

**A Thesis Submitted for the Degree of PhD at the University of Warwick**

**Permanent WRAP URL:**

<http://wrap.warwick.ac.uk/99705>

**Copyright and reuse:**

This thesis is made available online and is protected by original copyright.

Please scroll down to view the document itself.

Please refer to the repository record for this item for information to help you to cite it.

Our policy information is available from the repository home page.

For more information, please contact the WRAP Team at: [wrap@warwick.ac.uk](mailto:wrap@warwick.ac.uk)

THE INTRODUCTION OF OPERATIONAL RESEARCH INTO  
DEVELOPING COUNTRIES WITH SPECIAL REFERENCE TO NIGERIA

by

ADAMU IDAMA

B.Sc. (C.N.A.A.)

M.Sc. (Aston)

A thesis submitted in partial fulfilment  
of the requirements for the degree of  
"Doctor of Philosophy"

UNIVERSITY OF WARWICK

School of Industrial and Business Studies

September 1984

**REPRODUCED  
FROM THE  
BEST  
AVAILABLE  
COPY**

## CONTENTS

Chapter	Page
Title	(i)
Contents	(ii)
Tables	(viii)
Figures	(xi)
Acknowledgements	(xiii)
Abstract	(xiv)

### CHAPTER ONE

#### THE PROBLEM

Introduction	1
Paucity of Empirical Research	1
The Research Objective	3
A Review of the Chapters	3

### CHAPTER TWO

#### SURVEY OF LITERATURE ON OR IN DEVELOPING COUNTRIES

Introduction	5
PART A: LIST OF PROBLEM AREAS WHERE OR APPROACHES HAVE BEEN APPLIED IN DEVELOPING COUNTRIES	8
Water Resources	8
Agriculture	11
Health and Social Welfare	15
Industry	18
Sectoral and National Planning	21
Transportation	24
Road Transportation	24
Rail Transportation	24
Water Transportation	24
Air Transportation	25

Worrying Questions From The Literature	27
PART B: INTRODUCTION OF OPERATIONAL RESEARCH INTO ORGANISATIONS	30
CHAPTER THREE	
OR IN GOVERNMENT SERVICES IN DEVELOPED COUNTRIES	33
Introduction	33
OR IN THE BRITISH CIVIL SERVICE	33
Interview With a Senior OR Scientist in the British Civil Service	34
Examples of OR Studies in the British Civil Service Relevant to Developing Countries	38
OR IN AMERICAN CIVIL SERVICE	41
Examples of OR Studies in the American Civil Service	42
MODE OF INTRODUCTION OF OR - THE POINT OF PARTICULAR INTEREST	44
CHAPTER FOUR	
THE TRANSPORTATION STUDY	46
The Logic of the Approach	46
The Purpose of the Dialogue	47
The Particular Sectors Chosen for the Initial Study	48
OR IN BRITISH RAILWAYS BOARD	49
interview With a Senior OR Scientist in British Railways Board	49
Interview With an OR Scientist at "Transmark", a Consulting Firm	52
THE BACKGROUND TO THE CHOICE OF THE NIGERIAN RAILWAYS CORPORATION FOR THE STUDY	54
Market for Transportation Systems in Nigeria	55
RAILWAY TRANSPORTATION: PAST, PRESENT AND FUTURE	57
Projects Suggested as a Basis for a Dialogue on the Introduction of Operational Research into the Nigerian Railways Corporation	58
THE PROJECTS	59
Tactical Planning	59

Strategic Planning	61
Policy Planning	66
The Response to the Request for the Dialogue	67

CHAPTER FIVE  
THE METHODOLOGY

Introduction	70
THE NEW APPROACH	70
THE RESEARCH FORMAT	71
The Research Technique Adopted	72
Objective of the Survey	74
THE DESIGN OF THE RESEARCH INSTRUMENT	75
Interviewing	78
Types of Interview	78
The Questionnaire Design	81
Question Structures	82
The Significant Factors Covered by the Survey Questionnaire	84
The Sample Demography	85
THE PROBLEMS OF GAINING ACCESS	86
Gaining Access to Nigerian Senior Civil Servants	88
The Follow-Up Letter	89

CHAPTER SIX  
THE CUSTOMER

Introduction	90
SOME TACTICAL PROBLEMS	90
The Initial Response	91
The Amplifier	92
The First Letter of Request	93
Respondent Control	94
Difficulties in Making Appointments	95
Use of Tape Recorder	96

The Exceptions	96
Background Information	97
Participation	98
ANALYSIS OF THE INTERVIEWS	101
Introduction	101
Work for OR Scientists to do in the Civil Service	102
Availability of Funds in the Ministries to Support OR Investigations	112
Decision Making and Power Structure Within the Ministries in the Civil Service	113
Availability of Trained and Experienced OR Personnel Within the Civil Service	117
Existing Knowledge in the Civil Service About Operational Research	119
Existing Experiences in the Civil Service in Working With Consultants in General	122
Availability of Computer or Computer Terminals in the Ministries in the Civil Service	127
Preferred Mode for the Introduction of OR into the Government	129
Problems Perceived by Senior Civil Servants as Pertinent to the Introduction of OR into the Government	139
Summary of Findings Regarding the Essential Factors	143
CHAPTER SEVEN	
THE POTENTIAL SUPPLY	145
The Background	145
SELECTION OF OR SCIENTISTS	147
DEFINITION OF PERSONALITY	151
ASSESSMENT TECHNIQUES	153
THE SIXTEEN PERSONALITY FACTOR QUESTIONNAIRE (16PF)	154
The Cross-Cultural Validity of 16PF Tests and the Universality of the Personality Traits	156
Criticisms of Psychometric Instruments	158
THE SIXTEEN PERSONALITY FACTOR QUESTIONNAIRE PROFILE OF BRITISH OR SCIENTISTS	160

The Tests Administered	160
Participation	160
Scoring	161
Significant Personality Differences Between the British General Adult Population and OR Scientists	162
16PF TEST PROFILE AS A PREDICTOR	164
Comparison of 16PF Profiles	166
Individual-to-Group Comparison of 16PF Profile	166
Group-to-Group Comparison of 16PF Profile	167
Male Versus Female OR Scientists: 16PF Profile Comparison	169
ASSESSMENT OF PERSONS FOR OR WORK BASED ON THEIR 16PF PROFILES	170
16PF PROFILE OF BRITISH OR SCIENTISTS BASED ON AMERICAN GENERAL POPULATION	171
16PF Profile of British OR Scientists Based on American General Population Norm	171
Significant Personality Differences Between British OR Scientists and the American General Adult Population	172
COMPARISON OF 16PF PROFILE OF BRITISH OR SCIENTISTS WITH FIVE OTHER OCCUPATIONS	174
Significant Personality Differences Between British OR Scientists and Five Occupations: T-test Comparisons of 16PF Profiles	178
SUMMARY OF THE PERSONALITY PROFILE OF OR SCIENTISTS	181
OR Scientists Versus Research Scientists: A 16PF Profile Comparison	182
CHAPTER EIGHT	
CONCLUSIONS AND RECOMMENDATIONS	
	187
Introduction	187
THE RESEARCH SUMMARY	187
A GENERAL THEORY ON THE INTRODUCTION OF OPERATIONAL RESEARCH (OR) INTO ORGANISATIONS	189

SOME CONCLUSIONS REGARDING THE INTRODUCTION OF OR INTO THE NIGERIAN CIVIL SERVICE	191
SOME RECOMMENDATIONS ON THE INTRODUCTION OF OPERATIONAL RESEARCH INTO THE NIGERIAN CIVIL SERVICE	197
SUGGESTION FOR FURTHER RESEARCH	203
CONCLUDING REMARKS	204
BIBLIOGRAPHY	206
APPENDIX I : Questionnaire for Interviewing Senior Civil Servants in Nigeria	235
APPENDIX II : Letter Requesting to Interview Senior Civil Servants in Nigeria	242
APPENDIX III: Letters Inviting British OR Scientists to Participate in the Personality Study	247

TABLES

Description	Page
TABLE 2-1	10
Summary of literature reviewed on OR applications in developing countries in <u>Water Resources</u> studies showing problem area, analytical and quantitative model developed and country where project was undertaken.	
TABLE 2-2	14
Summary of literature reviewed on OR applications in developing countries in <u>Agriculture</u> showing problem area, analytical and quantitative model developed and country (or area) where project was undertaken.	
TABLE 2-3	17
Summary of literature reviewed on OR applications in developing countries in <u>Health and Social Welfare</u> showing problem area, analytical and quantitative model constructed and, country where project was undertaken.	
TABLE 2-4	20
Summary of literature reviewed on OR applications in developing countries in <u>Industry</u> showing problem area, analytical and quantitative model developed and, country where project was undertaken.	
TABLE 2-5	23
Summary of literature reviewed on OR applications in the developing countries in <u>Sectoral and National Planning</u> showing problem area, analytical and quantitative model developed and, country where project was undertaken.	
TABLE 2-6	26
Summary of literature reviewed on OR applications in the developing countries in <u>Transportation</u> showing problem area, analytical and quantitative model developed and, country where project was undertaken.	
TABLE 4-1a	64
Railway electrification from the 1930s.	

TABLE 4·1b	65
Total railway route mileage, total electrification route mileage, and total electrified track mileage in 1956 for some selected countries.	
TABLE 6·1	91
The Response Rate.	
TABLE 6·2	93
Number of Ministries and Corporations Visited in each Civil Service Unit (C.S.U.).	
TABLE 6·3	95
Seniority of Officers Interviewed According to Grade Level (GL).	
TABLE 6·4	135
Preferred mode for the introduction of Operational Research into the Civil Service in Nigeria.	
TABLE 7·1	158
The primary source traits covered by the Sixteen Personality Factor Questionnaire.	
TABLE 7·2a	161
Participation in the study of the 16PF profile of British OR Scientists: Number of usable response.	
TABLE 7·2b	161
Participation in the study of the 16PF profile of British OR Scientists: Age, experience and responsibility of respondents.	
TABLE 7·3	163
Significant Personality Differences Between OR Scientists and the British General Adult Population.	
TABLE 7·4	170
Weights for use in making comparisons among occupational groups.	

TABLE 7-5	173
Significant Personality Differences Between OR Scientists and the American General Adult Population.	
TABLE 7-6	176
Students T-Test Comparisons of 16PF Occupational Profiles.	
TABLE 7-7	184
Key features of OR Scientists on the 16PF test in relation to the general adult population and five selected professions.	
TABLE 7-8	186
Summary of 16PF test profile comparison between OR scientists and research scientists.	

--

FIGURES

Description	Page
Nigerian Railway System	62a
Interviewing Strategies	80
Nigeria: Showing State Boundaries and State Capitals	86a
A Generalised and Simplified Organisational Structure of a Typical Ministry in the Civil Service in Nigeria.	100
16PF Test Profile of British OR Scientists. (Based on British General Population Norm)	162a
16PF Test Profile of British OR Scientists. (Based on American General Population Norm)	171a
16PF Test Profiles of British OR Scientists and Accountants, England and Scotland.	175a
16PF Test Profiles of British OR Scientists and American Business Executives.	175b
16PF Test Profiles of British OR Scientists and American Research Scientists.	175c
16PF Test Profile of British OR Scientists and American Sales Managers.	175d
16PF Test Profile of British OR Scientists and American Social Workers.	175e

FIGURE 7·8

175f

16PF Test Profile of British OR Scientists - MALE. (Based on American General Population Norm - Male).

FIGURE 7·9

175g

16PF Test Profile of British OR Scientists - FEMALE. (Based on American General Population Norm - Female).

FIGURE 7·10

175h

16PF Test Profile of British OR Scientists, Male and Female. (Based on American General Population Norm).

#### ACKNOWLEDGEMENTS

Several individuals have contributed to the success of this research, many of them cannot be named in this acknowledgement. First, the patience and wisdom of my supervisor, Professor R.C. Tomlinson in guiding this research, particularly during the trying times, through to successful completion is most gratefully acknowledged.

My thanks are proffered to: Mr. T.E. Watson for jointly supervising Chapter Seven, Messrs M. Hirst, and G.M. Luck for constructive criticism of an earlier version of the questionnaire, Messrs T.P. Turner, R.E. Peake, and F. Southgate for granting me interviews, Mr. M.A.C. Bolton for making it possible for me to undertake the training in psychology testing, and Mr. K. Halstead for assisting in computer processing of the 16PF test results.

I am indebted to: The Head of Service of the Federal Republic of Nigeria, the Head of Service Lagos State, Oyo State, Kwara State, Benue State, and Plateau State; the General Manager Oyo State Water Corporation, Kwara State Water Corporation, and Benue State Agricultural Corporation; the Directors of the Nigerian Institute for Social and Economic Research, University of Ibadan Consultancy, and Nigerian Institute for Strategic and Policy Studies and, all the respondents who gave of their time to grant me interviews; all the OR Scientists who participated in the personality study; the Benue State Scholarship Board and the Federal Scholarship Board who funded part of this research.

A major acknowledgement goes to my wife, Sarah, our children, Iye, Ojonele, Enyomeji, Ojima and all others whose sacrifice made this research possible. To you all I proffer my most sincere thanks.

## ABSTRACT

The problems of the introduction of Operational Research (OR) into developing countries was examined with particular reference to the Nigerian Civil Service. Following preliminary investigations on OR in developing countries a questionnaire was used to interview fifty-nine Nigerian senior civil servants including nine permanent secretaries on the problems of the introduction of OR into government services in Nigeria. The interviews were conducted in thirty-five ministries, and in three public corporations in the Federal government, and in five State governments in Nigeria. This unique information which is the first of its kind from Nigeria was used to identify nine factors essential to the introduction of OR into the civil service in Nigeria.

