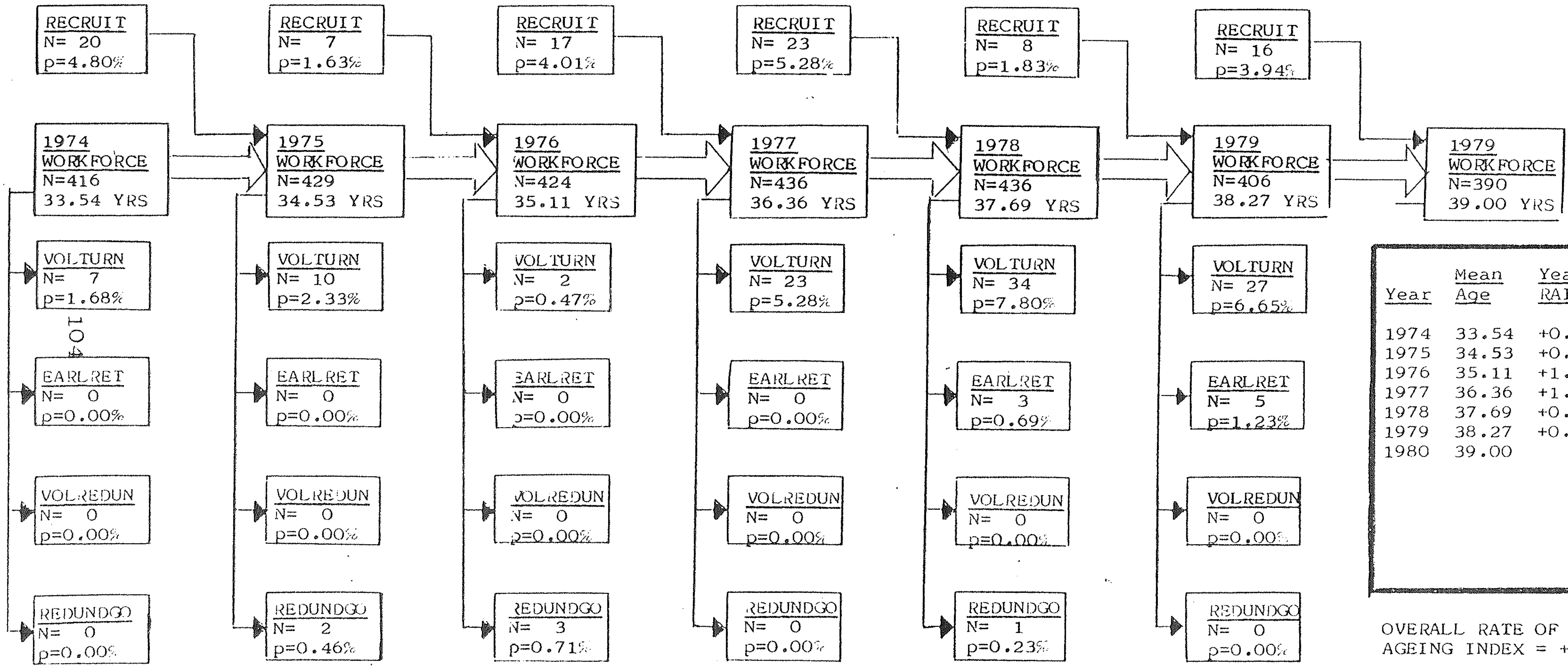
By 1980, Feature A had moved away from the far borders (age and service dimensions) into the 26-40 years service range with 3-14 years of service. The large central peak seen in 1974 somewhat diminished due to high levels of voluntary turnover during 1977 to 1978. Feature B pushed forward towards the end of the age dimension where mandatory retirement at the age of 65 was imposed. The clearest historical change was seen, however, in Features C and D. By 1980, Feature C moved to the very bottom corner of the graph, much reduced from its 1974 magnitude. Many individuals left this feature through early and mandatory retirement, or the compulsory redundancy schemes of 1975, 1976 and 1978. Feature D showed an interaction between historical change and age-linked change caused by personnel policy intervention. Of the many peaks that existed in 1974, only one remained. Those who left can be visualised as having either moved over the near "edge" of the graph into mandatory retirement (reached the exit point on the age dimension at 65 years); or as having left through "slits" in the horizontal plane which allowed early retirees to sever their connection with the organisation. Many of the individuals represented by Feature D availed themselves of such an opportunity in early retirement schemes during 1977 and 1979. Figure 3.2 shows that the particularly heavy 1979 programme (with 5.34 per cent attrition) occurred in conjunction with other manpower movements, and resulted in a 0.87 year drop in the mean age of the function.

3.4.2: Middle Management

The overview of longitudinal change in Figure 3.4 shows that the middle management function positively aged at +0.91 years per year, which was 2.88 times as fast as the organisation as a whole. This RAI was remarkedly close to the +1.00 rate expected through solely historical change. The OA/S structure for 1980 is included in Appendix 5 and graphically represented in Figure 3.5. Four features of the 1974 OA/S structure were highlighted.

Feature A was the modal group representing a large number of managers aged 18-30 years with 1-9 years of service. Feature B was a smaller number of managers aged 32-40 years with low service extending to 15 years. Feature C was divided into two groups, both with relatively low service. C(i) were aged in their late forties to early fifties, and C(ii) were aged in their early sixties. Finally, Feature D represented a small group of managers aged in their mid-fifties, but with very high service of over 25 years.

By 1980, the magnitude of Feature A had diminished as many left through voluntary turnover. The feature itself



Year	Mean Age	Yearly RAI
1974	33.54	+0.99
1975	34.53	+0.58
1976	35.11	+1.25
1977	36.36	+1.33
1978	37.69	+0.58
1979	38.27	+0.73
1980	39.00	

OVERALL RATE OF AGEING INDEX = +0.910

RATIOED RATE OF AGEING INDEX = +2.880

FIGURE 3.4: MARKOV CHAIN SUMMARISING MANPOWER MOVEMENTS AND AGEING DATA FOR MIDDLE MANAGEMENT FUNCTION FROM 1974 TO 1980

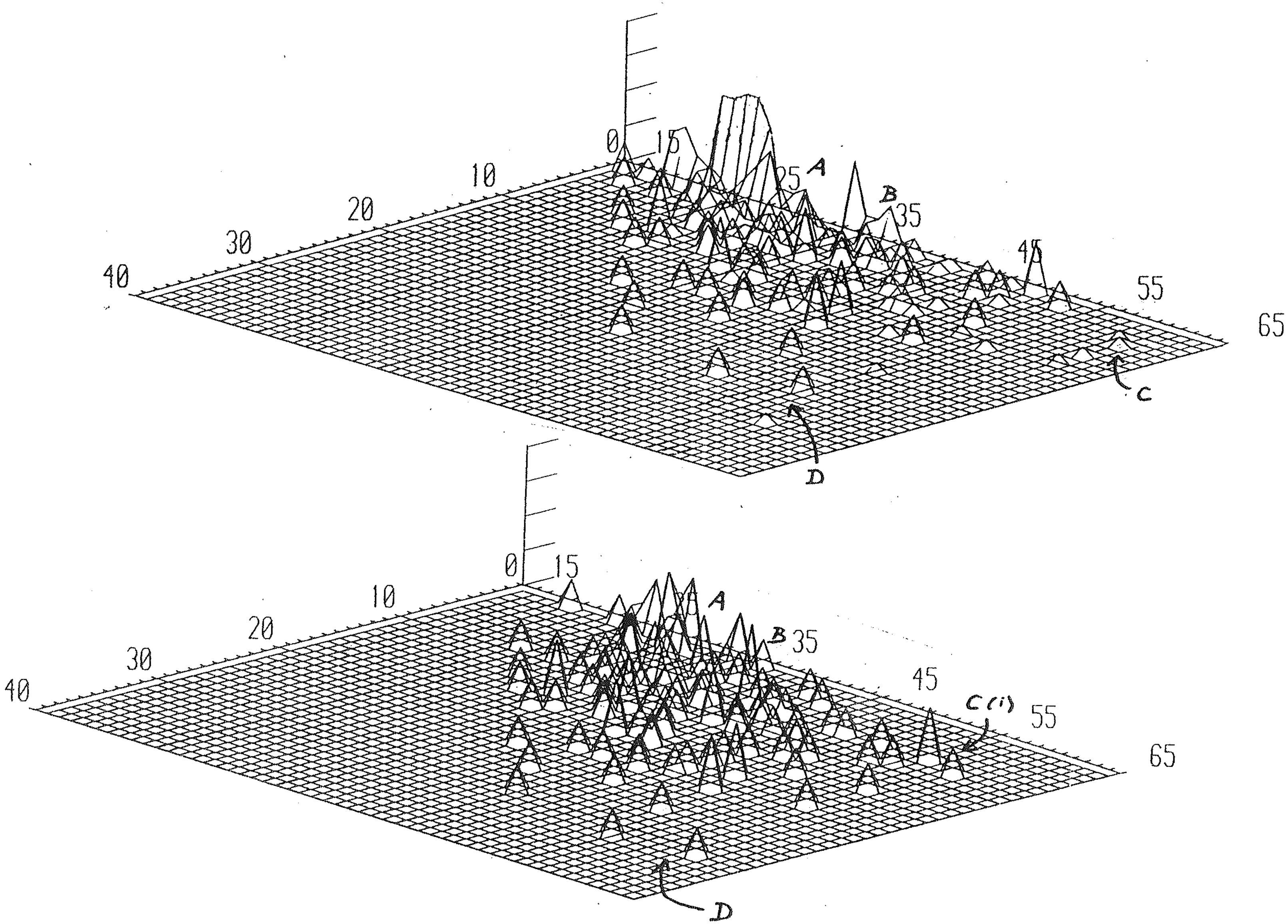


FIGURE 3.5: THREE-DIMENSIONAL GRAPHS SHOWING OCCUPATIONAL AGE/SERVICE STRUCTURE OF MIDDLE MANAGEMENT FUNCTION AT THE MANUFACTURING PLANT IN 1974 (TOP) AND 1980 (BOTTOM)

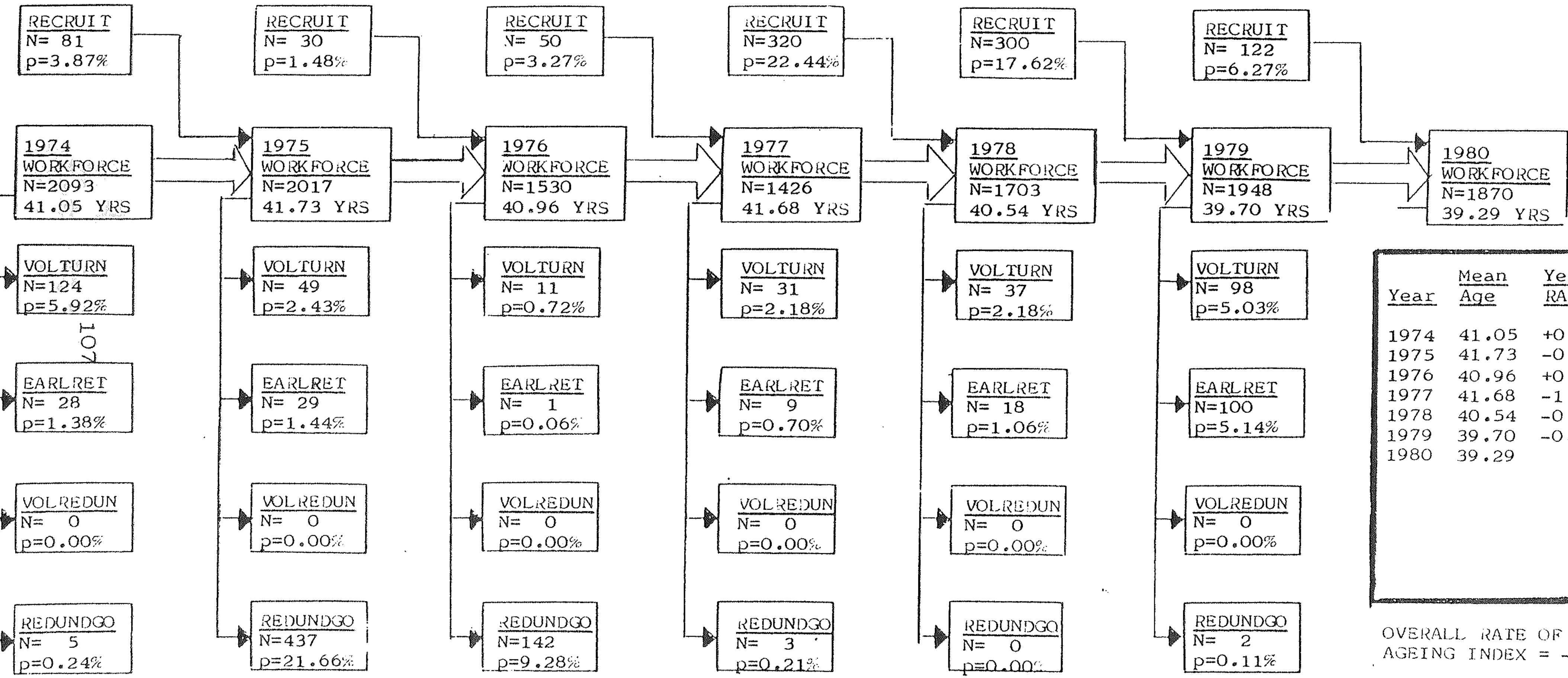
moved across the diagram in a diagonal line, but had been subject to some change in shape. The early distinction between Features A and B became less clear, as Feature B showed simple historical change. Feature C(ii) disappeared as these managers left in the limited early retirement schemes of 1978 and 1979 (0.69 per cent and 1.23 per cent attrition rates). Feature C(i) was not subject to personnel intervention and aged historically. Feature D, similarly, aged historically.

3.4.3: Skilled Manual

Figure 3.6 shows that the skilled manual function exhibited negative ageing, which suggests a strong age-linked change. The RAI was -0.29 years per year, with a Ratioed RAI pf -0.93. This function grew younger at an almost equivalent rate that the organisation as a whole aged. The OA/S structure for 1980 is included in Appendix 5, and graphically drawn in Figure 3.7. Four features of the 1974 OA/S structure were detailed.

Feature A represented the main amorphous block of low service staff, with ages ranging from 16-55. Feature B comprised those staff aged 28-40 years with service of more than 10 years. Feature C represented a few staff aged 50-60 with very high service of over 30 years. Feature D covered a spread of staff aged 55 and over with 1-15 years of service.

An examination of the 1980 OA/S structure shows how this



Year	Mean Age	Yearly RAI
1974	41.05	+0.68
1975	41.73	-0.77
1976	40.96	+0.72
1977	41.68	-1.14
1978	40.54	-0.84
1979	39.70	-0.41
1980	39.29	

OVERALL RATE OF AGEING INDEX = -0.293

RATIOED RATE OF AGEING INDEX = -0.933

FIGURE 3.6: MARKOV CHAIN SUMMARISING MANPOWER MOVEMENTS AND AGEING DATA FOR SKILLED MANUAL FUNCTION FROM 1974 TO 1980

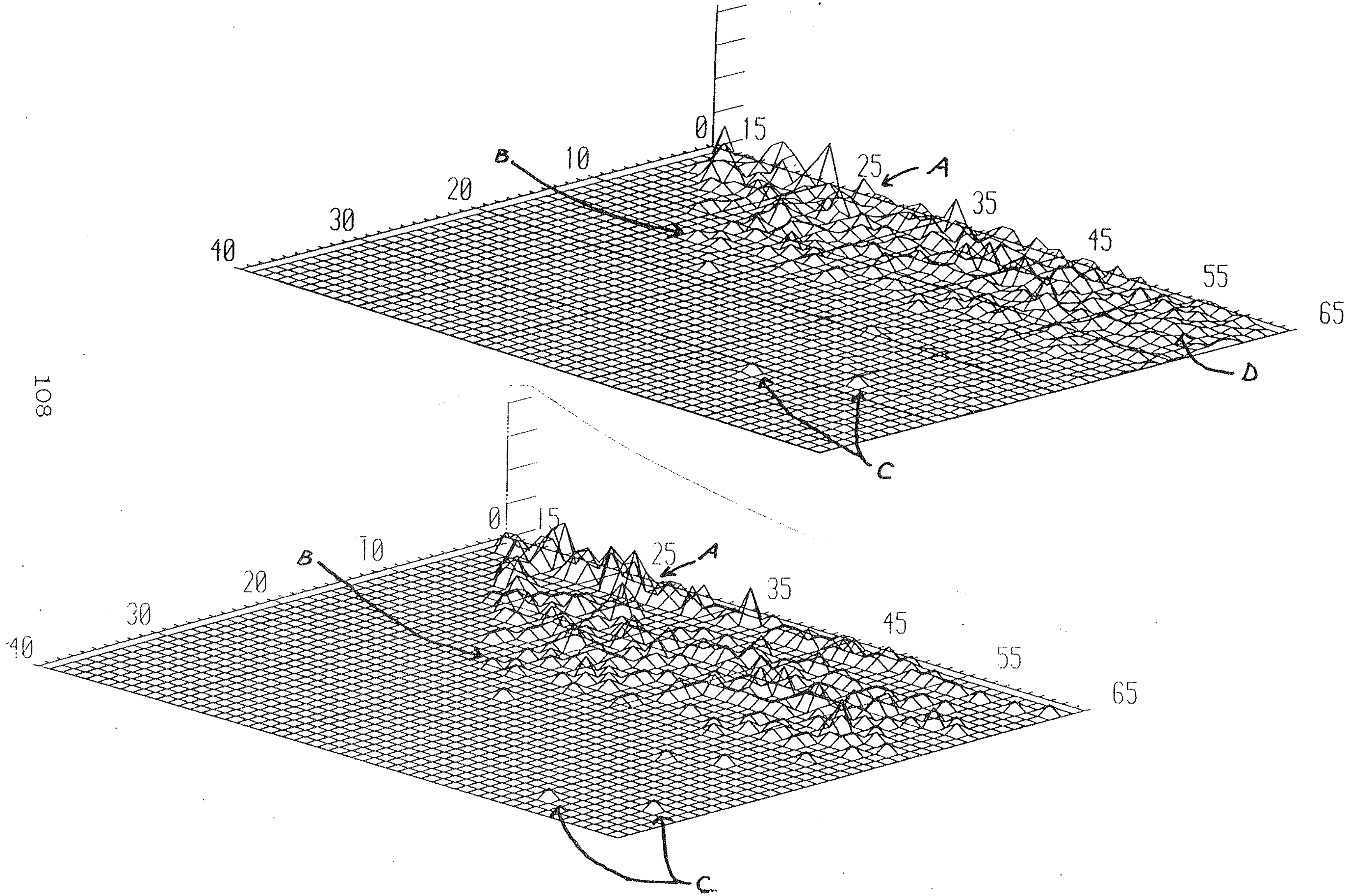


FIGURE 3.7: THREE-DIMENSIONAL GRAPHS SHOWING OCCUPATIONAL AGE/SERVICE STRUCTURE OF SKILLED MANUAL FUNCTION AT THE MANUFACTURING PLANT IN 1974 (TOP) AND 1980 (BOTTOM)

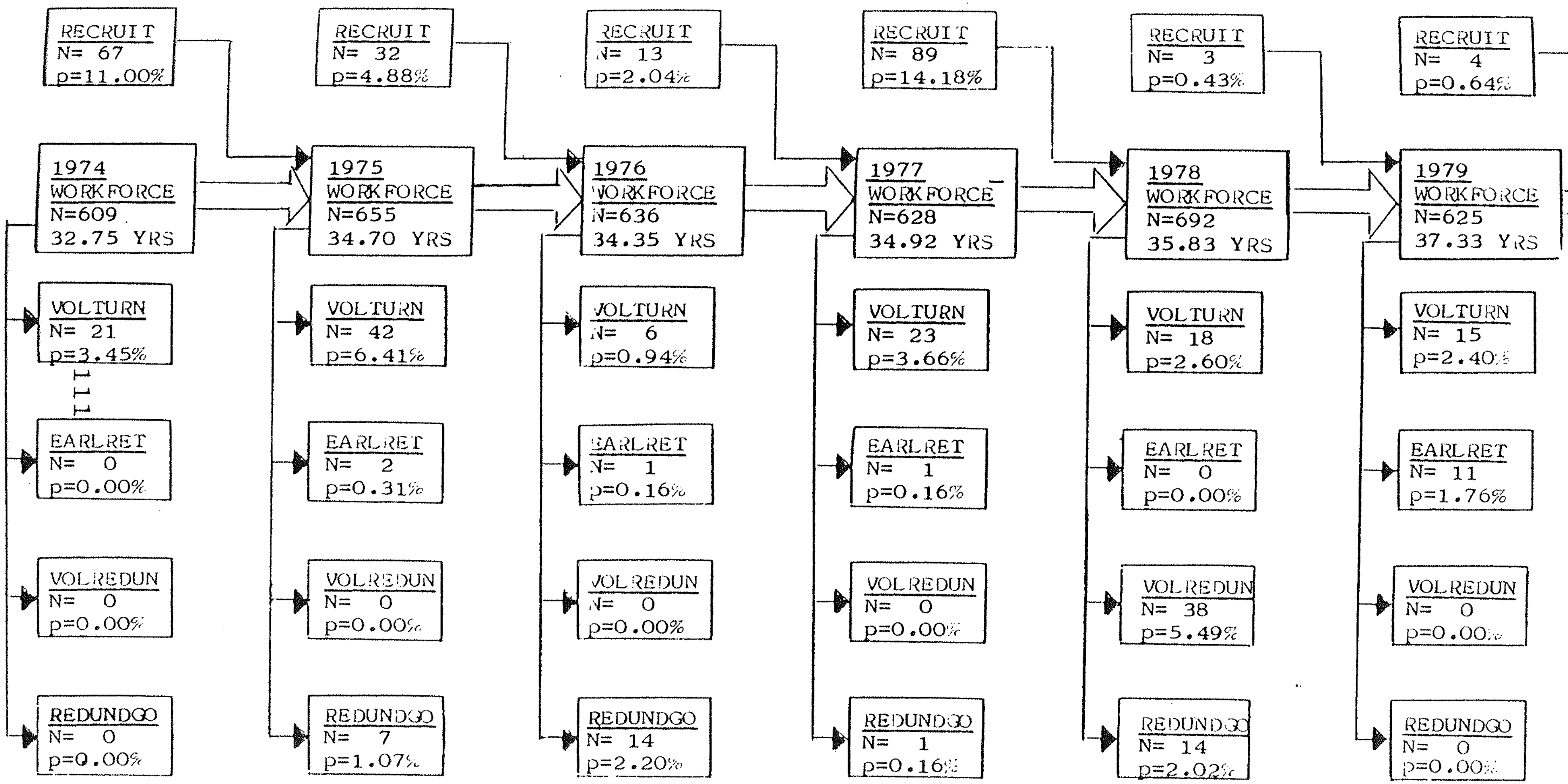
function clearly illustrated an interaction between historical and age-linked change. The massive compulsory redundancy scheme of 1975 to 1976, closely followed by a recruitment drive in 1977 to 1978, represented a significant personnel intervention which clearly affected the four features detailed. Although the mean age of the workforce dropped from 41.05 years to 39.29 years, the length of service increased. The shape of Feature A neither changed much nor moved along the age dimension. Features B and C, however, did show historical change. Feature B moved from a modal age of 28 years with 12 years of service, to one of 34 years with 18 years of service (i.e. a 6 year increase in both age and service representing historical change). Individuals in Feature C similarly moved across the graph. The majority of individuals in Feature D left the OA/S structure through a mixture of personnel interventions, including early retirement schemes in 1975, 1978 and 1979. The forward edge of Feature A replaced Feature D. A new Feature, labelled E, was formed. This comprised a group of workers with a wide age range, but all with service of under 6 years. It represented the recruits into the OA/S structure during 1977 to 1978. It is clearly distinguished from the old OA/S structure features by a gap of two to three years during which time there was zero recruitment to the function.

3.4.4: Technical

Figure 3.8 shows the longitudinal ageing data, revealing a RAI of +0.87 years per year for the technical function, which was 2.74 times as fast as the organisation as a whole. The 1980 OA/S structure in included in Appendix 5 and graphically displayed in Figure 3.9. There were five main structural features of the 1974 OA/S structure.

Feature A represented a wall of very young apprentices who were generally recruited between the ages of 16 and 18. This formed the beginnings of a wall which progressed diagonally across the matrix. The very high peak of recent 16 year old recruits was noticeable. Feature B represented a large group of older technicians aged 21-28 years with 1-9 years of service. This group represented the qualified and skilled recruits into the function. Feature C was a small tail of older technicians aged between 33-45 years with 2-12 years of service. Feature D represented a small spread of old technicians aged 55 and over with low service (2-10 years). Finally, Feature E comprised a few technicians in their forties to early fifties with very high service of over 20 years.

By 1980, the walled Feature A had diminished in magnitude and shown historical ageing. Those individuals leaving this feature did so by voluntary turnover and compulsory redundancy. Feature B exhibited historical ageing. The high peak of low length of service technicians was eroded during the 1978 voluntary redundancy scheme. Low service



Year	Mean Age	Yearl[y] RAI
1974	32.75	+1.95
1975	34.70	-0.35
1976	34.35	+0.57
1977	34.92	+0.57
1978	35.83	+1.50
1979	37.33	+0.62
1980	37.95	

OVERALL RATE OF AGEING INDEX = +0.86

RATIOED RATE OF AGEING INDEX = +2.74

FIGURE 3.8: MARKOV CHAIN SUMMARISING MANPOWER MOVEMENTS AND AGEING DATA FOR TECHNICAL FUNCTION FROM 1974 TO 1980

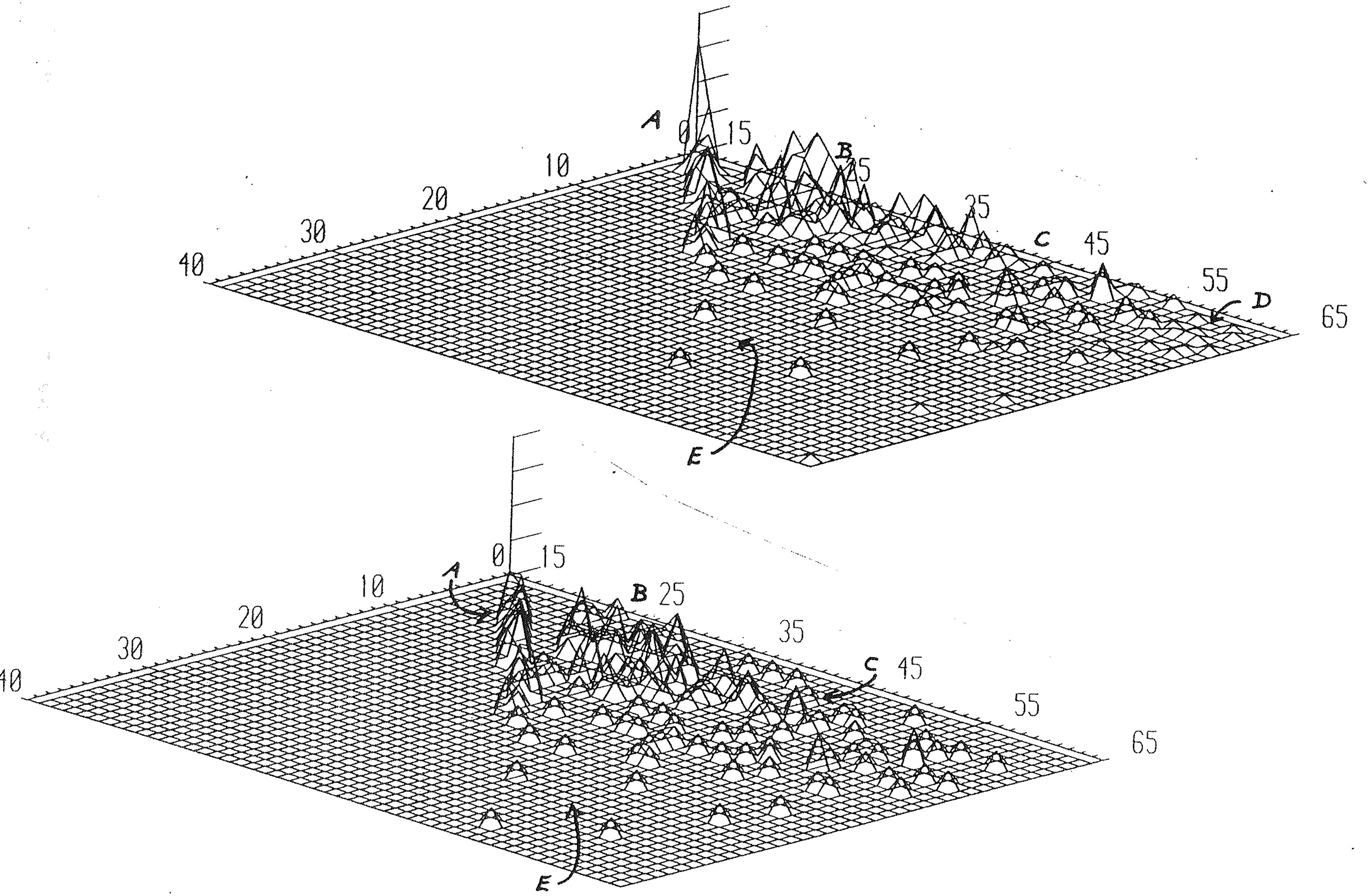


FIGURE 3.9: THREE-DIMENSIONAL GRAPHS SHOWING OCCUPATIONAL AGE/SERVICE STRUCTURE OF TECHNICAL FUNCTION AT THE MANUFACTURING PLANT IN 1974 (TOP) AND 1980 (BOTTOM)

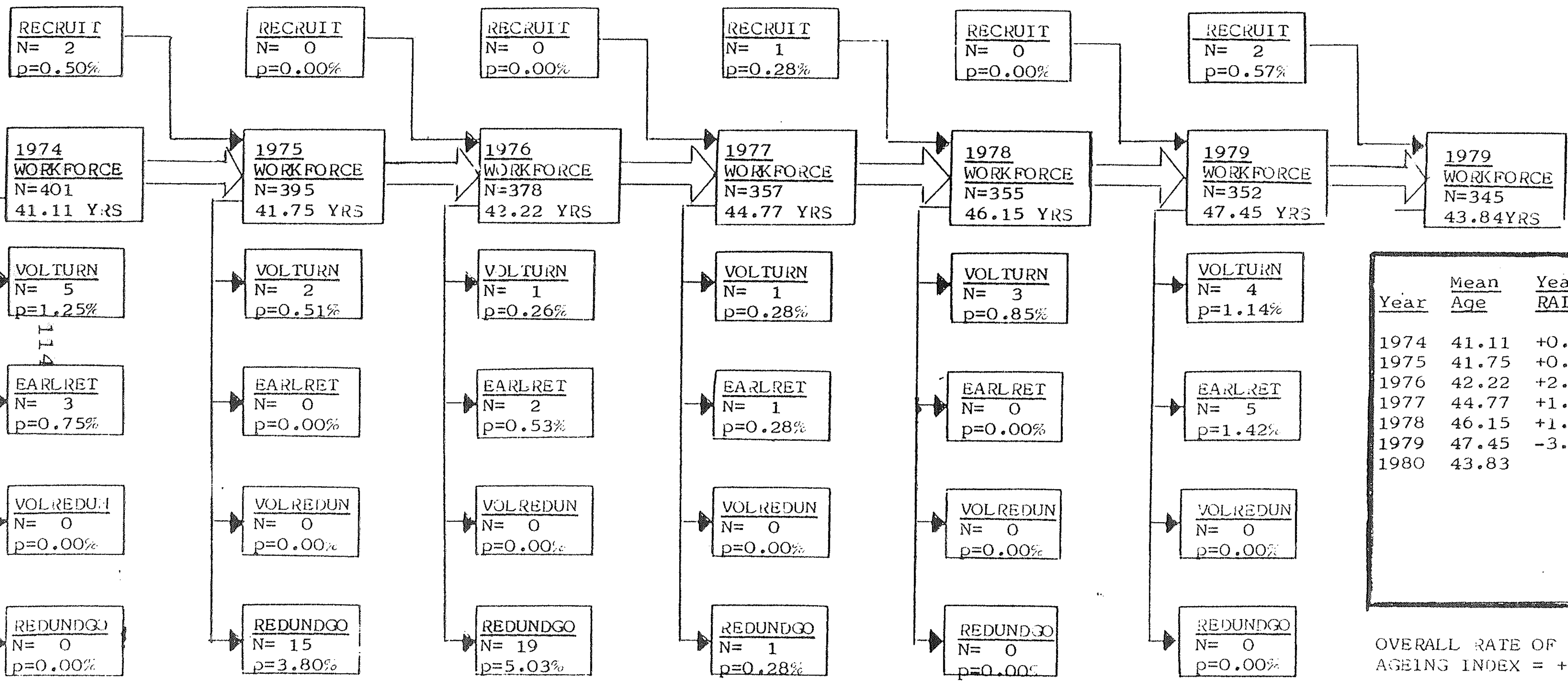
qualified technicians within the 21-28 year age range mainly took advantage of this. Feature D passed out of the system via mandatory and early retirement, or compulsory redundancy in 1976. Both Features D and E exhibited historical ageing.