In order to explore the problems of staffing, a psychometric instrument, the 16PF, was used to determine the personality traits which account for success in OR. The instrument was administered to fifty-six British OR scientists in order to construct a personality profile of OR scientists. This study represents the first attempt to understand using scientific method the traits which are responsible for success in OR, and the traits which significantly distinguish OR Scientists from the general adult population, the scientific community, and other occupational groups.

The thesis concluded by discussing a general theory on the introduction of Operational Research (OR) into organisations, and by making recommendations on the introduction of OR into the Nigerian Civil Service.

(OPERATIONAL RESEARCH; INTRODUCTION INTO ORGANISATIONS; DEVELOPING COUNTRIES; NIGERIAN CIVIL SERVICE; ESSENTIAL FACTORS; PERSONALITY TRAITS)

## CHAPTER ONE

### THE PROBLEM

#### Introduction:

How Operational Research (OR) might be started in an existing organisation is a problem which has been compounded by many years of ad hoc approaches to the problem of the introduction of OR into industrial and business organisations and into the Civil Service in many countries. This has resulted in the adoption of various modes for the introduction of OR the merits of which have never been adequately compared.

Whereas in the industrialised countries how to get OR started may no longer be a critical problem, the question nevertheless still stares the OR community in the face: Is there a way, a best way of getting OR started in an existing organisation? In other words, are there sets of necessary conditions which must be satisfied before OR can be effectively started in an organisation? In connection with the introduction of OR into the developing countries these are questions demanding careful investigation, since they may be critical elements in determining whether OR is used or not in these countries; if it is accepted that indeed OR has some important role to play in developing countries.

#### Paucity of Empirical Research:

For some time now the problem of how OR can be effectively and efficiently started and nourished in the developing countries of Africa, Asia, and Latin America has been agitating the minds of OR scientists. Nevertheless the problem has never been investigated in a scientific fashion; although much has been written, there is still paucity of empirical research on the subject.

That OR has world-wide application was attested to by Johnson (1966), and

that OR can in particular contribute meaningfully in finding solutions to the problems of development confronting the emerging economies is indisputable as argued by Ackoff (1968), Morse and Brown (1976) and Gazis (1979). The problem lies with how to get OR started in an efficient and effective manner and nourished in the environments of the developing countries. In other words, what does it take to persuade managers, public administrators and political decision makers in the developing countries that OR can help them find scientifically based solutions to some of the complex decision-making problems they face in order for them to start OR Groups in their organisations?

These are among the most daunting problems often encountered by OR scientists from the developing countries on returning to their home countries after completing their training abroad. Whereas for OR scientists in the industrialised nations of Europe (East and West), North America, and Japan, these may not pose much problems, for OR scientists in the developing countries of Africa, Asia, and Latin America, the problem is enormous. In the developed countries, OR is almost a household word among decision makers whether in government, industry, or business, regardless of whether the organisation has OR scientists working for it or not. The sources from which a decision maker gets to know about OR are numerous. On the contrary the situation in the developing countries is radically different, the decision maker seldom has heard about Operational Research. Almost always, OR has to be explained from scratch. Ignorance abounds about OR.

As Ackoff (1974) remarked, decision makers in the developing countries seldom know how to use the more advanced skills which their countrymen and countrywomen go to the developed countries to acquire. The result is that a number of such trained people take up employment where their skills may not be directly applicable, some emigrate, and others migrate to the less productive sectors of the economy.

The Research Objective:

The problem of knowing what to do in order to get OR started in an organisation often leaves industrialists and governments in the developing countries who might be interested in the introduction of OR into their particular organisation in a dilemma. This thesis is our contribution to the resolution of this dilemma. Its purpose is to increase our understanding in general, of the problems of the introduction of OR into organisations in the developing countries and in particular into the civil service in Nigeria.

A Review of the Chapters:

In chapter two we discuss the literature on OR in developing countries. The reviewed literature are grouped into two parts; Part A lists case studies on OR applications and Part B discusses literature relating to the problems of the introduction of OR.

Chapter three discusses the general application of OR in governments in the developed countries with Britain and the United States of America (USA) taken as examples.

The attempt to initiate a dialogue leading to the possible introduction of OR into the Nigerian Railways Corporation (NRC) is the subject discussed in chapter four.

In chapter five we discuss the methodology of identifying the situation with regards to factors which are significant and pertinent to the problems of the introduction of OR into the civil service in Nigeria.

Chapter six deals with the problems of the customer. It is the

analysis of the survey conducted in order to increase our understanding of the situation in the civil service in Nigeria with regards to the introduction of OR.

In chapter seven we discuss the problems of the potential supply of OR scientists. In order to facilitate the recruitment of scientists with the most suitable personality for OR work a scientifically designed instrument for personality studies, the Sixteen Personality Factor Questionnaire was employed to discover the personality traits which are responsible for success in OR.

We conclude in chapter eight by discussing a general theory on the introduction of OR into organisations, and by making recommendations on the introduction of OR into the civil service in Nigeria.

## CHAPTER TWO

### SURVEY OF LITERATURE ON OR IN DEVELOPING COUNTRIES

#### Introduction:

Having defined the research problem, a survey of literature on OR in developing countries was mounted in order to uncover previous work done on the problems of a planned introduction of Operational Research into organisations, in particular civil services in developing countries. Although literature abound on problem areas where OR has been applied in developing countries, there was paucity of literature on the particular problems of the systematic and deliberate introduction of OR into organisations, especially in the developing countries.

Since we believed that in trying to understand the problems of the introduction of OR into the government services in Nigeria, it would be vital to be able to identify problem areas in the civil service where OR could be beneficially applied, our first task was to amass data on problem areas where OR approaches have been applied in the developing countries. In order to make the problem manageable, six particular sectors in the civil service which we believed would be of major interest to the government in Nigeria were chosen as the areas in which to concentrate the literature search.

In collecting data on the problem areas where OR approaches have been applied in these six sectors, we started by searching literature in Operational Research and the management sciences using abstracts, indexes, and citations where appropriate. This was followed by more concentrated search in literature specific to the six chosen sectors and in literature dealing in general with the problems of developing nations. The six sectors on which literature was searched for the problem areas where OR approaches have been reported applied were:

- (i) Water Resources,
- (ii) Agriculture,
- (iii) Health and Social Welfare,
- (iv) Industry,
- (v) Sectoral and National Planning, and
- (vi) Transportation.

In classifying work as OR, a broad view of the subject was adopted. We were in particular more interested in studies dealing with problems in the real world in which governments function in the developing countries. As emphasised by Rivett (1964) and by Ackoff (1974) true OR studies should deal with the "muddles" or "messes" of real life. In general, the following points served as guidelines in the selection of the problem areas:

- (i) the use of scientific methodology,
- (ii) the use of analytical and quantitative based models, and
- (iii) application to real live decision making problems.

Listed in Part A are the problem areas in which OR approaches have been reported applied in the above six chosen sectors. As might be seen the volume of literature on problem areas where OR approaches have been applied in the developing countries has grown enormously in recent years although it is doubtful if the rate of implementation has kept this pace. Kemball-Cook and Wright (1961) reviewed a total of two hundred and five cases of OR applications to problem areas in the developing countries but expressed disappointment at the small proportion of cases where implementation was reported in the published materials. Although published materials may not represent the true state of the art as argued by Tomlinson (1977), it does provide a rough and ready guide in this particular case regarding problem areas where OR approaches were applied in the developing countries.

Finally, literature pertaining to the particular problems of the introduction of OR into organisations are discussed in Part B. A number of approaches suggested for the introduction of OR into organisations are reviewed, in particular to determine their applicability to the problems of a planned introduction of OR into the civil service in Nigeria. A summary is provided showing the diversity of approaches suggested for the introduction of OR into organisations, in particular in the developing countries.

PART 4: LIST OF PROBLEM AREAS WHERE OR APPROACHES HAVE BEEN APPLIED IN DEVELOPING COUNTRIES:

(i) Water Resources.

"The development of water resources involves large investments and is critical for growth of both the agricultural as well as the industrial sector and, for that matter, the economy as a whole. The planning involves a large number of choices, assumptions and uncertainties in both engineering and economic fields". (Sikka 1973).

Literature on OR applications in water resources studies have been reviewed in the following problem areas: irrigation intensity and feasibility study, Rose (1973); national and rural water system planning, Pike (1983), Carruthers (1973), Roycroft and Szliowicz (1980); regional water planning, Kirshen (1979), Nelson (1979); fisheries development, Binnie and Finlayson (1982), Donaldson (1980); efficient operation of a dam, Thomas and Revelle (1966), Guarisco et al (1980), Owen Thompson et al (1982); crop planting date planning, Hazelwood and Livingstone (1978); irrigation capacity, Hang and Wong (1977), Sharma et al (1982), Livingstone and Hazlewood (1979); choice of irrigation technology, Soltan-Mohammadi (1972), Glickman and Allison (1973), Hannah (1978); design and utilization of water resources; Sikka (1973), Lepschy et al (1973); evaluation of irrigation projects, Smith (1973), Easter (1975), Frankel (1975); water depth prediction, Omorinbola (1982); review of water supply practices, Barrett and Pescod (1982); social and environmental effects of water development, Biswas (1980), Wionczek (1982), Helland (1982).

The study reported by Rose (1973) is of particular interest. It illustrates the application of OR in a very complex problem. The research involved investigating how much, if any of an area covering approximately 1,000,000 acres of land should be irrigated for agricultural purposes and for the production of hydro-electricity; when it should be done; and how to use the land once it had been irrigated. The overall objective of the study was stated as follows:

"Choose that system of dams, reservoirs, river diversion points and major irrigation canals and determine which crops to grow, where, when and in what quantities in order to maximize the Internal Rate of Return of the project over its first 50-year period".

According to Rose the maximization was constrained by factors such as anticipated market demand for crops produced, availability of manpower, physical construction rates, economically justifiable canal capacity, availability of scarce resources including water, and cropping patterns. The problem was formulated as a mixed integer programme consisting of approximately 750 continuous variables, 50 integer variables and 250 constraints.

A particularly interesting feature of this study is that the lack of experience on the part of the consultants in applying the methods of Operational Research and Systems Analysis to complex problems of the sort presented to them provided an opportunity for contrasting the conventional approaches to tackling such problems with the scientific approach. As Rose pointed out:

"It was...decided at the outset that both the conventional and the mathematical approaches should proceed simultaneously until it became apparent that one or the other of them was no longer necessary. Accordingly it was possible to make direct comparison between the two solution procedures and in this instance it was found that the advantages which arose from the use of a mathematical model was considerable... starting from precisely the same basic information, setting out to achieve the same objectives and judged against the same yardsticks, the Systems Analysis/Operational Research approach proved to be demonstrably superior to the more conventional methods of analysis".

Thus one finds that OR is not only applicable to tactical problems, the method of Operational Research is equally capable of handling complex policy issues; it enables decision makers to explore a wide range of alternatives critically before committing scarce resources along a particular course of action.

TABLE 2.1

Summary of literature reviewed on OR applications in developing countries in Water Resources studies showing problem area, analytical and quantitative model developed and country where project was undertaken.

PROBLEM AREA	ANALYTICAL AND QUANTITATIVE MODEL DEVELOPED	COUNTRY WHERE PROJECT WAS UNDERTAKEN
Irrigation Studies	Mixed Integer Programming, Linear programming, Network flows, Fletcher-Powell algorithm, Heuristic mathematical modelling, Dynamic programming, Stochastic programming, Stochastic dynamic programming, Multi-objective programming.	Burma, Mexico, Taiwan, India, Tanzania, Bangladesh, Iran, Egypt, Oman.
Water Planning Studies	Linear programming, Mixed integer programming, Heuristic mathematical modelling, Generalised linear regression model,	Qatar, Kenya, Egypt, Thailand, Sahel-Sudan Region of West Africa, Latin America, India, Nigeria, Ethiopia, Mexico.

(ii) Agriculture

Agriculture is the dominant sector in the economy of most developing countries. Problem areas where literature on the application of OR have been reviewed are as follows: partial or whole agricultural sector modelling, Singh and Ahn (1978), Olayide et al (1973), Weiss et al (1973), Penson (1981), F.O.A. (1966), Abkin et al (1973), Abkin and Manetsch (1972), Manetsch et al (1971); evaluation of new technology packages, Spencer and Byerlee (1976), Perrin and Winkelmann (1976), Low (1975, 1976), Bowonder (1979i, 1979ii, 1981); crop fertilizer use and requirements, Palmer-Jones (1975), Minhas et al (1974), Johnson and Charoenwatana (1981); agricultural mechanisation, Van Rest (1976), Wuyts (1981), Roumasset and Thapa (1983); evaluation of impact of transportation programme on farmer income, Conley and Herdy (1981); food production, Freeman and Karen (1982); farm management, Bazaraa and Bouzaher (1981), Moghadam (1982); grazing management, Swartzman and Singh (1974); cropping patterns, Lakshminarayana and Rajagopalan (1977); dairy and livestock, Kellog (1972), Barras and Weintraus (1979), Mellalieu (1983i, 1983ii), Halter and Miller (1973), Charles et al (1982); storage systems, Barros (1975), Wright et al (1981), Pruzan (1978); agricultural products' price stabilization, Fajardo et al (1981), Hazell and Pomareda (1981); problems of drought, Mamrany (1975); rice buffer stocking, Dixon and Chen (1982); farm simulation, Crawford et al (1982); tree crop farming, Abalu (1975), Olayide and Olowude (1972), Diaz and Martinez (1973), Martinez (1973), Ogunfowora and Heady (1973); transportation of agricultural products, Osayimwese (1973, 1974); mathematical models in subsistence agriculture, Montazemi and Wright (1982); exports and rural wages policy, Pomareda and Simmons (1977).

One particular area where considerable research efforts have been directed in recent years is in the assessment of risk and uncertainty in peasant farmer decision making. Literature reviewed in this area include: Wiens

(1976), Schluter and Mount (1976), Low (1974, 1975), Barnett et al (1982), Moscardi and de Janvry (1977), Gladwin (1976), Herath (1980), Herath et al (1982), Abalu (1976), Wolgin (1975), Benito (1976), Rosegrant and Herdt (1982), Rangaswamy (1982), Feder (1980).

A particularly interesting research is Gladwin (1976). It is an example of the application of modern decision theory in real-world problem solving. In the study, Gladwin constructed models of the decision to adapt the recommendations of the Plan Puebla in Mexico. The decision model was based on hierarchical theory of choice (Lancaster and Tversky). The model was designed for use in predicting farmers' decisions to increase or decrease fertilizer use, increase plant population, and fertilize two times instead of one. The aim was to use the model to identify decision factors which can be affected by policy variation and to make necessary recommendations which will enable farmers to adopt the recommendations of the plan.

An important step in the model building process was the determination of the information that is actually used in farmers' decision making. Using a decision tree and a questionnaire, twenty-five farmers were interviewed. Among the factors which were actually used in the decision to increase or decrease fertilizer use, to use this one example, were availability of bank credit for more fertilizer, changes in available fertilizer technology, changes in the relative cost of fertilizer to corn, and changes in farmers' production technology.

Using the model Gladwin identified and recommended the following policy changes: increase in fertilizer given to farmers on credit, more explicit instruction on plant population, and the need to drop the recommendation to fertilize on type A soil at planting.

A major objective of OR studies is to enable the decision maker to make better decisions by identifying for him critical elements in the decision making process and suggesting to him various courses of action which can be taken on those critical elements in order to achieve his desired objective. This is what has been done in this particular study.

TABLE 2.2

Summary of literature reviewed on OR applications in developing countries in Agriculture showing problem area, analytical and quantitative model developed and country (or area) where project was undertaken.

PROBLEM AREA	ANALYTICAL AND QUANTITATIVE MODEL DEVELOPED	COUNTRY WHERE PROJECT WAS UNDERTAKEN
Agricultural sector modelling	Simulation, Input-output model, Pert, Recursive linear programming, Dynamic linear programming, Heuristic mathematical modelling.	Nigeria, Brazil, Nepal, Syria, Cuba, Camerouns, Sudan-Sahel Region of West Africa.
Assessment of risk and uncertainty	Quadratic-risk programming, stachastic linear programming, Multiobjective programming, Income stability model, Hierarchical theory of choice model, Safety-first decision rule, Neoclassical model of behaviour, Utility theory model, Multiple-attribute utility maximization, Single-attribute utility maximization, Expected profit mazimization.	Mexico, Ghana, Senegal, Sri Lanka, Kenya, Philippines, Nigeria.
Evaluation of new technology package	Multivariate analysis, Simulation, Multiple network technique, Linear response and plateau model, Dynamic programming, Heuristic mathematical formulation, Graphical method, Regression analysis, Linear programming,	Ghana, Sierra-Leone, Turkey, Brazil, Kenya, Malawi, India, Thailand, El-Salvador, Puerto-Rico, Colombia, Mozambique, Tunisia, Nepal.
Dairy and livestock	Linear programming, Mixed integer programming, Simulation.	Nigeria, Venezuala, Chile, Caribbean New Zealand, community.
Management of agricultural sector	Linear goal programming, Statistical modelling, Dynamic programming, Mixed integer programming, Network analysis, Stochastic optimal control technique, Linear programming.	Iran, Nigeria, Egypt, India, Chile, Bangladesh, Brazil, Taiwan,
Socio-economic problems	Linear programming, Price endogenous mathematical programming, Quadratic programming.	Thailand, Guatemala, Nicaragua, Mexico.

(iii) Health and Social Welfare

"Health care is one of the most important of all human endeavours to improve the quality of life and yet a large proportion of the world's population has no access to health care at all, and for many of the rest the care they receive does not alleviate their problems. The spectacular advances of medical science have not touched the majority of people in the world. The majority of the developing world's population still suffer and die from the same diseases which afflicted their forefathers". (Christian et al 1977).

Operational Research models and methodology have been applied to problem solving in health care in the developing countries. Literature have been reviewed in the following problem areas: disease control, Matzke (1963), Super et al (1961), Frerichs (1975), Wiess (1974); health centre location, Bennett et al (1963), Gershen-Berg and Haskell (1972), Patel (1979); resources allocation, Goyal and Yadav (1978), Lawrence and Mundiyo (1975), Haran (1979), Lawrence et al (1973), Fong (1962); sanitation planning, Daniel and Lloyd (1980); utilization of health services, Benyoussef and Messen (1974), Sargent (1960-1961), Odofalu (1975, 1976), Caldwell and Dunlop (1979), Habicht (1979), Johnson (1973), Mburu and Smith (1976); nutrition planning, Popkin et al (1960), Stickney et al (1973), Anderson and Earle (1963), Calkins (1961); obstetrical care decision making, Sargent (1962), Auerbach (1962); family planning, Ware and Dickert (1976), Gon (1961), Gould and Magazine (1971); national population control, Shaw (1973), Charnes et al (1970), Dyson et al (1977), Christian et al (1977), Bizien (1979), Reinke (1970), Patil et al (1963), population and infrastructure development, Mickle and Voyt (1975), Saeed (1962), Frederiksen (1961); developing OR capability, Luck (1979), Hindle (1978).

An interesting case study is that reported by Super et al (1961). The study illustrates the contribution statistical analysis can make in health studies. This particular research centred on the incidence of

methaemoglobinaemia in infants drinking well-water rich in nitrates. The study was undertaken in a two month period after the rainy season in Namibia when maximum nitrate levels prevail in water in the area.

Data were collected using questionnaire on the length of the mother's domicile in the region; her health in general and during pregnancies; her obstetrical history with special reference to abortions, still-births, and premature deliveries; and number of infants deceased in the first year of life. Emphasis was particularly placed on incidents of diarrhoea, upper and lower respiratory tract infections and breath-holding attacks.

Data on mother's dietary history were also collected noting particularly daily water intake, vitamin C taken as medication or as vegetables, fruit or juice; milk and the type of milk used, i.e. breast, cow, goat, or commercially available powdered milk. A number of other related data including clinical tests were gathered. Four hundred and eighty infants (approximately 75%) participated in the study and water from one hundred and fifty-three wells used by the infants was sampled in the survey.

The data were subjected to statistical analysis as well as clinical tests. The results showed a strong correlation between actual nitrate intake and methaemoglobin levels. Mothers who lived in the high nitrate-bearing areas were found to have increased infant wastage. The regular administration of vitamin C was recommended to lower methaemoglobin levels.

This is an example of how the use of scientific method can assist in solving real-live problems.

TABLE 2.3

Summary of literature reviewed on OR applications in developing countries in Health and Social Welfare showing problem area, analytical and quantitative model constructed and, country where project was undertaken.

PROBLEM AREA	ANALYTICAL AND QUANTITATIVE MODEL DEVELOPED	COUNTRY WHERE PROJECT WAS UNDERTAKEN
Population Control	Heuristic mathematical models, Probability theory, Simulation, Goal programming, Matrix analysis, simulation, Multiple regression analysis.	Singapore, Senegal, Nigeria, Turkey, India, Pakistan, Philippines
Hospitals and Health Centre problems	Minimal spanning tree algorithm, set covering algorithm, Dynamic programming, Heuristic mathematical programming, Simulation, Probability theory.	Colombia, Uganda, India, Nigeria, Malaysia, Honduras, Dominican Republic, Tunisia, Kenya, Guatemala, Tanzania, Benin
Disease Control	Simulation, Statistical method.	Colombia, Haiti, Africa, Namibia, Bangladesh
Nutrition planning	Benefit-cost model, Linear programming, Goal programming	Philippines, Kenya, Nigeria, Mexico, India, Turkey, Nepal.

(iv) Industry.

One of the reasons for referring to some of the countries of Africa, Asia, and Latin America as "developing countries" is the low level of industrialisation of these countries. Literature relating to the application of OR in industry in these countries were reviewed in the following problem areas: production planning, Bhatnagar (1981), Lingaraj (1980), Rao and Achanya (1975), Cabraal (1981), Muir et al (1964), Lietaer (1977), Davis (1981), Ghosal (1966); location of industries, Benkhelif et al (1973), Bhatia (1976); choice of production technique, Bowonder (1981), Perkins (1983), Hill (1983), Byerlee et al (1983), Rhel and Westphal (1977), Forsyth and Solomon (1977), Winston (1978); industrial marketing, Wortzel (1963), Brasch (1973), Davig (1980), Sarin (1982), Pal and Bowonder (1979), Wortzel and Wortzel (1981); nationalization of industries, Jones (1980); small scale industries, Isaac (1981), Banerjee (1973); industrial growth, Mesarovic (1981); problems of OR in industry, Glen and James (1980), Sagasti (1972, 1974), Clayson (1980), Vertinsky (1972), Adegbeyemi and Longe (1976), Bandyopadhyay (1980), Shiba (1976); appraisal and evaluation of industrial projects, Tang et al (1980), Oxtoby (1979), Freivalds (1973); exploration-data-collection modelling, Attanasi (1981); integrated industrial planning, Elsnafei and Elhadid (1981); Managerial innovation, Vertinsky and Barth (1972); technology purchasing, Irvin (1981); application of space technology, Freivalds (1973), life insurance, Varde (1976).

A particularly interesting study is that reported by Jones (1980). The study illustrates the application of analytical and quantitative modelling in unusual problem situations. Jones developed a mathematical model for predicting expropriation (or nationalization) in some developing countries. Data on the political situation in twenty-one Latin American countries were collected, these include riots, protest demonstrations, foreign interests, voting records in U.N. General Assembly, and successful military

coups. The countries were divided into two groups, those that nationalized controlling interests in foreign owned industries during the period 1968 to 1971, and those that did not.

Using the statistical models of factor analysis and discriminant analysis, the data were studied in details. The results showed that riots, U.N. voting on self determination issues, and repression were factors which identified expropriating governments very clearly. The models were then applied to investigate the possible nationalization of foreign-owned bauxite mining industries in Jamaica. The models successfully predicted expropriation.

TABLE 2.4

Summary of literature reviewed on OR applications in developing countries in Industry showing problem area, analytical and quantitative model developed and, country where project was undertaken.

PROBLEM AREA	ANALYTICAL AND QUALITATIVE MODEL DEVELOPED.	COUNTRY WHERE PROJECT WAS UNDERTAKEN
Evaluation of industrial project	Simulation, Linear programming, Scenario construction, Discrete dynamic programming, Social benefit-cost analysis, Preference theory, Domestic resource cost model, Game theory, Binomial-poisson distribution.	Algeria, India, Malaysia, Ethiopia
Production technique	Isoquant, Discriminant analysis, Linear regression, Inventory approach, Linear programming, simulation.	Indonesia, Ghana, Korea, Sierra Leone, Tanzania, Nigeria, India, Sri Lanka, Chile, Peru, Latin America.
Industrial marketing		Taiwan, Hong Kong, South Korea, Singapore, El Salvador, Brazil, India, Thailand, Philippines.
Expropriation of industry	Factory analysis, Discriminant analysis.	Latin America, Jamaica.

(v) Sectoral and National Planning.

Literature reviewed in this section include those in the following problem areas: Education and manpower planning, Correa (1978), Ozoro (1978), Gunawardena (1981), Ball (1976), Panitchpakdi (1977), Ritzen (1976), Durstine and Davis (1969), Bowless (1976), Biswas (1976), Ramanujam (1973), Seiver (1983), Bandyopadhyay and Varde (1980); urban activity location, Ayeni (1975); health services information systems, Bhatnagar (1982); rural-urban migration, Gordon (1982); banking systems, Bandyopadhyay (1978); Steel demand, Rao (1976); general planning problems, Ackoff (1977), Saaty and Vargas (1979), Cornelisse and Kol (1976), Hilhorst (1981), Burkner (1982), Dholakia et al (1979), Feder et al (1977), Butterfield and Rubursi (1981), Carter et al (1973), Elshafei (1976), Venu (1972), Lloyd (1979), Fass (1982), Chi-fa (1976), Okita (1976), Anastos et al (1980); tourism planning, Gearing et al (1973), Van Erden and Warndner (1982); control of social unrest, Legasto (1978); food demand planning, Malik and Ahmad (1981); project planning, Rondinelli (1979); telecommunications planning, Wellenius (1976), Walsham (1983); multi-sector investment planning, Martens and Pindyck (1975); lending risk assessment modelling, Feder et al (1981), Agtmael (1976), Thornblade (1978), Mayo and Barrett (1978), Holsen (1978), Blask (1976); economic modelling, Bhende (1964), Rondinelli (1978), Fei and Ranis (1975), Mahalanobis and Mukherjee (1961), Sparkar (1974), Slater and Walsham (1975); micro-electronic revolution, Rada (1981), Nilsen (1979); energy planning, Sharko et al (1973), Ganzaga (1973), Patel (1983), Wadhwa (1980), Iwayemi (1978), Ayodele (1982), Bernard (1982), Lahiri (1977), Hoffman (1980), Barzelay and Pearson (1982), Anderson (1972), Smith (1980), Weiss (1970), Goldberg (1982); export planning, Levary and Choi (1983), Picardi and Shorb (1983).

The study reported by Gearing et al (1973) is of particular interest. It illustrates the application of a mathematical programming model in

a soft problem area. The subject of the research was the development of tourism; the researchers examined the question of how Turkey could best allocate its capital budget for tourism in the Third Five Year Plan.