3.4.5: Supervisory

The longitudinal ageing data presented in Figure 3.10 shows that the supervisory function positively aged at +0.45 years per year, which was 1.44 times as fast as the organisation as a whole. The 1980 OA/S structure is included in Appendix 5 and illustrated in Figure 3.11. There were four structural features in the 1974 OA/S structure.

Feature A represented the modal point with fairly large numbers of 20-25 year old supervisors with 1-5 years' service. Feature B represented middle-aged supervisors with 1-12 years' service. Feature C was a small group of old, medium service supervisors (aged 55-65 with 5-15 years' service). Finally, Feature D represented a small number of older very high service supervisors (aged over 45 with over 20 years of service).

By 1980, the whole OA/S structure appeared to show historical ageing, with some slight modification to the 1974 structural features. Feature A reduced in magnitude as many individuals left through voluntary turnover. Feature B remained relatively unaltered in magnitude and



Year	Mean Age	Yearly RAI
1974	41.11	+0.64
1975	41.75	+0.47
1976	42.22	+2.55
1977	44.77	+1.38
1978	46.15	+1.30
1979	47.45	-3.61
1980	43.83	

OVERALL RATE OF AGEING INDEX = +0.455

RATIOED RATE OF AGEING INDEX = +1.440

FIGURE 3.10: MARKOV CHAIN SUMMARISING MANPOWER MOVEMENTS AND AGEING DATA FOR SUPERVISORY FUNCTION FROM 1974 TO 1980

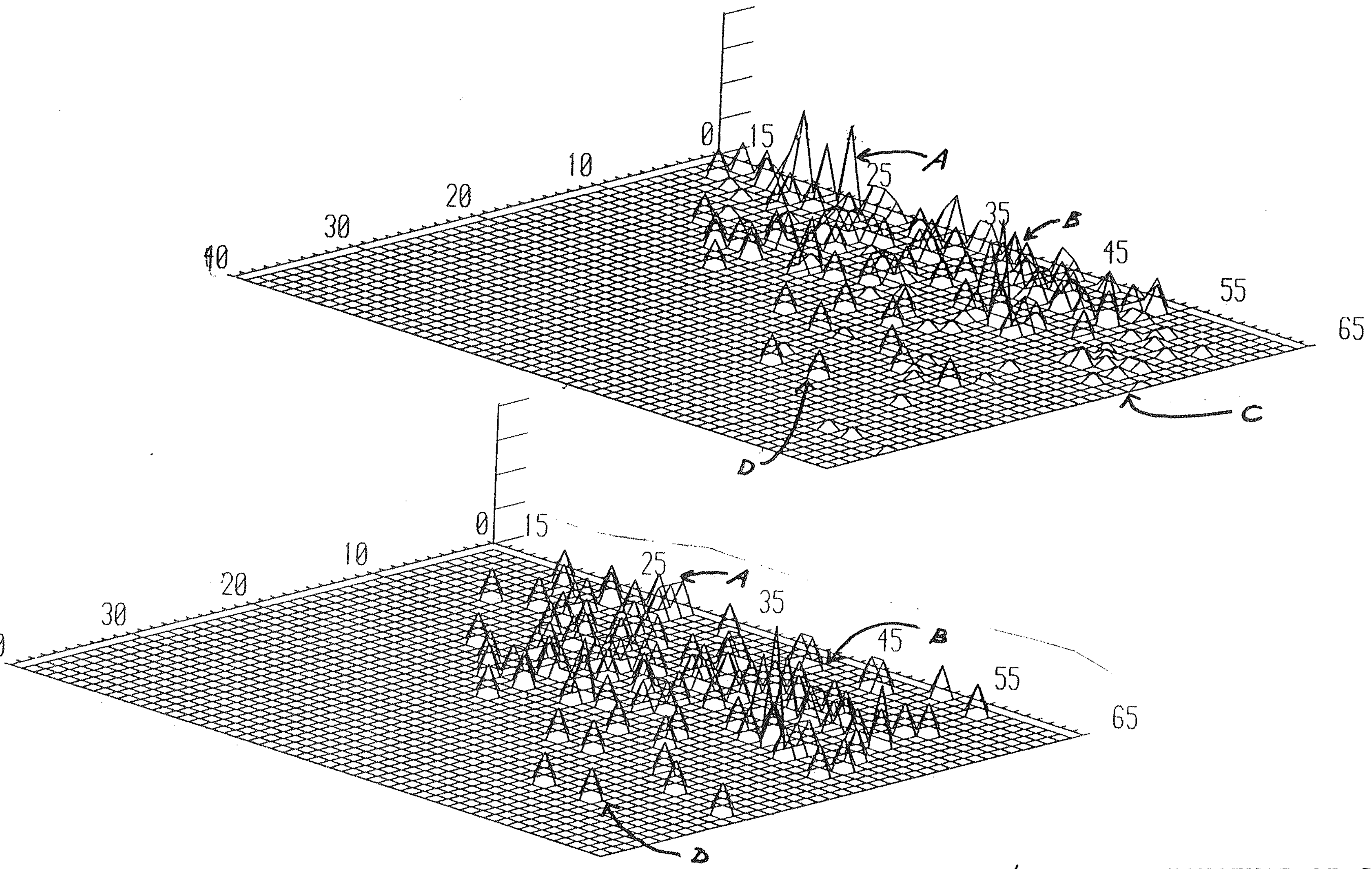


FIGURE 3.11: THREE-DIMENSIONAL GRAPHS SHOWING OCCUPATIONAL AGE/SERVICE STRUCTURE OF SUPERVISORY FUNCTION AT THE MANUFACTURING PLANT IN 1974 (TOP) AND 1980 (BOTTOM)

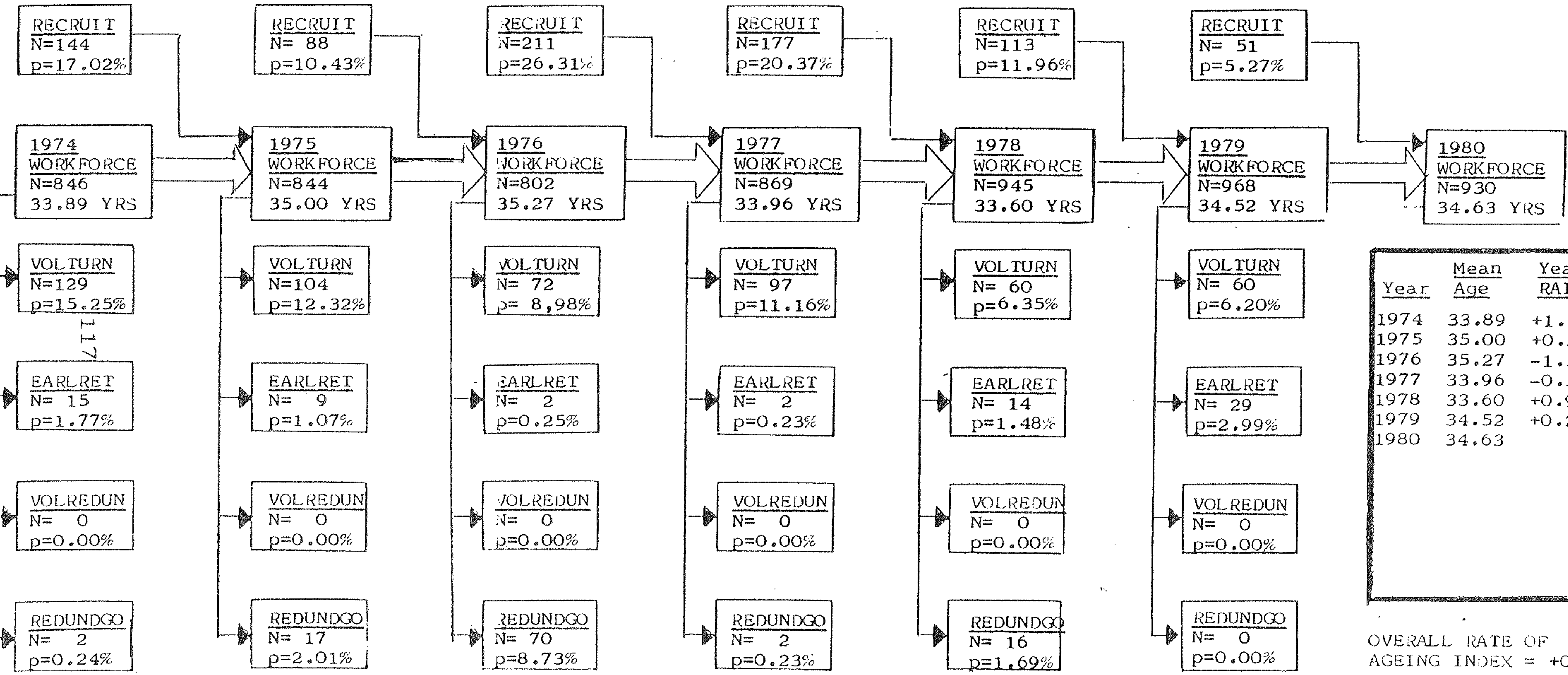
aged historically. Feature C disappeared as many older medium service supervisors were mandatorily retired or left in the 1976 redundancy scheme. Finally, Feature D exhibited historical ageing. Much of the increase in service of this function can be attributed to the relative lack of recruitment.

3.4.6: Clerical

Figure 3.12 shows that the clerical function revealed only very slight positive ageing, with a RAI of +0.12 years per year. It aged at approximately one third the rate of the organisation as a whole (Ratioed RAI = +0.39). The 1980 OA/S structure is included in Appendix 5 and drawn in Figure 3.13. Five main features of the 1974 OA/S structure were detailed.

Feature A represented the modal point of a large group of low age, low service clerical staff (aged 16-30 with less than 10 years' service). Feature B was a group of middle-aged low service staff, aged 30-45 with less than 10 years' service. Feature C was a group of staff aged 45-55 with less than 10 years of service. Feature D was a series of old, low to medium service clerical staff aged over 55 with 2-20 years' service. Finally, Feature E represented a small number of middle-aged medium service clerical staff aged 35-48 with 12-22 years of service.

By 1980, there was little change in the overall shape



Year	Mean Age	Yearly RAI
1974	33.89	+1.11
1975	35.00	+0.27
1976	35.27	-1.31
1977	33.96	-0.36
1978	33.60	+0.92
1979	34.52	+0.21
1980	34.63	

OVERALL RATE OF AGEING INDEX = +0.123

RATIOED RATE OF AGEING INDEX = +0.392

FIGURE 3.12: MARKOV CHAIN SUMMARISING MANPOWER MOVEMENTS AND AGEING DATA FOR CLERICAL FUNCTION FROM 1974 TO 1980

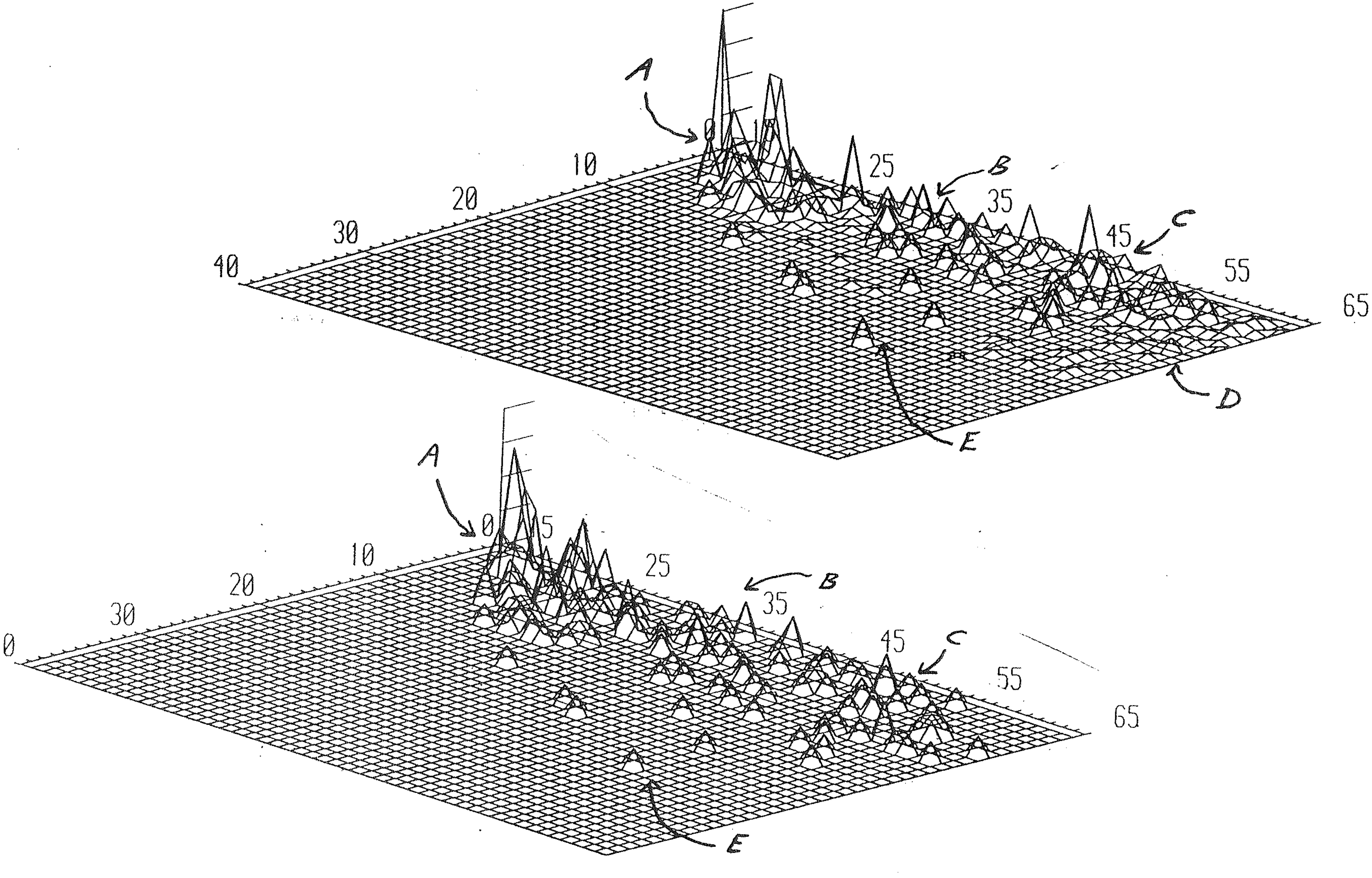


FIGURE 3.13: THREE-DIMENSIONAL GRAPHS SHOWING OCCUPATIONAL AGE/SERVICE STRUCTURE OF CLERICAL FUNCTION AT THE MANUFACTURING PLANT IN 1974 (TOP) AND 1980 (BOTTOM)

and position of the OA/S structure. Feature A enlarged slightly as the numbers in the workforce increased, and tended to be young recruits. All other features moved relatively slowly across the matrix, suggesting age-linked change. Feature D all but vanished as the individuals retired, and Feature C moved into the older regions on the graph.

3.4.7: Summary of longitudinal change in occupational functions

The mean age and observed RAI for each occupational function over the period 1974 to 1980 are summarised in Table 3.2 overleaf.

The descriptions of longitudinal change in Sections 3.4.1 to 3.4.6 show that an OA/S structure is not just subject to either historical ageing, or an age-linked change. An OA/S structure can be subdivided in clear features, and, in general, it is these features which are subject to one of the two types of change specified. It is the summation of these changes within the many features of an OA/S structure which may give the whole OA/S structure the appearance of either historical or age-linked change. A high positive RAI reflects an OA/S structure in which the majority of features changed historically. Conversely, a low positive (or negative) RAI reflects an OA/S structure in which the majority of features were subject to age-linked change.

The data presented in Table 3.1 show that there is long-

YEAR	MP SUPERVISORY		MP SKILLED MANUAL		MP HIGHER MANAGEMENT		MP MIDDLE MANAGEMENT		MP TECHNICAL		MP CLERICAL	
	MEAN AGE	RAI	MEAN AGE	RAI	MEAN AGE	RAI	MEAN AGE	RAI	MEAN AGE	RAI	MEAN AGE	RAI
1974	41.11		41.05		37.73		33.54		32.75		33.89	
1975	41.75	0.64	41.73	0.68	38.88	1.15	34.53	0.99	34.70	1.95	35.00	1.11
1976	42.22	0.47	40.96	-0.77	40.92	2.04	35.11	0.58	34.35	-0.35	35.27	0.27
1977	44.77	2.55	41.68	0.72	40.17	-0.75	36.36	1.25	34.92	0.57	33.96	-1.31
1978	46.15	1.38	40.54	-1.14	41.54	1.37	37.69	1.33	35.83	0.91	33.60	-0.36
1979	47.45	1.30	39.70	-0.84	42.83	1.29	38.27	0.58	37.33	1.50	34.52	0.92
1980	43.84	-3.61	39.29	-0.41	41.96	-0.87	39.00	0.73	37.95	0.62	34.63	0.21
MEAN	43.90	+0.46	40.71	-0.29	40.57	+0.50	36.36	+0.91	35.40	+0.87	34.41	+0.14

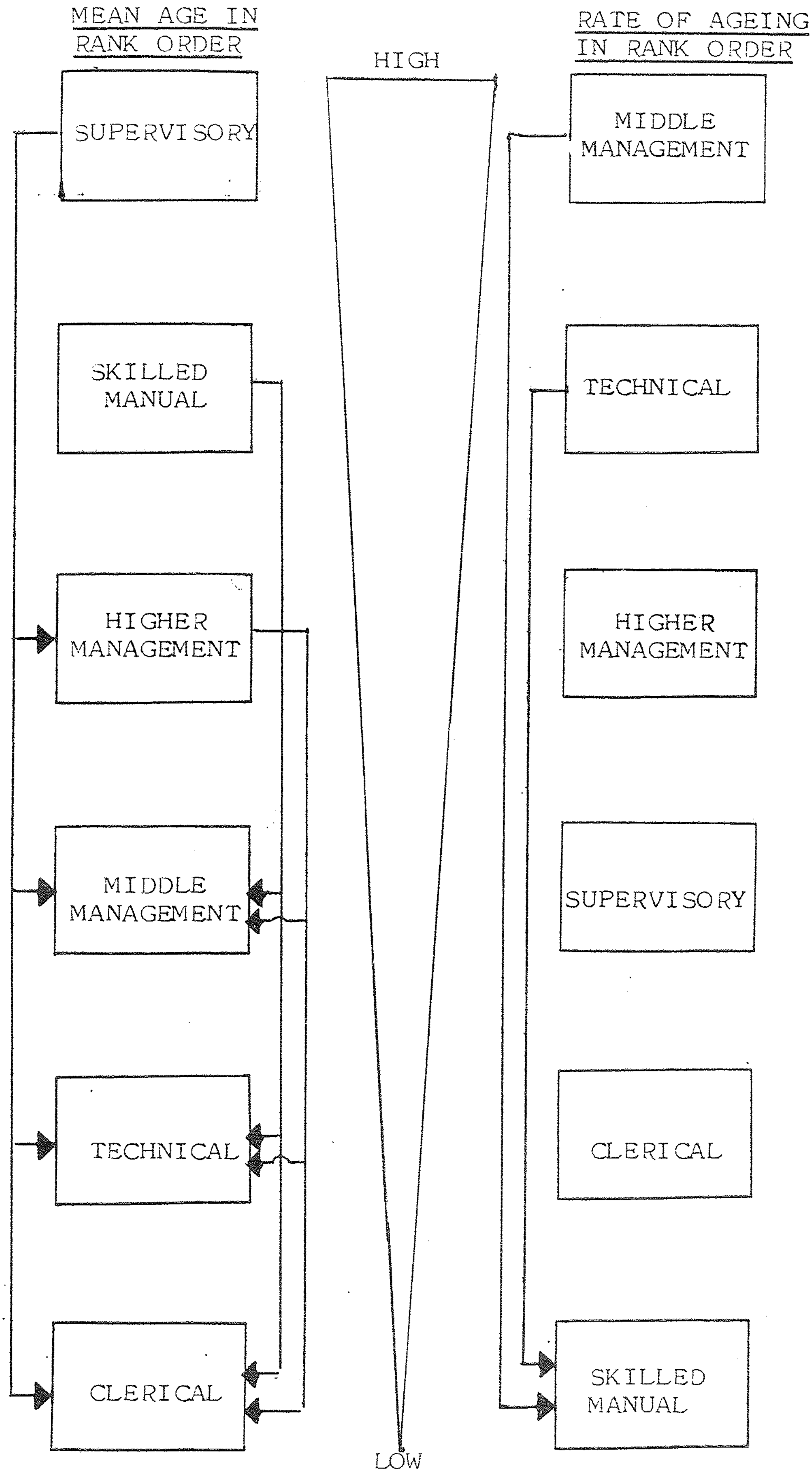
TABLE 3.2: SUMMARISED AGE DATA FROM THE QUASI-LONGITUDINAL STUDY OF SIX OCCUPATIONAL FUNCTIONS AT THE MANUFACTURING PLANT

itudinal change within OA/S structures measured at the organisational level. Consideration can now be given to the second question posed in Section 3.1 i.e. does this change differ between occupational functions?

3.5: DIFFERENTIAL CHANGE BETWEEN OCCUPATIONAL FUNCTIONS

3.5.1: Statistical methodology

Two aspects of the longitudinal age data presented in Table 3.2 shall be compared between occupational functions. These are the mean ages over the sampled time period and the established rates of ageing. Two-tailed correlated t tests are calculated for each of the fifteen comparisons between the six occupational functions. A more conservative alpha level of $p < .01$ is employed due to the large number of comparisons. The sample size is small for most tests in Part Two, but statistical corrections are made. The results of the t tests are included in Appendix 6, and summarised overleaf in Figure 3.14. This shows that there are clear age differences between most of the occupational functions (although comparisons to those functions nearest to each other in age are not always significant). Of more note are the significant differences in the rate of ageing. The two fastest ageing occupational functions are the middle management and the technical functions. The high positive RAI observed for these functions (particularly middle management) suggest that the longitudinal change in these two functions was due to historical factors. Both these functions aged



KEY Arrows denote statistically significant differences

FIGURE 3.14 : SUMMARY OF SIGNIFICANT DIFFERENCES IN MEAN AGE AND RATE OF AGEING BETWEEN OCCUPATIONAL FUNCTIONS

significantly faster than the skilled manual function which actually grew younger. This function appears to have been subject to a particularly strong age-linked change.

3.6: THE LINK BETWEEN THE LEVEL OF MANPOWER MOVEMENTS AND LONGITUDINAL AGE CHANGES

3.6.1: An external cause of change

It is possible that the rates of ageing observed in the occupational functions each year were due to the initial age of the function. The older a function is, the faster it subsequently ages, or vice versa. A glance at Figure 3.13 which presents the six occupational functions in rank order of first mean age, and then rate of ageing, appears not to support this 'internal' cause of longitudinal change. However, the relationship is tested by correlating the mean age of each occupational function with the subsequent RAI. The data are drawn from Table 3.2, and six pairs of cases are correlated for each of the occupational functions. The results are included in Table 'a' of Appendix 7. Not one of the correlations is significant and it is concluded that the rates of ageing observed in the occupational functions, had nothing to do with the initial mean age. The reasons behind the varying longitudinal change were external.

In Section 3.4.3, it was pointed out that any change in the OA/S structures which was not purely historical could only stem from the manpower meovements being age-linked. If the manpower movements are responsible for governing the longitudinal change in the occupational functions, then it should be possible to predict the mean age of each occupational function from the foregoing manpower movements.

3.6.2: Statistical methodology

3.6.2.1: Univariate correlations

The percentage rates of each of the five possible manpower movements were correlated with the resultant mean age for each of the six occupational functions. The results are included in Table 'b' of Appendix 7, and show that there are some significant links between the percentage rates of even a single manpower movement and the resultant age of an occupational function. As the manpower movements occur in a variety of mixes, such links between single manpower movements represent very powerful effects. In the higher management function, higher levels of recruitment were associated with a lower subsequent age ($r=-0.8196$; $Df=5$; $p<.05$). In the middle management function, higher levels of both voluntary turnover ($r=+0.8392$; $Df=5$; $p<.05$), and early retirement ($r=+0.7826$; $Df=5$; $p<.05$) lead to a higher subsequent mean age.

3.6.2.2: Multiple regressions

The previous section has shown that there are significant links between levels of a single manpower movement and subsequent age. It should, therefore, be possible to predict the mean age of an occupational function from a mixture of levels of manpower movements. Multiple regressions are calculated for each of the six occupational functions.

Forward stepwise inclusion of independent variables (levels of up to four manpower movements) was used to yield the optimal prediction equation. Given the small sample size, and a high number of predictive variables in relation to sample size, a series of criteria were incorporated into the methodology:-

1. The statistical strength of effect of the predictive equation is usually given by r^2. However, it is easier to explain more variance (r^2) if many predictor variables are used to estimate a few sample points. Therefore, the effect of the number of predictor variables and sample size need to be used to adjust the explained variance. Accordingly, the strength of effect is adjusted, or 'shrunk', using the formula derived by Thiel (1971):-

$$\text{Adjusted } r^2 = r^2 - \left(\frac{(k-1)(1-r^2)}{(N-k)}\right)$$

where k = number of predictor variables
N = number of cases

2. A statement on the level of significance of the observed result is made. The sample regression equation is usually the best guess made about

the particular rule that applies in the population, but there is no guarantee that the multiple linear predictive relationships in the sample are not a chance result, rather than a true reflection of the population situation. Hays (1963) has established the following equation to test the hypothesis that the true r is zero, using the F sampling distribution:-

$$F = \frac{(\text{Adjusted } r^2)}{(1 - \text{Adjusted } r^2)} \frac{(N-k)}{(k-1)}$$

where N = number of cases
k = number of predictive variables

Degrees of freedom are k-1 (denominator)
N-k (numerator)

The statistical details including the predictive equation, standard error, multiple r, multiple r^2, adjusted r^2, F value with significance and sample size are specified in Appendix 7, and a summary of the results is provided overleaf in Table 3.3. It can be seen that, for three out of the six functions, by knowing the percentage levels of specific manpower movements, the resultant mean age at the end of those manpower movements could be significantly predicted. This suggests that the degree of intervention (as realised through the magnitude of specific manpower movements) is related to the resultant age in the higher management, middle management and technical occupational functions. These are the fastest, third fastest, and slowest (negative) ageing functions respectively. The magnitude of manpower movements is

Occupational Function	Adjusted Strength of Effect, F Value & Level of Significance
HIGHER MANAGEMENT	0.7322 F=10.93 (1,4) p<.05
MIDDLE MANAGEMENT	0.9683 F=20.36 (3,2) p<.05
SKILLED MANUAL	0.7542 F=12.27 (1,4) p<.025
TECHNICAL	0.3602 F= 2.25 (1,4) N.S.
SUPERVISORY	0.9454 F=11.54 (3,2) N.S.
CLERICAL	0.79669 F= 3.92 (3,2) N.S.

KEY Top figure denotes the adjusted strength of effect
Middle figure denotes the F value for the significance of the strength of effect with degrees of freedom shown in brackets
Bottom figure shows the level of significance
N.S. denotes non-significance

TABLE 3.3: RESULTS OF MULTIPLE LINEAR REGRESSIONS USING LEVELS OF MANPOWER MOVEMENT AS PREDICTORS OF RESULTANT MEAN AGE OF OCCUPATIONAL FUNCTIONS

associated with the mean ages found in occupational functions which showed either historical change (the two management functions) or age-linked change (the skilled manual function).

3.7: THE IMPORTANCE OF MANPOWER MOVEMENTS

3.7.1: The study of manpower movements

The study has so far shown that there is longitudinal change within the OA/S structures. This change differs across occupational functions, and has been categorised as either historical or age-linked. The cause of the change has been shown to be external to the OA/S structure and clearly linked to the extent of manpower movements. The levels of manpower movement each year can be used to predict subsequent mean age in those occupational functions which show clear historical or age-linked change. The reasons as to how different levels of certain manpower movements influence the OA/S structure need to be clarified. To do this, a detailed analysis of age and service patterns within manpower movements needs to be undertaken.

3.7.2: The extent of manpower movements

The study has covered each of six occupational functions over six one-year periods. For each of these 36 occupation/time periods, data for age and service has been recorded within five possible manpower movements (see Section 3.3.3) making a total of 180 theoretical occupation/time/manpower movement cells of data. Data for the sex of the individual manpower movers was, unfortunately, not available from the source used, and so cannot be controlled for. All forms of manpower movement were not exhibited in every occupational function every year, and Table 'a' in Appendix 8 shows which cells applied. It can be seen that data existed for 118 of the 180 possible cells. The number of cells and the number of individuals in each of the five types of manpower movement each year (across occupational functions) is summarised in Table 3.4. Data were recorded over the six year period for 4330 individuals. 2297 (53 per cent) moved out of the occupational functions, and 2033 (47 per cent) moved in. Of those who moved out, 780 (34 per cent) did so totally involuntarily (compulsory redundancy) and 1517 (66 per cent) did so with some voluntary control (voluntary turnover, early retirement and voluntary redundancy). This balance of one-third involuntary/two-thirds voluntary was not static. In 1975 and 1976, the proportions were totally reversed. Therefore, the relative importance of the five manpower movements changes over time.

3.7.3: The operationalisation of a measure of age and service manpower movement behaviour

Two independent variables of occupational function and the type of manpower movement are used to isolate differences in the dependent variable of age/service behaviour. This dependent variable has to be operationalised.