The research team first identified seventeen criteria of "touristic attractiveness", numerical weightings were then assigned to each of these by a panel of twenty-six persons acquainted with the tourist business. Sixty-five touristic areas were chosen for consideration. A dynamic programming model was then developed to aid in decision making. The formulation consisted of three hundred and seventy-two zero-one variable problems subject to three hundred and eight constraints.

TABLE 2.5

Summary of literature reviewed on OR applications in the developing countries in Sectoral and National Planning showing problem area, analytical and quantitative model developed and, country where project was undertaken.

PROBLEM AREA	ANALYTICAL AND QUANTITATIVE MODEL DEVELOPED	COUNTRY WHERE PROJECT WAS UNDERTAKEN
Manpower planning	Linear programming, Linear regression, Quadratic programming, Heuristic mathematical modelling, Multiple channel queueing model, Open static Leonlief input-output model, Simulation.	Mexico, Nigeria, Asia, Latin America, Bangladesh, Colombia, India.
Sectoral planning	Dynamic programming, Box-Jenkins Transfer Function, Management information system, Multiple regression analysis, Simulation, Linear goal programming, Logit analysis, Check list system, Discrimmarly analysis.	Turkey, Puerto Rico, Kenya, Tunisia, India, South Korea, Saudi Arabia
General planning	Simulation, Analytical hierarchy, Linear programming, Risk aversion model, Optimum seeking methods, Linear regression analysis.	Mexico, Syria, Sudan, Iran, Pakistan, Turkey, Haiti, China, Saudi Arabia, Korea, Taiwan, India, Malta, Thailand, Kenya.
Energy planning	Graph theory, Forward dynamic programming, Simulation, Mixed integer programming, Linear programming, Social profitability analysis, Multiple regression analysis.	Brazil, India, Australia, Nigeria, Tunisia, New Zealand.
Social Systems planning	Simulation, Confidence limits, Beaten paths approach, Entropy maximization.	Philippines, Libya, Nigeria.

(vi) Transportation.

"In advanced countries, transportation development takes place largely because of a demand that is already there. In the developing countries, transportation acts as a catalyst in the development process. The provision of new transportation services is in itself an important factor in increasing the demand" (Budhu and Hobeika 1980).

A number of studies have been reported in the literature in this basic sector of the economy. Literature have been reviewed in the following problem areas in the four basic modes of transportation.

- (a) Road Transportation: Truck deployment, Mortagy and Eleithy (1980); fuel economy evaluation, Gandhi et al (1983); daily expenditure on travels, Roth and Zahavi (1981); vehicle import restrictions, Mwase (1983); urban transport, Adeniji (1983), Ogunsanya (1982), Micheli (1982); scheduling problems, Saha (1970), Tinker (1975); problems in transport planning; Akom (1984), Subramaniam (1976), Hays (1969), Wijesinghe(1976); inventory control, Vrat and Buba (1979); traffic conflict studies, Chang (1980).
- (b) Rail Transportation: Coach utilization, Ramani (1981); scheduling problems, Szpigel (1973), Aoel (1981); economies of operation, Koshal (1970), Due (1980), Olanrewaju (1979), Johnson (1963); capacity expansion, Alexander (1979); planning problems, Subramaniam (1979), Due (1979), Leung (1982), Madeley (1981); problems of rail transportation in Africa, The Courie (1979), Kleenik (1971), Makoni (1972), Bickers (1976).
- (c) Water Transportation: Containerized shipping, Al-Kazily (1983); scheduling problems, Cunto (1978); harbour and ports studies, Udife (1975), Monnanteuil (1973), Gribbin (1975), Vidali and Truesdell (1977).

Shneerson (1981), Wood (1982); planning problems, Kumar (1976), Budhu and Hobeika (1980).

(d) Air Transportation: Airport site selection, Saatcioglu (1982); choice of aeroplane, Rasmusen (1978); air shuttle studies, Shah and Rastogi (1973); planning problems, Subramaniam and Sharma (1975), Filani (1975).

General Transportation Studies: Emerson et al (1973), Boyd and Fouracre (1973), Gupta (1982), Mahmassani and Gakenheimer (1983), Saaty (1977i, 1977ii), Sargious and Salinas (1973), Hofmeier (1980), Gauthier (1970), Voight (1967), Carter et al (1984).

The study reported by Shneerson (1981) is particularly interesting. It is concerned with the application of an analytical and quantitative model in solving the problems of port congestion in a developing country. Following the embarrassing port congestion in Nigeria in 1975, a study was commissioned to draw up a masterplan for Nigeria's port requirements to the year 2000. The objective of the study was to determine the size, timing, and location of investment in the port system.

Demands were estimated for commodities, port facilities, exports and imports, and projections (or forecasts) were made for the period 1980 to 2000. Assumptions were further made about containerization, conventional break-bulk cargo, future port capacity, future container ship sizes, and costs of port construction. The problem of determining the size, staging, and location of ocean terminals was then formulated and solved using dynamic programming model.

TABLE 2.6

Summary of literature reviewed on OR applications in the developing countries in transportation showing problem area, analytical and quantitative model developed and, country where project was undertaken.

PROBLEM AREA	ANALYTICAL AND QUANTITATIVE MODEL DEVELOPED	COUNTRY WHERE PROJECT WAS UNDERTAKEN
Road transportation	Heuristic mathematical model, Linear regression analysis, Traffic conflict technique, Multiple regression analysis, R-mode factor analysis, Inventory model, Algorithm	Egypt, India, Colombia, Singapore, Chile, Brazil, Tanzania, Nigeria, Taiwan, Korea
Rail transportation	Computerized information system, Branch-and-bound algorithm, Multiple regression analysis, Linear regression analysis.	India, Australia, Africa, Nigeria.
Water transportation	Heuristic scheduling algorithm, Dynamic programming, Priority queueing theory, Linear programming.	Venezuela, Nigeria, Algeria, West Indies, Egypt, India, Guyana.
Air transportation	Integer programming, Heuristic mathematical modelling, Simulation, Slate programming, Scenario construction, Analytical hierarchy.	Turkey, India, Greenland, Nigeria, Egypt, Sudan, Algeria, Africa.

#### Worrying Questions From The Literature :

The review of the literature has left one with some worrying questions.

- (i) One questions the wisdom in the use of the sophisticated and advanced optimisation techniques on the scale revealed in the literature in an area where little or nothing is known about OR. This has led some to question the applicability of OR in the developing countries (McCarthy 1978). It has also given substance to the accusation that OR is a bundle of sophisticated advanced mathematical techniques which may be inappropriate for dealing with the "mess" confronting public administrators and managers in the developing countries. (Bandyopadhyay 1980). Kemball-Cook and Wright in their review of literature on OR in the developing countries similarly showed a disapproval of the preponderance of optimisation techniques in the literature on OR in developing countries.
- (ii) Rarely is there any clear statement about client involvement, since this is vital to successful OR, that is, implemented OR, one is rather worried that little is said about the client involvement in most of the literature.
- (iii) The academic nature of the studies is another worrying point. Often the reported cases were the results of studies undertaken as part of the requirements for the award of some academic qualifications. Whereas this is not to be condemned, one argues that more benefits could have been derived from the exercise if it was directed at solving some real-world problems which some identifiable person had. Since the researcher often appeared to be more interested in proving his point rather than solve any real world problem such exercises often left the impression that OR is an irrelevant intellectual activity rather than practical problem-solving.

- (iv) It is often not clear from the literature whether many of the problems investigated were those which actually confronted a decision-maker or just problems on which the scientist had ready-made tools which he wanted to test in a developing country. This theory testing research although it is not to be condemned, one argues should be designed to be beneficial.
- (v) The literature is dominated by haphazard one-off application of OR techniques rather than systematic attempts to establish OR in particular organisations.
- (vi) Seldom does the report give a clear picture of the state of implementation or non-implementation of the study, this is perhaps the most worrying aspect of the literature on OR in developing countries. The thing which most singularly distinguished OR in the days of its birth was the remarkable benefits that resulted from the implementation of its findings. One is persuaded that one reason why OR has not made the breakthrough it needs in order to become widely used in many developing countries is that researchers rarely cared enough to ensure the implementation of their findings as they often are in ensuring that the studies are published.
- (vii) A good number of the studies were undertaken by foreign experts and the studies were often financed by aid organisations. Since these foreign experts are believed by the administrators in the developing countries to be the brains behind the spectacular achievements of OR in the developed countries, the administrators can not understand why these experts fail to achieve the same spectacular results in the developing countries particularly when much scarce resources are generally committed into ensuring that the expert is

comfortable. The lack of results has led administrators in the developing countries to accuse the foreign experts of paying lip service to problem solving in the developing countries.

Walsam (1978) expressed apprehension about the uncomplimentary attitudes of expatriates (experts) working as consultants or advisers in the developing countries who consider the whole exercise as a holiday in contrast to the serious business of earning his living back in his home country. Sagasti (1973) also warned about ego satisfying trips of foreign researchers to the developing countries.

Speaking on the dangers of non-implementation of OR studies Ackoff (1960) cautioned that amassing technical successes could be counter-productive. Luck (1973) advocated that in doing OR in developing countries implementation rather than publishing should be the aim. Clayson (1980) emphasised that governments in the developing countries may not institutionalise the use of OR unless they see results.

The problem of non-implementation worries one very much because public administrators and managers in the developing countries, just like their counterparts in the developed countries are only going to be persuaded to use OR by the results they get from OR investigations. Unimplemented OR investigations make no positive contribution towards this process.

PART B: INTRODUCTION OF OPERATIONAL RESEARCH INTO ORGANISATIONS:

Literature dealing with the particular subject of the introduction of OR into an organisation either in the developed or in the developing countries based on empirical research is relatively scarce. In the literature some suggestions, mostly based on the experience of individual practitioners have been advanced on how OR might be introduced into an organisation. Rivett and Ackoff (1963) suggested acquainting management executives with what OR does, how the OR scientist does his work and what is likely to be involved in setting up OR as a way of introducing OR into an organisation. Morse (1967) suggested the use of external consulting OR teams backed by strong support from the administrator and his staff. Morse and Brown (1976) and the team appointed by the National Academy of Sciences (1976) to examine the relevance of SA/OR to the problems experienced in the developing countries recommended setting up a prototype SA/OR Group under an administrator persuaded of OR and committed to its success. Luck (1979) by his experiment in growing ORSA in the Indonesian Health Service demonstrated the possible role employees of international aid organisations who act as consultants to public administrators in the developing countries can play in the introduction of OR into the developing countries. In the Luck experiment, executives and would-be researchers were intimated with what OR does, they were then given simple practical assignments in real-live practical problem solving using OR methodology. Based on the results of his experiments Luck advanced eleven propositions, for example, in propositions 3, 4 and 1, Luck declared:

" 'Managers and Researchers should train together from the start'. 'The ORSA approach is learnt through facing real problems in the field'. 'The ratio of foreign consultants to nationals in an R & D institute should be less than 1:10'."

Other approaches suggested for the introduction of OR into the developing countries in particular include making OR techniques available as common resources (Clayson 1980), the creation of OR centres in developing

countries (Bandyopadhyay and Varde 1980), the mass mobilization of scientists in a crusade for national development (Ackoff 1968), the application of OR in solving problems with clear cut solutions (Shoba 1976, Gupta and Krishnamorthy 1976, McCarthy 1973) the introduction of OR through aid organisations (Walsham 1978), and the introduction of OR through offering OR courses in local Universities.

Some of the obstacles to the introduction of OR were suggested by Sagasti (1972, 1974), however the central problem facing the introduction of OR into the developing countries have been succinctly stated by Morse and Brown (1976) as follows:

"All of us are persuaded that OR can be of great help to the less developed countries. The question is, how can it be introduced, fostered, and brought to bear on the many special problems that these countries contend with...A crucial part of the process consists in making the developing countries aware of OR and receptive to its application. Every member of a national society who is here knows that OR did not prosper in his country until some administrators were persuaded to try out its methods and until some countrymen had learned its techniques. Assistance from outside can do just so much; full participation requires participation from within".

But as Ackoff (1974) pointed out, an important factor limiting the application of new skills in the developing countries is that the countrymen who have learned the new techniques were not being usefully employed in their own countries. Ackoff declared:

"Many of the students from less-developed countries who go abroad for education do not return to their countries, not so much because they are attracted by a higher standard of living (although this has its effects), but because they recognise that the skills they acquire are more salable in a developed country than in a less-developed one. Of those that return home many find that their skills are not in demand and are subject to misuse. Of these some emigrate and others settle into academia where they transmit their irrelevant skills to others in their country" (p.223).

The introduction of Operational Research into the developing countries is a member of the family of the genetic problems of technology transfer to the developing countries. OR, and indeed any technology, can only be considered to have been successfully introduced (or transferred) if it is effectively integrated into the institutions of the acceptor country such that it comes into routine use. How this can be done is the objective of this research.

In summary the following approaches have been suggested in order to get OR started in organisations particularly in developing countries.

- (i) The education of executives on what OR does, how OR can aid him in his work and, what is likely to be involved in setting up OR.
- (ii) Setting up a prototype OR group under an administrator who is persuaded of OR and who is committed to its success.
- (iii) Persuading administrators in developing countries to try OR methods.
- (iv) Using employees of international aid organisations who act as consultants in the developing countries.
- (v) Urging foreign aid organisations to formulate projects undertaken in developing countries based on OR studies.
- (vi) The establishment of OR Centres in developing countries.
- (vii) Use of external OR consulting firms.
- (viii) Mobilization of scientists in developing countries in a crusade for national development.
- (ix) Application of OR initially to problems with clear cut solutions.
- (x) Introduction of courses in OR in local universities.