MANPOWER MOVEMENT TYPE

YEAR	VOLUNTARY TURNOVER		EARLY RETIREMENT		VOLUNTARY REDUNDANCY		COMPULSORY REDUNDANCY		RECRUITMENT		TOTAL
	Data Sets	Cases	Data Sets	Cases	Data Sets	Cases	Data Sets	Cases	Data Sets	Cases	
1974	6	292	3	46	0		2	7	6	329	17
1975	6	215	3	40	0		6	482	5	159	20
1976	6	98	4	6	0		6	250	5	305	21
1977	6	202	5	15	0		4	7	6	616	21
1978	6	168	4	27	1	38	4	32	5	427	19
1979	6	213	6	157	0		1	2	6	197	19
TOTAL	36	1188	25	291	1	38	23	780	33	2033	

Total No. of Leavers = 2297

Total No. of Joiners = 2033

TABLE 3.4: SUMMARY OF MANPOWER MOVEMENTS BY TYPE AND BY YEAR ACROSS OCCUPATIONAL FUNCTIONS

Within each of 118 data cells, the age and length of company service of individuals was recorded to the nearest whole year. The OA/S structures for each occupational function were established for the years April 1974 to April 1980 by backdating the workforce. The frequency and percentage of individuals who worked were recorded in five-year age and service bands, making a total of 40 possible age/service cells (see Section 2.7.1). Using the same age and service bands, the frequency of individuals making the appropriate type of manpower movement was also recorded. This frequency, however, is not the most appropriate measure of age or service manpower movement behaviour. For example, there may be twenty people aged 20-24 who leave voluntarily, and ten people aged 25-29 who do the same. This does not mean, however, that 20-24 year olds are more likely to leave, since, for example, the twenty 20-24 year olds left from a population of 100 (therefore, 20 per cent of the population left), whilst the 25-29 year olds left from a population of only 40 (therefore 25 per cent of the population left). The measure used, then, is the proportion of workforce making the movement, expressed as a four figure probability. It is, henceforth, called the propensity to move, and is calculated as follows:-

$$\text{Propensity to move} = \frac{\text{Number of movers in sample age/service cell}}{\text{Number of individuals in age/service cell}}$$

This propensity to move was calculated in each of the 118 occupation/year/manpower movement data sets for three different facets:-

1. For each of the 40 age/service cells.
2. Summated across cells for the ten five-year age bands.
3. Summated across cells for the eight five-year service bands.

These three measures of propensity to move were then averaged over the six one-year time periods to provide a single set of data for each occupation/manpower movement group. The propensities for voluntary turnover were always averaged over six years (since voluntary turnover was always possible). The propensities for early retirement, voluntary redundancy, compulsory redundancy and recruitment were all averaged, however, by the number of years in which they existed. It was impossible for anyone to realise any propensity to move in the years in which movement did not exist in that the organisation either did not practice the movement (e.g. redundancy and recruitment), or did not allow or agree to terms for it (e.g. early retirement and voluntary redundancy).

The propensities for each manpower movement are summarised by age and service for each of the six occupational functions. These data are presented in Tables 3.5 to 3.10.

AGE BANDS	SERVICE BANDS	VOLUNTARY TURNOVER		COMPULSORY REDUNDANCY		EARLY RETIREMENT		RECRUITMENT	
		AGE	SERVICE	AGE	SERVICE	AGE	SERVICE	AGE	SERVICE
16-20	1- 5	0.0000	0.1141	0.0000	0.0088	—	0.0000	0.0000	—
21-25	6-10	0.0303	0.0751	0.0000	0.0000	—	0.0556	0.2073	—
26-30	11-15	0.0481	0.0464	0.0159	0.0205	—	0.1050	0.0657	—
31-35	16-20	0.1154	0.0185	0.0000	0.0000	—	0.5000	0.0599	—
36-40	21-25	0.0845	0.0208	0.0000	0.0000	—	0.0000	0.0410	—
41-45	26-30	0.0798	0.0000	0.0000	0.0833	—	0.0000	0.1021	—
46-50	31-35	0.1233	0.0000	0.0000	0.0000	—	0.1333	0.0098	—
51-55	36-40	0.0255	0.0000	0.0375	0.3333	0.0000	0.2222	0.0079	—
56-60	—	0.0000	—	0.1023	—	0.1111	—	0.0000	—
61-65	—	0.0000	—	0.1111	—	0.4722	—	0.0000	—

TABLE 3.5: PROPENSITIES TO MOVE WITH AGE AND SERVICE FOR THE HIGHER MANAGEMENT FUNCTION

AGE BANDS	SERVICE BANDS	VOLUNTARY TURNOVER		COMPULSORY REDUNDANCY		EARLY RETIREMENT		RECRUITMENT	
		AGE	SERVICE	AGE	SERVICE	AGE	SERVICE	AGE	SERVICE
16-20	1- 5	0.0000	0.0741	0.0000	0.0000	—	0.0000	0.0000	—
21-25	6-10	0.0109	0.0373	0.0000	0.0056	—	0.1112	0.0635	—
26-30	11-15	0.0658	0.0085	0.0000	0.0261	—	0.1270	0.0721	—
31-35	16-20	0.0640	0.0048	0.0000	0.0000	—	0.0500	0.0479	—
36-40	21-25	0.0334	0.0000	0.0070	0.0000	—	0.1250	0.0181	—
41-45	26-30	0.0162	0.0000	0.0100	0.0000	—	0.0000	0.0186	—
46-50	31-35	0.0222	0.0000	0.0000	0.5000	—	0.0000	0.0169	—
51-55	36-40	0.0117	0.0000	0.0278	—	0.0405	0.5000	0.0000	—
56-60	—	0.0111	—	0.0500	—	0.0715	—	0.0000	—
61-65	—	0.0000	—	0.1250	—	1.0000	—	0.0000	—

TABLE 3.6: PROPENSITIES TO MOVE WITH AGE AND SERVICE FOR THE MIDDLE MANAGEMENT FUNCTION

AGE BANDS	SERVICE BANDS	VOLUNTARY TURNOVER		COMPULSORY REDUNDANCY		EARLY RETIREMENT		RECRUITMENT	
		AGE	SERVICE	AGE	SERVICE	AGE	SERVICE	AGE	SERVICE
16-20	1- 5	0.0960	0.0630	0.0397	0.0680	—	0.0387	0.5183	—
21-25	6-10	0.0729	0.0136	0.0639	0.0608	—	0.0714	0.2237	—
26-30	11-15	0.0454	0.0053	0.0620	0.0546	—	0.0597	0.1497	—
31-35	16-20	0.0309	0.0049	0.0497	0.1050	—	0.0565	0.0862	—
36-40	21-25	0.0165	0.0098	0.0576	0.1215	—	0.0722	0.0722	—
41-45	26-30	0.0150	0.0118	0.0478	0.1725	—	0.0260	0.0532	—
46-50	31-35	0.0110	0.0000	0.0497	0.0400	—	0.0604	0.0554	—
51-55	36-40	0.0142	0.0000	0.0618	0.5000	0.0042	0.0000	0.0292	—
56-60	—	0.0275	—	0.0870	—	0.0409	—	0.0260	—
61-65	—	0.0112	—	0.1249	—	0.1933	—	0.0036	—

TABLE 3.7: PROPENSITIES TO MOVE WITH AGE AND SERVICE FOR THE SKILLED MANUAL FUNCTION

AGE BANDS	SERVICE BANDS	VOLUNTARY TURNOVER		COMPULSORY REDUNDANCY		VOLUNTARY REDUNDANCY		EARLY RETIREMENT		RECRUITMENT	
		AGE	SERVICE	AGE	SERVICE	AGE	SERVICE	AGE	SERVICE	AGE	SERVICE
16-20	1- 5	0.0000	0.0602	0.0000	0.0132	0.0000	0.1186	—	0.0349	0.0049	—
21-25	6-10	0.0469	0.0170	0.0148	0.0154	0.0854	0.0278	—	0.0470	0.1299	—
26-30	11-15	0.0516	0.0104	0.0104	0.0161	0.1310	0.0090	—	0.0218	0.0874	—
31-35	16-20	0.0368	0.0000	0.0098	0.0000	0.0298	0.0000	—	0.0625	0.0446	—
36-40	21-25	0.0249	0.0000	0.0107	0.0357	0.0135	0.0000	—	0.0000	0.0237	—
41-45	26-30	0.0059	0.0000	0.0125	0.0625	0.0635	0.0000	—	0.0000	0.0300	—
46-50	31-35	0.0227	0.0000	0.0156	0.0000	0.0000	0.0000	—	0.0000	0.0667	—
51-55	36-40	0.0077	0.0000	0.0000	0.0000	0.0513	0.0000	0.0068	1.0000	0.0112	—
56-60	—	0.0289	—	0.0063	—	0.0000	—	0.0064	—	0.0218	—
61-65	—	0.0152	—	0.1674	—	0.0000	—	0.1776	—	0.0208	—

TABLE 3.8: PROPENSITIES TO MOVE WITH AGE AND SERVICE FOR THE TECHNICAL FUNCTION

AGE BANDS	SERVICE BANDS	VOLUNTARY TURNOVER		COMPULSORY REDUNDANCY		EARLY RETIREMENT		RECRUITMENT	
		AGE	SERVICE	AGE	SERVICE	AGE	SERVICE	AGE	SERVICE
16-20	1- 5	0.0000	0.0024	0.0000	0.0127	—	0.0357	0.0000	—
21-25	6-10	0.0160	0.0120	0.0682	0.0298	—	0.0201	0.0000	—
26-30	11-15	0.0094	0.0081	0.0000	0.0719	—	0.0284	0.0000	—
31-35	16-20	0.0028	0.0034	0.0085	0.1000	—	0.0625	0.0000	—
36-40	21-25	0.0103	0.0000	0.0114	0.0919	—	0.0938	0.0185	—
41-45	26-30	0.0041	0.0000	0.0411	0.1250	—	0.0000	0.0000	—
46-50	31-35	0.0074	0.0000	0.0410	0.5000	—	0.1667	0.0137	—
51-55	36-40	0.0027	—	0.0481	0.0000	0.0053	—	0.0000	—
56-60	—	0.0074	—	0.1429	—	0.0283	—	0.0000	—
61-65	—	0.0000	—	0.6458	—	0.2817	—	0.0000	—

TABLE 3.9: PROPENSITIES TO MOVE WITH AGE AND SERVICE FOR THE SUPERVISORY FUNCTION

AGE BANDS	SERVICE BANDS	VOLUNTARY TURNOVER		COMPULSORY REDUNDANCY		EARLY RETIREMENT		RECRUITMENT	
		AGE	SERVICE	AGE	SERVICE	AGE	SERVICE	AGE	SERVICE
16-20	1- 5	0.1473	0.1291	0.0185	0.0208	—	0.0523	0.3524	—
21-25	6-10	0.1709	0.0397	0.0165	0.0336	—	0.0551	0.1631	—
26-30	11-15	0.1933	0.0375	0.0438	0.0504	—	0.0777	0.1465	—
31-35	16-20	0.0836	0.0150	0.0167	0.0057	—	0.1185	0.1493	—
36-40	21-25	0.0455	0.0417	0.0168	0.0000	—	0.2175	0.0958	—
41-45	26-30	0.0281	0.0000	0.0213	0.2500	—	0.0625	0.0916	—
46-50	31-35	0.0236	0.0000	0.0252	0.0000	—	0.2500	0.0716	—
51-55	36-40	0.0275	—	0.0213	—	0.0094	—	0.0508	—
56-60	—	0.0201	—	0.0387	—	0.0490	—	0.0517	—
61-65	—	0.0224	—	0.0748	—	0.2067	—	0.0120	—

TABLE 3.10: 'PROPENSITIES TO MOVE WITH AGE AND SERVICE FOR THE CLERICAL FUNCTION

3.8: AGE AND SERVICE BEHAVIOUR PATTERNS

3.8.1: Statistical methodology

The analysis of age and service differences in the propensities to move detailed in Tables 3.5 to 3.10, is correlational in nature. There are two fundamental methodologies:-

1. Two-tailed Pearson Product Moment Correlation Coefficients were calculated using the median age within each of the ten age bands as the independent variable, and the various propensities to move (in each appropriate occupation/manpower movement group) as the dependent variable. This entailed the calculation of 25 correlations and so a more conservative alpha level of $p < .01$ was employed. The results are detailed in Table 3.11 overleaf.

   A similar analysis was conducted using service bands as the independent variable. Nineteen correlations were calculated and the results are included in Table 3.12.

2. Correlations may be compared to each other to see if they are significantly different. This is done by converting the correlations to z scores (Rolhf & Sokal, 1969; Table M, p. 143). The significance of the difference between the z scores is tested using the normal distribution.

	HIGHER MANAGEMENT	MIDDLE MANAGEMENT	SKILLED MANUAL	TECHNICAL	SUPERVISORY	CLERICAL	AVERAGE z SCORE
VOLUNTARY TURNOVER	-0.1185 Df=9 N.S. -0.1186	-0.3162 Df=9 N.S. -0.3272	-0.8033 Df=9 p <.01 -1.1070	-0.2848 Df=9 N.S. -0.2931	-0.3120 Df=9 N.S. -0.3228	-0.8589 Df=9 p <.01 -1.2895	-0.5765
COMPULSORY REDUNDANCY	0.7623 Df=9 p <.01 1.0010	0.7466 Df=9 p <.01 0.9661	0.6782 Df=9 N.S. 0.8254	0.5148 Df=9 N.S. 0.5695	0.6267 Df=9 N.S. 0.7365	0.5722 Df=9 N.S. 0.6505	+0.7915
EARLY RETIREMENT	0.9563 Df=2 N.S. 1.8972	0.8799 Df=2 N.S. 1.3758	0.9429 Df=2 N.S. 1.7645	0.8650 Df=2 N.S. 1.3129	0.9011 Df=2 N.S. 1.4775	0.9052 Df=2 N.S. 1.8318	+1.6100
RECRUITMENT	-0.1218 Df=9 N.S. -0.1226	-0.5964 Df=9 N.S. -0.6869	-0.8028 Df=9 p <.01 -1.1070	-0.3511 Df=9 N.S. -0.3666	0.0723 Df=9 N.S. 0.0721	-0.8750 Df=9 p <.01 -1.3540	-0.5942
VOLUNTARY REDUNDANCY	—	—	—	-0.4230 Df=9 N.S. -0.4513	—	—	-0.4513
AVERAGE z SCORE	+0.6642	+0.3320	+0.0940	+0.3057	+0.4908	-0.0403	

TABLE 3.11: PEARSON-PRODUCT MOMENT CORRELATION COEFFICIENTS BETWEEN PROPENSITIES TO MOVE AND AGE

	HIGHER MANAGEMENT	MIDDLE MANAGEMENT	SKILLED MANUAL	TECHNICAL	SUPERVISORY	CLERICAL	AVERAGE z SCORE
VOLUNTARY TURNOVER	-0.9180 Df=7 p<.01 -1.5762	-0.7998 Df=7 p<.01 -1.0986	-0.3480 Df=7 N.S. -0.3632	-0.7496 Df=7 N.S. -0.9730	-0.6484 Df=6 N.S. -0.7736	-0.8070 Df=6 N.S. -1.1184	-0.9838
COMPULSORY REDUNDANCY	0.6201 Df=7 N.S. 0.7266	0.6027 Df=6 N.S. 0.6978	0.6327 Df=7 N.S. 0.7464	0.0074 Df=7 N.S. 0.0070	0.7748 Df=6 N.S. 1.0327	0.2758 Df=6 N.S. 0.2833	+0.5820
EARLY RETIREMENT	0.1937 Df=7 N.S. 0.1965	0.4640 Df=7 N.S. 0.5024	-0.4800 Df=7 N.S. -0.5230	0.5388 Df=7 N.S. 0.6027	0.5690 Df=6 N.S. 0.6460	0.7079 Df=6 N.S. 0.8832	+0.3846
VOLUNTARY REDUNDANCY	—	—	—	-0.7045 Df=7 N.S. -0.8772	—	—	-0.8772
AVERAGE z SCORE	-0.2182	+0.0339	-0.0466	-0.1211	+0.3017	+0.0160	

TABLE 3.12: PEARSON-PRODUCT MOMENT CORRELATION COEFFICIENTS BETWEEN PROPENSITIES TO MOVE AND SERVICE

The calculated z difference is established as follows (Yeomans, 1968):-

$$z \text{ (difference)} = \frac{z_1 - z_2}{\sqrt{\left(\frac{1}{(n_1-3)}\right) + \left(\frac{1}{(n_2-3)}\right)}}$$

where z_1 = z score for first correlation
z_2 = z score for second correlation
n_1 = number of cases in first correlation
n_2 = number of cases in second correlation

The results of this significance testing between the correlations shown in Tables 3.11 and 3.12 are included in Appendix 9.

3.8.2: Voluntary turnover

Age is significantly negatively correlated with the propensity to leave voluntarily in the clerical function ($r=-0.8589$; $Df=9$; $p<.01$) and the skilled manual function ($r=-0.8033$; $Df=9$; $p<.01$). Older individuals in these occupations are significantly less likely to leave voluntarily. This is not the case in the other four functions. In higher management, there is virtually no relation between age and the propensity to leave voluntarily, and this is significantly different from the high negative relationship found in the clerical function ($z=2.98$; $p<.01$). It is interesting that the two functions in which age is related to voluntary turnover behaviour are those two functions which showed the lowest RAI's (and consequently are hypothesised as having the highest extent of age-linked change).

Service is not linked to voluntary turnover in these two slowest ageing functions. Rather, service is significantly negatively linked to propensity to leave voluntarily in the higher management function ($r=-0.9180$; $Df=7$; $p<.01$) and middle management function ($r=-0.7998$; $Df=7$; $p<.01$). This negative link between service and propensity to leave voluntarily in higher management is significantly different from the zero relationship seen in the skilled manual function ($z=2.84$; $p<.01$).

In summary, then, age is negatively linked to the propensity to leave voluntarily in those occupational functions which show a high degree of age-linked change. Conversely, service is negatively linked to the propensity to leave voluntarily in those functions which show a high degree of historical change.

3.8.3: Compulsory redundancy

There is a significant positive relationship between age and the propensity to be made redundant in the higher management function ($r=+0.7623$; $Df=9$; $p<.01$) and the middle management function ($r=+0.7466$; $Df=9$; $p<.01$). Although age is not associated with an increased likelihood of redundancy in the other functions, the correlations are not significantly different.

Length of service is not significantly related to the likelihood of being made redundant in any of the six occupational functions.

In summary, two of the functions which show high levels of historical ageing not only exhibit a negative relationship between service and voluntary turnover, but also a positive relationship between age and redundancy.

3.8.4: Early retirement

Because only the three upper age bands are associated with early retirement, the age correlations are based upon only three pairs of observations. The correlation values do not reach significance as a consequence, although the overall link between age and early retirement is obvious.

Service is not significantly related to early retirement in any of the six occupational functions, although a high positive correlation ($r=+0.7079$; $Df=6$; $p<.05$) is found in the clerical function, and a negative correlation ($r=-0.4800$; $Df=7$; N.S.) in the skilled manual function. This negative correlation found in the skilled manual function is significantly different from the high positive correlations found in the clerical function ($z=3.22$; $p<.01$), supervisory function ($z=2.68$; $p<.01$) and technical function ($z=2.64$; $p<.01$).

3.8.5: Recruitment

Age is negatively linked to the propensity to be recruited in the clerical function ($r=-0.8750$; $Df=9$; $p<.01$) and in the skilled manual function ($r=-0.8028$; $Df=9$; $p<.01$). Age, then, is a clear handicap when jobs in skilled manual work or clerical work are offered.

Higher management and supervisory functions show a total lack of any relationship between age and recruitment, and this is significantly different from the negative link in the skilled manual and clerical functions.

3.9: SUMMARY OF THE LINK BETWEEN AGE AND SERVICE BEHAVIOUR PATTERNS AND RATES OF AGEING

In the previous section, the relationships between age and service, and propensities to move were detailed. These data represent age and service behaviour patterns, in that the likelihood of being made redundant or of leaving voluntarily, for example, are both significantly related to age, but in different directions.

The correlations across occupational functions are converted into z scores and then averaged (see Tables 3.11 and 3.12). The average z scores show that, in general, higher age is associated with a lower likelihood of leaving voluntarily, taking voluntary redundancy, or being recruited. Conversely, higher age is associated with a higher likelihood of being made redundant, or taking early retirement. The service relationships are all in the same direction.

The nature of these age and service behaviour patterns did, however, differ across occupational functions, and the tendency was noted for these differences to group around those occupations which had shown either historical or age-linked change. Those occupational functions which showed a high rate of ageing, which was diagnosed as being historical in nature, were characterised by a positive link between age and redundancy; a negative link between service and voluntary turnover; and no relationship between age and voluntary turnover.

Occupational functions which were diagnosed as showing age-linked change, characteristically showed a negative link between age and both voluntary turnover and recruitment. In other words, older individuals were less likely to leave work voluntarily. This, perhaps, was linked to the fact that they were also less likely to be recruited into the same sort of work.

3.10: CONCLUSIONS TO THE LONGITUDINAL STUDY OF CHANGE IN OCCUPATIONAL AGE/SERVICE STRUCTURES

The analyses conducted in this chapter have provided the following conclusions and findings:-

1. A quasi-longitudinal study of change in occupational age/service structures showed that OA/S structures (such as those studied in Chapter Two) are not all static over time. The age structures change.

2. Previous research (Smith, 1973) has categorised such longitudinal change in age structures as being either historical or age-linked in nature. A detailed analysis of change showed that most OA/S structures are subject to both these types of change. Specific features within the structure generally, are associated with one of the two types of change.

3. However, the result of this mixture of change in OA/S structures can still generally be categorised as being either historical or age-linked. The metric used to distinguish between the two types of change is the RAI. This metric significantly differed across occupations. Historical change was noted in the middle and higher management functions, and age-linked change was noted in the skilled manual, clerical and supervisory functions.

4. The observed rates of ageing seen in the occupational functions were shown not to bear any relationship to the initial OA/S structure. The cause of change was external, and hypothesised as being due to age-linked manpower movements into and out of the occupational functions.

5. Multiple regressions significantly predicted the rate of ageing from the magnitude of these

manpower movements in those occupational functions which had shown extremely high or low rates of ageing. For such relationships to occur, it was hypothesised that there must be a link between age and service, and the likelihood of making the manpower movements.

6. A measure based on the probability of making a manpower movement was operationalised. Significant relationships were indeed found between age and service, and the measures of propensity to move. These findings generally support those discussed in Chapter One in that increased age is associated with a lowered likelihood of leaving voluntarily, taking voluntary redundancy or being recruited. Increased age is, however, positively associated with being made redundant or taking early retirement.

7. The sets of probabilities of making manpower movements by age and service constitute discrete age/service behaviour patterns. However, these age/service behaviour patterns differ across occupational functions. These differences tended to group around the two categories of change i.e. historical and age-linked. Historical change tended to be associated with occupations in which high age meant a higher likelihood of being made redundant, but was not

related to voluntary turnover. Those most likely to leave voluntarily had low service.

8. Age-linked change tended to be associated with occupations in which high age was associated with less chance of being recruited, and so less chance of leaving voluntarily.

P A R T   T W O

FUTURE OCCUPATIONAL AGE/SERVICE STRUCTURES AND A COMPUTER AGEING SIMULATION TECHNIQUE

CHAPTER FOUR

THE DEVELOPMENT OF A COMPUTER AGEING SIMULATION TECHNIQUE

4.1: THE NEED TO MODEL FUTURE LONGITUDINAL CHANGE IN OCCUPATIONAL FUNCTIONS

Sonnenfeld (1978) has drawn attention to the increasing awareness of the composite effects of demographic trends, improvements in life expectancy and changes in social legislation within organisations. Such an awareness is being used to anticipate changes in matters such as employee performance and attitudes, performance appraisals, retirement incentives, training programmes and blocked career paths, but, as Sonnenfeld (1978) pointed out, one of the major problems facing organisations is not just knowing that there will be a "fire", but knowing "where to send the fire-engines".

The research in Part One of this thesis has established the occupational age/service structures within an organisation. These occupations were studied over time so that those which were ageing rapidly, or showed an age-linked change, were diagnosed. Some of the major mechanisms which underlay the historical longitudinal change were revealed by a sophisticated methodology which controlled for different types of manpower movement. It was shown that many occupational age/service structures were not subjected to either pure historical change, (Smith's (1973) Hypothesis H), or to pure age-linked change (Hypothesis A). Rather, these two types of longitudinal change could be seen to apply to specific features within the OA/S structures. The discrete change, according to Hypothesis H or A observed within national age structures, is, in fact, a summation of differential change within age/service structures at the organisational level. At present, an OA/S structure may show historical change, suggesting that there is no age-performance link within the occupation. However, careful analysis might have shown that, whilst overall, the OA/S structure changed historically, specific (older) features within the OA/S structure were, in fact, subject to age-linked change. In such a case, it is argued that, at some future date, the longitudinal change associated with this (hypothetical) occupation would cease to be historical, and would become age-linked. In other words, before occupational age/service structures may be used to evaluate performance and other personnel implications (when measured at the organisational level), then the complete pattern of longitudinal change of the OA/S structure needs to be considered. Clearly, a short six-year observation is insufficient for this purpose, and so future change needs to be simulated. In this sense, not only could occupational psychologists know "where to send the fire-engines" (Sonnenfeld, 1978), but they could also learn to know "when" such action might be necessary.

The aim of this second part of the research is to develop a methodology which will validly and reliably project occupational age/service structures over time, drawing upon, and using to the full, the findings and conclusions already established in Part One. Before this methodology is developed, some of the underlying principles of manpower and human resource planning are discussed.

4.2: AN OUTLINE OF SOME THEORETICAL ISSUES WITHIN MANPOWER AND HUMAN RESOURCE PLANNING

4.2.1: Incidence and extent of manpower planning

There is no clearly defined practice of manpower planning, and, as a consequence, many different approaches are used. Thakur (1975) has defined manpower planning as consisting of four distinct processes:-

1. Taking stock of existing manpower.
2. Determining demand for manpower in the future.
3. Forecasting supply of manpower for the future from internal and/or external sources.
4. Deciding appropriate actions to ensure that manpower resources match future needs.

Thakur's (1975) research, carried out under the auspices of the Institute of Personnel Management, involved a national survey of companies (equal spread of workforce size, ranging from under 2000 to over 20000, and equal spread of geographical location of central operations across the U.K.). The database response rate was 60.4 per cent with 308 participating companies.

Differences were found in the extent to which the above four approaches to manpower planning were employed as well as the purpose for which manpower planning was used.

Most organisations use manpower planning to take stock of their manpower (87.98 per cent), and considerably fewer organisations practise manpower planning which will allow for actions to match future needs (76.62 per cent). Manpower planning is used for a variety of purposes. These are listed below:-

To determine recruitment needs	71.4%
To assess training and development needs	67.9%
To anticipate/avoid redundancies	47.7%
To assist career planning	44.8%
To monitor manpower costs	41.2%
To forecast changes in terms of skills	33.4%
To monitor imbalanced age distribution	33.4%
To help industrial relations negotiations	29.2%

Thakur (1975) argued that the responses illustrated some of the common difficulties experienced in manpower planning, namely:-

1. The process of taking stock of manpower is often understood to be confined to a perusal of personnel records and monthly salary print-outs. Whilst this may give some valuable information to gauge the present stock, it does not indicate manpower movement within and across various skill levels.
2. The comparison of responses showing a determination of demand of manpower with those of forecasting supply, shows a significant difference (82.79 per cent to 64.28 per cent respectively). This is not surprising as forecasting supply is the most difficult of the

two, for it needs a close examination of both micro- and macro-environmental factors.

3. Only 33 per cent of companies use manpower planning to monitor imbalances in their age distribution. The use of manpower planning techniques to model the supply of individuals into and out of future occupational age/service structures is, therefore, likely to be a relatively untried methodology.

4.2.2: The need to represent the decisions made by the organisation and the individual

The planning of human resources associated with observed and expected OA/S structures within a series of representative work functions must be considered as macro-level planning. Heyel (1980) points out that this type of approach is essential to sound thinking about long range staffing needs and policies, and must incorporate the attitudinal and behavioural patterns associated with the resources in question, i.e. those which relate to age and length of service.

The actual technique used to project the changing shape of the human resources within the organisation, must centrally operate around, and account for, what Heyel (1980) refers to as:-

1. The formal and informal decisions by private individuals.
2. The formal and informal decisions by the organisation.

Any examination, or simulation of the problems associated with this type of organisation-individual interaction inevitably incorporates problems inherited from the past. Many such problems experienced by organisations who are faced with managing change both in the present and in the future, have their origins outside the organisation. Evans (1979) highlighted those aspects of the economic environment which have had a direct influence on issues and problems faced by organisations concerned with the management of work.

The major aspects which bear an influence are:-

1. the level of full employment;
2. economic difficulties or success of the nation which may be represented via a series of indices such as a factored score for national wealth and GDP growth rate;
3. unemployment levels and trends;
4. inflation and interest rates.

There is a series of channels through which these aspects of the environment affect the company. The trading climate and market-demand for new products are major channels, as is governmental intervention in finance control and legislation relating to manpower. However, there is another major consideration which is often neglected. Evans (1979) has emphasised the importance of the social and work attitudes of employees, and the manner in which social and educational changes associated with the economic climate influence the expectations of employees. The raising or lowering of an individual's expectations in this manner, must influence the formal and informal decisions he makes.

4.2.3: Markov chains and manpower models

There are several books on manpower models in the literature (e.g. Bartholomew, 1973; Bartholomew & Forbes, 1979; Bryant and Niehaus, 1978; Clough, Lewis & Oliver, 1974; Grinold & Marshall, 1977; Smith, 1970). Many of the models discussed are based on a Markov chain model for the behaviour of employees. Individuals may be classified along a series of dimensions. Then, based upon previously established behaviour, the probability of individuals within each class (or conditional upon membership within a series of classes) is derived, and exactly this proportion of individuals is allowed to 'behave' in the measured manner. Verhoeven (1981) developed a model which used such a Markov chain where age was one of the classifications used. For the present research, manpower movement behaviour has been established which is conditional upon:-

1. age
2. length of service
3. occupational function
4. type of manpower movement.

The data already gathered and analysed in the previous chapter may be used to develop the conditional probabilities characteristic of a Markov chain. These conditional probabilities will then be placed within a framework of organisational and individual decisions. To this framework for applying Markov chains to manpower movements, will be added estimates of the supply and demand for manpower. All these elements will consitute a manpower model which will be able to simulate future OA/S structures.

4.3: SIMULATION OF AGEING WITHIN OCCUPATIONAL FUNCTIONS

4.3.1: Manpower movements and their representation of organisational and individual decisions

The theoretical discussion in the previous section has shown that the central aim of any manpower model must be to represent the decisions made by both organisations and individuals in some measurable manner. This concept of organisation-individual interaction is central, not only to the literature on manpower planning, but also on organisational behaviour (e.g. Porter, Lawler & Hackman, 1975; Schein, 1978). In order, therefore, to accommodate this need for a central measurement of organisation-individual decisions, the most appropriate form of behaviour must be chosen.

The previous chapter has shown that the level of manpower movements, and the internal age/service behaviour patterns associated with these movements, are both predictive of longitudinal change within OA/S structures. Furthermore, these two 'variables' can be shown to represent organisational and individual decisions, therefore forming a valid base around which a manpower model may be built. Control over the decisions relating to manpower movements can be one of three types:-

1. A totally individual decision over which there is no organisational control.
2. An interaction of joint decisions where control is negotiable between the individual and the organisation.
3. A totally organisational decision over which the individual has no control.

The outcome of such decisions (independent of who makes them) exerts an influence on the OA/S structures and causes two things to vary:-

1. the actual numbers or level of people who make, or are 'moved' by the decision;
2. the mixture of ages and length of service (or 'age pattern') that is associated with those who do move.

Table 4.1 overleaf summarises the control of this interaction between organisational and individual decisions in relation to the two ways in which the five possible outcomes of manpower movement may vary.

Type of Manpower Movement	Numbers who make decision	Age Pattern associated with decision
Voluntary Turnover	I	I
Early Retirement	O/I+	O/I+
Voluntary Redundancy	O+/I	O+/I
Involuntary Turnover	O	O
Recruitment	O	O

Where I = Total individual control

O/I+ = Negotiable organisation/individual decision where control resides more with the individual

O+/I = Negotiable organisation/individual decision where control resides more with the organisation

O = Total organisational control

Mandatory Retirement is an option where the decision resides neither in the control of the individual, nor in the organisation, but is made externally

TABLE 4.1: CONTROL OF TWO ASPECTS OF MANPOWER MOVEMENT AS A FUNCTION OF ORGANISATION VERSUS INDIVIDUAL DECISION

4.3.2: The measurement of organisation/individual decisions

Historical data for the seven work functions have been gathered over a six-year period for the years 1974-1979. The levels of attrition and recuitment for each workforce over this period were presented in the form of Markov chains in Chapter Three, and the individual-organisational decisions were calculated as follows.

Data were collected for every individual who ever left or entered the site over this six-year period. For each year's 'movement', all individuals were classified by occupational function. Once the individuals had been placed within the appropriate occupational function, they were classified into the five possible manpower movements. Each of these sub-groups of movers can be seen as a 'decisional group' under either individual or organisational control as specified in Table 4.1. Individuals can be aged anything from 16 to 65(+) years (J=1, 50 years), and their length of service can be anything from 0 to 40(+) years (I=1, 40 years). This allows the establishment of a 2000 cell matrix of all individuals in the sub-group. The probability (n) that any individual of age (J) and length of service (I) decided to move within each particular 'decisional group' is then calculated. The age/service behaviour patterns established as a result of this were presented in the previous chapter. Thirty-five conditional probability matrices were established which represent the average decisions made by both individuals and the organisation. The probability depends upon:-

1. the occupational function
2. the type of manpower movement decision invoked
3. the age of the employee
4. the length of service of the employee.

The collection of these data involved the calculation of 280980 'probabilities of decision'. Due to the complexity and magnitude of the operation, a computer simulation is established.

4.3.3: The hierarchy of personnel operations as simulated by the computer model (C.A.S.T.)

All aspects of manpower movement which affect the organisation's age/service structure have been placed under the relative control of organisational or individual decision (see Table 4.1), and these decisions have been operationalised as 35 'decisional groups' which consist of 2000 conditional probabilities each dependent upon the occupational function, type of manpower movement, age, and service of the employee (see Section 4.3.2). These data have to be applied to each of the occupational functions so that personnel operations within the organisation are simulated year by year, and the subsequent age/service structures revealed.

On the basis of extensive discussions within the Personnel Department, it was discovered that the decisions made operate within a hierarchy. For each of the occupational functions, a target is set for the numbers required the following year. This target planning is usually only short-term (on average two years), and given the aim of projecting over an eleven-year period, future targets will need to be predicted. Once this target has been set, the organisation has to take account of the anticipated voluntary turnover and mandatory retirement, before it is able to operate any control over the manpower movements. The hierarchy applied is illustrated in Figure 4.1 overleaf and is now described in terms of the computer simulation.

The program reads in every individual from the occupational function to be projected, and checks their age, length of service, and sex. Mandatory retirement is imposed and all males aged over 65 and females aged over 60 are withdrawn from the labour pool. A series of manpower movement policies are then operated in hierarchical order. The first one (which is always operated) is voluntary turnover. The anticipated level of turnover (which is statistically predicted) is used to calculate the required number of individuals to fulfil the quota. The decision as to whether a specific individual should be withdrawn is made as follows. The age and length of service of the individual is read, and the appropriate 'decisional group' of probabilities called up from the databank. The probability that any individual:-

1. within that occupational function
2. of that age
3. with that length of service
4. will conditionally leave voluntarily

is then extracted. Let us say, for example, that this probability is 0.0700. This means that, over the past six years, roughly seven out of every hundred such individuals made that decision. A random probability is generated and compared to this expected probability of leaving. If the generated probability is smaller, then

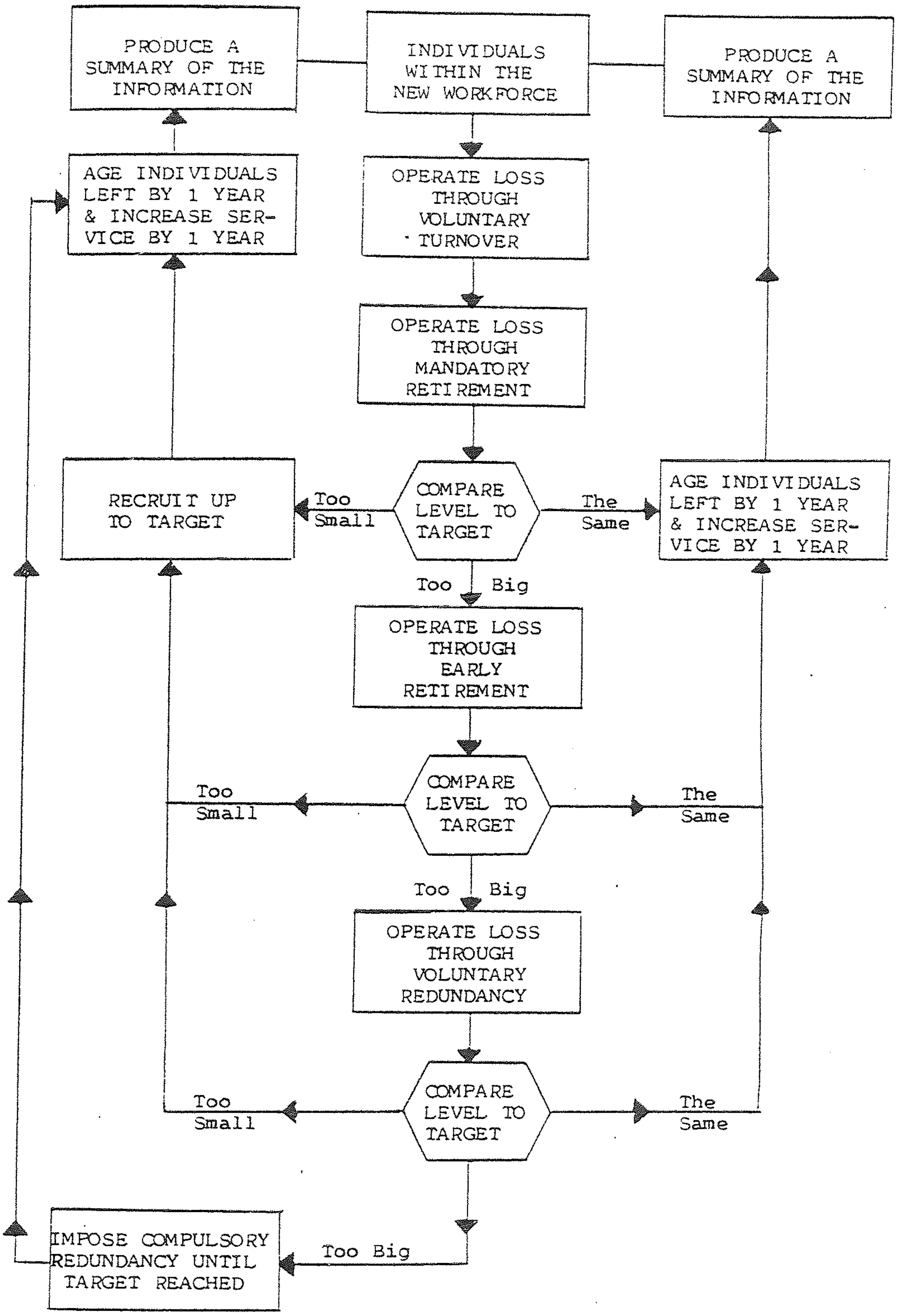


FIGURE 4.1: ALGORITHM TO ILLUSTRATE THE HIERARCHY OF PERSONNEL DECISIONS OPERATED BY THE COMPUTER AGEING SIMULATION TECHNIQUE (C.A.S.T.)

that individual will be withdrawn. If, however, it is larger, then he stays. In this manner, all the individuals who are withdrawn from the labour pool exactly simulate the age/service pattern previously exhibited. The program will continue to withdraw individuals according to this behaviour pattern, until the quota of predicted leavers has been fulfilled.

The decision as to which policy option is needed next to control the manpower movements is made on the basis of the number of individuals left in the labour pool. If, after loss through mandatory retirement and voluntary turnover, the number in the labour pool has fallen below the required target, then the program moves into the recruitment function. This operates in the following manner. The number of individuals required is calculated, and the program recruits exactly this number of people. Their length of service is automatically set at zero years. The databank includes the probability that any recruit into the occupational function will be male. Let us say that this has been, on average, 0.7500 over the last six years. A random probability is again generated, and if it is smaller than this expected event, then the recruit is male. Conversely, if it is larger, then the recruit will be female. This ensures that the sex distribution of all recruits simulates the expected sex distribution. Finally, the computer has to decide what age to assign to the recruit. The databank contains a series of probabilities which describe the average age profile of all recruits to that occupational function over the last six years. Another random probability is generated, and the age associated with that probability is assigned to the recruit. By using this technique, whenever the recruitment function is brought into operation, it will create the correct number of recruits needed to reach the target workforce, and these new recruits will be distributed according to the expected age pattern and sex pattern. Unfortunately, it proved impossible to simulate the interaction between sex and age as sex was not able to be recorded as one of the variables in the manpower movement data.

The other eventuality, however, is that the numbers left within the labour pool after mandatory retirement and voluntary turnover are still too high. If this is the case, then the first policy the organisation encourages within the hierarchy is early retirement. The computer enters the remaining individuals into the early retirement function, which operates in an identical manner to the description given of the voluntary turnover function. The overall anticipated level of loss is predicted, the number required to be withdrawn calculated, and the decisions as to who actually leaves made by comparing a randomly-generated probability to the expected one which is dependent upon their age and service. Once more, the decision on the next required policy after early retirement is based upon the numbers still left. At all these decision points (highlighted in Figure 4.1), the program either brings in recruitment, or continues to move down the hierarchy of policies used to reduce numbers. After early retirement, voluntary redundancy may be imposed. If numbers are still too high, the final option left is compulsory redundancy. Each of these attrition policies operates in the same way, i.e. simulating the differential age/service patterns associated with them.

The end result of this simulation of varying personnel policies is a pool of individuals who represent the following year's workforce. All these individuals have their age and service increased by one year. This having been done, they are ready to be projected for the next year.

A computer program was written in Fortran. One year was spent developing the program so that it followed the algorithm detailed in Figure 4.1. For each year which is projected, a record is made of:

1. the sequence of personnel policies which were required;
2. the practised levels of turnover and the individuals involved;
3. the occupational age/service structure of the projected workforce, which is then graphically drawn using a GINO package;
4. the projected workforce, including details of

each individual's age, service and sex.

An early version of the Fortran program, along with an example run are included in Appendix 10.

The next section describes the methodology employed to predict the target size of workforce for each occupational function, and the anticipated levels of attrition for the relevant manpower movements.

4.4: THE USE OF ECONOMIC/SOCIAL INDICES TO PREDICT THE DEMAND AND SUPPLY PARAMETERS

4.4.1: The development of a battery of economic/social indices to measure the organisational climate

The theory discussed in Section 4.2 showed that many problems experienced by organisations exert an influence on the decisions they have to make concerning manpower movements. Evans (1979) highlighted levels of employment and unemployment, growth rates and levels of wealth, inflation and interest rates, as all having a direct influence. Social and work attitudes are also important.

In order to predict the target size of workforce, and appropriate levels of manpower movement, a battery of indices was developed. Social and work attitudes are represented by introducing time lags into the economic indices, such that next year's anticipated level of unemployment might be expected to influence an individual's decision to move, etc. As there is a need to project economic indices so that the relationship between the shape of the economy, attrition levels and workforce sizes may be statistically determined. The indices chosen have to fulfil the following criteria:-

1. As a group, they must cover the most important aspects of the economic/social climate in which both the organisation and individuals make their decisions.
2. The indices chosen must be ones about which there are reliable forecasts which can be projected into the future along defensible premises.

Fifteen indices were included in the battery, and these are listed below:-

1. An indexed score for the Gross Domestic Product (1972 = 100) to represent national wealth.
2. An indexed score for the level of employment in manufacturing industry (1975 = 100), to take account of the national employment levels in plants similar to the Manufacturing Plant which is being simulated.
3. The unemployment rate for the year in question.
4. Unadjusted numbers for U.K. unemployment.
5. GDP rate for the year in question.
6. GDP rate for the previous year (to allow for a one year lag in the effects of national wealth

creation or diminishment).

7. GDP rate for two years prior to the year in question (to allow for a two-year lag).
8. GDP rate for one year hence (used to represent a measure of apprehension or optimism about the direction of the economy).
9. Level of company profits in the U.K. for the year in question.
10. Level of company profits in the U.K. for the preceding year.
11. Inflation rate for the year in question.
12. Level of company profits in the U.K. for the forthcoming year.
13. Inflation rate for the forthcoming year.
14. Numbers of unemployed in the U.K. for the forthcoming year.
15. Unit labour cost indexed at 1977 = 100.

Data need to be established for the years 1974 to 1980 so that they can be used to establish relationships with the existing manpower movement data over this period. There is also a need to establish data for the years 1981 to 1991 so that they may be used to make predictions for subsequent manpower movement data. The data were collected during the summer months of 1980, and reflect the economic outlook for this period.

The relevant data for the predicted economic indices are included in Table 4.2. Predictions are taken from a series of sources including economic projections from the Treasury, the London Business School, Cambridge Economic Policy Unit and the National Institute of Economic and Social Research.

The picture is one of a sharp increase in unemployment, with levels remaining high, and beginning a slow trend upwards. The figures given for unemployment were derived by Leicester (1977), and assumed a 2 per cent growth rate. Before this level of growth is reached again, Britain will have emerged from the present recession, and this is not expected until 1982. Inflation is projected to move down into single figures by 1983 and to remain around that level throughout the eighties. There will also be an immediate very sharp drop of employment within the manufacturing industries, which will recover slightly in 1982, and then continue to decline persistently following a long-term trend.

Predictions are always extremely hazardous, and the whole scenario may be abruptly changed due to sudden world events such as the oil shock experienced in 1974, or wars, or major changes in the political system, and so on. Although the indices until 1982 are fairly valid, and not likely to be too disparate from actual events, indices projected beyond this point must, of course, be subject to considerable limitations.

YEAR	INDICES 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1974	105.3	104.7	2.7	614.9	-1.6	7.0	2.4	-0.9	7500	-	14.0	8750	22.0	977.6	57.36
1975	104.4	100.0	4.8	977.6	-0.9	-1.6	7.0	3.1	8750	7500	22.0	10833	23.0	1358.8	62.44
1976	107.6	96.9	5.7	1358.8	3.1	-0.9	-1.6	2.0	10833	8750	23.0	13750	16.0	1483.6	75.63
1977	109.7	97.2	6.2	1483.6	2.0	3.1	-0.9	2.6	13750	10833	16.0	15833	11.0	1475.0	100.00
1978	112.6	96.5	6.1	1475.0	2.6	2.0	3.1	2.1	15833	13750	11.0	15000	12.2	1400.8	114.00
1979	115.0	95.2	5.7	1400.8	2.1	2.6	2.0	-2.9	15000	15833	12.2	4167	15.6	1850.0	160.00
1980	112.6	89.9	6.8	1850.0	-2.9	2.1	2.6	-1.2	4167	15000	15.6	2500	10.6	2438.0	179.00
1981	111.2	83.8	10.2	2438.0	-1.2	-2.9	2.1	2.6	2500	4167	10.6	13991	9.2	2668.0	150.25
1982	114.1	82.8	11.2	2668.0	2.6	-1.2	-2.9	1.1	13991	2500	9.2	11588	9.7	2898.0	146.95
1983	115.3	79.5	12.3	2898.0	1.1	2.6	-1.2	1.4	11588	13991	9.4	12069	8.8	3128.0	152.89
1984	117.0	76.9	13.3	3128.0	1.4	1.1	2.6	2.0	12069	11588	8.8	13030	8.5	3358.0	154.87
1985	119.3	74.5	14.3	3358.0	2.0	1.4	1.1	2.0	13030	12069	8.5	13030	8.5	3588.0	154.87
1986	121.7	71.9	15.3	3588.0	2.0	2.0	1.4	2.0	13030	13030	8.5	13030	11.0	3783.0	138.38
1987	124.1	69.2	16.3	3784.0	2.0	2.0	2.0	2.0	13030	13030	11.0	13030	11.0	3980.0	138.38
1988	126.6	66.9	17.2	3980.0	2.0	2.0	2.0	2.0	13030	13030	11.0	13030	11.0	4175.0	138.38
1989	129.1	64.6	18.1	4175.0	2.0	2.0	2.0	2.0	13030	13030	11.0	13030	11.0	4371.0	138.38
1990	131.7	62.4	19.1	4371.0	2.0	2.0	2.0	2.0	13030	13030	11.0	13030	11.0	4557.0	138.38
1991	134.3	60.1	20.0	4567.0	2.0	2.0	2.0	2.0	13030	13030	11.0	13030	11.0	4751.0	138.38

TABLE 4.2: ECONOMIC INDICES FOR HISTORICAL AND PROJECTED PERIODS

4.4.2: Methodology employed

The intention is to test for correlations between the economic/social indices and levels of manpower movement. If sufficient significant relationships are found, then multiple regressions will be used to establish predictive equations. The statistical detail and procedures associated with the use of multiple regressions with small samples has previously been discussed in Section 3.5.2.2. The projected economic/social indices shown in Table 4.2 will be inserted into the predictive equations established to derive estimates for future manpower movements. Three dependent variables need to be predicted. These are:-

1. The target size of workforce.
2. The percentage level of attrition through voluntary turnover.
3. The percentage level of attrition through early retirement.

Reference to Figure 4.1 shows that, before the model adjusts for the final size of the workforce by using either compulsory redundancy or recruitment at the bottom of the hierarchy of personnel operations, an estimate is also needed for the percentage level of attrition through voluntary redundancy. Unfortunately, as described in the last chapter, only one voluntary redundancy programme was practised over the period, 1974 to 1980. It is, therefore, not possible to use multiple regressions to predict attrition levels for voluntary redundancy, so a static rate will be assumed.

4.4.3: The problem of multicollinearity in the economic/social indices

Section 4.4.1 shows historical data for a battery of fifteen economic/social indices which are to be used to establish an association between the magnitude of manpower movements and the national economic/social environment. Bartholomew and Forbes (1979) point out that, whilst correlational methods are very versatile and provide an attractive way of using historical data to establish manning requirements, the most ignored problem is that of multicollinearity in the database. Kim and Kohout (1970a) specify this problem. Extreme collinearity exists when intercorrelations are in the range of 0.8 - 1.0, and use of such confounded data increases the likelihood of statistical artefact.

A check was made for multicollinearity in the database of fifteen economic/social indices by correlating each with the others. The results are shown in Table 4.3 overleaf. 16.2 per cent of the intercorrelations fall within the extreme range of 0.8 - 1.0 specified by Kim and Kohout (1970a). Therefore, the data need to be transformed to form a more suitable correlational base. Bartholomew and Forbes (1979) suggest that the most appropriate way to tackle this problem is to carry out a principal components analysis, and to use the principal component composite scores as the predictive variables.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	-0.75	0.68	0.75	0.28	0.10	-0.23	-0.52	0.42	0.98 *	-0.66	-0.35	-0.76	0.67	0.90 *
2		-0.91 *	-0.96 *	-0.01	0.34	0.17	0.23	0.05	-0.83 *	0.11	0.39	0.79	-0.95 *	-0.88 *
3			0.97 *	0.29	-0.48	-0.26	0.11	0.23	0.75	-0.04	-0.01	-0.85 *	0.75	0.70
4				0.17	-0.31	-0.31	-0.07	0.11	0.81 *	-0.15	-0.16	-0.91 *	0.84 *	0.81 *
5					-0.26	-0.53	0.30	0.88 *	0.16	-0.02	0.62	-0.28	-0.26	-0.10
6						-0.18	-0.53	-0.06	-0.02	-0.69	-0.20	-0.02	-0.23	-0.04
7							0.04	-0.26	-0.08	-0.02	-0.29	0.52	-0.05	-0.07
8								0.18	-0.48	0.53	0.85 *	0.06	-0.43	-0.61
9									0.30	-0.37	0.52	-0.26	-0.28	0.01
10										-0.58	-0.43	-0.75	0.77	0.95 *
11											0.23	0.38	-0.10	-0.50
12												-0.04	-0.64	-0.63
13													-0.62	-0.70
14														0.90 *

KEY: Figure denotes correlation coefficient

* denotes falls within extreme range of collinearity

Numbers 1-15 relate to variables specified by these numbers in Section 4.4.1

TABLE 4.3: INTER-CORRELATIONS BETWEEN ECONOMIC/SOCIAL INDICES OVER PERIOD 1974-1980 (N=7)

4.4.4: Principal components analysis on the fifteen economic/social indices and the production of an appropriate correlational base

4.4.4.1: Statistical methodology

The purpose of the factor analysis according to Burt (1940) is the "orderly simplification" of a number of interrelated measures by identifying and classifying the scores in an attempt to make them more intelligible. Child (1970) explains that the common language which all the measures have is their variance (an index of the dispersion of scores), which may be either common or unique. Common variance accounts for the intercorrelations between measures. The primary aim of factor analysis is to discover these common factors by taking out as much common variance as possible in the first factor. Subsequent factors are intended to account for the maximum amount of the remaining common variance, until hopefully no common variance remains.

The relationship within a series of measures is given as follows:-

V_T	=	V_c	+	V_u
Total variance of a test		Common variance		Unique variance

The common variance (V_c) may be spread out across several factors, so that, strictly speaking, V_c consists of $V_{c1} + V_{c2} + V_{c3} + \ldots + V_{cn}$. Each symbol, V_{c1} and so forth, represents the variance in each factor up to the last common factor V_{cn} (where n is the total number of common factors).

The total variance (V_T) is made equal to 1. Therefore, V_{c1} to V_{cn} are made to represent specific proportions of the total variance. The loading of each of these factors is taken as the square root of the variance (the equivalent to a standard deviation).

Two basic models are applied. A factor analysis takes account of some of the unique variance, whereas a principal components analysis ignores the unique variance. In a components analysis, the unique variance is merged with the common variance. A principal components analysis is performed when no estimate of the common variance is known.

Up to 'n' factors can be derived depending upon the common variance within the series of measures. This factor can be one of three types:-

1. A general factor, where all the measures analysed possess a significant amount of the factor variance.
2. A group factor, where a number of the measures possess a significant amount of the factor variance.
3. A specific factor, where only one of the measures significantly loads on the factor. This sort of factor is really tapping unique and not common variance.

Every measure has a loading on every factor, depending upon the extent to which it possesses each type of common variance. Clearly, then, the interpretation of a factor, or principal components analysis critically revolves around two criteria:-

1. How many of the 'n' common factors represent meaningful common variance?
2. Which measures significantly load on each factor?

There are minor differences between researchers as to the best grounds for halting extraction of factors. However, in considerable use at present is Kaiser's criterion suggested by Guttman and adopted by Kaiser. Only factors having latent roots greater than one are considered as common factors. When there are less than twenty measures used, there is a slight tendency for this criterion to extract a conservative number of factors. It is considered by Child (1970) as the most appropriate criterion to apply with principal components analysis, and is, therefore, adopted for this research.

Finally, we have to decide which factor loadings are worth considering once factors are considered significant. Factor loadings are, in effect, correlation coefficients, and decisions may be made on this basis. However, the use of such a set rule does not make any adjustment for the number of measures entered into the analysis, nor for the factor under consideration. Burt (1952) showed that, as one progresses from the first to the last factor, it should become harder for a measure to load on the factor, because with principal components analysis, more unique variance intrudes into the later factors. Burt and Banks devised a formula to adjust the level of significance depending upon the sample size, number of measures incorporated, and the number of factors considered.

$$\text{Standard error of a loading deemed to be significant} = \text{Standard error of a correlation} \left(\sqrt{\frac{n}{n+1-r}} \right)$$

where n = the number of measures in the analysis
r = the factor number

The standard error of the correlation is obtained from Appendix B in Child (1970). The value is governed according to the sample size and the alpha level required. An alpha level of $p < .01$ is adopted for loadings in this research.

4.4.4.2: <u>Results of principal components analysis</u>

The analysis yielded four factors which satisfy Kaiser's criterion. Together they account for 95 per cent of the total variance. The eigenvalues, individual and cumulative percentage accounted for by the four factors are presented in Table 4.4 overleaf.

Factor Number	Eigenvalue	% Variance	Cumulative %
1	7.25230	48.3	48.3
2	3.42402	22.8	71.2
3	2.48079	16.5	87.7
4	1.08732	7.2	95.0

TABLE 4.4: EIGENVALUES AND VARIANCE FOR THE FOUR FACTORS UNDERLYING THE ECONOMIC/SOCIAL INDICES

The aim of the principal components analysis is not to provide any psychological or economic interpretation of the factors, but rather to create a mathematical base which does not exhibit collinearity. The composite factor scores for the four factors should represent a suitable base for the multiple regressions. Table 4.5 overleaf shows the factor score coefficients for the fifteen economic indices on the four significantly loading factors.

Kim (1970) suggested that it is preferable for all variables on a factor to be incorporated into the composite factor score. This method of including all variable coefficients has the advantage over employing only those variables with substantial loading in that the smaller loading variables will affect the composite scale through their intercorrelations. The complete method favoured by Kim (1970), and employed in this study, treats the low loading variables as suppression variables to give the best estimate for each factor.

VARIABLE	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
ECON1	0.09522	-0.14359	0.12551	0.09052
ECON2	-0.15895	-0.08434	0.06737	0.01456
ECON3	0.15859	0.13321	0.04489	0.00003
ECON4	0.15094	0.08488	-0.02286	-0.10075
ECON5	0.00948	0.00640	0.30277	-0.01711
ECON6	-0.11945	-0.31187	-0.07998	-0.32378
ECON7	0.01610	0.02212	0.09292	0.71765
ECON8	0.01084	0.25061	0.11007	0.02799
ECON9	-0.00048	-0.09758	0.39957	0.21679
ECON10	0.11937	-0.09696	0.10489	0.17918
ECON11	0.02495	0.31408	-0.15915	-0.11467
ECON12	-0.04037	0.11140	0.19642	-0.13373
ECON13	-0.10091	0.00706	-0.00143	0.29170
ECON14	0.14473	0.05540	-0.15436	-0.00844
ECON15	0.11862	-0.08548	-0.03142	0.06734

TABLE 4.5: FACTOR SCORE COEFFICIENTS FOR THE FIFTEEN ECONOMIC INDICES ON THE FOUR FACTORS

For each year, the composite factor scores are calculated as follows:-

For i = 1 to 15 economic/social indices

$$\text{Factor Score Coefficient} = \sum \left(\frac{\text{Index for (i)} - \text{Mean of Index (i)}}{\text{Standard Deviation Index (i)}} \times \text{Coefficient for Index (i) from factor solution} \right)$$

The economic/social indices presented in Table 4.2 are transformed into four composite factor scores for each year. These composite factor scores are presented overleaf in Table 4.6. These data provide the base for the multiple linear regressions. The independent variables which the factor scores represent are now orthogonal as Table 4.7 shows.

YEAR	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
1974	-1.7626	-1.0814	-0.7519	-0.3862
1975	-0.6440	1.3089	-0.3056	1.6001
1976	-0.0424	1.2019	0.1663	-1.0599
1977	0.1055	0.2204	0.6799	-1.1963
1978	0.3117	-0.2935	1.4030	0.4774
1979	0.6258	-1.2342	0.4465	0.6969
1980	1.4060	-0.1220	-1.6382	-0.1219
1981	2.0173	1.7550	-1.0768	-0.7405
1982	2.2453	1.1085	0.1261	-1.6298
1983	2.9147	0.7087	-0.0671	-1.3031
1984	3.3373	1.1587	0.1581	-0.3081
1985	3.7479	1.1989	0.2690	-0.6667
1986	4.0779	1.2776	0.2896	-0.5092
1987	4.5005	1.5809	0.2140	-0.4268
1988	4.8822	1.6884	0.2112	-0.4308
1989	5.2638	1.7958	0.2081	-0.4347
1990	5.6564	1.9078	0.2130	-0.4362
1991	6.0401	2.0116	0.2136	-0.4380

TABLE 4.6: COMPOSITE FACTOR SCORES DERIVED FROM THE FIFTEEN ECONOMIC INDICES FOR THE YEARS 1974 TO 1991

FACTOR	1	2	3	4
1	1.00000	0.00001	0.00003	0.00002
2		1.00000	-0.00003	-0.00002
3			1.00000	-0.00001
4				1.00000

TABLE 4.7: INTERCORRELATIONS BETWEEN THE FOUR COMPOSITE FACTOR SCORES FOR THE PERIOD 1974 TO 1980

4.4.5: Correlations between economic factor scores and dependent manpower movements

The various attrition rates and workforce sizes for the six occupational functions over the period 1974 to 1980 have been established in the previous chapter. These data are now correlated with the data for the four economic factors shown in Table 4.6. Two-tailed Pearson Product-Moment correlation coefficients are used and the results of the testing are summarised overleaf in Table 4.8.

Eighteen sets of correlations are produced. The four factors are correlated with three dependent variables (target size of workforce; level of voluntary turnover; and level of early retirement) for each of the six occupational functions. In eleven out of the eighteen, at least one of the four underlying economic factors correlates significantly with the dependent variable (using an alpha level of $p < .05$). It is, therefore, assumed appropriate to use the four economic factors as a base from which to derive multiple regressions for the three dependent variables.