## CHAPTER THREE

### OR IN GOVERNMENT SERVICES IN DEVELOPED COUNTRIES

#### Introduction:

Following the survey of the literature on OR in developing countries, it was found necessary that although the circumstances which led to the growth of OR in the developed countries may be different from those prevailing in the developing countries, much useful insight can be gained from examining the development and practice of OR in the civil service in the developed countries.

In this chapter we discuss briefly the development of OR and its practice within the British Civil Service and the United States of America Civil Service. The discussion is based on literature and on interview with a senior OR scientist in the British Civil Service.

#### OR IN THE BRITISH CIVIL SERVICE:

Following the impressive success of OR during the World War II, the Advisory Council on Scientific Policy recommended after the war the establishment of OR Groups in the major government departments, to assist in peace-time problem solving. OR Groups were initially set up in the Home Office, the Board of Trade, and the Ministry of Works; later the services were extended to the Ministry of Housing, Local Government, and Police Service respectively. Following the Plowden Report of 1961, an OR Group was set up in Her Majesty's Treasury in 1965 (Baldwin 1978, Widdington and Crowther 1947).

The Fulton Report of 1968, to which the Operational Research Society submitted a Memorandum, further emphasised the need to use scientific method in government (Baldwin 1978). The report was followed by a seminar at Oxford in 1969 at which ministers, civil servants, academics, and OR practitioners sought

"to clarify what OR could do for government if more of it were done, where, if anywhere, it should be placed in government and how it should be organised" (Baldwin 1978).

The most important development which followed from the seminar was that the Head of Service, Sir William Armstrong, made recommendations to all permanent secretaries urging them to establish OR Groups in their departments. As a result a number of additional OR Groups were established in departments to undertake problem solving research with the executives, thereby extending the use of OR in the Service (Baldwin 1978). The need to use more numerate abilities in decision making in the civil service was further emphasised by the Holdgate Report of 1980.

The use of OR is now wide-spread and well established in the British Civil Service. It is estimated that there are approximately two hundred OR scientists presently within the non-military civil service and excluding the large number of OR workers operating within the nationalised industries. The main concentration of OR scientists in the Civil Service are in Defence, Treasury, Health, Home Office, Inland Revenue and, Department of the Environment. (Baldwin 1978, Turner 1981, Biffen 1980, Bray 1968, Tomlinson 1970).

The application of OR is strong in Local Governments and in the Regional Health Authorities throughout the United Kingdom. (Ward 1964, 1970, Friend and Jessop 1969, Pinkus and Dixson 1981).

#### Interview With a Senior OR Scientist in the British Civil Service:

Following the brief review of literature on the history of OR in the British Civil Service an arrangement was made for the author to visit Mr. P. Turner, the head of the OR Group in Her Majesty's Treasury to hold informal discussion on points of particular interest. The discussion

centred in particular on aspects of OR considered to be relevant to the introduction of OR into the civil service in a developing country.

Questions were asked by the author on:

- (i) the organisation of OR within the British Civil Service.
- (ii) the work of OR in the civil service.
- (iii) the introduction of OR into a civil service particularly in a developing country.

The particular points made can be summarised as follows:

The organisation of OR within the British Civil Service: According to the Officer, "the present arrangement came about by an act of history", he explained that traditionally the Ministry of Defence, the Department of the Environment and, the Home Office each had large OR Groups. These three co-operate in the recruitment and training of their staff and in publications. In the late sixties there was an attempt to form a single OR Group in the Civil Service but that did not prove politically feasible, the result of that experiment was the formation of the large OR Group in the Treasury. Although the groups in the various departments and ministries co-operate, they are independent groups, each group reports within its ministry or department.

Questioned about recruitment, career planning and, management development of OR staff in the civil service, he replied that OR staff were generally recruited from the same pool as any other employers of OR in the country. On coming into the civil service such officers were initially given short introductory courses in the civil service training school. In order to keep the OR staff abreast of developments in OR, they were often sent on seminars, conferences and short courses in the universities. The career of the scientists is designed to allow an OR worker to transfer to

administration if the worker so desired, while those who wish to remain in OR may be promoted within the rank of the scientific officers.

On the future of OR in the civil service Mr. Turner expressed the belief that government would continue to require the assistance of OR scientists for as long as there were problems of decision making. But he lamented the absence of outstanding intellectuals such as Blackett and others during the war. This he attributed to the existing set up in the government which does not permit the introduction of eminent scientists into OR in the government.

In a final reflection on the organisation of OR in the civil service in the U.K., Mr. Turner remarked that although there had been some talk about a single OR Group with one Head for the civil service, he did not believe that would strengthen OR in government. OR is an "assistance" and has to be seen as useful by those who use it. By withdrawing it from the direct users more could be lost than gained.

The work of OR in the civil service: OR has made enormous contribution to problem-solving in the government over the years, many of the studies have been reported in journals. Three examples of large OR studies carried out in recent years which were cited during the discussion were:

- (a) the development of the Lp model for the reinforcement of forces reserves in the Far-East - undertaken in 1960,
- (b) the balance of care model developed for planning health care into the 1990s, this model is now being used by Regional Health Authorities in the allocation of financial resources among the Authorities and,
- (c) The Financial Information Model designed for the Treasury which has been in use now for some years. This model enables the Treasury to

monitor government spending and hence exercise control on government expenditure.

According to Mr. Turner senior civil servants and ministers often showed interest in major studies being undertaken for them or in their departments. The police study during the time that Mr. Roy Jenkins was the Minister for Home Affairs, and the study of the movement of staff from London undertaken when Mr. Kenneth Baker was the Minister for Defence were quoted as examples. It would however be misleading to suggest that all or even a majority of administrators fully appreciated the opportunities made available to them through Operational Research.

The rate of implementation of OR studies within the Civil Service was generally satisfactory. With regard to the relevance of OR projects, it was stated that OR scientists always had work in hand. Priority in projects undertaken was generally given to officers or departments where no previous studies had been carried out, or where no work had been done in recent months. Problems were usually identified in the first place by OR scientists approaching heads of departments or sections to enquire about possible studies. If the scientists were aware of a problem that a particular department was grappling with they would go there and offer to help. In some cases some one in another ministry gets to know of a model that OR has developed to help solve a particular problem that another ministry had and invites OR people to come and help them solve a similar problem confronting them in their ministry.

Mr. Turner suggested that in order to get OR into government one needed to understand the process of decision making in the government. He emphasised in particular that "a persuasive ability is very important". He noted that politicians do not usually want quantitative advice, they

tend to take decisions on sheer political will. Hence the particular tendency of scientists to be easily carried away with "doing science", to the neglect of political factors in particular during problem solving, is something to guard against in doing OR in government.

Examples of OR Studies in the British Civil Service Relevant to Developing Countries:

Of the numerous OR studies undertaken in the British Civil Service since the 1940s, five have been selected for mentioning in this thesis primarily to illustrate how OR studies done in the civil service in the highly industrialised nations can have particular relevance to problems faced by public administrators in the developing countries. The studies were selected to particularly highlight certain problem areas in the civil service in Nigeria where OR might be of assistance. The studies will be outlined briefly without going into the model detail since that is not of particular interest.

- (i) "Peterhead Bay Harbour - An OR Study into its Capacity for Tankers Traffic" (Russell 1976). This study involved determining the number of berths to be built to handle the expected traffic at Peterhead Bay harbour in Scotland.

The particular relevance of this study lies in the fact that since the seventies ports congestion has been a perennial problem in Nigeria. Given the well known contribution of OR to ports and harbour studies in the developed countries, one would like to suggest that setting up an OR Group in the Nigerian Ports Authority is something that the Nigerian government administrators should think about more seriously.

- (ii) "The Financial Information System Project" (Butler and Aldred 1977).

This study was referred to in the discussion with Mr. Turner. It was a very large study which involved a large number of disciplines. The study was undertaken for Her Majesty's Treasury, the objective was to develop a standard reporting system on central government spending which will make it possible to monitor government spending through a single internally consistent flow of figures and hence to be able to compare them with planned estimates. The model was accepted and implemented by the Treasury. The system was further updated in 1979 (Aldred 1979).

This is a study that one believes is of relevance to Nigeria, the financial problems confronting the country presently (see Financial Times January-March 1984) shows that there is a need for the government to have a decision-aiding-model which will give it better understanding (and hence better control) of its expenditure. This is an area where OR as an interdisciplinary activity can assist the government.

- (iii) "The Road to Cardiff - the Development of MOD's Dispersal Network" (Pardoe and Williamson 1979). This particular study is one which may have immediate relevance to the Nigerian Civil Service, should the government continue its planned movement of the Federal Capital from Lagos to Abuja. The study illustrates ways in which OR investigations can assist government in undertaking such movement with maximum efficiency and the least disruption.

The study involved a network model developed by OR scientists which assisted the Ministry of Defence in determining the best ways to disperse some ten-thousand jobs to Cardiff and Glasgow from London. Using the model that complex exercise was conducted in the most

efficient and effective manner and with minimum disruption in the services.

(iv) "Assessing the Effects of New U.K. Coins" (Maddock and Morgan 1981).

This study was conducted at the Royal Mint. OR scientists were commissioned to study the effect on business of replacing the £1 note by a £1 coin and, to examine the need for an intermediate coin of twenty-pence or twenty-five pence. The cost of this operation was also to be assessed.

Mathematical models were developed and from computer runs of various alternatives it was accepted that the introduction of a twenty-pence coin with a one pound coin offered slightly greater advantage in business transactions than issuing a twenty-five pence coin together with a one pound coin given the existing coins in circulation. The new twenty-pence coin and the one-pound coin are now both in circulation.

This interesting study illustrates how much governments in the developed countries value scientific investigations in every phase of decision making. One hopes that governments in the developing countries, in particular the Central Bank in Nigeria, will give more thought to the use of scientific method in decision making.

(v) "The Metropolitan Police M.S. Department" (Hand 1974). Although the Police Service was one of the departments where OR was established soon after the War, in the early sixties consultants were requested to examine ways in which the Metropolitan Police can make more efficient use of Management Science (M.S.) in its operations. Hand (1974) discussed how the Metropolitan Police has been employing the

services of management scientists on a larger scale following the recommendations of that study.

This particular study was included because of its implications for the Nigerian Police Force.

#### OR IN AMERICAN CIVIL SERVICE:

The United States of America (USA) as a member of the Allied Forces during the Second World War had groups of scientists in their military doing what they called Operations Research (OR), a similar activity to that being done in the British Military at the time. After the war OR moved largely into industry, consultancy and the Universities. (Radnor and Neal 1973, Radnor, Rubinstein and Tansik 1970).

Unlike the British who maintained an in-house OR Group in the Ministry of Defence, the American defence establishments opted largely for a consultancy mode. RAND, a non-profit research or advisory organisation was set up soon after the war to assist the U.S. defence establishments in analysing the complexities of modern warfare. Like war-time OR Groups, RAND is made up of civilian scientists who carry out extensive research for the military on numerous aspects of planning, operations, and weapons procurement and deployment policies (Smith 1966, Schlesinger 1963). RAND work is now mostly civilian.

In the civil sector of the American government administration, the application of OR was evolutionary. In the 1950s only a few government departments had OR scientists working with them. However, by the 1960s the volume of demand for OR applications had grown dramatically, so that by late 1960s most departments had a number of OR scientists working with them. The departments of Commerce, Transportation, Health, Education,

and Welfare are among the departments that greatly increased their OR strength during this period. (White 1975; White, Radnor and Tansik 1975).

Today in almost every department of government and at all levels of governmental administration - Federal, State, Local, or City, one can find OR scientists undertaking problem solving research with the executives.

A classical example of OR contribution to problem solving at the very local level was the impressive work done for the City of New York by "The New York City - Rand Institute" (Operations Research May-June 1972).

Examples of OR Studies in the American Civil Service:

OR penetration into American civil service is now very extensive, a number of successful and highly rewarding OR studies can be cited at every level of governmental administration. Five studies selected to illustrate areas where OR applications might assist in developing countries will now be outlined briefly.

(i) "Model for a total Criminal Justice System" (Blumstein and Larson (1969). In this elaborate study the criminal justice system was modelled so that the flow of arrested persons through the system can be examined and the system of apportioning costs carefully studied. The objective was to present in a quantitative way the operation of the system of criminal justice and to assess the effect it has on the future behaviour of criminals, the workloads, the resources required, and the costs inherent in the system.

(ii) "Cost-effectiveness in Urban Transportation" (Dodson 1969). This article is a report of extensive OR investigations into the present and future modes of transportation within four selected cities so as

to determine how to improve the quality of urban life. The study was undertaken for the Department of Housing and Urban Development. It examined among other things, the costs of investment and operation, benefits and costs to users, social costs and benefits, the use of buses, and private cars, railway transits, stations, terminals, parking lots and the host of factors relevant to urban transport planning. A simulation model was developed in order to study the interaction of the various sections.

- (iii) "A Black Ghetto's Research on a University" (Ackoff 1970). This rather extra-ordinary case illustrates the power of OR to assist in unusual circumstances. The report is concerned with how a black poor community "used" a University to solve some of its problems. The project involved largely the planning and the development of the community (or Ghetto) so as to improve the standard of living of the mainly black residents. Among the projects undertaken were the establishment of nine manufacturing firms, the provision of a number of small businesses, and the establishment of schools to cater for drop-outs.
  
- (iv) "Cost-Effectiveness Analysis of Civil Engineering Systems: New York City's Primary Water Supply" (Neufville 1970). This is a report of how cost-effectiveness analysis was used to relate the technical issues in civil engineering designs to public-policy objectives. The differences between civil engineering standards and policy-objectives had created an impasse on the planning and design of New York City's Third Water Supply Tunnel. By applying OR approach, the gap was successfully bridged.
  