4.4.6: Results of multiple linear regressions to predict manpower movements

Eighteen forward stepwise multiple linear regressions were calculated using the same methodology as detailed in Section 3.5.2.2. Table 4.9 summarises the results. Detail is provided for the multiple r^2, the F value

ECONOMIC/ SOCIAL FACTOR	OCCUPATIONAL FUNCTION																	
	HIGHER MANAGEMENT			MIDDLE MANAGEMENT			SKILLED MANUAL			TECHNICAL			SUPERVISORY			CLERICAL		
	T	V	E	T	V	E	T	V	E	T	V	E	T	V	E	T	V	E
ONE	-.7612 p<.05	.4960 N.S.	.6451 N.S.	-.4251 N.S.	.6564 N.S.	.6367 N.S.	-.3458 N.S.	-.4299 N.S.	.3310 N.S.	-.0073 N.S.	-.3810 N.S.	.5058 N.S.	-.9230 p<.001	-.2867 N.S.	.3483 N.S.	.6236 N.S.	-.9196 p<.001	.0811 N.S.
TWO	.5170 N.S.	-.0984 N.S.	-.6088 N.S.	.4005 N.S.	-.4963 N.S.	-.6136 N.S.	-.3980 N.S.	-.8428 p<.01	-.6358 N.S.	.2944 N.S.	.2478 N.S.	-.4286 N.S.	.2661 N.S.	-.8738 p<.01	-.2507 N.S.	-.6490 N.S.	.1104 N.S.	-.7814 p<.05
THREE	.2969 N.S.	.7063 N.S.	.3755 N.S.	.7594 p<.05	.8031 p<.05	.5000 N.S.	-.5090 N.S.	-.4451 N.S.	.0177 N.S.	.7531 p<.05	-.3617 N.S.	.0678 N.S.	-.1986 N.S.	-.2039 N.S.	.7395 p<.05	.1747 N.S.	-.8121 p<.05	-.0445 N.S.
FOUR	-.1063 N.S.	-.2994 N.S.	.2473 N.S.	-.0577 N.S.	.2543 N.S.	.4002 N.S.	.6692 p<.05	.2170 N.S.	.4840 N.S.	.4061 N.S.	.6040 N.S.	.3545 N.S.	.1355 N.S.	.3503 N.S.	.2031 N.S.	.3726 N.S.	-.1580 N.S.	.5454 N.S.

where T = target of workforce, V = voluntary turnover, E = early retirement

TABLE 4.8: CORRELATION COEFFICIENTS BETWEEN ECONOMIC FACTOR SCORES AND MANPOWER PARAMETERS FOR SIX OCCUPATIONAL FUNCTIONS

PARAMETER	OCCUPATIONAL FUNCTION					
	HIGHER MANAGEMENT	MIDDLE MANAGEMENT	SKILLED MANUAL	TECHNICAL	SUPERVISORY	TECHNICAL
TARGET SIZE	0.8922 $F= 8.28$ (3,3) N.S.	0.6969 $F= 9.19$ (1,4) $p<.05$	0.9697 $F=32.00$ (3,3) $p<.01$	0.6650 $F= 7.94$ (1,4) $p<.05$	0.9610 $F=24.64$ (3,3) $p<.025$	0.9588 $F=23.27$ (3,3) $p<.025$
VOLUNTARY TURNOVER	0.4582 $F= 3.38$ (1,4) N.S.	0.8114 $F=17.21$ (1,4) $p<.025$	0.9719 $F=23.06$ (3,2) $p<.025$	0.3408 $F= 2.07$ (1,4) N.S.	0.8556 $F=23.70$ (1,4) $p<.01$	0.8247 $F=18.82$ (1,4) $p<.025$
EARLY RETIREMENT	0.9931 $F=95.94$ (3,2) $p<.01$	0.7709 $F=13.46$ (1,4) $p<.025$	0.9913 $F=75.96$ (3,2) $p<.01$	0.9983 $F=391.49$ (3,2) $p<.001$	0.9211 $F= 7.78$ (3,2) N.S.	0.8820 $F=29.90$ (1,4) $p<.01$

TABLE 4.9: STRENGTH OF EFFECT AND SIGNIFICANCE OF THE EIGHTEEN PREDICTIVE EQUATIONS USING RAW PARAMETERS

associated with this (and degrees of freedom), and the level of significance of the result. The statistical details of the multiple regressions along with the predictive equations, are included, for reference, in Appendix 11.

Using an alpha level of $p \leq .05$, fourteen of the eighteen equations can be accepted as significant. Four equations, those for higher management target size and level of voluntary attrition, technical voluntary attrition, and supervisory early retirement, must be rejected and an alternative relationship established before any estimates are made.

4.4.7: Results of multiple linear regressions using Log Base 10 transformations of the parameters as the dependent variable

The previous section has shown that 78 per cent of the required dependent variables have been estimated significantly using a linear relationship between them and the composite economic factor scales. Four variables, however, do not illustrate any simple linear relationship and an alternative relationship must be found. Multiple linear regressions may still be used if the dependent variable is transformed (Kim & Kohout, 1970a). Consequently, the data for the four remaining parameters were transformed to Log Base 10 which reduces an exponential relationship to a linear base. Four multiple linear regressions were calculated on these transformed data using the same methodology as before. The results are shown below in Table 4.10.

Higher Management Target Size	0.9117 F=10.33 (3, 3) $p<.05$
Higher Management Voluntary Attrition	0.5364 F= 4.63 N.S.
Technical Voluntary Attrition	0.3101 F= 1.80 N.S.
Supervisory Early Retirement	0.7521 F=12.14 (3, 2) $p<.05$

TABLE 4.10: STRENGTH OF EFFECT AND SIGNIFICANCE OF THE FOUR PREDICTIVE EQUATIONS USING LOG BASE 10 PARAMETERS

A further two of the dependent variables have been significantly estimated by reducing their exponential relationship to one which can be predicted linearly. Two variables, however, have remained unpredictable. These are the level of voluntary attrition in both the higher management and technical occupational functions. A static rate of attrition based upon the average over the previous six years will be assumed for these two variables. Any resulting error will be represented by the invalidity of the projected OA/S structures. Checks will be made for both the validity and reliability of the whole technique before any projected data are considered.

4.4.8: Standard error of estimates; prediction accuracy; and the need for five alternative sets of projections

The amount of prediction error within the eighteen multiple regressions has already been examined using the adjusted r^2 statistic. However, given the importance of the statistical estimates, an assessment of their predictive accuracy based upon the absolute amount of explained or unexplained variation is required. The most widely used statistic for this purpose is the standard error of estimate (β = population estimate; B = sample estimate).

$$\text{Standard Error of B} = \sqrt{\frac{\sum(Y-Y^1)^2/(N-2)}{\sum(X-\bar{X})^2}}$$

(from Kim & Kohout, 1970a)

where Y = actual parameter value
Y^1 = predicted parameter value
X = predictor value
N = number of cases

The standard error of estimate is simply the standard deviation of actual dependent variable values from the predicted values. Since B is estimated from a single sample, its value theoretically varies from sample to sample. In order to generalise the sample estimates to the population as a whole, a range of estimate values must be provided upon which we can give a statistical confidence limit. For a large sample size, the values of B approximate to a normal distribution. However, for the low sample sizes as employed in these multiple regressions, the t distribution is required. The accuracy levels for the eighteen multiple regressions are derived as follows:-

Target size of workforce estimate (N=7)	=	Sample estimate	± 2.36 x	Standard error of estimate
Attrition level estimates (N=6)	=	Sample estimate	± 2.45 x	Standard error of estimate

There is, in essence, a confidence range associated with each estimate. The sample estimate must be complemented by an upper and a lower limit between which we can confidently ($p < .05$) say that there is a significant relationship. Therefore, in using C.A.S.T., projections must be made which utilise not only the sample estimates drawn from using the predictive equations in Appendix 11, but also the upper and lower confidence limits. This leads to five logically extreme sets of dependent variables. These are listed below:-

1. Sample estimates
2. Upper population size of workforce with upper population levels of attrition
3. Upper population size of workforce with lower population levels of attrition
4. Lower population size of workforce with upper population levels of attrition

5. Lower population size of workforce with lower population levels of attrition.

Therefore, projections for each occupational function should be made using these five sets of dependent variables, which cover both sample estimates and estimates from the upper and lower level of the population from which they are drawn. A decision will then have to be made as to which of the five sets of projections should be considered as representative of the future OA/S structures. The sample and population estimates for each of the six occupational functions now need to be detailed.

4.5: SAMPLE AND POPULATION ESTIMATES FOR FUTURE SIZE OF WORKFORCE AND LEVELS OF ATTRITION IN THE SIX OCCUPATIONAL FUNCTIONS

The sample and population estimates are presented overleaf in Tables 4.11 to 4.16, for each of the six occupational functions. The estimates are based upon applying the predictive equations (in Appendix 11) to the future levels of economic factor scores (see Table 4.6). Upper and lower population estimates are derived by using the standard error of estimates for each sample estimate (see Section 4.4.8).

4.5.1: Higher management

The estimates within higher management over the next ten years can be characterised by the following points:-

YEAR	NUMBERS			VOLUNTARY TURNOVER			EARLY RETIREMENT		
	SAMPLE	UPPER	LOWER	SAMPLE	UPPER	LOWER	SAMPLE	UPPER	LOWER
1981	132	133	131	2.63	2.63	2.63	0.00	0.31	0.00
1982	132	133	131	2.63	2.63	2.63	2.26	2.57	1.94
1983	115	116	114	2.63	2.63	2.63	2.16	2.47	1.84
1984	115	116	114	2.63	2.63	2.63	2.29	2.60	1.98
1985	110	111	109	2.63	2.63	2.63	2.58	2.89	2.27
1986	107	108	108	2.63	2.63	2.63	2.55	2.86	2.24
1987	102	103	101	2.63	2.63	2.63	1.95	2.26	1.64
1988	100	101	99	2.63	2.63	2.63	1.81	2.12	1.50
1989	96	97	95	2.63	2.63	2.63	1.67	1.98	1.36
1990	93	94	92	2.63	2.63	2.63	1.54	1.85	1.23
1991	89	90	88	2.63	2.63	2.63	1.42	1.73	1.11

TABLE 4.11: PARAMETER SAMPLE AND POPULATION ESTIMATES FOR THE HIGHER MANAGEMENT OCCUPATIONAL FUNCTION

1. <u>Numbers in workforce</u>: There will actually be a slight increase on present numbers throughout 1981 and 1982 as the recession works its way through. However, as there is a recovery in the economy and organisational climate, these numbers will, as in the past, begin to decline. The slow growth rates of 1983 and 1984 will be accompanied by a slow decline in the number of higher managers required. Once a 2 per cent growth rate is assumed, then these numbers will decline at a faster rate, resulting in there only being a demand for 67.4 per cent of the 1981 workforce by 1991.

2. <u>Voluntary turnover</u>: Because a linear relationship was not found, an averaged static rate of 2.63 per cent has been calculated.

3. <u>Early retirement</u>: The demand for early retirement is seen to increase consistently throughout the 1980's. In the past, early retirement has been the major tool used within this function to reduce numbers in the workforce ($r=+0.8813$, $p<.010$). If present personnel policies and attitudes remain unchanged, this would necessitate early retirement rates averaging at around 1.84 per cent throughout the next decade. The simulation technique will attempt to fulfil

these 'quotas' using the appropriate age/service behaviour patterns associated with early retirement. However, it is possible that these 'quotas' will not be fulfilled. The behaviour patterns associated with early retirement do not only represent biographical descriptive data, but also are a psychological measure of an individual's "propensity to decide" on early retirement. If not enough individuals could be induced to 'decide' to take early retirement (simply because, given people's propensity to leave or not, the percentage of those within the appropriate region of the age/service structure is not enough), then the simulation will allow all those who would be expected to leave to do so, note that the predicted number did not and bring in the appropriate personnel policies to compensate for this. Throughout all this operation, the age and length of service patterns will be validly represented.

4.5.2: Middle management

1. Numbers in workforce: The estimates are shown in Table 4.12 overleaf. During the first couple of years of projection, the numbers will increase slightly. By 1982, numbers will, once more, begin to decline, such that there will be a 3.07 per cent reduction in the size of the

YEAR	NUMBERS			VOLUNTARY TURNOVER			EARLY RETIREMENT		
	SAMPLE	UPPER	LOWER	SAMPLE	UPPER	LOWER	SAMPLE	UPPER	LOWER
1981	391	416	366	0.00	3.63	0.00	0.70	1.41	0.00
1982	405	430	380	2.26	5.89	0.00	0.99	1.70	0.28
1983	398	423	373	2.16	5.79	0.00	1.38	2.09	0.67
1984	398	423	373	2.29	5.92	0.00	1.42	2.13	0.71
1985	396	421	371	2.58	6.21	0.00	1.57	2.28	0.86
1986	394	419	369	2.55	6.18	0.00	1.68	2.39	0.97
1987	390	415	365	1.95	5.58	0.00	1.76	2.47	1.05
1988	388	413	363	1.81	5.44	0.00	1.88	2.59	1.17
1989	384	409	359	1.67	5.30	0.00	2.00	2.71	1.29
1990	382	407	357	1.54	5.17	0.00	2.13	2.84	1.42
1991	379	404	354	1.42	5.05	0.00	2.25	2.96	1.54

TABLE 4.12: PARAMETER SAMPLE AND POPULATION ESTIMATES FOR THE MIDDLE MANAGEMENT OCCUPATIONAL FUNCTION

workforce by 1991.

2. Voluntary turnover: Initially, movement out of the function will be small. Whilst the depression continues, very few middle managers will voluntarily leave. However, as the economy begins to recover, (predicted for 1982 at the time of study), then levels of turnover slowly increase until 1986. Thereafter, turnover again diminishes.

3. Early retirement: Here the situation projected is much more controllable. The levels of early retirement will diminish to very small levels until 1982, again whilst there is a depression. By 1983, they begin to increase, and early retirement is projected to play a more important role in personnel planning as the decade passes.

4.5.3: Skilled manual function

1. Numbers in workforce: The period 1980 to 1983 will see a very sharp decline in the numbers required. Lagging two years behind growth in the economy, the benefits of the recovery from the recession are expected to lead to an increase of numbers in 1984. However, after this temporary increase in demand, the need for a smaller and smaller industrial workforce will

YEAR	NUMBERS			VOLUNTARY TURNOVER			EARLY RETIREMENT		
	SAMPLE	UPPER	LOWER	SAMPLE	UPPER	LOWER	SAMPLE	UPPER	LOWER
1981	1459	1586	1332	1.75	2.90	0.60	7.07	7.65	6.49
1982	1200	1327	1073	0.96	2.11	0.00	5.24	5.82	4.66
1983	1261	1388	1134	1.93	3.08	0.78	7.86	8.44	7.28
1984	1318	1445	1191	1.28	2.43	0.13	8.43	9.01	7.85
1985	1204	1331	1077	0.95	2.10	0.00	8.85	9.43	8.27
1986	1191	1318	1064	0.85	2.00	0.00	9.56	10.14	8.98
1987	1147	1274	1020	0.49	1.64	0.00	10.37	10.95	9.79
1988	1103	1230	976	0.32	1.47	0.00	11.12	11.70	10.54
1989	1059	1186	932	0.15	1.30	0.00	11.86	12.44	11.28
1990	1012	1139	885	0.00	1.15	0.00	12.61	13.19	12.03
1991	968	1095	841	0.00	1.15	0.00	13.35	13.93	12.77

TABLE 4.13: PARAMETER SAMPLE AND POPULATION ESTIMATES FOR THE SKILLED MANUAL OCCUPATIONAL FUNCTION

return. By 1991, it is expected that only 66.35 per cent of the 1981 numbers will be required.

2. Voluntary turnover: The levels of voluntary turnover expected will be relatively low, and will fluctuate around 0.79 per cent. This will force a high demand for early retirement.

3. Early retirement: Given the demand for a smaller and smaller workforce, but the relatively static and low levels of voluntary turnover, the need for early retirement to supply the required leavers will markedly increase. Demand will consistently increase throughout the decade. However, the levels projected are so high that, as with the higher managers, it is unlikely that there will be enough takers, and other policies such as voluntary and compulsory redundancy will probably need to be employed in the skilled manual projections.

4.5.4: Technical function

1. Numbers in workforce: The numbers in the workforce are anticipated to grow over the next few years, with a particularly marked increase in demand in 1984. From this point onwards, the numbers will remain 5.48 per cent above 1981 levels.

YEAR	NUMBERS			VOLUNTARY TURNOVER			EARLY RETIREMENT		
	SAMPLE	UPPER	LOWER	SAMPLE	UPPER	LOWER	SAMPLE	UPPER	LOWER
1981	602	647	557	2.67	2.67	2.67	3.81	3.91	3.71
1982	618	663	573	2.67	2.67	2.67	2.90	3.00	2.80
1983	618	663	573	2.67	2.67	2.67	4.08	4.18	3.98
1984	635	680	590	2.67	2.67	2.67	4.32	4.42	4.22
1985	633	678	588	2.67	2.67	2.67	4.63	4.73	4.53
1986	636	681	591	2.67	2.67	2.67	4.99	5.09	4.89
1987	635	680	590	2.67	2.67	2.67	5.48	5.58	5.38
1988	635	680	590	2.67	2.67	2.67	5.90	6.00	5.80
1989	635	680	590	2.67	2.67	2.67	6.32	6.42	6.22
1990	635	680	590	2.67	2.67	2.67	6.74	6.84	6.64
1991	635	680	590	2.67	2.67	2.67	7.16	7.26	7.06

TABLE 4.14: PARAMETER SAMPLE AND POPULATION ESTIMATES FOR THE TECHNICAL OCCUPATIONAL FUNCTION

2. Voluntary turnover: This is the second projection where the relationship between the environment and the levels of attrition was not linear. Consequently, an averaged static rate of 2.67 per cent has been assumed.

3. Early retirement: Projected rates will fall slightly during 1981 and then start a rapid increase up to a rate of 7.16 per cent by 1991.

4.5.5: Supervisory function

1. Numbers in workforce: There will be a slight increase in demand for supervisors during 1981, but as there is an economic recovery, the demand slackens and there will be a gradual whittling down of the numbers required. By 1991, only 74.71 per cent of the 1981 workforce will be required.

2. Voluntary turnover: In the longitudinal analysis of change in Chapter Three, it was pointed out that the supervisory function represented a zero-recruitment function, and also that levels of voluntary turnover were minimal. Reduction in the size of the workforce was only achieved by compulsory redundancy. The projected scenario for the 1980's is the same, with voluntary turnover effectively operating at zero.

YEAR	NUMBERS			VOLUNTARY TURNOVER			EARLY RETIREMENT		
	SAMPLE	UPPER	LOWER	SAMPLE	UPPER	LOWER	SAMPLE	UPPER	LOWER
1981	340	353	327	0.02	0.48	0.00	3.02	4.41	1.63
1982	324	336	311	0.12	0.58	0.00	4.47	5.86	3.08
1983	310	323	297	0.30	0.76	0.00	3.16	4.55	1.77
1984	306	319	293	0.28	0.74	0.00	2.24	3.63	0.85
1985	296	309	283	0.22	0.68	0.00	2.46	3.85	1.07
1986	290	303	277	0.21	0.67	0.00	2.24	3.63	0.85
1987	283	296	270	0.12	0.58	0.00	2.14	3.53	0.75
1988	276	289	263	0.08	0.54	0.00	2.04	3.43	0.65
1989	269	282	256	0.04	0.50	0.00	1.99	3.38	0.60
1990	262	275	249	0.01	0.47	0.00	1.91	3.30	0.52
1991	254	267	241	0.00	0.46	0.00	1.86	3.25	0.47

TABLE 4.15: PARAMETER SAMPLE AND POPULATION ESTIMATES FOR THE SUPERVISORY OCCUPATIONAL FUNCTION

3. Early retirement: The role of early retirement increases during the recession. The supervisory function is the oldest function to be projected, and by 1982, the associated levels of early retirement are expected to increase to a level of 4.47 per cent. After this point, the level of early retirement decreases as the numbers are reduced at a slower rate.

4.5.6: Clerical function

1. Numbers in workforce: Until 1982, a fairly drastic slimming of the workforce is projected, as the recession will bite deeply into clerical numbers. However, as the business environment becomes more favourable, there will be a continual build-up of numbers throughout the decade, so that by 1991, the workforce will have expanded by 19.08 per cent from 1981 levels.

2. Voluntary turnover: The projected figures for voluntary turnover suggest that there will be a problem over the decade. Whilst the demand for numbers slackens, so do the expected levels of voluntary turnover. This suggests that there will be a call for complusory redundancy policies during this period. As the economic and organisational climate improves, voluntary attrition vanishes.

YEAR	NUMBERS			VOLUNTARY TURNOVER			EARLY RETIREMENT		
	SAMPLE	UPPER	LOWER	SAMPLE	UPPER	LOWER	SAMPLE	UPPER	LOWER
1981	865	901	829	1.83	6.04	0.00	0.00	1.01	0.00
1982	892	928	856	1.31	5.52	0.00	0.00	1.01	0.00
1983	939	975	903	0.00	4.21	0.00	0.10	1.11	0.00
1984	963	999	927	0.00	4.21	0.00	0.28	1.29	0.00
1985	970	1006	934	0.00	4.21	0.00	0.07	1.08	0.00
1986	983	1019	947	0.00	4.21	0.00	0.09	1.10	0.00
1987	989	1025	953	0.00	4.21	0.00	0.00	1.01	0.00
1988	999	1035	963	0.00	4.21	0.00	0.00	1.01	0.00
1989	1010	1046	974	0.00	4.21	0.00	0.00	1.01	0.00
1990	1020	1056	984	0.00	4.21	0.00	0.00	1.01	0.00
1991	1030	1066	994	0.00	4.21	0.00	0.00	1.01	0.00

TABLE 4.16: PARAMETER SAMPLE AND POPULATION ESTIMATES FOR THE CLERICAL OCCUPATIONAL FUNCTION

3. <u>Early retirement</u>: The need for early retirement is minimal as demand for clerical staff is increasing.

4.5.7: <u>Summary of estimates</u>

The estimates described are those from the sample. There is some latitude in these estimates across population limits, and these will also be used to project OA/S structures. The actual shape of these projected OA/S structures is based upon a series of assumptions:-

1. That the projected future economic/social indices detailed in Table 4.2 are correct.
2. That the application of the regression equations (based on 1974 to 1980 data) to a different set of economic data (where indices go beyond the initial sample values) will not invalidate the estimated values.
3. That the present attitudes, practices and personnel policies (reflected in the age/service behaviour patterns and personnel hierarchy within C.A.S.T.) do not change markedly over the decade.

Clearly, a newly-developed model based upon such untested assumptions needs to be carefully evaluated in terms of its validity and reliability before any analysis may be made upon its projected data. This process of checking on validity and reliability forms the next chapter, and actual projections are discussed in Chapter Six. First of all, however, the mechanisms of the model and the methodology under which it will operate, will be summarised.

4.6: A SUMMARY OF THE COMPUTER AGEING SIMULATION TECHNIQUE (C.A.S.T.) AND THE METHODOLOGY EMPLOYED IN ITS OPERATION

4.6.1: A clarification of the variables manipulated by the model

Figure 4.2 overleaf summarises the development of C.A.S.T. Circles in Figure 4.2 denote information or data inputs to the system. Pointed rectangles denote analytical processes, and normal rectangles denote the output from such analyses. The system revolves around seven inputs:-

1. Historical data for a battery of fifteen economic/social indices is factor analysed to produce a series of underlying scores which quantify the outside environment which surrounds manpower movement.
2. Future predictions for these same economic indices are then input, and converted into future underlying scores using the principal components factor equations.
3. The historical factor scores are entered into a series of multiple regressions against historical data for a series of parameters for manpower movements. The three parameters which are

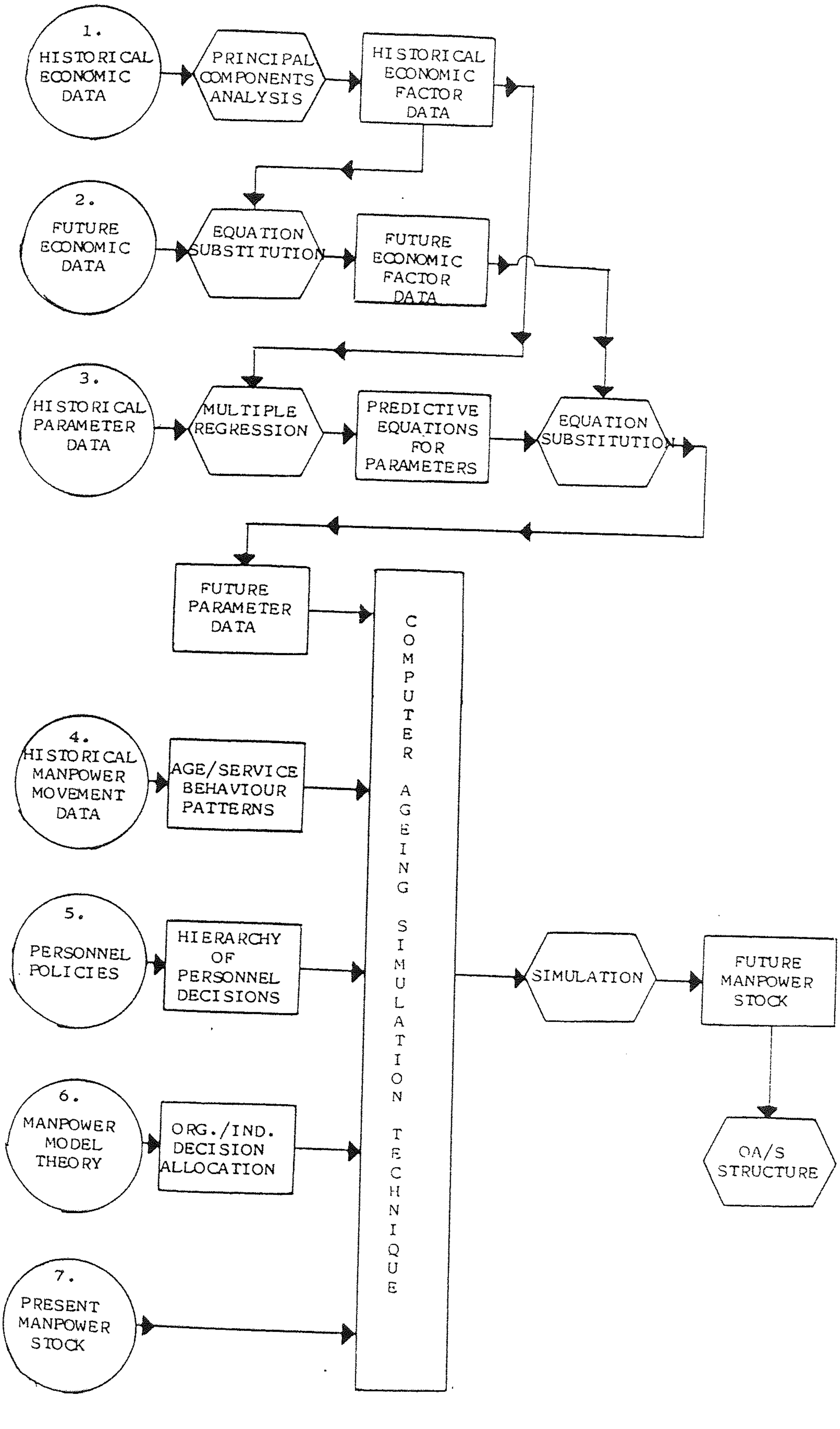


FIGURE 4.2: ALGORITHM ILLUSTRATING THE METHODOLOGIES EMPLOYED WITHIN C.A.S.T.

regressed are the target size of workforce (a demand parameter), and the levels of voluntary turnover and early retirement attrition (supply parameters). The multiple regression equations are then applied to the future economic factor scores to produce a series of estimates for the parameters under a range of sample and population confidence limits.

4. A series of age/service behaviour patterns is calculated from a historical analysis of five types of manpower movements.
5. The internal policies of the organisation are represented as a hierarchy of personnel decisions which introduces a priority into the practice of the five types of manpower movements.
6. Theoretical discussions of manpower models express the centrality of decisions made by either the organisation or the individual. These decisions (operationalised as the age/service behaviour patterns practised under a hierarchy of personnel decisions) are placed within a framework of either organisation or individual control whereby influence may be exerted on the age/service behaviour.
7. Finally, the present manpower stock is fed into C.A.S.T. which simulates the anticipated manpower movements (drawing upon the previous six inputs) and calculates the future manpower stock with its associated OA/S structure.

4.6.2: The economy-related predictions as governors of demand and supply

Smith (1971) suggested that there are three main features of manpower planning which depend upon the varying degrees of sophistication and emphasis the company gives to corporate planning. These features are:-

1. Demand work - which includes the analysing, reviewing and attempting to predict the numbers, by kind, of the manpower needed by the organisation to achieve its objective. This feature of planning was incorporated into the model by the use of a battery of economic indices to determine the relationship between the observed numbers within specialised functions, and the environment of the time. This series of relationships were statistically determined at a confidence level of 95 per cent based upon a seven-year time period. Using the expected indices for the next eleven years, the relationships were applied to determine the manpower demands on the functions and these figures were then treated as target workforce sizes. The system also took account of Smith's (1971) second feature, which is:-

2. Supply work: This includes attempting to predict what action is and will be necessary to ensure that the manpower needed is available when required. This aspect of planning was again established by determining the observed

statistical relationship between the various economic indicators and the relevant levels of manpower movement (level of voluntary turnover and early retirement) based upon six years of data. These relationships were also applied, and the projected supply side of the system was thus established.

3. The third main feature is Designing the Interaction between Demand and Supply, so that skills are utilised to the best possible advantage and the legitimate aspirations of the individual are taken into account. This feature of planning was incorporated into the system by C.A.S.T. which orchestrated the various demand and supply levels established, and manipulated these interactions in relation to age and service. This manipulation was achieved by applying a series of conditional probability matrices dependent upon age and service to each of the required supply manpower movements. These probability matrices were viewed as age/service behaviour patterns, and their internal make-up, as with the hierarchy of their implementation required to satisfy the size of workforce demands, was placed within a matrix of organisation versus individual control.

4.6.3: The simulation technique as a Quantifiable Hypothesis Tester which can be compared to the idea of a 'natural' or 'no change' projection

The preceding section illustrated how the target numbers set for each occupational function, and the actual attrition levels for each type of manpower movement within that function, were viewed as the demand and supply features of the simulation technique. By applying this demand and supply framework to the underlying age structures which exist at present, the subsequent rates of ageing and OA/S structures are produced in a quantifiable manner.

Section 4.6.1 showed that there are two main sets of variables within the simulation technique:-

1. the demand and supply levels for each of the manpower movements; and
2. the internal age/service behaviour pattern associated with these manpower movements.

Table 4.1 placed these two sets of variables within a matrix which allows for either organisational or individual control It is, therefore, possible for the organisation to hypothesise about those demand and supply features and those age/service behaviour patterns which may be altered. Once the appropriate assumptions have been made, they may be tested out using the simulation technique, and quantified as explained.

The testing, quantifying and comparison of results between these hypotheses requires the establishment of a 'control' or 'standard' situation from which all other hypotheses can be drawn. This control situation can be termed a 'natural' or 'no change' situation which indicates what will happen if nothing is done. Nothing done implies the continuation of present practices on behalf of both the organisation and the individual, in the light of the anticipated social and economic environment. It is this control set of assumptions which will be applied to the OA/S structures to produce the future structures described in Chapter Six.

CHAPTER FIVE

VALIDITY AND RELIABILITY OF PROJECTIONS MADE BY THE COMPUTER AGEING SIMULATION TECHNIQUE

5.1: RESEARCH DESIGN

In the previous chapter, a projection technique based on the statistical process of Markov-chaining has been developed. The model, called a Computer Ageing Simulation Technique (C.A.S.T.) is a manpower planning system. It has two major sets of parameters which govern its operation. The first set of parameters governs the supply of manpower, and estimates have been made for the levels of voluntary turnover and early retirement which might be expected over the range of population limits. The second set governs the demand for manpower, and similar estimates have been made for the target size of workforce. Both sets of estimates were made using multiple linear regressions from a battery of economic/ social indicators. Inherent in this statistical technique is the problem that the actual predictions are equivalent to a sampled 'best estimate'. Around this sample estimate is a population of estimates from which the best estimate was drawn. By using the upper and lower extremes of this population of estimates, five alternative sets of parameters were isolated (see Section 4.4.8 in the previous chapter). A decision now needs to be made as to which of these five sets of parameters represents the most appropriate base to use for the eleven-year projection period.

Ideally, the set of parameters which, when modelled, produces the most accurate result in comparison to actual conditions should be chosen. In order to establish this, a validity study of the six OA/S structures will be carried out. On the basis of this validity study, the most valid of the five sets of parameter data will then be used to project each OA/S structure. Once these projections have been made, a statement about their reliability will be made before the details of future age structures are discussed.

5.2: THE CONCEPT OF VALIDITY

5.2.1: Content validity

Anastasi (1976) distinguishes three types of validity. The first is content validity, which is used to determine whether or not the test (or methodology) covers a "representative sample of the behaviour domain to be measured". In order to establish such validity, the total behaviour domain must be systematically analysed to make sure that all major aspects are covered. The behaviour domain relevant to C.A.S.T. is that of age/service behaviour patterns within manpower movement. The model used is, in fact, exhaustive as all movement into and out of the discrete occupational functions has been sampled. The categorisation of these manpower movements into five separate types rests upon the validity of the research findings discussed in Chapter One which showed different relationships between age and, for example, voluntary turnover and redundancy.

5.2.2: Criterion-related validity

Anastasi (1976) defines criterion-related validity as "the effectiveness of a test in predicting an individual's behaviour in specified situations". For this purpose, performance on the test (in this case C.A.S.T.) is checked against a criterion which is "a direct and independent measure of that which the test is designed to predict". If this comparison is aimed at establishing suitable performance at the same time as the test is administered, then the validity is said to be concurrent. If, however, the comparison is aimed at establishing suitable performance for some time in the future, then the validity is said to be predictive.

C.A.S.T. is used to project future OA/S structures which result as a consequence of individuals leaving and joining the occupation. Criterion-related validity would be tested by comparing these projected OA/S structures against those which actually occurred. This form of validity is predictive, and can only be carried out at future dates with one-year intervals (as the output from C.A.S.T. is measured around calendar year periods). Tests for predictive validity over as long a period as the research permits will be carried out.

5.2.3: Construct validity

The construct validity of a test is the extent to which the test may be said to measure a theoretical construct or trait. This validity is applicable to the measure developed for OA/S structures, and to the RAI's, both of which are used by C.A.S.T. as the essential traits of age and service structure, and change. The fact that both these measures have been able to statistically discriminate between occupations along theoretical dimensions is used to infer construct validity.

5.3: THE CONCEPT OF RELIABILITY

In the previous chapter, the Computer Ageing Simulation Technique (C.A.S.T.) was developed to project the age/service structure for each of the six occupational groupings, under five alternate sets of statistical assumptions, over an eleven-year period (from 1981 to 1991 inclusive). In each case, this was accomplished using a single simulation run, or test. No test or technique is a perfectly reliable instrument and therefore must be accompanied by a statement of its reliability (Anastasi, 1976; Cronbach, 1970). Anastasi (1976) defines reliability as "the consistency of scores obtained by the same persons when re-examined with the same test on different occasions, or with different sets of equivalent items, or under other variable examining conditions". Cronbach (1970), however, points out that, whilst error of measurement is a familiar concept, it is also ambiguous. Much of this ambiguity can be attributed to the variety of possible sources of error variance which might affect a specific test or technique. Consequently, there is a need to briefly consider the major sources of error variance present in tests, and to specify those sources most relevant to C.A.S.T.

5.4: THREE MAJOR SOURCES OF ERROR VARIANCE

Anastasi (1976) considers three main sources of error variance.

5.4.1: Time sampling

An identical test may be administered on two separate occasions. In such a situation, the error variance corresponds to the random fluctuations of performance from one test session to the other. Such error variance is usually present where the testing conditions may vary, as may the condition of the subject. The use of C.A.S.T. however, does not invoke such error variance since the technique is applied to a static set of data. There is no need to consider this form of test-retest reliability.

5.4.2: Content sampling

Consistency of responses to various items or content of a test may be measured. Error variance here would be attributed to ambiguity within the meaning or operation of an item. This form of reliability within C.A.S.T. is represented by the individuals allocated to any of the five possible manpower movements (voluntary turnover, early retirement, voluntary redundancy, compulsory redundancy and recruitment). These five manpower movements represent the main Content Items of the technique and, consequently, the consistency of the output or input created within these manpower movements will be evaluated.

5.4.3: Scorer reliability

The different types of reliability vary in the factors they subsume under error variance. Factors excluded from measures of error variance are broadly of two types:-

a) Those factors whose variance should remain in the scores since they are part of the true differences under consideration.

b) Those irrelevant factors which cannot be experimentally controlled.

One such source of uncontrollable variance is scorer variance, where error is introduced by differences between raters of a test. C.A.S.T. is a computer model, and scores are not individually rated. However, contamination from uncontrollable external factors between a series of runs or simulation is possible, and a statement of this form of reliability is required.

A study of reliability will be conducted on the run-rerun reliability of the model. This will allow for a statement to be made on the reliability of a single projection run. This concept of reliability underlies the computation of the error of measurement whereby one can predict the fluctuation of numbers within the age/service bands likely to occur as a result of irrelevant chance factors.

5.5: TWO FEATURES OF THE DATA GENERATED BY C.A.S.T. WHICH NEED TO BE EVALUATED

There are two features of the projected data which need to be evaluated in both the reliability studies and the validity study.

5.5.1: The occupational age/service structure

A major application of C.A.S.T. is the derivation of the age/service structure of a workforce, and, consequently, the reliability of the projected age/service structures needs to be assessed.

5.5.2: The sample size or size of workforce

Given the manpower nature of C.A.S.T., the actual size or numbers in a workforce also needs to be evaluated. Two parallel projections might create workforces which have an identical distribution of age and service across individuals, yet one projection is based on a workforce of 100 individuals, and the other on 500 individuals. This is commonly referred to as the problem of elevation (Cronbach & Gleser, 1953). In the above example, the correlation between the age/service bands would be high, from which reliability of the operation might be inferred, but there would be a fundamental difference in the aspect of the operation which controls the number of individuals who remain within the workforce.

Essentially, both studies must utilise a measure which incorporates the age/service structure and its relative magnitude into the measure of similarity.

5.6: THE SELECTION OF AN APPROPRIATE STATISTICAL MEASURE OF RELIABILITY AND VALIDITY

5.6.1: Linear correlation

Linear correlation could be used to establish the reliability of a run-rerun projection. However, it has been noted that the analysis of reliability for C.A.S.T. must take account of the elevation effect. Linear correlation does not do this (Neale & Liebert, 1973) so a more sophisticated statistical technique is required.

5.6.2: D^2 measures

Cronbach and Gleser (1953) have described the use of a D^2 model to assess the degree of similarity between two or more profiles. The majority of the D^2 techniques utilise the general formula:-

$$D^2_{12} = \sum_{j-1}^{k} (x_j1 - x_j2)^2$$

where j = any of the variates a, b, c,........ which are k in number

i = any one of the persons, raters, etc. numbered 1, 2,...... N

x_{ji} = the score of person i on variate j

Although elevation can be statistically eliminated from the analysis of similarity using this approach, the resultant D^2 does not have a population metric. The analysis of reliability for C.A.S.T. requires a statement to be made on the relative reliability of each comparison. Therefore, the technique used must provide a statistic which may be measured against a population metric (such as the F distribution, t distribution or normal distribution). For example, a D^2 of 26 versus a D^2 of 54, does not allow for any quantitative statement to be made on the relative similarity between those two comparisons. The use of any D^2 techniques must, therefore, be rejected.

5.6.3: <u>Variance models</u>

The three most commonly used measures of strength of association based upon a variance model are:-

1. w^2 (Kirk, 1968)
2. Cronbach's Alpha (Cronbach, 1970)
3. Intraclass correlation (Winer, 1971)

All three measures incorporate the elevation effect, but only Cronbach's alpha and intraclass correlation are applicable to a random-effects model such as C.A.S.T. The assumptions underlying Cronbach's Alpha and the intraclass correlation may be summarised as follows. A person may possess magnitude 'π' of a specified characteristic. In appraising this characteristic with some measuring device, the observed score may have the magnitude 'π' + 'n'. The quantity 'n' is the error of measurement which, as noted, is present in all measurement. This error of measurement is due in part to the measuring device, and in part to the conditions surrounding measurement. Upon repeated measurement with the same instrument, 'π' (the true magnitude of the specific characteristic) is assumed to remain constant, whereas 'n' is assumed to vary. If 'π' remains constant, the variance of scores across repeated measurement is due to error of measurement. This is represented by the pooled within-person variance.

In Winer's model, the measurement on person 'i' with measuring instrument 'j' is represented as:-

$$x_{ij} = \pi_i + n_{ij}$$

where x_{ij} = observed score
π_i = true magnitude of specified characteristic
n_i = quantity of error possessed by measurement

Upon repeated measurement, the true magnitude (π_i) is assumed to remain constant, whilst the quantity of error (n_{ij}) varies. The mean of 'k' such repeated measurements can be represented as:-

$$\Sigma_j \frac{x_{ij}}{k} = \bar{P}_i = \pi_i + \bar{n}_i$$

This formula relates to the schematic representation of analysis shown overleaf in Figure 5.1.

If the true magnitude (π_i) remains constant, then variance within person 'i' is due to error of measurement. On the other hand, the variance in the mean of measurements for

Person	Comparable Measurements						Total	Mean
	1	2	..	j	..	k		
1	x_{11}	x_{12}		x_{1j}		x_{1k}	P_1	$\bar{P}_1$
2	x_{21}	x_{22}		x_{2j}		x_{2k}	P_2	$\bar{P}_2$
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
i	x_{i1}	x_{i2}		x_{ij}		x_{ik}	P_i	$\bar{P}_i$
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
n	x_{n1}	x_{n2}	..	x_{nj}	..	x_{nk}	P_n	$\bar{P}_n$
Total	T_1	T_2		T_j		T_k	G	

FIGURE 5.1: SCHEMATIC REPRESENTATION OF THE ESTIMATION OF RELIABILITY USING WINER'S INTRACLASS

persons 'i' ($\bar{P}_i$) is due to:-

a) the true magnitude of the characteristic possessed by 'n' people; and also,

b) in part, to differences in the average error of measurement.

If Judge 1 rates persons 'i' in the same order as Judge 2, but he tends to give everyone a higher score than Judge 2, such differences (represented by T in Figure 5.1) would be included in the error variance (π_i). In relation to the studies of validity and reliability, this means that, if the projected OA/S structures produced age/service cells which, whilst ranked in the same order as the validated OA/S structure, actually always consisted of too many or too few individuals, then the resultant intraclass correlation would reflect this error and be lowered.

There is also a potential problem in the nature of the data. The measure of frequency within age/service cells represents an ordinal measurement. Normally, only data at the interval level or above would be used for analysis in a variance model. However, Winer (1971) himself uses ranked data (ordinal measurement) in the development of his technique. On these grounds, it is felt that the statistical assumptions of Winer's intraclass correlation are not unduly violated by the OA/S structure data.

5.7: THE STUDY OF VALIDITY

5.7.1: Methodology

The model developed is used to project each OA/S structure over an eleven-year period. The initial OA/S structure is projected from its April 1980 state to its estimated structure in April of each of the subsequent eleven years (1981 to 1991 inclusive). In order to check on the validity of these projections, the real OA/S structure at the Manufacturing Plant in April of each year needs to be established. The initial projection parameters were established during 1980, and used to make five sets of estimates. During this period, arrangements were made to return to the Manufacturing Plant in April 1981 and April 1982 to resample the workforce. Two samples were accordingly made on these dates. The methodology used was exactly the same as practised in April of 1980, and has been detailed in Section 2.3 above. The age, length of service, job grade and sex were recorded for all individuals. The six occupational functions detailed in Section 3.1 were sampled, and their OA/S structures were calculated. The twelve OA/S structures obtained in order to complete the validity study are included in Appendix 12. For each occupational function, in each of the first two years of the projection period, data have now been established for:-

1. The actual OA/S structure
2. The projected OA/S structure under five sets of alternative parameters.

In total, then, 60 tests will be made to test for the validity using Winer's intraclass correlation technique (see Section 5.6.3 and Figure 5.1 above).

5.7.2: Results of Winer's intraclass correlation

The results of the calculations are summarised overleaf in Table 5.1. In order to determine which set of parameters produced the most accurate OA/S structure (with the closest number of individuals also accounted for), the intraclass correlations for years 1981 and 1982 are converted into z scores, and then averaged. The set of

OCCUPATIONAL FUNCTION	YEAR	PROJECTION PARAMETER POPULATION BOUNDARIES				
		Sample	Upper Demand and Upper Supply	Upper Demand and Lower Supply	Lower Demand and Upper Supply	Lower Demand and Lower Supply
CLERICAL	1981	0.9079	0.8962	0.9000	0.9184	0.8993
	1982	0.8845	0.8603	0.8677	0.8678	0.8790
HIGHER MANAGEMENT	1981	0.8050	0.7871	0.7871	0.8126	0.8126
	1982	0.9819	0.9869	0.9869	0.7885	0.7885
SKILLED MANUAL	1981	0.8156	0.8205	0.8198	0.7834	0.8153
	1982	0.7466	0.7243	0.7876	0.7077	0.7459
SUPERVISORY	1981	0.6523	0.6454	0.6603	0.6478	0.6895
	1982	0.7080	0.6920	0.7226	0.7264	0.7191
MIDDLE MANAGEMENT	1981	0.8826	0.8364	0.8628	0.8759	0.8881
	1982	0.7684	0.5809	0.7199	0.6721	0.8015
TECHNICAL	1981	0.8741	0.8530	0.8530	0.8785	0.8785
	1982	0.9058	0.8228	0.8228	0.9183	0.9183

TABLE 5.1: DIFFERENTIAL VALIDITY WITHIN PROJECTION PARAMETER POPULATION

parameters which produced the highest average validity over the two years was then chosen for further study. The most valid set of projections for each of the six occupational functions are noted in Table 5.1, and the statistical detail for these estimates is included in Appendix 13.

It can be seen that, after two years, the most valid set of projections chosen for each of the occupational functions all satisfy the +0.70 criterion for the correlation (as recommended by Anastasi, 1976; Cronbach, 1970).

The highest validity coefficient for the clerical and higher management functions is achieved using the sample estimates for the parameters. After two years, the validity of the projected OA/S structures are +0.8845 and +0.9819 respectively. These are both highly significant results.

The skilled manual function produced the most valid projections using the upper demand and lower supply parameters.

The supervisory, middle management and technical functions all produced the best projections using the lower demand and lower supply parameters.

5.7.3: A statement on the validity of projections made by C.A.S.T

Clearly, as the projections are being made over an eleven-year period, whilst validity has only been established for the first two years, no inferences can be made about the validity of the later projections. However, the ability to make a valid prediction of the manpower stock within an occupational function two years hence is a useful one and worthy of comment. The following statements can be made about this two-year validity of the projected OA/S structures:-

1. All six occupational functions can be validly projected in that the range of correlations established (+0.7191 to +0.9819) for the functions are all above the arbitrary though traditional criterion of +0.7000.

2. It might be expected that as more projection years pass, the validity of the results suffer. Two sample points do not allow for such trends to be tested, but as three of the six occupational functions showed more valid results in the second year in comparison to the first year, and the other three functions showed less valid results, it is contended that no such linear decrement or increment pattern of validity coefficients can be assumed.

3. Does validity significantly differ across occupations? The statistical technique detailed in Section 3.7.1 (see Yeomans, 1968) for comparing correlations for significant differences is used to compare the six second-year validity intraclass correlations detailed in Table 5.1. All the correlations have 103 degrees of freedom associated with them. As fifteen comparisons are made, a more conservative alpha level of $p<.01$ is adopted. The results are detailed in Table 5.2 below.

	SKILLED MANUAL	MIDDLE MANAGEMENT	CLERICAL	TECHNICAL	HIGHER MANAGEMENT
SUPERVISORY	1.17 N.S.	1.44 N.S.	3.59 $p<.001$	4.92 $p<.001$	10.55 $p<.001$
SKILLED MANUAL		0.28 N.S.	2.42 N.S.	3.75 $p<.001$	9.38 $p<.001$
MIDDLE MANAGEMENT			2.15 N.S.	3.48 $p<.001$	9.11 $p<.001$
CLERICAL				1.33 N.S.	6.96 $p<.001$
TECHNICAL					5.63 $p<.001$

KEY: Upper figure denotes the z score generated by the comparison between the correlations

Lower figure denotes the level of significance associated with the z score

TABLE 5.2: z SCORES TO ESTABLISH SIGNIFICANT DIFFERENCES IN VALIDITY ACROSS OCCUPATIONAL FUNCTIONS

The high validity of +0.9819 established for the higher management function is significantly higher than the validity established for all other occupational functions. The validity of +0.9183 established for the technical function is higher than that for the middle management, skilled manual and supervisory functions. Finally, the validity of +0.8845 established for the clerical function is higher than that for the supervisory function. So validity does differ significantly across occupational functions.

5.8: THE STUDY OF RELIABILITY

5.8.1: Methodology employed

Five parallel but independent computer runs were made for each year projected by C.A.S.T. These runs operated under the same external conditions which, as noted, consist of two sets of variables - the parameters and the age behaviour patterns - and were also independent. Run One input the original 1980 workforce into the program, and produced the first version of the 1981 workforce. Run Two similarly started with the 1980 workforce, and created a second version of the 1981 workforce. This procedure was carried out five times. Since the operating variables were controlled, any differences observed between the five projected workforces for each year are only due to error within the manipulations made by

C.A.S.T. when used repeatedly. The dependent variable generated in this study is the number of individuals within 52 age/service cells using five-year bands. Six occupational functions have been projected under one set (the most valid) of parameters. Five runs were made for each function. Winer's intraclass (see Section 5.6.3) is used to measure the similarity between the resulting OA/S structures from these five runs. An estimate of reliability is made for each of the eleven years projected.

5.8.2: Results of Winer's intraclass correlations

Table 5.3 overleaf summarises the 66 estimates of reliability for each of the six occupational functions over eleven years. The statistical details for the first year's reliability estimate for each function are included in Appendix 14 as examples of the calculations.

It can be seen from Table 5.3 that the OA/S structures projected by C.A.S.T. are highly reliable over a series of parallel runs. The average intraclass correlations range from +0.9837 to +0.9961. The range is so little across such high correlations that no attempt will be made to test for significant differences between correlations. It is also apparent that there is no time trend in reliability, although the methodology employed is not very well-suited to test for this.

The high reliability confirms that the age/service

YEAR	OCCUPATIONAL FUNCTION					
	HIGHER MANAGEMENT	TECHNICAL	CLERICAL	MIDDLE MANAGEMENT	SKILLED MANUAL	SUPERVISORY
1981	0.9673	0.9877	0.9913	0.9906	0.9818	0.9631
1982	0.9819	0.9899	0.9919	0.9945	0.9613	0.9741
1983	0.9802	0.9904	0.9953	0.9863	0.9920	0.9837
1984	0.9807	0.9834	0.9982	0.9989	0.9878	0.9963
1985	0.9880	0.9927	0.9987	0.9954	0.9864	0.9862
1986	0.9914	0.9467	0.9980	0.9985	0.9608	0.9842
1987	0.9876	0.9933	0.9979	0.9969	0.9943	0.9924
1988	0.9850	0.9945	0.9974	0.9969	0.9926	0.9833
1989	0.9836	0.9956	0.9973	0.9988	0.9922	0.9864
1990	0.9875	0.9945	0.9958	0.9966	0.9946	0.9922
1991	0.9884	0.9915	0.9957	0.9948	0.9917	0.9803
AVERAGE RELIABILITY	0.9837	0.9873	0.9961	0.9953	0.9850	0.9838

TABLE 5.3: INTRACLASS CORRELATIONS TO SHOW RELIABILITY OF OA/S STRUCTURES OVER PROJECTION PERIOD

behaviour patterns used to decide which individuals will leave or join the workforce operate reliably with regard to age and service.

5.9: CONCLUSIONS FROM THE STUDIES OF VALIDITY AND RELIABILITY

The analyses conducted in this chapter have provided the following findings and conclusions:-

1. The validity of the OA/S structures projected by C.A.S.T. varies across the population of demand and supply parameters that may be used to govern the movement of manpower.

2. However, the methodology employed has allowed for the upper and lower population limits to be used as the best estimate for these parameters. The set of parameters which produced the most valid OA/S structures is used as the basis for the eleven-year projections.

3. After two years, the validity of all six occupational function projections was high, and above the +0.70 correlation criterion. Validity coefficients ranged from +0.7191 to +0.9819.

4. These validity coefficients differ significantly across occupations. Whilst all projections are

suitably valid, the most valid projections are those for the higher management, technical and clerical occupational functions.

5. Not only are the projections made by C.A.S.T. highly valid over a two-year period, but they are also extremely reliable. The reliability coefficient for any one projection (from a population of five) ranges from +0.9837 to +0.9961.

6. The data which are projected for the six occupational functions in the next chapter, though based on a simulation of future longitudinal change, can be considered both valid and reliable.

CHAPTER SIX

CHANGING AGEING CHARACTERISTICS IN THE FUTURE: RESULTS OF THE PROJECTIONS FROM C.A.S.T.

6.1: INTRODUCTION TO THE RESULTS OF THE PROJECTIONS

The following short chapter concludes Part Two of the research by detailing the results of the projections made by C.A.S.T.. Briefly, the argument so far has been as follows. Part One studied occupational age structures within the organisational setting. A departure from previous research was made by incorporating the additional variable of length of service. This made study of change within the occupational age/service (OA/S) structures easier to follow. However, the one disadvantage was that the proportions of individuals within age bands could not be ratioed against similar proportions of economically active individuals (see Smith, 1968a, 1973; and Chapter One for discussion of statistical measurement of age structures). Ten occupational functions within a large organisation were studied, and their OA/S structures derived. In similar vein to Smith (1970, 1975), these OA/S structures were clustered, and classified into four underlying types of age/service structure. A representative sample of these underlying types of structure were drawn from a single site within the organisation (the manufacturing plant). Longitudinal change in the rates of ageing and mean age of this sample of occupations was established in a quasi-longitudinal study using retrospective data. Detailed analysis and description showed that, whilst (on the basis of observed RAI's) change in the OA/S structures could be summarised as following either Smith's (1963) Hypothesis A or

Hypothesis H (see Sections 1.5.5 and 3.3.4); in fact, the majority of OA/S structures were subject to a mixture of both historical and age-linked effects. Consequently, the balance between the two conflicting influences upon the OA/S structures could change over time, rendering results based purely on retrospective study invalid. Future change in the OA/S structures (in which the relative importance of Hypothesis A or H might alter) must be accounted for before occupational age/service structures are used to diagnose underlying links between age and performance.

Part Two of the research has been aimed at developing a suitable technique to allow future change in OA/S structures to be measured, and accounted for. The technique (called C.A.S.T.) was developed as a manpower model, based upon a series of methodologies (see Figure 4.2) and statistical techniques. The reliability and validity of projected OA/S structures has been tested in the previous chapter, and concluded as being sufficient to allow the use of the projected data. This chapter is designed to present the results of the projections in a comparative manner to the retrospective study described in Chapter Three. As attention is focussed upon those data which measure age change, (RAI's and the OA/S structures), detail of the manpower movements will be presented for reference, but not discussed.

6.2: RESULTS OF PROJECTIONS TO ESTABLISH FUTURE AGEING

6.2.1: Rates of Ageing Indices over three time periods

Appendix 14 includes all the relevant information produced by the projections. Tables 'a' to 'l' show the data for the OA/S structures in 1985 and 1991 for each of the six occupational functions. Figures 'a' to 'f' illustrate these two age structures for the aforementioned years. The manpower movement information, including the number of individuals and percentage movement rate for: who was recruited; left voluntarily; took early retirement; retired mandatorily; took voluntary redundancy; or was made redundant; sample size; mean age; RAI; mean length of service and RSI are also included. These data are summarised for each of the six occupational functions in Tables 'm' to 'r' in Appendix 14.

Table 6.1 overleaf presents the RAI's for each of the six occupational functions under study. The data for the years 1974 to 1980 are drawn from the retrospective study described in Chapter Three. The data for the years 1981 to 1991 are drawn from the projections made by C.A.S.T..

From Table 6.1, it is apparent that the magnitude of the RAI's changes between the retrospective and projected period for some of the occupational functions. These changes are detailed overleaf in Table 6.2, which shows

YEAR	OCCUPATIONAL FUNCTION					
	HIGHER MANAGEMENT	MIDDLE MANAGEMENT	SKILLED MANUAL	TECHNICAL	SUPERVISORY	CLERICAL
1975	1.15	0.99	0.68	1.95	0.64	1.11
1976	2.04	0.58	-0.77	-0.35	0.47	0.27
1977	-0.75	1.25	0.72	0.57	2.55	-1.31
1978	1.37	1.33	-1.14	0.91	1.38	-0.36
1979	1.29	0.58	-0.84	1.50	1.30	0.92
1980	-0.87	0.73	-0.41	0.62	-3.61	0.21
1981	0.34	1.39	0.90	0.84	0.68	1.44
1982	1.12	0.53	1.36	0.75	0.66	0.85
1983	0.67	0.93	0.51	0.40	0.82	0.25
1984	0.45	0.92	0.35	-0.02	0.51	0.44
1985	0.43	0.75	0.53	0.91	0.35	0.98
1986	0.97	0.73	0.79	0.78	0.99	0.30
1987	0.53	0.75	0.02	0.57	0.34	0.03
1988	0.97	0.58	-0.36	0.05	0.87	-0.27
1989	0.84	0.55	-0.04	0.37	0.66	-0.26
1990	0.91	0.69	-0.09	0.48	0.39	0.16
1991	0.34	0.61	0.86	0.92	1.05	0.20

TABLE 6.1: RETROSPECTIVE AND PROJECTED RAI'S FOR SIX OCCUPATIONAL FUNCTIONS (1975 TO 1991)

OCCUPATIONAL FUNCTION	MEAN RAI 1974-1980	MEAN RAI 1981-1986	MEAN RAI 1987-1991	MEAN DIFFERENCE IN RAI'S	t VALUE AND SIGNIFICANCE (Df=9)
TECHNICAL	+0.87	+0.61	+0.48	-0.39	-1.01 N.S.
MIDDLE MANAGEMENT	+0.91	+0.88	+0.64	-0.27	-1.79 N.S.
HIGHER MANAGEMENT	+0.50	+0.66	+0.72	+0.22	0.02 N.S.
SUPERVISORY	+0.46	+0.68	+0.67	+0.21	0.21 N.S.
CLERICAL	+0.14	+0.71	-0.03	-0.17	-0.41 N.S.
SKILLED MANUAL	-0.29	+0.74	+0.08	+0.37	0.91 N.S.
MEDIAN RAI	+0.48	+0.70	+0.56		

TABLE 6.2: DIFFERENTIAL CHANGE IN RAI'S OVER TIME IN SIX OCCUPATIONAL FUNCTIONS

the average RAI for three time periods; the mean difference between these RAI's in years per year; and the results of two-tailed independent t tests between the two extreme sets of data for each occupational function.

The t tests show that the RAI's for each occupational function do not significantly differ between the periods 1974 to 1980 and 1987 to 1991. However, the RAI metric is measured over a small range, and is not discriminating enough to show statistically significant differences. For example, a mean difference of +0.50 years per year (with a sample of only six in each group) would be unlikely to produce a significant value of t, and yet the effect of such a difference in RAI would be extremely marked upon OA/S structures.

6.2.2: <u>Differences in mean age within occupational functions</u>

Table 6.3 overleaf presents the mean age in years from 1974 to 1980, and 1987 to 1991 for each occupational function. The t value for tests between the mean ages in these two time periods are also shown.

All six occupational functions age significantly between the periods 1974-1980 and 1987-1991. The relative order in terms of age changes slightly. For example, the skilled manual function was the second oldest (out of the six) occupation from 1974 to 1980, but by 1987 to 1991, it had dropped two ranks and was the third

OCCUPATIONAL FUNCTION	MEAN AGE 1974-1980	MEAN AGE 1987-1991	MEAN DIFFERENCE	t VALUE (Df=10)
SUPERVISORY	43.90	49.66	+5.76	5.00 $p<.001$
SKILLED MANUAL	40.71	43.60	+2.89	6.52 $p<.001$
HIGHER MANAGEMENT	40.57	48.20	+7.63	8.13 $p<.001$
MIDDLE MANAGEMENT	36.36	46.19	+9.83	9.86 $p<.001$
TECHNICAL	35.40	42.87	+7.47	8.67 $p<.001$
CLERICAL	34.41	38.52	+4.11	14.26 $p<.001$

TABLE 6.3: CHANGE IN MEAN AGE OVER TIME IN SIX OCCUPATIONAL FUNCTIONS

youngest occupation.

6.3: A TYPOLOGY OF AGEING CHARACTERISTICS

The data in Table 6.2 show that the median RAI for the six occupational functions increased from +0.48 years per year, to +0.56 years per year between the periods 1974-1980 and 1987-1991. There was a general acceleration of ageing in the occupational functions across these two periods. However, the years between 1981 and 1986 were characterised by extremely rapid ageing in all occupational functions. This was most probably due to the extraordinary types of manpower movements practised throughout the recession from 1980-1983, and the immediate aftermath of this turbulent period. The second half of the projection period is characterised once more by differential ageing across occupational functions. There are, in fact, four types of change which are possible, and these are illustrated overleaf in Figure 6.1.

Occupational functions which show a RAI which is higher than the sample median RAI (above median ageing) are classified as conforming to Hypothesis H. A RAI lower than the sample median RAI (below median ageing) is classified as Hypothesis A. There are, then, four patterns of potential change:-

1. occupation shows consistent age-linked change
2. occupation has shown historical change in the

		1987-1991	
		HYPOTHESIS A	HYPOTHESIS H
1974-1980	HYPOTHESIS A	1. Consistent Age-Linked	3. Developing Historical from Age-Linked
	HYPOTHESIS H	2. Developing Age-Linked from Historical	4. Consistent Historical

FIGURE 6.1: TYPOLOGY OF FOUR TYPES OF CHANGE IN THE AGEING CHARACTERISTICS OF OCCUPATIONAL FUNCTIONS

past, but will begin to show age-linked change in the future

3. occupation has shown age-linked change in the past, but will begin to show historical change in the future

4. occupation shows consistent historical change.