- (v) "Operations Research in the Health Services" (Flagle 1962). The paper

discussed the problems of providing health services in the areas of staffing, financing, management, demand for services, scope of services, distribution and allocation of resources and communication. It examined the contribution OR is making in solving these problems. Examples of studies undertaken by OR scientists in the various sections of health services are cited. Areas where urgent OR assistance is needed are also suggested.

MODE OF INTRODUCTION OF OR - THE POINT OF PARTICULAR INTEREST:

The objective of this phase of the research was to discover what useful insight can be gained from a history of the growth and practice of OR in the civil service and in public corporations in the developed countries. An important insight gained from this phase of the research was the complexity of the problem of the introduction of OR into the civil service in developing countries. Five basic modes can be discerned for the introduction of OR into the civil service, these are:

- (i) The establishment of a Central OR Group to provide OR services for all the ministries and departments.
- (ii) The establishment of a government corporation on the lines of the RAND Corporation in the U.S.A. to provide OR services for all ministries and departments.
- (iii) The establishment of OR Groups in selected key government ministries and departments to provide OR services.

Hybrid Modes

- (iv) The establishment of a government corporation on the lines of the RAND Corporation in the U.S.A. to provide OR services for ministries and departments together with the location of small OR groups in

the ministries and departments to work closely with the Corporation.

- (v) The use of Private Consulting Groups together with small OR Groups located in the ministries and departments.

It is possible that the adoption of a particular mode may be an important factor in the success or failure of the programme for the introduction of OR into a civil service in a developing country.

CHAPTER FOUR  
THE TRANSPORTATION STUDY

The Logic of the Approach:

Following the survey of literature on OR in developing countries, and the study of OR in government services in developed countries the preparations necessary in order to proceed to Nigeria were nearly completed. Since in general OR studies cannot be undertaken in isolation it was realised from the initial conceptualisation of the problem that any study must be done with the active participation of appropriate officials in the civil service in Nigeria. The immediate problem we had in this connection was how to turn to the officials in the government in order to enlist their support.

Since our research was concerned with the problems of the introduction of OR into the civil service we thought that the best approach would be to try and initiate some sort of dialogue between ourselves and some senior officials in the government; in this way we thought also to ensure their active involvement in the study. Hence it was decided that in order to enlist the interest and support of the officials, the discussions or dialogue would be in terms of problems on which OR can assist and not on the approval or "selling" of OR. After considering carefully a number of possible ways to initiate such a dialogue we were convinced that the best approach in this particular case would be to draw up a tentative list of problems in some particular sectors of the civil service which might be perceived by senior civil servants as being of significance to the Nigerian government. This would be problem areas in which OR expertise have been well tested (see Chapter Two). This approach had the merits that:

- (i) It would show at once that we meant business and hence could generate sympathy from officials.

- (ii) It would make plain clear who and where we were directing our request, this being particularly important in dealing with civil servants.
- (iii) There would be minimum doubts about what our request is, why we are making it, and what we are trying to achieve and hence minimize correspondence between us.

The Purpose of the Dialogue:

As might be seen from the foregoing section, the first purpose of the dialogue therefore was to try and find some sort of client for the study, and to try and ensure their active involvement in every phase of the study. As pointed out in Chapter Two, most of the studies reported in the literature did not say much about the client and his involvement. We believed that for the study to have a real chance of making an impact on the Nigerian Civil Service as well as make some meaningful contribution to knowledge in the area of the introduction of OR into developing countries it was essential that there should be some sort of client and that the client should be involved in the studies as much as possible.

The second and perhaps the more important purpose of the dialogue was to use it as a vehicle for studying the problems of getting OR started in the civil service. It was not our intention in this respect to undertake any particular OR studies in the sector. Our objective was to work with the officials to identify sufficient policy, strategic and tactical problems which were perceived by the management as being of significance to them and on which OR scientists can assist. We believed that in this way the management could be persuaded that the introduction of OR into the particular organisation would be a worthwhile investment, and was to be preferred to calling in external consultants for example, to study the problems,

or to just hoping that somehow the problems would be solved by sheer ad hoc decision making.

The next phase would have been to work with the management to develop a strategy for the introduction of OR and to explore the tactical problems involved in getting OR successfully started in the organisation. In that way we hoped to have acquired experience which could have enhanced our understanding of the complexities of the introduction of OR albeit on a small scale. We hoped from that experience to have been able to generate some hypotheses on the introduction of OR which other researchers would hopefully have been able to test in larger studies elsewhere.

#### The Particular Sectors Chosen for the Initial Study:

In view of the importance of transportation and health services in the process of socio-economic development and, in view of the unsatisfactory state of transportation systems and health services in Nigeria, transport and health were initially selected as areas where dialogue may be started and hence the introduction of OR into the Civil Service discussed. The background to the choice of transportation systems is discussed in detail in the text.

Following the decision to start the dialogue in the areas of transportation and health services, a comprehensive survey of the literature was first undertaken in transportation systems with particular emphasises on transportation systems in developing countries. The purpose of this survey was to acquaint oneself with problems in transportation systems in order to be able to draw up a sensible tentative project list for the dialogue with the appropriate officials. The survey crystallised in our interest centring on rail transportation systems for reasons discussed in detail in the text.

Having decided to concentrate on rail transportation system an interview was arranged with the Operational Research Manager in British Railways Board to enable the author to examine OR applications in British Rail. Detail of the discussions are briefly outlined in the next section.

#### OR IN BRITISH RAILWAYS BOARD:

Just as much useful insight can be gained from a review of OR growth and practice in the main body of the civil service in the developed countries, so much can also be learnt from the application of OR in government corporations in the developed countries. Our particular attraction to this is derived from the unsatisfactory state of government corporations in the developing countries.

In Nigeria for example, public utility corporations constitute perennial sources of problems to successive governments because their operations are generally unsatisfactory. Believing that OR can assist some of the public corporation in the developing countries, we thought it would be beneficial to examine OR applications in one of the economic government corporations in the United Kingdom.

An informal interview was arranged with a senior OR scientist in the British Railways Board (BR) to enable the author to have a feel of OR contributions in this particular industry. As a follow up from that discussion another informal interview was arranged with a senior OR scientist at "Transmark" (Transportation Systems and Market Research Limited), a Consulting firm linked to British Railways Board. A summary of the points discussed is presented below.

#### Interview With a Senior OR Scientist in British Railways Board:

British Railways Board has a sizeable force of OR scientists. The OR Group

in this nationalised industry is located in the Planning Division instead of the Management Services Division, the latter being more identified with computer and data processing. During the informal interview with Mr. R. E. Peake, the Operational Research Manager, the discussion centred mainly on the problems OR scientists have investigated on the railways over the years. A sample of some of the studies cited will now be presented in brief outlines in order to illustrate the diversity of studies undertaken by the OR scientists in the last couple of years. These studies were selected "in principle" to indicate areas where OR may assist in railway transportation in developing countries.

- (i) Models for planning of the Inter-City passenger traffic. These are a set of decision-aiding models developed to assist management in planning the Inter-City Services and the necessary investment needed. They are based on the so-called gravity and elasticity models.
- (ii) Models for Assessing the Demand for High Speed Train Services. These studies were undertaken to assess the effect on traffic of the introduction of the High Speed Train (HST) and the Advanced Passenger Train (APT).
- (iii) Assessing the Number of HSTs and APTs Required to Run an Efficient and Effective Service. This study was undertaken to determine the number of HSTs and APTs needed in order to provide uninterrupted services taking into consideration maintenance and possible breakdown.

- (iv) Alternative Train Length and Car Composition. This study was undertaken in connection with the APT. It is one of a series of projects undertaken before the train service was introduced.
- (v) Study of the Maintenance and Operation Plans for HST.
- (vi) Study of the Effects on Revenue of Changes in Rail Services. This interesting study was aimed at increasing BR revenue through improved time-table. A computer programme was developed to assist in studying the revenue changes expected from alternative time-tables.
- (vii) Railway Electrification. A number of studies were undertaken in this area.
- (viii) Railway Canteen Services. British Rail Canteens are among the most expensive in the country. BR scientists have conducted a number of studies aimed at improving the efficiency of the services over the last couple of years.
- (ix) Train Car Seats. The effect of comfortable car seats on passenger traffic have also been the subject of BR investigations.

Interview With an OR Scientist at "Transmark", a Consulting Firm:  
Transportation Systems and Market Research Limited (Transmark) is a company linked to the British Railways Board. It was formed in 1969 to undertake consultancy, give technical advice and carry out market research. Transmark has clients throughout the world, it undertakes studies for national and state governments, industrial and commercial organisations.

The visit to Transmark was organised to give the author opportunity to know more about the nature of transportation studies investigated by OR scientists particularly in the developing countries. A list of four studies recently undertaken in developing countries and one recently undertaken in a developed country are presented below to illustrate some of the work done by the company. Because of the confidentiality associated with the consultancy services detail of the projects were not discussed.

- (i) Preparation of long-term investment programme to Bangladesh Railways and, assessment of a series of alternative investment strategies. This study was conducted for the Asian Development Bank and Bangladesh.
- (ii) Preparation of freight and passenger forecasts. The study was undertaken for the Ministry of Transport, Argentina and the World Bank.
- (iii) Study of alternative transport routes across the Kalahari region and the scale of economic and financial costs entailed by their construction and their operation. The research was conducted for the Commonwealth Secretariat and Botswana/Namibia.
- (iv) Cost control and pricing studies for freight and passenger traffic on Vicrail. This investigation was undertaken for Victoria's Ministry of Transport, Australia.
- (v) Demand analysis and behavioural modelling for feasibility study of

high speed passenger rail services. This study was undertaken for Michigan Department of Transportation, U.S.A.

Two planning models, SIGNAL and BUFFERS, developed by Transmark are available real-time world-wide. SIGNAL (Strategic Intermodal Generation and Network Analysis System) is suitable for public transport passenger forecasting. BUFFERS (Bulk and Unitizable Freight Forecasting and Economic Research Systems) is a model for forecasting freight trends.

Two particularly interesting points emerged from the visit to Transmark.

- (i) As with other studies reported in the literature the implementation of the studies undertaken in the developing countries could not be vouchsafed.
- (ii) The majority of the studies were financed by international agencies. Remembering that a good number of the studies reported in the literature on OR applications in developing countries originated from similar financial bases, one wonders whether lack of finance is one of the factors militating against the introduction of OR into the developing countries. In other words, to what extent does lack of fund to finance OR impede the introduction of OR into the developing countries?

Another point of significance in this respect is that studies commissioned by international agencies are generally done to determine the prospects for some form of investment which means that only certain types of operations get studied.

THE BACKGROUND TO THE CHOICE OF THE NIGERIAN RAILWAYS CORPORATION FOR THE STUDY:

Considering the unsatisfactory state of transportation systems in Africa in general and in particular in Nigeria, and encouraged by the significant contributions that Operational Research has made to efficiency and effectiveness in transportation systems in the developed countries we were persuaded that it may be as productive and educative in attempting to understand the problems of the introduction of OR into developing countries if we could grapple with the problems of getting OR started in a transportation corporation in Nigeria as Luck (1979) experimented in the Indonesian Health Service and as suggested by Bandyopadhyay and Verde (1980).

For example, in recognition of the enormous transportation problems facing the African continent, the U.N. General Assembly declared the ten year period 1978-1988, a Decade of Transport in Africa in order to draw worldwide attention and to call for help in solving the problem. As Hofmeier (1980) noted,

"Africa as a whole certainly still lags far behind all other continents with regard to the penetration of transport arteries."

In a country, and in particular in a developing country, efficient and civilized transportation is essential for agricultural, industrial and business prosperity, for opening up socio-economic centres, geo-politically sensitive areas and environmentally hostile areas, and for the general well-being of the people as argued by Rowntree (1910), Leung (1982), Budhu and Hobeika (1980), Due (1980) and Priest (1980).

One is persuaded that although most railways particularly in the developing countries do not presently make monetary profit, their contribution to socio-economic development can still be significant if well planned and efficiently managed.

Urban transportation and inter-city transportation in Nigeria is largely unsatisfactory (Adiniji 1983, Hays 1969, Wijesinghe 1976). High levels of congestion on roads both within urban areas and in between urban areas are common even though government has committed much resources to road and airport building in the past decade. High accident rates involving losses of lives and properties are recorded annually on urban and inter-city roads. Air pollution and urban noise levels are high. A primary reason for this is the concentration of urban and inter-city transport on automobiles due to the overt run down of the railways as pointed out by Due (1979, 1980).

Although the history of the railways in Nigeria dates as far back as 1898, its operation has been progressively unsatisfactory since the 1960s. In 1978 the Federal Government had to call in a foreign firm to take over the management of the Railways Corporation due to increasing public dissatisfaction with the railway services (Madeley 1981).

Under the Fourth National Development Plan, 1981-85, a massive amount of money was allocated for the rehabilitation and construction of the railways. Some of the large industrial projects contained in the plan depend to some reasonable extent on the railways for their success (Metra Consulting 1981).

In the light of the foregoing situation we were persuaded that the railways would be an interesting industry into which to consider the introduction of Operational Research.

#### Market for Transportation Systems in Nigeria:

That there is a market for transportation which can be stimulated by providing an efficient transport system offering a high quality of service at competitive prices is evident from the growth in private car ownership,

long distance taxi cabs, motor coaches, and heavy-duty haulage trucks since the mid 1960s in spite of the high death toll on Nigerian roads. The phenomenal growth taking place in domestic air travel despite the high cost and the long check-in time associated with air travel gives further credence to the growing market for transportation in Nigeria. In fact it is not uncommon for air passengers to be turned back at Nigerian airports.