6.3.1: Occupations which show consistent age-linked change

Figure 6.2 overleaf illustrates the ageing characteristics of the skilled manual and clerical functions, both of which showed consistent age-linked change in the periods of 1974 to 1980, and 1987 to 1991. The skilled manual function showed an acceleration of ageing, but still remained as an occupation which showed clear age-linked change. The average RAI from 1987-1991 was only +0.08 years per year. The clerical function actually

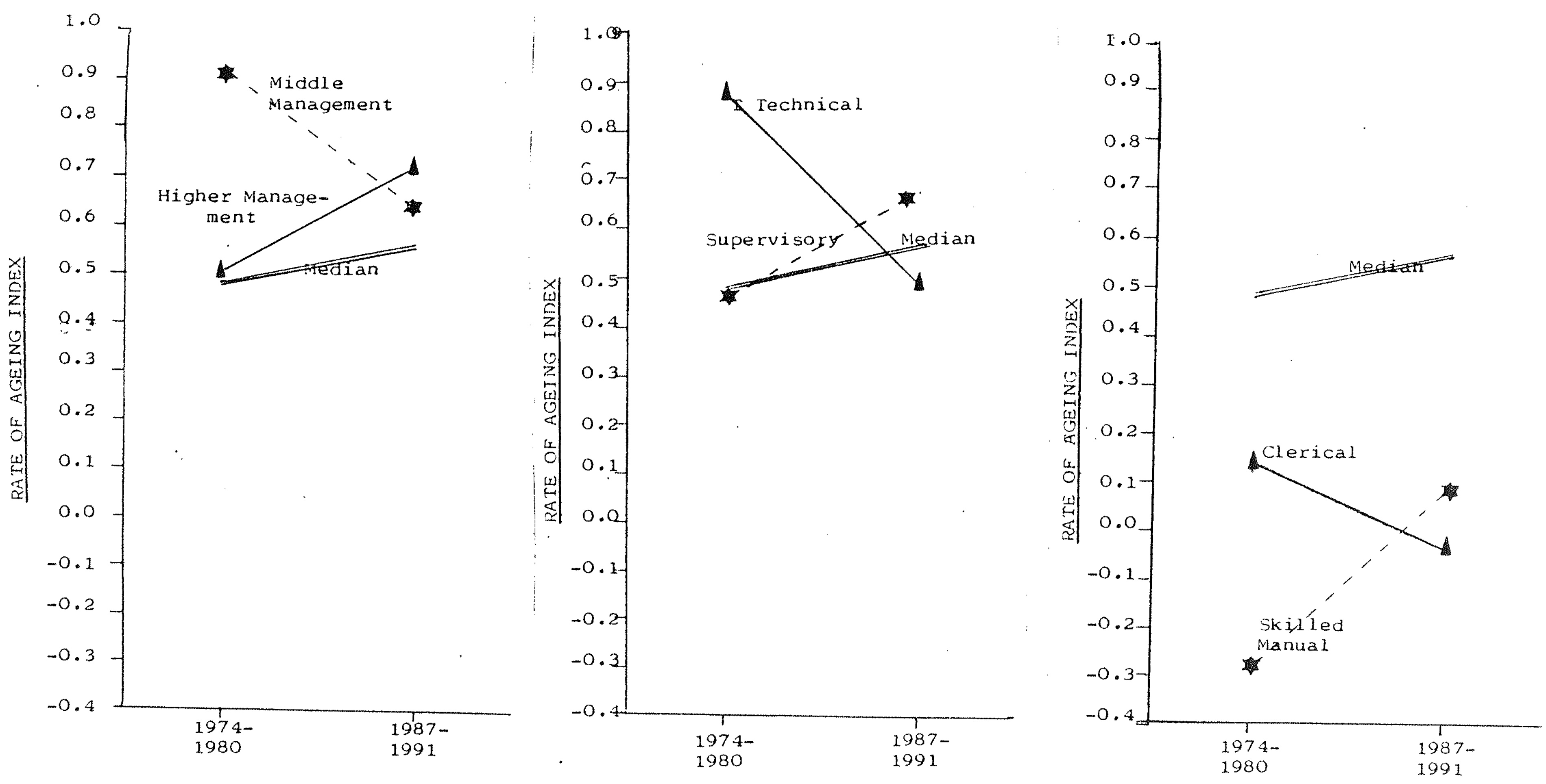


FIGURE 6.2: CHANGING AGE CHARACTERISTICS OF THE SIX OCCUPATIONAL FUNCTIONS OVER TIME

showed a deceleration of ageing over the two time periods, from +0.14 years per year to -0.03 years per year.

6.3.2: Occupations which will show age-linked change in the future

There is only one occupation which will show age-linked change in the future, having shown historical change in the past. The RAI for the technical function decelerates from +0.87 years per year in 1974 to 1980, to +0.48 years per year in 1987 to 1991, as illustrated in Figure 6.2.

6.3.3: Occupations which will show historical change in the future

Figure 6.2 also shows the changing ageing characteristics of the supervisory function. This occupation showed marginal age-linked change in 1974 to 1980 (+0.46 years per year). By 1987 to 1991, the RAI has accelerated to +0.67 years per year.

6.3.4: Occupations which show consistent historical change

Figure 6.2 illustrates the changing age characteristics of the higher and middle management occupational functions, both of which show consistent historical change. The RAI for the higher management function accelerates from +0.50 years per year, to +0.72 years per year. Conversely, there is a deceleration of ageing in the middle management function from +0.91 years per year, to +0.64 years per year. Both occupations remain clearly in the category of historical change.

6.4: CONCLUSIONS TO THE STUDY OF FUTURE AGEING

The age data gathered as part of the information provided by the manpower model projections has led to the following findings and conclusions:-

1. All six occupational functions significantly age from the period of retrospective study (1974 to 1980), to the last five years of the projection period (1987 to 1991). Mean ages increase between these two periods by as much as 9.83 years for middle management.

2. The majority of this increase in age occurs between the years 1981 and 1986. During these years, the manpower parameters take account of the economic recession, and the fluctuations of growth which immediately follow (see Chapter Four). Voluntary turnover and recruitment both drop to relatively low levels, and there is consequently an increased trend to historical ageing in all occupational functions.

3. By 1987, differences in the RAI's between occupational functions re-emerge. Whilst later rate of ageing rates do not significantly

differ from those established in the earlier retrospective study, there are still marked changes in the magnitude of the RAI's.

4. These changes fall into four patterns. The middle and higher management functions show consistent historical ageing (above median RAI's). The clerical and skilled manual functions show consistent age-linked change (below median RAI's). The supervisory function changes from showing age-linked change to historical ageing. The rate of ageing accelerates by +0.21 years per year, maintaining this function as the oldest in the sample. The technical function shows a fourth type of change. It moves from showing historical ageing to age-linked change. The rate of ageing decelerates by -0.39 years per year, and the technical function remains as the second youngest out of the six occupations.

5. Following the hypotheses made by Smith (1973), all those occupations which have shown a consistent age-linked change over both the period of retrospective study, and projection, are likely to exhibit an underlying relationship between age and performance. Furthermore, the technical occupational function, which has been shown to move towards age-linked change,

is also likely to exhibit an underlying relationship between age and performance.

6. There is a need to theoretically review the evidence which has studied the link between age and work performance within several occupations, and to establish experimentally if there is a relationship between age and work performance.

PART THREE

AGE AND PERFORMANCE IN THE WORKPLACE

CHAPTER SEVEN

AGE AND PERFORMANCE IN THE WORKPLACE: REVIEW OF RESEARCH FINDINGS

7.1: INTRODUCTION TO THE REVIEW OF RESEARCH ON THE AGE - WORK PERFORMANCE RELATIONSHIP

Part One of the research analysed occupational age/service structures (OA/S structures) within an organisation, and a quasi-longitudinal study was carried out to analyse change in a sample of these OA/S structures. In broad terms, this change has been categorised into two types by Smith (1973). Hypothesis H occupations show longitudinal changes which purely reflect the historical development of that occupation. In such occupations, age and service of individuals increase in line with the years that pass. Hypothesis A occupations show age-linked change, in that the OA/S structure remains the same over time. It is implied that movement into and out of such occupations is such that the age distribution remains unaltered. The cause of, for example, a continual paucity of individuals aged over 50 is assumed to be an age-job demands effect starting at this age.

The longitudinal study in Part One showed that, at the organisational level, OA/S structures were, in fact, influenced by a mixture of these factors. Nevertheless, age change as operationalised by RAI's could still be categorised as overall historical, or age-linked change.

From the analysis of age behaviour patterns in Part One, it was clear that some occupations which, in the past, had shown historical change, might, at some future date, have aged sufficiently to be affected by age-linked change. Conversely, other occupations which had initially shown age-linked change, might simply, through the weight of numbers, "overpower" the organisation's ability to control the age structure, and ageing would accelerate.

A computer ageing simulation technique (C.A.S.T.) based upon a series of data and statistical techniques was developed to project the sample of OA/S structures into the future. Once the reliability and validity of these projections were established, the future change was detailed, and compared with the previous period of change. Whilst the overall categorisation of occupations into type A or H remained unaltered, two types of change were noted. Most occupations showed a tendency for accelerated ageing. However, the technical and middle management occupational functions showed a clear deceleration of ageing. These two occupations, and especially the technical function, showed a developing tendency to become age-linked occupations.

The central question which must now be answered is the following. Does actual performance in the workplace bear out the contention that there is an age-performance relationship within these OA/S structures? The technical occupation showed the strongest historical to age-linked change, and a job from this overall occupational function will be studied.

Before details of the study are discussed, a detailed review of research findings is presented. The performance study described in Chapters Eight and Nine is intended to overcome the methodological limitations of previous research where possible.

7.2: METHODOLOGICAL ISSUES

In a recent and comprehensive review of age differences in work attitudes and behaviour, Rhodes (1983) developed a framework which partitioned the causes of observed age-related differences in behaviour. There are four major effects which might cause behaviour to change in relation to age.

7.2.1: Period effects (present environment)

Baltes (1968) classified a period effect as a time-of-measurement difference representing present environmental influences. Period effects include:-

1. change in the work environment, e.g. nature of supervision, co-worker relations, rewards;
2. change in the non-work environment, e.g. labour market conditions, services;
3. age-related expectations of others.

7.2.2: Cohort effects (past environment)

Rosow (1978, p.67) defines a cohort as "a sociologically meaningful entity, a social cohort:

1. consists of people who share a given life

experience;

2. this experience is socially or historically structured;

3. it occurs in a common generational framework;

4. its effects distinguish one generation from another; and

5. these effects are relatively stable over the life course."

Cohort effects result from successive cohorts each being influenced by their particular set of life experiences. These different sets of life experiences determine their attitudes and behaviours. Aspects of the cohort effect which may be reflected in age-related behaviour include:

a) past experiences, e.g. Great Depression, World War Two;

b) size and structure of cohort;

c) educational level of cohort.

Cross-sectional studies, in particular, are liable to confound cohort effects with age effects.

7.2.3: Systematic error effects

There are four sources of systematic error which could account for age-related differences in behaviour:-

1. Selective sampling - Whilst cross-sectional studies are liable merely to reflect cohort effects, longitudinal studies often suffer from selective sampling. The repeated and prolonged participation required biases the subjects

studied (normally in an upward direction with higher intelligence and socio-economic status). Such error limits the generalisability of results, and comparability with cross-sectional studies.

2. Selective survival - This refers to changes in the composition of a given cohort "in conjunction with the aging process as a result of death or incapacitation" (Baltes, 1968, p.150). Welford (1958) notes that the use of production records as a performance criterion is often subject to this error. It is unlikely that a marked drop in productivity would go unnoticed. The poor performer is likely to have left the sample, and if such behaviour is linked with age, then those left in the sample no longer truly represent their cohort. Jobs which have high attrition are likely to represent samples which show selective survival.

3. Selective drop-out - This is where subjects drop out of an experiment during its course due to loss of interest, changing residence and so forth. This drop-out is also referred to as experimental mortality, and affects longitudinal studies particularly.

4. Testing effects - These occur notably in

longitudinal studies, or poorly-controlled cross-sectional studies. Sources of systematic testing effects include increased sophistication due to practice, deliberate coaching, time of testing effects, and the 'age-fairness' of the tests used. To the extent that these features vary with age, they introduce systematic error into the results.

7.2.4: Age effects

Finally, changes in behaviour related to age can be caused by pure age effects. These are developmental in nature and systematically related to time. There are two categories of age effects:-

1. Psychosocial ageing - This refers to systematic changes in personality, needs, expectations, performance and behaviour in a sequence of socially prescribed roles and accumulation of experiences. These roles involve particular expectations for behaviour, and influence an individual's needs.

2. Biological ageing - This refers to anatomical and physiological changes that occur with age, e.g. changes in sensorimotor performance, muscle strength, brittleness of skeletal structure, visual acuity, and reaction time.

7.2.5: General methodological problems

The majority of experimental designs make it difficult to isolate the cause of any observed age differences, given the above range of effects. There is, however, another set of effects which need to be highlighted as general methodological problems:-

a) Incomplete reporting of age characteristics - Rhodes (1983) noted that approximately 18 per cent of studies did not report age characteristics of the samples. Knowledge of complete age characteristics (mean, standard deviation, range, etc.) are invaluable for interpretation of results.

b) Choice of population or sample - Studies which use representative samples or massed aggregates are both necessary, but have different benefits. Large-scale studies are more generalisable, but may obscure causal explanations, whereas sample studies are less generalisable, but often provide causal explanations because of the increased control over conditions. Rhodes (1983) points out that many sample studies had insufficient numbers in the older age bands, limiting the statistical validity of the results.

c) Performance criterion - The major requirement of performance criteria is that they are specified, reliable and valid (see Chapter Five for a discussion of these concepts). Cascio (1982) has documented the instability of performance output indices (with the exception of piece rate measures), and such unreliability may cause systematic errors in the age-performance relationship. Reliability may be increased either by obtaining statistical estimates, or by averaging criteria data over a sufficiently long time period. Validity of criteria is extremely important, and is often overlooked. The use of one criterion of performance, unless based on a thorough job analysis, may often only measure a single facet of job performance of undetermined usefulness. The measurement of several performance criteria can again help to increase the validity of the results.

d) The law of small numbers - Schmidt and Hunter (1978) showed that many proposed moderators in personnel psychology may be illusory. Adequate statistical power in moderator research requires much larger sample sizes than are typically employed, and a pooling across several small sample studies to obtain statistical power equivalent to that of a large sample study can show that many moderators do not exist, e.g. race. Many studies of the age-performance relationship are based on small sample studies, and the extent of the overall statistical strength of effect is untested.

7.2.6: The framework for the review of studies on the age-performance relationship

The following review of the age-performance relationship will attempt to conform to the requirements detailed above. Studies are classified according to:

a) the performance criterion employed (e.g. production records, ratings, appraisals)

b) occupational area.

The division of studies into this framework should help to clarify the research findings which "generally provide mixed results on the relationship between age and performance" (Rhodes, 1983).

Details on the sample nature and size; measure of performance; and statistical result will be given where possible. A distinction will also be made between univariate and multivariate studies, that is studies which have used age as the only independent variable (univariate); or age, with at least one other independent variable (e.g. service experience) controlled for (multivariate).

7.3: PRODUCTION RECORD STUDIES OF SEMI-SKILLED AND SKILLED MANUAL JOBS

7.3.1: Univariate studies showing an inverted U relationship

Four production record studies of semi-skilled and skilled manual work have shown an inverted U relationship between age and performance. King (1956) analysed the production records of female semi-skilled sewers engaged in such trades as overlocking, flat locking, welting, elasticating and plain sewing. Production records were sampled for four eight-week periods in 1949, 1950, 1952 and 1953. Only 13.6 per cent of the sample were aged over 40, producing a truncated upper age band of 40-60 years old.(e.g. only twelve subjects were aged over 40 in the 1950 sample). The mean age of the samples was 26.27 years, showing a strong negative skew over the age range. Turnover rates were also high. The results showed that performance initially rose, reaching a peak somewhere between the ages of 30 and 40. Average performance of the 40-60 year olds dropped by 3.75 per cent in the 1950 sample. This below-peak production was still above average and 16.67 per cent above the level of production shown by the 15-17 year olds. The exact age limit of the decline in production could not be established because of the truncated age range. The criticism of selected attrition caused by high turnover was, to some extent, countered by a series of sub-analyses conducted on the four year longitudinal data. The majority of movers into and out of the workforce were aged between 21-30 years. The performance of those who left, or were about to leave, was consistently lower than those who stayed. However, this low performance did not differ between leavers aged either under or over 20 years. King (1956) argued that the slow decline in performance with age was not due to selective attrition whereby older leavers performed significantly worse than younger leavers. Age changes in sensorimotor capacity were hypothesised as affecting the ability to deal with new tasks more than the ability to maintain an already established skill. This inability to deal with new tasks was considered to be the cause of the slight age decline in production.

Clay's (1956) study was carried out at two printing works (Works A and B). Her sample consisted of 35 machine compositors, 100 hand compositors and 14 proof readers. Production records were obtained in three thirteen-week periods over a three-year period. Turnover rates in both works were negligible. Unfortunately, different production indices were used for each of the two works, and separate analyses were required. Figure 7.1 overleaf shows the relationship between age and performance averaged across job groups. Clay's data indicate that the performance of machine compositors in the age range 50-59 years declined by either 10 per cent (Works A) or 6 per cent (Works B) from peak productivity, which occurred between the ages of 40-49 years. At Works A, performance of hand compositors only declined by 2 per cent for 50-59 year olds, and 9 per cent for workers in their sixties. At Works B, hand compositor performance did show a marked decline of 16 per cent for the 50-59 year olds. Performance in skilled work showed a continuous improvement with age until the age of 45, after which there was a

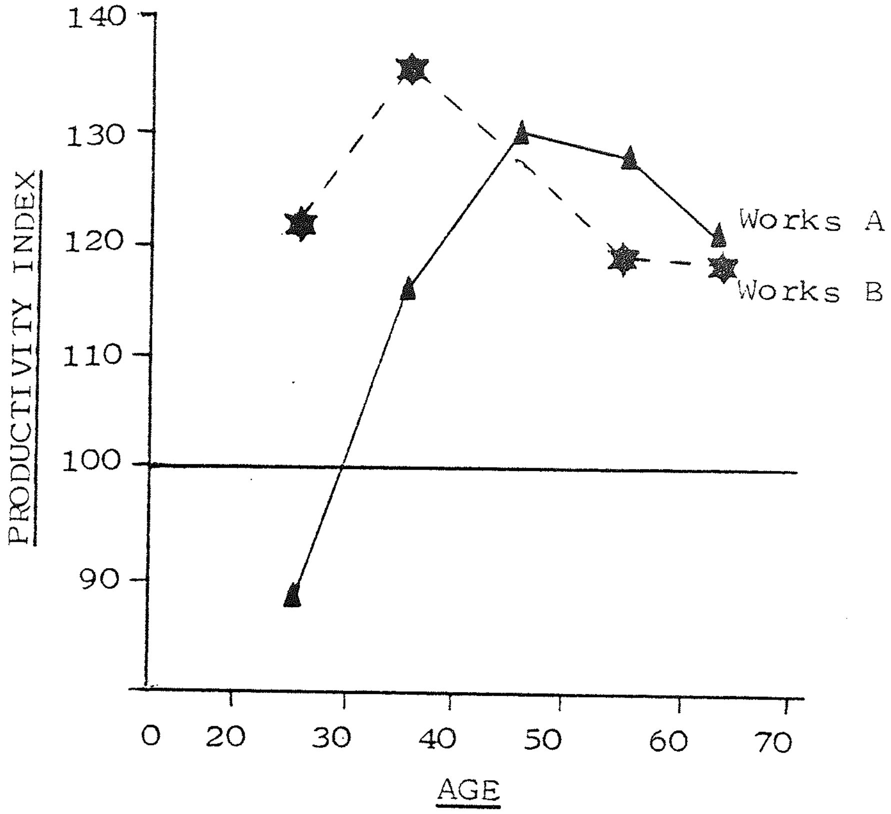


FIGURE 7.1: AGE AND PERFORMANCE AT TWO PRINTING WORKS (after CLAY, 1956)

Source: Smith (1981)

gradual decline. However, except for seven machine compositors at Works B, the performance of the oldest age groups was always higher than that of the 20-29 year olds. One difficulty associated with Clay's study is the relatively small samples of older employees in some jobs. Around 35 per cent of the sample was aged over 50, but in some cases, data were collected from very small numbers of individuals (for example, one machine compositor aged over 60 at Works B; two machine compositors aged over 50 at Works A).

The study conducted by the United States Department of Labor (1957; see also Greenberg, 1961) was not subject to the limitations of a small sample. Records of output-per-man-hour were examined in a range of industries. Records were transformed so as to give the 35-44 year old age group an index of 100, with the performance of other age groups being expressed as a proportion of this index. Data from 15 large establishments in the men's footwear industry showed that performance increased until the age of 34, and thereafter showed a continual decline. Performance of the over 65 year olds was still only 17 per cent below the peak performance. Similarly, data from eleven establishments in the household furniture industry showed a 14 per cent decline in output from peak performance by the age of 64 years.

Finally, Mark (1957) studied production records for 5100 male and female blue collar workers, and reported lower performance for both the under 25 and over 55 age groups.

7.3.2: Univariate studies showing a negative relationship

Two univariate studies of age and work performance in semi-skilled and skilled jobs have reported a negative relationship between age and performance (Greenberg, 1961; Mark, 1956).

7.3.3: Univariate studies showing no relationship

Three studies have reported no relationship between age and performance in blue collar jobs (Breen & Spaeth, 1960; Chown & Heron, 1965; Heron & Chown, 1961; Salvendy, 1972). Salvendy (1972) studied the link between various psychological test scores and production indices with a sample of 181 female operators making confectionary and electro-mechanical goods. Test performance did not decline for dexterity, and productivity rose with age. This study, as with many others, was subject to selective survival. A further difficulty was that supervisors allocated the easier tasks to the older operators, thereby inflating their production indices. The lack of task control within job performance is a common difficulty in studies based on production records. Chown and Heron (1965) reported that, in a sample of factory workers, whilst performance on psychomotor tests declined with age, production record performance did not.

7.3.4: Multivariate studies of age and work performance

There have been two multivariate studies on the performance of blue collar workers (Giniger, Dispenzieri & Eisenberg, 1983; Schwab & Heneman, 1977) in which length of service (experience) is controlled for. Experience is often assumed to counteract the effects of age on job performance. Schwab and Heneman (1977) obtained productivity indices over a five-week period for 124 mainly female semi-skilled assemblers. The average age was 36.3 years, and company service was 7.1 years. The two were highly related ($r=+0.61$; $p<.01$). Initial analysis showed that productivity apparently increased with age ($r=+0.29$; $p<.01$), and with service ($r=+0.42$; $p<.01$). The independent effect of each variable was obtained by partialling out the linear variance described by the correlations. Once age was controlled for in this manner, the positive relationship between service and productivity remained ($r=+0.32$; $p<.01$), but age showed no relationship to productivity. The authors contend that the relationships between age and job performance revealed from the univariate studies may be caused by the influence of company service, which covaries with age. There are, however, three limitations to this study:-

1. The age range of the sample was negatively skewed (only 8 per cent of the sample were aged over 55).
2. Attrition was high and uncontrolled.
3. The technique of partialling out linear correlations which are based upon data which show a non-linear trend is suspect. The raw means of performance by age band analysed by Schwab and Heneman (1977) do not necessarily constitute a valid basis on which to calculate linear correlations, as much of the variance is unaccounted for. The technique only controls for age and service in those small proportions of variance which have been explained by the correlation metrics (8.41 per cent for age and 17.64 per cent for service).

Nevertheless, the importance of controlling for length of service, given there is a high degree of correlation with age, is unquestioned.

The most recent multivariate study by Giniger et al (1983) controlled for age and length of service in a sample of 667 garment industry workers. Separate analyses were conducted for jobs deemed as requiring speed (n=212) and skill (n=455). The sample was mainly female, with men constituting 6.6 per cent of the speed job sample and 37.1 per cent of the skill job sample. Productivity was operationally defined as average hourly piece rate wages, and data were gathered over a three-month period in 1979. Performance on the speed jobs was slightly below average for those aged 25-34, and steadily rose until ages 45-54. Thereafter performance plateaued at this peak level. The correlation between age and performance was +0.33 ($p < .001$). Checks were made for linearity, which accounted for the largest significant proportion of the data at 10.9 per cent. Age and experience were highly correlated ($r=+0.69$; $p < .001$), and once experience was partialled out, the relationship between age and performance was found to be insignificant ($r=+0.02$), whereas experience was still significantly related to productivity ($r=+0.35$; $p < .001$). This result is identical to that of Schwab and Heneman (1977). A similar result was found with the sample of skilled jobs. Age was initially highly correlated with productivity ($r=+0.61$; $p < .001$), but once the effect of service was partialled out, became insignificant ($r=-0.03$). Conversely, service remained significantly positively related to productivity once age was controlled for ($r=+0.39$; $p < .001$).

The results showed that the relationship between age and performance was mediated by service in both speed and skill jobs. However, the distinction between the two samples was poorly defined, based initially on the opinion of a union director, and then on ratings of 1 to 5 for speed and skill by the investigators. Many job titles defined as "primarily" speed still involved a fair proportion of skill, and many skill jobs involved speed.

7.4: PRODUCTION RECORD STUDIES OF CLERICAL AND SALES JOBS

The importance of specifying the type of work being performed when considering the age-performance relationship is apparent once clerical and sales jobs are considered. The inverted U relationship shown by univariate studies of blue collar jobs is replaced by a lack of any relationship in clerical and sales work (Kutscher & Walker, 1960; Tanofsky, Shepps & O'Neill, 1969; United States Department of Labor, 1957). No age differences in output per man hour were observed for office workers in the U.S. Department of Labor (1957) study referred to earlier, although a gradual decline in performance after the age of 25 was shown for Federal Mail sorters. Performance of workers aged 65 and over was still only 8 per cent below peak performance.

In a sample of 1525 insurance salesmen, Tanofsky, Shepps and O'Neill (1969) reported no relationship between age and job performance, and, in a study of the relationship between age and job performance in two large department stores, it was found that performance tended to improve with age and experience (see Kelleher & Quirk, 1973).

One multivariate study was performed by Kutscher and Walker (1960) on a sample of 6000 incentive office workers in 26 institutions. Once length of service was matched at over nine months, there were no significant differences between age groups.

7.5: PERFORMANCE RATING STUDIES OF SKILLED AND SEMI-SKILLED MANUAL AND CLERICAL JOBS

Bass and Barrett (1972) cite a 1964 survey in the United States which showed that 71 per cent of sampled companies used merit ratings as the most frequent base for awarding salary increases. A detailed analysis of the advantages and disadvantages of rankings and merit ratings concluded that there is a tendency for raters to make stereotyped judgements on the basis of a limited set of characteristics. To the extent that ratings of the job performance of older workers are influenced by stereotypes of the older worker, rated performance would be expected to show a steady decline with age, rather than the inverted U observed in univariate studies based on production records in blue collar work (Davies & Sparrow, 1984).

Smith (1953) compared supervisors' evaluations, as entered on personnel records, of 903 men working at skilled, unskilled and clerical jobs in a large manufacturing company and Crook and Heinstein (1958) studied Californian industrial workers using a specially devised seven-point scale. Smith (1953) found that men aged 45 and over received proportionately as many above average ratings on ability to do the job as did younger men. Whilst overall efficiency was considered to show no decline with age, speed of work and ability to learn were rated as being lower than for younger men. Crook and Heinstein (1958) also found no overall difference in rated performance between older and younger men.

Arvey and Mussio (1973) studied rated job performance and test scores in a sample of 266 female clerical workers. Whilst test performance was again shown to decrease with age, actual job performance was rated equally across age groups. Maher (1955) reported that age was positively related to rated performance for sales personnel.

7.6: PERFORMANCE RATING STUDIES OF TECHNICAL JOBS

From 1960 to 1973, numerous studies conducted by the U.S. Civil Aeromedical Institute consistently showed that age at time of entry into air traffic control specialist training was negatively related to ranked performance, attrition, retention and aptitude test scores (Cobb, Nelson & Mathews, 1973). In one of the earliest of these studies, Trites and Cobb (1962) concluded that the chances of an individual being considered a satisfactory controller decreased from 1 in 2 when aged under 33 years, to 1 in 5 when older. This difference was attributed to increased stress on older controllers.

Two of this series of studies were multivariate, controlling for length of service. A survey study in 1965 (see Cobb, Nelson & Mathews, 1973) considered the interrelationships between age, experience and rated performance in 568 radar controllers. With length of service controlled, a negative relationship between age and performance was found. A second multivariate study on 614 radar controllers (Cobb, Nelson & Mathews, 1973; Mathews & Cobb, 1974) also reported a negative relationship between age and rated job performance, controlling for service ($r=-0.44$; $p<.01$). Once more, certain methodological problems need to be noted:-

1. The age range was truncated. Only 12 per cent of the sample were aged over 45.
2. The reliability of the performance ratings was low. Supervisors, crew chiefs and peers provided ratings on 29 elements of work presented in the contexts of technical radar control, technical local control, general related elements, and overall proficiency. The average inter-rater reliability was only +0.39.
3. The age of the rater affected the rating given.

Crew chiefs aged under 40 rated the over 41 year old controllers lower than did older raters.

7.7: PERFORMANCE RATING STUDIES OF PROFESSIONAL KNOWLEDGE-BASED JOBS

The changing structure of the workforce in advanced industrialised countries is leading to an increase in the number of "knowledge workers" who apply ideas, concepts and information rather than manual skill or brawn. An age decline, or obsolescence, in the job performance in such knowledge-based occupations is less likely to be caused by a loss in physical or mental skills. It is more likely to result from a deterioration in the quality of information forming the knowledge base.

Clearly, several performance criteria may be used in such work. Studies of engineers, scientists and scholars have revealed primarily an inverted U relationship between age and rate of publication, or occurrance of important or pioneering discoveries (Cole, 1979; Dennis, 1954, 1968; Lehman, 1953; Roe, 1965). Lehman (1953) studied more than 10000 practitioners in the sciences, medicine, surgery, philosophy, music, art and literature, and found that peak performance occurred in the thirties, with earlier peaking in the abstract sciences. Pelz and Andrews (1966) found a double peaking of performance in the late thirties or early forties, and again 10 to 15 years later. The drop between these ages was attributed to family and financial needs leading to a reluctance to take on new assignments, or the experience of the "mid-life crisis". However, all these researchers noted that the age of peak performance varied both between fields and within fields. Cole (1979) found that initially strong publishers remained strong throughout their life-times, and the diminution in publication rate was observed in initially poor performers.

The relationship between age and technical obsolescence has been investigated by Dalton and Thompson (1970, 1971). Their sample consisted of 2500 engineers aged between 21 and 65 years, employed in six large technological companies in the aerospace industry. All engineers were engaged in design work in the electrical, mechanical, chemical, optical and aeronautical engineering divisions of these companies. Managerial ratings were obtained for each engineer's overall contribution to the company on a 1 to 50 scale. The average rating for each group was converted into 100 per cent. Performance rose until the mid-thirties, thereafter showing a consistent decline. By the ages of 55 to 65, performance only reached 57 per cent of peak levels. Differences were noted in the complexity of task allocation given by managers. Older engineers were assigned the least complex tasks. High performing engineers were found to have left the sample, but by combining data for first and second level managers, supervisors and engineers, the performance decline was merely delayed until the late forties (in the case of managers). There was considerable variation in scores, and many older engineers maintained high ratings.

A comparison to data gathered by Pelz and Andrews (1966), and a historical comparison of the age effect in their own data, led Dalton and Thompson (1970) to conclude that the rate of technological obsolescence was accelerating. In 1960, there was little relationship between age and rated job performance except for the oldest groups. Over the following eight years, age became a progressively better predictor of job performance. By 1968, each age group above the age of 30 years obtained lower average ratings than the next youngest age group. Such acceleration of the obsolescence of technical expertise is likely to continue, given the rapid advance of technology and the rate of ageing of the labour force occurring in most industrialised countries (Davies & Sparrow, 1984).

Expectancy theories of work view motivation as being a function of both the value attached to a specific outcome, and the belief that a particular course of action will produce that outcome. Consequently, if either a course of action is not highly valued, or it is believed that such a course is unlikely to lead to a valued outcome, then the motivation to pursue that course will be low. It has been suggested that such motivational problems lie at the heart of the age decline in the performance of engineers (Arvey & Neel, 1976; Kopelman, 1977). Arvey and Neel (1976) studied the work motivation of older and younger lead engineers from such an expectancy theory perspective. Supervisory ratings suggested that performance (in terms of overall effectiveness) was on average 90 per cent lower for those aged over 40 in comparison with the younger group. The older group was also rated as being less independent, having a lower 'team attitude', lower 'job curiosity' and lower 'professional identity'. Members of this older group were then asked to rate the desirability of ten job outcomes, such as making use of their abilities, advancement, high salary, security of employment and praise. These ratings were combined into a single 'motivation index' which was then related to the measures of job performance. Higher motivation was significantly related to higher overall job effectiveness, professional identification and job curiosity. The lower job performance observed in the older engineers was also associated with differential motivation. Older engineers placed more value on making use of abilities, accomplishment, and security of employment. Less value was placed on praise, supervising others and advancement. Arvey and Neel (1976) concluded that motivational interventions designed to facilitate those aspects valued by older engineers could mediate the age decline in performance. Broadly similar findings were shown by Kopelman (1977) in a study of 376 design and development engineers. Expectancy was shown to lower with age, and three reasons were put forward as an explanation:-

1. The career hierarchy is pyramidical in shape in engineering, resulting in an ever-decreasing chance of promotion.
2. There is a low level of rewards mediated by the organisation.
3. Engineering is widely viewed as a "young man's game".

Such findings were followed up in a second study of age and knowledge obsolescence by Dalton, Thompson and Price (1977). 550 professionally trained employees from science, engineering, accountancy and university lecturing were interviewed. The sample was selected to give a representative group of both high and low performers. High performers at an early stage in their career were found to be performing different functions to high performers in mid or late career. Based on the different functions carried out, four career stages were highlighted:-

1. close supervision, or apprenticeship stage
2. independent stage
3. mentor stage
4. organisation shaping stage.

Managers were asked to place the interviewees into one of these four stages, and then age and performance were analysed. All professionals aged over 40 and still in the lowest (apprenticeship) career stage were below average performers. 82 per cent of over 40 year olds at career stage two were below average performers. This proportion dropped to 21 per cent at career stage three, and at career stage four, all over 40 year olds were above average performers. It was concluded that a successful transition through the career stages reversed the age decline in performance shown in previous studies in knowledge occupations.

7.8: MANAGERIAL PERFORMANCE STUDIES

Few studies have examined the relation between age and managerial performance. There have been two studies, both of which employed simulation exercises as opposed to ratings of actual job performance (Meyer, 1970; Taylor, 1975). An incidental finding from the study by Meyer (1970), designed to validate an 'in-basket' test for plant managers in a large electrical company, was a significant negative relationship between age and performance ($r=-0.49$; $p<.001$).

Taylor (1975) systematically described how age and experience related to the use of different decision strategies in managerial work in a sample of 79 line managers. A managerial decision-making simulation was used, from which the following scores were obtained:-

1. the amount of information sought
2. information processing rate
3. information rating accuracy
4. decision time

5. decision accuracy

6. decision confidence, and

7. decision flexibility.

The effects of management level, years of management, and experience in personnel decisions were controlled for by partialling out the zero order correlations between the independent variables and the various decision-making scores. Age was associated with significantly more accurate ratings of the value of items of information with a longer decision time. The increased time taken to reach a decision by older managers was attributed to a seeking of more information as opposed to a slower information processing rate. Older managers were significantly less confident about their decisions, and consequently, more flexible. Both these aspects of performance, along with the tendency to use more information in arriving at a decision, were influenced by decision-making experience, although age appeared to be the more important influence. As no relationship was found between age and the accuracy of the final decision, Taylor concluded that age does not affect the efficiency of managerial performance in decision-making situations. Rather, older and younger managers tend to employ different strategies in formulating similar decisions.

7.9: CONCLUSIONS ON THE RELATIONSHIP BETWEEN AGE AND WORK PERFORMANCE

The methodological difficulty of isolating the cause of any observed age-related differences in performance was specified along with a series of systematic errors which potentially confound studies. The review of research categorised studies by performance criterion, occupation, and number of variables studied. Production records and performance ratings were the most common criteria. The vast majority of studies are cross-sectional, univariate, and based upon small sample sizes. As relatively few studies have been conducted, only a small proportion of the occupational spectrum detailed in Chapter Two has been examined. The moderation of age-related changes in performance by length of service (loosely termed experience) has received limited attention. Only six multivariate studies have been conducted, and these all only incorporated service experience as a second independent variable. The variable of training has been totally neglected as a moderator of the age-performance relationship. Given its centrality to much work, this is surprising, and an oversight. Another major limitation is the lack of control over the tasks performed. Some studies have been on large occupations. Others were directed at specific jobs, and some have studied task performance which only constitutes one aspect of the job. No control, for example, of task allocation within job performance is generally applied.

Given the above limitations, the following conclusions are made about age and performance:-

1. Univariate studies of age and production record performance in skilled and semi-skilled jobs generally showed an inverted U relationship. Performance for the young is below average. It increases with age until between the ages of 30 and 40, thereafter showing a gradual decline. However, performance of the oldest age groups is still only from between 9 per cent and 17 per cent below peak performance, and is usually better than that of the youngest age groups.

2. Multivariate studies on skilled work control for both length of service and age. The age effect becomes insignificant, and performance is usually found to improve with increased length of service.

3. Performance in clerical and sales jobs generally shows no relationship with age, although the results of the four studies vary slightly. One multivariate study again shows that, once service experience is controlled, the age effect disappears.

4. Performance rating studies of skilled manual work show that, whilst overall efficiency is not rated any lower with increased age, speed of work and ability to learn are rated lower

for older than for younger men. Test performance also tends to decline with age.

5. A clear age-related decline in rated performance is shown in technical work. This decline remains when service is controlled for.

6. Performance in knowledge-based jobs shows a strong inverted U relationship with age. Performance peaks in the early thirties, and declines by 43 per cent in the 55-65 age group. The rate of this technological obsolescence appears to be accelerating. However, motivational problems associated with the lack of career development seem to exert a strong mediating effect.

7. Finally, managerial performance as measured by appraisal tests shows a decline with age, supporting the stereotypes of managerial performance discussed in Chapter One. However, a detailed multivariate study of decision-making concluded that there are no age differences in the accuracy of performance. Older managers perform differently from younger managers, with no resultant decrement in performance.

CHAPTER EIGHT

THE STUDY OF AGE AND PERFORMANCE IN A TECHNICAL WORKFORCE

8.1: INTRODUCTION TO THE STUDIES OF PERFORMANCE OF THE SERVICE ENGINEER WORKFORCE

8.1.1: Introduction to two studies of performance

The review of literature on age and work performance in Chapter Seven produced four major conclusions:

1. Many of the studies of age and work performance previously conducted have been subject to severe methodological problems.
2. Apart from limitations of small sample size; selected survival or drop-out from the sample; and choice of a poor performance criterion; one of the major shortcomings has been a lack of control over the actual task performed. Most performance studies in the field have been conducted at the level of job or occupation. Consequently, results of performance are subject to possible confounding by differential task allocation within the level of 'job' or 'occupation' across age groups.
3. Nevertheless, the evidence provided from previous studies suggests that the presence of age effects on performance is strongly linked to the nature or type of work done. Areas of work notably influenced by age effects include semi-skilled and skilled manual; technical and knowledge-based jobs; and high stress jobs.
4. There are a lack of multivariate studies in these 'target' areas of work which have studied

the effect of age whilst controlling for other variables such as length of service and training.

It is aimed to conduct two analyses on a large scale field study to establish age effects on performance in a job which is - within the 'target' area of work likely to be influenced by age; allows for valid measurement of performance; is not subject to the effects of selective survival or drop-out; allows for the control of tasks performed within the job; and provides a large sample size.

8.1.2: Performance Study One: Performance Differences

The first study will concentrate upon the presence or not of performance differences in four aspects, namely - the quality of performance; the relative efficiency of performance, or speed; the total quality of performance; and the time actually spent working. The study is multivariate, and differences in these aspects of performance will be tested for along four main factors. The effects of Age; Length of Service; Time since Training; and Skill Complexity of the Task will be studied, along with any possible interaction effects between these.

8.1.3: Performance Study Two: Performance Strategies

The key aspect of performance analysed in the first study is quality. It is mainly from the relative quality of service that the major cost is passed on to the company. Therefore, the best performance is that which results in the highest quality. There are, however, many possible strategies which might facilitate high quality. It might be that by performing more slowly (thereby probably producing a smaller quantity of services unless slow performance is compensated for by longer hours worked), fewer errors are made, and a higher quality of service results. The speed of performance might not be linked to quality at all, in which case the best performer would be the person who produces a higher quantity of high quality services. Furthermore, these various strategies of performance might vary across the four main analytical factors of age, service, training and skill complexity of the task. The second study, then, will attempt to explain the results of the first study by considering how performance is achieved.

Section 8.2 which follows, describes the historical background to the job chosen for study, and points to those methodological problems overcome by this choice of workforce.

8.2: HISTORICAL BACKGROUND TO THE SERVICE ENGINEER WORKFORCE

8.2.1: Details of selection; skills involved in job; and career path

Service Engineers play a central role in the company as continued custom is in a large part contingent upon the successful maintenance of leased equipment. The educational attainment of the workforce is to at least O.N.C.

level, although economic influences allow for an intake at H.N.C. level in some regions, e.g. Newcastle. Many of the older engineers received technical qualifications through National Service.

There is no central criterion for selection; but tests used include the Gordon Personality Profile, an internally developed test for electrical and mechanical knowledge, and a mechanical reasoning test. New recruits undertake an initial six week training programme, followed by up to four weeks' training every year on various machines, which are grouped into product families.

No detailed skill analysis based upon psychometric measures has been conducted on the job. However, an internal analysis produced an hierarchical representation of the Core Skills utilised. This analysis is presented overleaf in Figure 8.1. In utilising these skills, the engineer follows a set procedure of communication channels and these are illustrated by the algorithm in Figure 8.2. The service engineer works on the basis of a preliminary diagnosis forwarded to him by a work controller. The engineer must effect at least 90 per cent of the maintenance calls. Serious machine faults move out of the sphere of service engineer diagnosis and repair.

The career structure of the workforce is self-contained. All new recruits are external, and there is no transfer from other company functions into the workforce. There

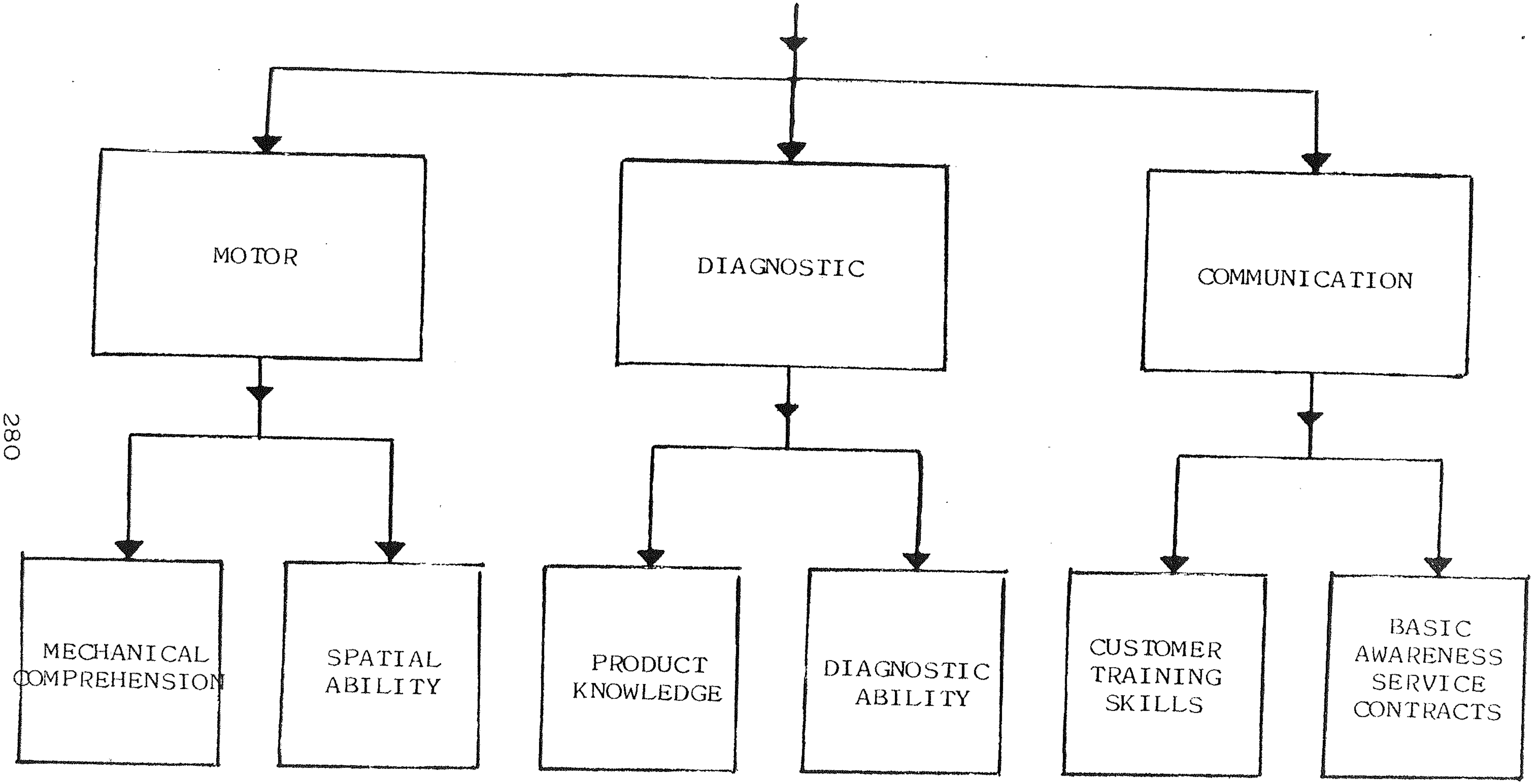


FIGURE 8.1: HIERARCHICAL REPRESENTATION OF THE CORE SKILLS INVOLVED IN THE JOB OF SERVICE ENGINEER

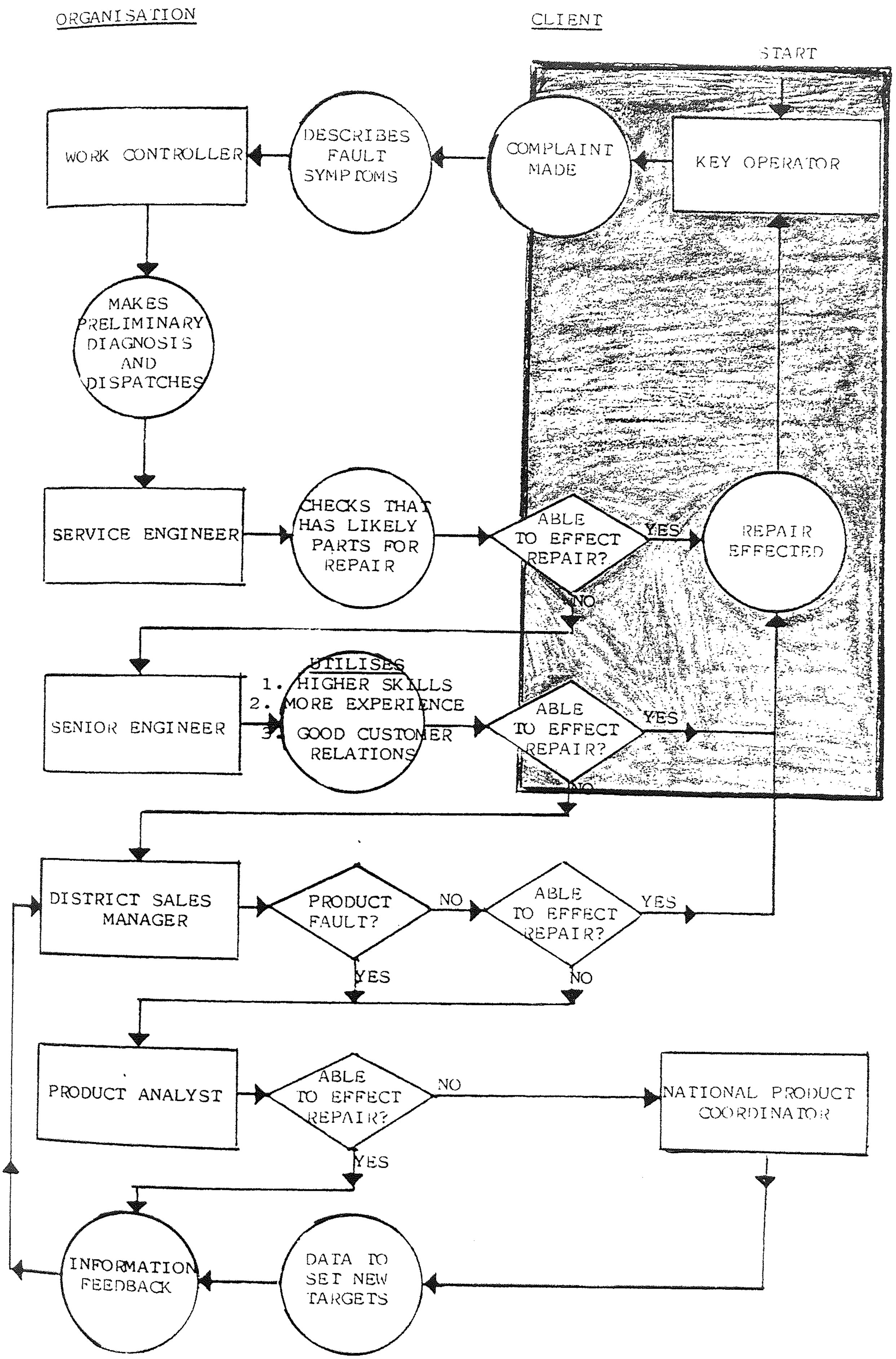


FIGURE 8.2: ALGORITHM SHOWING THE PROCEDURES CARRIED OUT BY SERVICE ENGINEERS

are four grades within the career spectrum - Service Engineer I to III, and Senior Engineer. Promotion through the first three grades is on a time-served basis and not linked to proficiency. Transfer out of the function is minimal. The only management vacancies open are for District Sales Manager, and these vacancies represent only 2 per cent of the workforce, of which only a small proportion fall to service engineers.

The selection of service engineers as a target for a performance study overcomes the following methodological problems discussed in the last Chapter:

1. The various grades within the job do not represent different tasks. They are not proficiency-based.
2. The technical nature of the job and selection procedures have ensured that there is little educational variation amongst the workforce. Educational cohort effects will therefore be minimal.
3. The workforce is not contaminated by transfer into or out of it from differentially-skilled individuals.

8.2.2: The extent of turnover in the Service Engineer workforce

Several authors (Rhodes, 1983; Welford, 1958) have suggested that a major methodological problem associated with the study of performance of older workers is the presence of high levels of attrition. High levels of attrition may hide the operation of 'selective survival' and 'selective drop-out', whereby those older workers who are poor performers either leave the job voluntarily, or are dismissed. It is advantageous to conduct a performance study on a workforce which has low attrition.

A small study was initiated to establish the relative levels of attrition in the target sample of service engineers, and other samples throughout the company. The data gathered measure total wastage (i.e. leavers within all four of the Manpower Movements detailed in Chapter Two). The data for the functions of Service Engineer; Supply; Sales; and Administrative Staff represent 4216 employees of the April 1980 company staff, and cover the period 1970 to 1980 inclusive. Yearly wastage rates covering the period 1974 to 1979 have already been established in Chapter Two for the functions of Higher Management; Middle Management; Skilled Manual; Technical; Supervisory; and Clerical Staff operating at the Manufacturing Plant. Both of these sets of data represent a total of 8471 employees out of the 12587 employed in April 1980 (i.e. 67.3 per cent). They are shown in Table 8.1.

The service engineer workforce historically has the fourth lowest attrition rate, averaging 7.28 per cent over the period 1970 to 1980. This rate has shown a fairly consistent decline over time, with an annual rate of only

OCCUPATIONAL FUNCTION

YEAR	SERVICE ENGINEERS	SUPPLY	SALES	ADMINIS-TRATION	MP SKILLED MANUAL	MP HIGHER MANAGEMENT	MP MIDDLE MANAGEMENT	MP TECHNICAL	MP SUPERVISORY	MP COMMERCIAL
1970	1.53	23.50	16.33	45.98						
1971	7.18	17.84	24.07	30.23						
1972	7.82	15.30	34.24	37.83						
1973	11.37	16.87	21.98	38.94						
.Rate 70-73	9.48%	18.38%	24.16%	38.25%						
1974	8.46	18.38	24.50	38.58	7.50	3.65	1.68	3.45	2.00	17.26
1975	6.76	9.86	23.85	39.96	25.53	6.86	2.80	7.79	4.30	15.40
1976	8.45	9.14	18.50	42.66	10.06	4.88	1.18	3.30	5.82	17.96
1977	5.28	5.39	18.11	33.74	3.02	17.16	5.28	3.98	0.84	11.62
1978	5.32	7.24	22.01	37.70	3.22	12.93	8.72	10.12	0.85	9.52
1979	5.73	23.84	21.07	37.90	10.26	12.21	7.88	4.16	2.56	9.19
1980	2.22	14.20	27.20	23.40	-	-	-	-	-	-
.Rate 74-80	6.03%	12.58	22.18%	36.28%	9.93%	9.62%	4.59%	5.47%	2.73%	13.49%
umbers n April 1980	2036	721	1131	328	1870	117	390	603	345	930

TABLE 8.1: COMPARATIVE ATTRITION RATES OVER PERIODS 1970-1973 AND 1974-1980 FOR TEN WORK FUNCTIONS

2.22 per cent in 1980. It is useful to note that the technical workforce at the Manufacturing Plant had similar low attrition, averaging only 5.47 per cent over the period 1974 to 1979. Although the service engineer workforce has relatively low attrition in comparison to other work functions in the company, it is still possible that such attrition is concentrated upon the older workers. If this were true, then it could be that the performance average for the older age-bands is an over-estimate of the true performance, because poor performers have left.

8.2.3: The age/service behaviour pattern of Service Engineer leavers

A second small study was carried out to establish the frequency of leavers from the service engineer workforce within the various age and service bands. The date gathered covered the six month period from April 1979 to May 1980 inclusive. There were 29 leavers over this period, and the frequencies by age and service are detailed in Table 8.2. The modal leaving age band is 26-30 years, and the trend is one of decreasing propensity to leave with increased age. This evidence suggests that the service engineer workforce is not strongly influenced by the methodological problems of selective survival or selective drop-out, and as attrition declines with age, whatever influence there may be will be directed at the younger age bands.

LENGTH OF SERVICE IN YEARS. / AGE IN YEARS	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	NUMBER AND % TOTAL LEAVERS BY SERVICE BAND
0-5	–	4 13.79%	9 31.03%	2 6.90%	2 6.90%	–	–	–	–	–	17 58.62%
6-10		–	5 17.24%	2 6.90%	1 3.45%	–	–	1 3.45%	–	–	9 31.03%
11-15			–	–	–	2 6.90%	–	1 3.45%	–	–	3 10.34%
16-20				–	–	–	–	–	–	–	–
20+					–	–	–	–	–	–	–
NUMBER AND % TOTAL LEAVERS BY SERVICE BAND	0 0.00%	4 13.79%	14 48.28%	4 13.79%	3 10.34%	2 6.90%	0 0.00%	2 6.90%	0 0.00%	0 0.00%	29 100.00%

TABLE 8.2: THE AGE/SERVICE BEHAVIOUR PATTERN FOR SERVICE ENGINEER WITHDRAWEES FOR THE PERIOD DECEMBER 1979 TO MAY 1980 INCLUSIVE

8.3: THE INDEPENDENT VARIABLES OPERATIONALISED FOR THE PERFORMANCE STUDY

Data were gathered for 1308 service engineers, and the following seven independent variables were utilised.

8.3.1: Age

Each record provided the subject's date of birth by month and year. By subtracting the birth date from the sample date (July 1982), the subject's age was recorded to the nearest integer year. Six months or more was rounded up to one whole year.

8.3.2: Length of company service

The date of joining the company was also transcribed using the same rules. The figure recorded was the number of integer years since joining the company. However, as all entrants were selected and trained for the job of service engineer, and there were no transfers from other company functions, this figure also represents length of time performing the job.

8.3.3: Level of complexity

Performance was detailed for each of 29 different machine types, or product families. Discussions with Personnel and Training staff, and with service engineers themselves, suggested that these 29 product families varied in the degree of complexity required to effect a successful service. It was decided that level of complexity would be used as an independent variable. This variable was operationalised by grouping the 29 product families into exclusive categories along the dimension of complexity. The criterion used for this categorisation was the time taken to complete the training course for each product family. Training for all product families was both centralised and standard. A system of functional documentation was used, whereby a set training sequence and time was allowed for each function performed by machines. The longer the course time, the more functions the machine operated, and the more complex was the service required, (both in terms of diagnosis and the knowledge-base underlying each function). On this basis, four discrete levels of complexity were arrived at. Level One covered the very basic, small and single-function machines. Level Four incorporated the extremely complex, immovable and multi-function machines. The four complexity levels in hierarchical order consisted of 10, 6, 6 and 7 product families respectively.

8.3.4: Performance combination

There are, then, up to four possible complexity levels which incorporate 29 different product families on which each subject may perform. One would expect that not all engineers would perform across all levels of complexity. There are many operational factors, such as geographical spread of product families, and concomitant product specialisation, which might affect the combination of product families (and consequently complexity levels) on which an engineer works. In areas covering a small part of a major town, the sheer number of clients dictates that engineers will specialise in the services they perform. Conversely, in large rural areas, one engineer might have to service all levels of machines within the area. The fact that an engineer services machines at complexity level Four as well as level One, might make his performance on the lower complexity level better than that of an engineer who only services the lower level machines. To control for such effects, the performance combination practised by an engineer is operationalised as an independent variable.

With four levels of complexity, there are sixteen possible combinations. These are detailed overleaf in Table 8.3. A check will be made to see if performance at each complexity level differs across these combinations. If it does, then an adjustment will be made to the dependent variable to control for such effects.

8.3.5: <u>Training combination</u>

Similarly, there are sixteen possible combinations of training across the four complexity levels. However, the combination in which an engineer is trained, might not be the same as the combination to which his performance is allocated. Therefore, the training combination is also used as an independent variable.

Complexity levels in combination	Sum of complexity tasks in combination	Integer code given to combination
4,3,2,1	10	15
4,3,2	9	14
4,3,1	8	13
4,3	7)	12
4,2,1	7)	11
4,2	6)	10
3,2,1	6)	9
4,1	5)	8
3,2	5)	7
4	4)	6
3,1	4)	5
3	3)	4
2,1	3)	3
2	2	2
1	1	1
0	0	0

KEY) Denotes that the sum of the ranked levels is
) the same complexity

TABLE 8.3: SIXTEEN POSSIBLE COMBINATIONS OF PERFORMANCE OR TRAINING ACROSS THE FOUR LEVELS OF COMPLEXITY

8.3.6: Number of training courses attended

One of the methodological problems associated with studies of performance which use only age as an independent variable is that there are other equally causal covariates which might be associated with it. Perhaps the most important of these are training factors. Differential performance across age groups may just be the result of differential training. One measure of such training is the number of training courses which an engineer has attended at each complexity level. The personnel records for each engineer noted the training courses attended, specified the product family of the training course, and the date on which the course was completed. By grouping the product families into their underlying complexity levels, the integer number of training courses attended at each of the four levels was recorded for each engineer.

8.3.7: Average time since training

Another aspect of training which might influence performance is the time elapsed since it was completed. At each of the four complexity levels, the average time elapsed since courses were completed was calculated, and recorded to the nearest integer year.

8.3.8: Summary of independent variables

Data have been collected which allow for the control of seven independent variables. These variables group along four main factors - Age; Time spent performing Job; Level of Complexity (complexity level and performance combination);

and Training Factors (training combination, number of courses attended and time elapsed since training). The complexity level is an ordinal measure. The performance and training combinations are nominal. All other independent variables are ratio measures.

8.4: THE DEPENDENT VARIABLES OPERATIONALISED FOR THE PERFORMANCE STUDY

Four dependent variables were operationalised. These were - the Quality of Service achieved; the Efficiency of the Service; the Number of Services effected; and the Hours worked per month. The first three of these measures were recorded for performance at each of the four complexity levels. The operationalisation of each measure is now discussed.

8.4.1: Quality of service

The machine rate of operation was used as a basis for the measure of quality of service. Basic company data on the machine rate of operation were transformed into the operationalised measure using a series of mathematical steps.

When servicing a machine, the number of copies the machine had made before a new maintenance call was required to rectify the fault is recorded by the engineer, along with the date on which the service is made. This past performance is attributed to the engineer who made the last service. Clearly, to simply use the number of copies the machine made after an engineer's service, without regard to the conditions under which the machine was used, would be an unfair measure of the engineer's ability. One machine might have been used continuously at a fast rate, whilst another recorded the same number of copies under easier conditions of use. This rate of machine use by the clients can be expected to affect the machine operation above and beyond the quality of service effected by the engineer, and so it has to be accounted for. Therefore, it is the rate of machine copies achieved as a result of the service which forms the basis of the measure of quality. This rate is calculated over a one month period for each of the 29 possible product families on which the engineer may have worked:

For Product Families, where I=1,29

$$P_I = \frac{(\underline{A/B})}{N_I} \quad \text{where}$$

P_I=Average Product Family Rate of Operation achieved by an individual engineer over one month
A =Volume of copies made after each service
B =Number of days elapsed before fault occurred
N_I=Number of services made by an individual on each Product Family.

For example, an engineer might have achieved an average product family rate of operation (P_I) of 120.20 copies/day during the month on machine type 'x'. To give this performance meaning, it is compared to the national average of product family rate of operation (P_N) for machine type 'x'. The national average is calculated by adding up and averaging the rates of operation achieved by all machines of that type over the whole country. For example, on average, machine type 'x' achieved a national rate of operation of 98.50 copies/day. A statement can be made about the quality of an individual's performance by ratioing his performance over the average expected performance. The individual score (P_I) is ratioed over the national average (P_N) so that we can express his standardised performance (P_R). A ratio standard performance of under 1.0 denotes below average quality of performance, whilst a score of over 1.0 denotes above average performance. In the worked example given, the engineer in fact has a standard performance of 1.22 on machine type 'x', which means that the quality of his performance is of above average standard. However, this score has to control for the effects of temporal variation. This monthly index can be affected by a number of factors. If an engineer has just returned from a prolonged period of absence, or is about to attend a training course, he is able to select to some extent those machines he services, allocating those he will not service to a colleague. In this manner, an engineer can 'bounce' known faulty machines on to another man's index for that month, by choosing not to service those machines that month. To control for such temporary aberrations, a six month sampling period for quality of performance was used. The individual ratios of quality of performance for each machine type were averaged over the six month period.

As detailed in Section 8.3.3, the 29 separate product families or machine types were classified into one of four complexity levels. Consequently, the six month average ratios of quality of service are summated across all constituent product families within each complexity level, and averaged. This is done by multiplying the six month average ratio of service by the number of services on which it was based. These products are then summated for all machine types within a complexity level, and the sum divided by the total number of services effected within that level (N_{SLTS}). This produces four measures of quality of service, one at each complexity level. Each is a measure of an individual's standard of quality (based upon the relative rate of operation his machines achieved after his services), adjusted for a six month period, and averaged across a complexity level.

8.4.2: Number of services completed

The first dependent variable has measured the quality of an engineer's performance. The second measures the quantity of work by recording the total number of services completed on machines within each of the four complexity levels, over a six month sampling period. The derivation of this measure has been described in the previous section.

8.4.3: Efficiency of services

An engineer might perform very high quality services, yet this might be at the expense of his efficiency, in that to achieve a high quality of service, he spends several hours on the machine. Another engineer might achieve the same quality of service by only spending an hour on the machine. The second engineer can be deemed to be the better performer for he is both of high quality and efficient.

The time spent working on each service is logged in hours, and the database sampled provided a record of all logged services by each engineer and by product family for a one month period. The efficiency for each complexity level was calculated by summing the total logged time on services on machines (product families) within that level, and dividing the summed time by the number of services completed. The result is the average time spent servicing machines in each complexity level, expressed in hours/machine. A one month sampling period had to be used as opposed to a longer period because records were not kept for a longer period. It is therefore possible that this variable is subject to the confounding effect of 'bouncing', but this should be slight.

8.4.4: Hours worked over a one month period

The fourth dependent variable quantifies the time spent working in hours per month. The total time contracted to an engineer over a month is 187.5 hours, but, depending on absences and unlogged time, the actual time working can be less than this. The actual logged time was recorded, which includes time spent on services of all kinds, training time and time in transit. As data could only be gathered for a one month period, the data do not represent a valid base for a study of absenteeism because temporal