Under these circumstances, one believes that the train as a people mover and goods carrier, noted for safety, short check-in-time, efficient land use, energy savings and many other advantages over its rivals has a market potential both in passenger traffic and in freight operations which should be more carefully investigated.

In pre-independent Nigeria, when the economy was primitive and not as buoyant as it has been since independence, the railways made profit. Since oil exploration started in the 1960s, massive economic development has been taking place. Heavy and bulky equipments and materials are being moved around the country. Massive movement is taking place among the population. Imports have grown astronomically. One reckons that in these circumstances, if there is a satisfactory rail transportation system operating under an efficient and effective management it shall provide an essential national service and it should make monetary profit.

In order to examine these and other problems in rail transportation in Nigeria, a number of areas have been suggested as a possible project list for OR scientists and these were intended to form a basis for discussion with the management on the essential value and hence the introduction of Operational Research into the industry. However, before discussing this list of projects, a brief discussion of the future of railway transportation in general is in order.

## RAILWAY TRANSPORTATION: PAST, PRESENT AND FUTURE.

With the advent of convenient road transportation systems in the form of cars, lorries, and heavy-duty trucks since the later half of the twentieth century many people thought the age of the train, which began in about 1824, was over. This view was further enhanced by the development of the aeroplane and the phenomenal growth in air transportation which the world has experienced in the last couple of years. However, the energy crisis in the sixties, combined with the revolutionary technological advancements in the last few decades, have made transportation planners, particularly in the developed countries, to think once more on the potentialities of the train.

Today High Speed Trains are in operation in most of the developed countries. From Japan in South-East Asia through almost all the countries of Europe (East and West) to North America, modern efficient railway systems are in operation. Even in the less developed countries of South America, Asia, and Africa, many countries now enjoy the benefits of High Speed Trains.

These benefits have come mainly from two developments in railway traction.

- (i) Diesel Locomotives: with improved technology, diesel locomotives are now available which can travel at speeds of up to 200 Km/hour (Piper 1982). But with energy crisis still lurking overhead, scientists, engineers and technologists are still searching for more energy-efficient tractions.
- (ii) Electric Locomotives: even before the dawn of the present energy problems, many of the technologically advanced nations have started to convert their railway systems to the neat, clean, decent, energy-efficient and economical to operate electric traction.

Deluxe high speed and efficient electric trains are in operation in many countries of the world today and the outlook gives the impression that the trend may continue because of the enormous advantages accruing from the use of these trains, since these electric trains are not subject to the same pressure of energy costs as aircraft and road vehicles which depend directly on oil.

There are electric trains available today which can travel at speeds of up to 380 Km/hour (Piper 1982). Nevertheless, research is still going on in many parts of the world to try to improve on this speed.

As Due (1980) rightly declared,

"A good, efficient rail system is a prestige symbol important to governments and community pride".

And according to a British Rail advertisement, "this is the age of the train."

Besides providing efficient and civilized transportation, other advantages of railway transportation which should be of particular interest to a developing country is the enormous opportunities railways offer for the transfer of technology; employment, and the growth of engineering industries. With the Nigerian Iron and Steel project nearly completed, we believe that railway transportation is an industry worthy of OR investigations.

A number of the projects suggested for consideration will now be discussed.

Projects Suggested as a Basis for a Dialogue on the Introduction of Operational Research into the Nigerian Railways Corporation:

Listed below are suggested projects relating to the Nigerian Railways.

The projects may imply a somewhat revolutionary approach to the problems of transportation planning in Nigeria.

The projects cover the three areas of decision making often encountered by management namely; tactics, strategy and policy. Projects in these three categories are referred to respectively as tactical planning, strategic planning, and policy planning.

#### THE PROJECTS:

We shall first present an outline of the suggested projects. A brief explanation follows later.

##### Tactical Planning Projects:

- (i) Inventory control and stock control
- (ii) Locomotive maintenance
- (iii) Train scheduling
- (iv) Railway signalling

##### Strategic Planning Projects:

- (i) Passenger express train services to Abuja
- (ii) Railway electrification
- (iii) Inter-State railway link-up
- (iv) Decision support system

##### Policy Planning Projects:

- (i) National transportation research

##### Tactical Planning:

The attempt in this section is to examine the way specific tasks are executed in the railways so that suggestions can be made for OR studies

in specific areas or on specific aspects of operations. The objective is to seek improvements in productivity, efficiency and effectiveness in the area. Four projects were suggested for discussion in these operations areas.

(i) Inventory Control and Stock Control.

In developing countries where most of the locomotives and wagons parts have to be imported from overseas, one is always faced with the possibility of stock-outs often. As Madeley (1981) pointed out, lack of spare parts is one of the primary problems responsible for inefficiency on Nigerian railways. We wish to propose scientific investigation into the problems of inventory and stock control on the railways. The research will examine the list of items stocked, how much is stocked at any particular time, where it is stocked, the consumption and replenishment. The objective of the research will be to design and install scientifically based inventory system which will improve the balance between service and its inventory investment and replenishment costs. Such a system may be manual or computer-based.

(ii) Locomotive Maintenance.

A common problem with railways in the developing countries is poor maintenance resulting in low levels of locomotive availability. In Nigeria, this is an acute problem as Due (1979) and Madeley (1981) indicated. What is intended in this case is to develop maintenance schedules based on scientific method, which will greatly improve locomotive availability.

(iii) Train Scheduling.

Scheduling of trains to maximize locomotive usage is an important

factor in improving the capacity of rail tracks. On single track systems such as is the case in Nigeria, this becomes even more critical. Using modern computers, trains are being scheduled to arrive within a few minutes of each other in many countries today. We believe that this is an area where OR studies can yield valuable results on Nigerian railways.

(iv) Railway Signalling.

Efficient signalling is recognised as an important weapon in the fight for capacity improvements on railways as Alexander (1979) pointed out. A long standing problem on African railways is that of poor communications as mentioned by Due (1979). This is an area of operation where we believe OR can assist. Signalling studies conducted on Abidjan-Niger Railways (RAN) and another one conducted on Northern Ireland Railways (NIR) have both shown substantial improvements in railway operations, worker safety and finance as shown in Myers (1981), and Railway Gazette Int. (1981). It is not unlikely that similar benefits may result on Nigerian railways.

The study will involve detailed examination of the existing signalling systems, the rail route and considerations for introducing advanced signalling systems such as Centralised Traffic Control. The objective will be to produce system designs which will carry the railways into the next age in railway operations.

Strategic Planning:

These are projects of greater complexity, the investigation and implementation of which may spread over a couple of years. They may require large initial financial investments or some re-allocation of existing resources. The aim is to accomplish corporate objectives more efficiently and more effectively.

The creation of modern railways in Nigeria will require radical and revolutionary planning, it cannot be based on mere projections of estimates based on the existing railways. We are thinking of a railway system befitting the economic, social and political status of Nigeria. The four projects suggested for discussion in this area are briefly described below.

(i) Passenger Express Train Services to Abuja

The first phase of this project is designed to maximise the use of existing facilities and capacities, the second phase will involve the introduction of new routes. Under the first phase, the services to be studied using scientific method are listed below in the order it is suggested to be carried out, the emphasis is on passenger transportation.

Although there is no rail link yet to the new capital, Abuja, an inter-modal express train service may be operated using Minna Railway Station as the point of interchange (see figure 4.1).

- (a) Lagos to Abuja
- (b) Kano to Abuja
- (c) Port Harcourt to Abuja
- (f) Maiduguri to Abuja
- (g) Kaura Namoda to Abuja

The purpose of this study will be to determine:

- (a) the level of traffic the service will generate in the short-term and in the long-term,
- (b) the profitability or otherwise of the service,
- (c) the socio-economic benefits of the service,
- (d) the developmental impacts of the service and,
- (e) what additional capacities, if any, may be needed for the service to become operational.

FIGURE 4-1 : NIGERIAN RAILWAY SYSTEM



Source: Metra Consulting (1981), p.88  
Figure 5.5

(ii) Railway Electrification

Since the late 1800s, the world-wide trend among the industrialised and technologically advanced countries have been towards railway electrification. For example by 1938 Switzerland had 73.8 percent of its railway tracks electrified and by 1961 the electrified rail network of the Swiss federal railways stood at 96.3 percent. In the less developed worlds, India had its first electrified railway in 1925 (Johnson 1963, Johnston 1949, See Table 4.1 and 4.1b).

Railway electrification is both for economic reasons and efficient energy usage as well as for pollution-free environment. For example, in the 1940s, when British Rail (BR) was facing very stiff competition from road transport, Johnston (1949) argued with convincing ebullience that the road to BR's economic recovery laid in the electrification of the railways. Johnson (1963) forcefully advanced similar arguments in the 1960s for the large scale electrification of the Indian railways. One considers it a matter of great national concern that in 1984 Nigeria has no electrified rail route. As Due (1980) stated

"A good, efficient rail system is a prestige symbol important to governments and community pride".

Although the present state of the railways and the erratic nature of electricity power supply in Nigeria presently may not inspire transportation policy makers to be enthusiastic about this project now, what one has to bear in mind is that this is a long-term project spreading over several years of planning, designing and implementation. Studying the problems of railway electrification now will enable the Nigerian Electricity Power Authority (NEPA) to plan to make the energy available when the railways will be ready to use it.

Furthermore, this is a project which will require large financial investments to implement, one considers it necessary to suggest that detailed studies should be carried out early enough so that there will be sufficient time to examine critically all the technological and financial options available for implementing the project most efficiently.

Table 4.1a Railway electrification from the 1930s.

SWEDISH ELECTRIFICATION STATISTICS IN 1938		%
Route miles converted .....	21.0	
Track miles converted .....	42.4	
Traffic electrically run .....	84.0	
ESTIMATED STATISTICS FOR FRANCE IN 1950		
Route miles covered .....	40.0	
Traffic electrically run .....	86.0	
PERCENTAGE OF ELECTRIFIED TRACK, 1938		
Belgium .....	0.0	
Denmark .....	1.6	
Hungary .....	3.3	
Germany .....	5.0	
Great Britain .....	5.3	
France .....	7.8	
Norway .....	9.2	
Holland .....	15.1	
Italy .....	28.2	
Sweden .....	42.4	
Switzerland .....	73.8	
PROPORTION OF TOTAL ROUTE MILES ELECTRIFIED UP TO 1938		
Great Britain North of Thames .....	1.0	
U.S.A. ....	1.1	
U.S.S.R. ....	1.8	
Japan .....	2.3	
South Africa .....	3.0	
France .....	4.8	
Great Britain (whole country) .....	4.9	
German Reich .....	5.0	
Sweden .....	21.0	
Italy .....	29.4	
England (Southern Railway only) .....	30.7	
Morocco .....	41.0	
Switzerland .....	50.0	

(Source: Johnston, Kenneth H. (1949) *British Railways and Economic Recovery*, pp 328 - 329)

Table 4.1b Total railway route mileage, total electrified route mileage, and total electrified track mileage in 1956 for some selected countries.

Country	Railway Route Mileage	Electrified Route Mileage	Electrified Track Mileage
India .....	35,213	240	579
U.K. ....	19,470	1,172	3,158
U.S.A. ....	2,21,666	2,044	5,368
Canada .....	43,132	31	87
U.S.S.R. ....	74,753	3,430	N.A.
France .....	25,223	3,090	5,881
Japan .....	14,113	6,618	9,137
Australia .....	26,562	398	977
Argentina .....	27,273	88	209
West Germany .....	22,878	1,326	3,501
Italy .....	11,210	4,297	7,923
Brazil .....	23,100	1,433	N.A.

(Source: Johnson, J. (1963) The Economies of Indian Rail Transport, p 366)

(iii) Inter-State Railway Link-Up

Considering the geography and population of Nigeria and the few areas served by the existing railways, the need to examine the case for railway extensions becomes irresistible. The advantages and benefits of vast rail extensions covering whole country areas have long been realised and exploited by many nations. In spite of the high cost of railway extensions, it has been found necessary for the development of nations as fiercely argued by Johnson (1963), Johnston (1949), Leung (1982), Priest (1980), and Rowntree (1910).

With the prospects for the local production of iron and steel now very real, Nigeria may soon be able to extend its railways using indigenous materials and indigenous labours coming from the vast expansions now taking place in the educational system. We wish to suggest at this stage research projects which will examine all the factors involved in planning railway systems that will link-up the States, open-up vast areas of the country and designed to enhance

the economic, social and political development of the nation.

(iv) Decision Support Systems (DSS)

The management of modern organisations is a complex business. We believe that it is appropriate to suggest that thoughts should be given to the introduction of modern management decision-making aids in the administration and management of public services and government corporations in the developing countries. It may even be necessary to consider redesigning the organisational structures in some cases to make them more responsive to the demands and challenges of modern management in complex institutions.

Decision Support Systems (DSS) may be thought of as information systems dedicated to improving the performance of organisations. DSS is usually computer-based; they are aids which an administrator or a manager of a complex business organisation can use in the process of decision-making. (Chacko 1975).

One would wish to suggest the setting-up of an interdisciplinary team to examine the possible introduction of DSS into the management of Nigerian railways.

Policy Planning:

(i) National Transportation Research

Only one large scale study is proposed in this area, - a national transportation research. This will be a grand transportation study which will examine in detail all the transportation modes available in Nigeria for developmental purposes. The study will concentrate on road, rail, air and water transports (and any others to be identified). The study will attempt to determine the contributions

that investments in each of the transportation modes will make to agricultural, industrial and commercial developments; politico-economic harmony and national integration; and the general opening-up of the country to cheap, efficient, safe and civilised means of transportation for the masses of the population.

The purpose of the research will be to assist transportation policy makers in the country in the formulation in implementable terms of transportation and land use policies for the country taking the long term view. It will be a large scale planning exercise aimed at designing the transportation system that is most desired by the nation in the years ahead. As Tomlinson (1980) declared, "If you want a future you have got to make it" or as Ackoff (1981) warned, "plan or be planned for". We believe that there is a need for a grand transportation design that will carry Nigeria into the industrial age.

This is a study to which OR as an interdisciplinary profession with the capability to organise and co-ordinate scientists and experts from wide disciplinary backgrounds, and with methodology and tools suitable for the study of complex systems can make significant contributions. For example, in 1973 a team of about thirty people with various expertise used the methodology and techniques of OR to carry out detailed studies of the transportation needs of the Sudan (Saaty 1977ii).

#### The Response to the Request for the Dialogue:

Our request was an unusual one, the stereotype of the research student simply asked for government publications. In our particular case we requested for a dialogue and not just dumb statistical data. We know

that the introduction of OR into an organisation would require a definite decision by the management of the organisation. As such we were interested in working with the officials in order to identify problem areas in their organisation which are of significance to them and on which OR assistance can be arranged as a prelude to the introduction of OR.

Another important point which was stressed in our letter of request was the need for governments in developing countries to put more thought and research into how to use the skills that their students go abroad to acquire. We believe that one way to make their training more relevant to the needs in their country is to link the training to some specific problems in their home country. This was the objective we were trying to achieve in this particular case, that is, link the problems of the introduction of OR into the Civil Service in Nigeria to some specific cases.

The reply to our request took some time to come, - approximately three months. This caused us to develop the feeling that we may be at least one step ahead in our investigation into the problems of the introduction of OR into the Civil Service and public corporations in Nigeria. After weeks of intense efforts through friends of the author who lived in Lagos to try and understand what the difficulties were, the reply finally came. It said:

"I am directed to acknowledge the receipt of your letter dated 10th August, 1982 on the above named subject matter and to assure you that it is receiving the necessary attention".

(No further communication has of course been received on the matter).

The letter confirmed our feeling that we may be at least one step ahead in our investigation of the process of the introduction of OR into organisations in developing countries. It became clear to us that a new

approach was needed if there was to be any chance of understanding the problems of the introduction of OR into developing countries. We felt that at that point in time little was known about the administrator and their problems, and the situation regarding factors which are basic and pragmatically significant in the process of the introduction of OR into an organisation.

The new approach which followed from this realisation is the subject discussed in the next chapter.

CHAPTER FIVE  
THE METHODOLOGY

Introduction:

Following the collapse of the approach discussed in the preceding chapter, it soon became clear to us that there was need to understand the administrators, and the situation with regards to factors which we believed to be of pragmatic importance and pertinence in the process of the introduction of Operational Research (OR) into the civil service in Nigeria. Furthermore the situation regarding the potential supply of OR scientists in order to meet the challenges of the introduction of OR into the civil service was unclear and needed to be specifically investigated.

In this chapter we discuss the methodology of the field investigations which was conducted in order to increase our understanding of the administrators, and the situation with regards to factors which we believed to be pertinent to the process of the introduction of OR in the civil service in Nigeria. In the next chapter (Chapter Six) we shall discuss the results of the field investigations. The particular problems of the potential supply of OR personnel in order to meet the challenges of the introduction of OR into the civil service is the subject discussed in Chapter Seven.

THE NEW APPROACH:

The difficulties encountered in getting effective responses to the letter of request to examine the problems of the introduction of Operational Research (OR) into the Nigerian Railways Corporation convinced us that it was probable that not much was known about Operational Research (OR) in the civil service. In which case it would be premature to investigate the problems of the introduction of OR into particular public corporations or sectors in the civil service in Nigeria then. That realisation per-

sueded us to direct our research efforts into the larger issue of attempting to understand the administrators, and the situation with regards to factors which we believed to be of pragmatic significance and pertinence to the introduction of OR into an organisation, and to examine the particular problems of the potential supply of OR personnel.

We believed that such study would increase our understanding of the environment, the people, their work, their awareness of OR, the decision making aids available to them, their attitude towards the use of scientific method in decision making, and the difficulties and the problems in applying such method in their particular setting. In the sections which follow we shall discuss the research format, the design of the research instrument, and the problems of gaining access to the respondents during the field investigations.

#### THE RESEARCH FORMAT:

For a study of this nature and scope, there are two broad alternative research techniques available to a scientist namely; case study and survey method.

##### (i) Case Study:

The case study approach is characterised by the in-depth, intensive, and exhaustive study of one case or unit (e.g. person, group, or organisation). As argued by Forcese and Richer (1973):

"The essential feature of a case study is that the unit of study whether a group or an individual, is studied intensively as an entity" (p.82)

Mitroff and Kilman (1978) further explained that:

"...the case study focuses on the...in-depth detailed rendering of the life space of a single individual or social group" (p.96)

Thus we may conclude that the case study approach could be taken to examine the problems of the introduction of OR into specific government organisations in Nigeria; the proposed transportation study discussed in Chapter Four being an example and one which clearly illustrated the difficulties in getting cases to study.

Data collection tools used in case study include interviews, observations, and documentary materials. The data is generally collected in the natural settings of the object being studied. As argued by Forcese and Richer (1973) and by Stone (1978), case study may be useful for generating hypotheses and insights, but it is inappropriate for making causal inferences or general explanatory statements about phenomenon, for hypotheses testing, and for generalization of the findings.

(ii) Survey Method:

In survey method several units (e.g. persons, groups or organisations) are studied, data is collected from a sample of a known universe using systematic techniques (e.g. questionnaire, interviews or observations). The data is collected directly from the respondents in their natural settings. Ackoff and Pritzker (1951), Forcese and Richer (1973), and Stone (1979) each took the view that survey method is more appropriate for generalization, for making explanatory statements about phenomena, and for hypotheses testing compared with case study.

The Research Technique Adopted:

The principal differences between case study and survey method lie in the

questions each seek to answer, and in whether the study is concerned with one, a few, or many units. While survey method is suitable for hypotheses testing, case study is more relevant to hypotheses generation. And while it is possible to generalise from the results of survey, such generalisation might be inappropriate from the results of case study.

Nevertheless, as Forcese and Richer (1973) have pointed out, the decision to employ a particular technique depends on one's special orientation. Forcese and Richer argued:

"Surely the choice of case study or survey depends not on any sense of the absolute merit of each, but on the purpose of the study... The choice cannot be portrayed as that between a right and a wrong selection" (p.107, 87).

Thus, in deciding on which technique to employ in this study we were influenced by a number of factors as argued by Forcese and Richer (1973) and by Ackoff and Pritzker (1951). The most prominent of these factors were:

- (i) the objective of the research,
- (ii) the benefit of the research to the Nigerian Civil Service.
- (iii) the value of the research to the general understanding of the problems of the introduction of OR into organisations elsewhere.
- (iv) the benefit that other potential users of the research results can derive,
- (v) the influence of the research on the Nigerian Civil Service.
- (vi) the time available to conduct the research,
- (vii) the financial resources available for undertaking the research, and
- (viii) the experience gained from the transportation study.

In the light of the foregoing argument, we were fully persuaded that the

purposes of the study would be best served if we adopted the technique of survey method, hence survey method was employed in this study.

**Objective of the Survey:**

The limited global objective of this research was the introduction of OR into the civil service in Nigeria. It was our hope that from analysis of data amassed from the survey we would be able to make some explanatory statements with regards to the particular problems of the introduction of OR into the civil service in Nigeria, in other words draw some conclusions on the problems, and make some recommendations for finding solutions to the problems. Furthermore, it was our hope to be able to generalise our findings to civil service organisations in other developing countries, and to be able to advance some theories on the introduction of Operational Research (OR) into organisations elsewhere.

Although survey method is appropriate for hypotheses testing, it was our belief that in a relatively unresearched problem area such as the introduction of OR into developing countries, it would be more beneficial to the research consumers in the developing (and perhaps developed) countries, if a pragmatic problem-solving research-approach was adopted at this point in time, giving the existing state of knowledge about the subject. As argued by Mintzberg (1975), the testing of specific hypothesis rigorously and exhaustively in order to prove conclusively the existence or otherwise of some necessary and sufficient conditions for the introduction of OR such as was advocated by Ackoff and Pritzker (1951) would not be beneficial in a problem area where research is very much in its infancy.

Our mission in this study was to examine the situation with regards to essential factors which we believed to be of pragmatic significance and pertinence to the introduction of OR into an organisation in a developing

country, the Nigerian Civil Service in this particular case. And to identify the contributions which that understanding would make to knowledge both of the particular case and on the larger global problem of the introduction of OR into organisations elsewhere.

In essence this research has focused on the field in order to gain better understanding and hopefully to be able to develop some theories rather than for theory testing since there is little theory to test. We believe that it is in the field that we can gain the understanding and experience needed in order to develop the rich theories which we believe to be lacking in this rather underdeveloped area of Operational Research (OR). Just as Mintzberg (1975) argued in the case of policy research, (and we believe the introduction of OR into an organisation is a policy decision), it is our view that for research on the processes of the introduction of OR to be most fruitful it would have to be undertaken in the real-world where the decisions are made and any theories should be abstractions from that real-live experience as argued by Poper (1974).

#### THE DESIGN OF THE RESEARCH INSTRUMENT:

There are basically three tools employed in survey data collection namely;

- (i) Personal interview which is the oldest tool used in survey method, it involves administering a questionnaire to a respondent in a face to face situation in a convenient location,
- (ii) Telephone (and other electro-mechanical device) interview, this involves the administration of a questionnaire to a respondent over a telephone (or some electro-mechanical) device, and
- (iii) Mail interview, this generally involves posting a questionnaire to a respondent who administers the questionnaire on himself and

returns the completed questionnaire, in most cases by post, to the researcher.

Each of these three tools have their advantages and disadvantages in survey data collection. The particular tool which one employs depends on the nature of the survey which one is conducting. As Toll and Hawkins (1930) have argued, there is no particular tool which is universally the best for all survey data collection.

In this particular case, telephone interviews, although would have been unsuitable for other reasons, could not be seriously considered because telephone services were generally not widely available in Nigeria, and even where a telephone was available, it was most likely to be out of order.

Mail questionnaire which could by far have been the cheapest tool could not be employed because of the nature of the research. Operational Research being a relatively new subject, it was possible that respondents could have difficulties in understanding the purposes of the questions asked or appreciate the purposes of the survey as a whole. It would have been impossible to probe any responses more deeply. Perhaps more important, the responses to the questions relating to the knowledge which existed in the civil service about OR could have been grossly distorted.

The actual seniority of the respondents, an important factor in this research, could not have been accurately determined since it would have been difficult to know who actually completed the returned questionnaires. Furthermore, as argued by Kane (1933), in the absence of any face to face encouragement, busy senior administrators may have been more inclined to put the questionnaires aside particularly when the subject of the survey could seem rather remote. The consequence of such reaction would have been an unduly high non-response rate.

As Moser and Kalton (1975) argued, under these conditions the use of mail questionnaire would be inappropriate. Moser and Kalton argued:

"...the method [mail questionnaire] can be considered only when the questions are sufficiently simply and straight forward to be understood with the help of the printed instructions and definitions... It is unsuitable where the objective and purpose take a good deal of explaining, where the respondent is being asked difficult questions or where it is desirable to probe deeply or get the respondent talking... where it is important that the views of one person only are obtained, uninfluenced by discussions with others; and where questions testing a person's knowledge are to be included." (p.260)

It was our belief that Operational Research being a less familiar field, the presence of a human observer can be an important factor in determining both the response rate and the quality of data collected. As Mitroff and Kilman (1973) have argued, there can hardly be any substitute to the presence of an interested observer in undertaking research in a rather difficult area. Mitroff and Kilman declared:

"No amount of quantitative sophistication or theoretical generation can substitute for the physical presence of a concerned, caring, human observer and the interaction that takes place between observer and observed." (p.97)

Overwhelmed by the strength of the foregoing arguments and mindful of the experience gained in the transportation study (Chapter Four), we considered it essential for the researcher to be out there to listen to the prospective customers of OR and also to act as an interested and caring observer. As argued by Mintzberg (1975) in respect of policy research, and by Rivett (1983) in the particular case of conducting OR investigations, it is vital for the researcher to be out there in the field, the natural work environment, to listen and to observe. The particular point made by Rivett is worth underscoring, he declared:

"...there is no substitute for personal observation on site. Isaac Newton said it all three hundred years ago. 'If instead of sending the observations of seamen to able mathematicians on the land the mathematicians would themselves go to sea, then this would signal more for the safety of men's lives on that element'... The second stage in our method is to listen."

Our conclusion based on these arguments was that, personal interview, although very costly was the most appropriate tool to be employed for data collection in this study. And that the data would be collected by the researcher himself, this enabled the author to observe first hand the conditions under which the administrators worked, to listen to their problems, and to demonstrate to them the interest of OR scientists in the problems which they grappled with in their jobs.

#### Interviewing:

In general interviews can take several forms, varying from unstructured (or informal) interview to highly structured (or highly formal) interview, depending on the purpose of the interview and the interview schedule employed. Research interviews are generally for information gathering in particular areas, it can take any form in the continuum between unstructured interview and structured interview; and the interview schedule can similarly take any form in the continuum from open-ended questions to closed-ended questions.

#### Types of Interview:

In the continuum from unstructured to structured interviews which are commonly employed in surveys, four main types of interviews are discernible (Tull and Hawkins 1980, Cox III 1979):

- (i) Direct-structured interview,

- (ii) Indirect-structured interview,
- (iii) Direct-unstructured interview, and
- (iv) Indirect-unstructured interview.

The major difference between "direct" and "indirect" interview lies in whether the purposes of the research is made known to the respondent or not. As defined by Cox III (1979):

"A direct interview is one in which the respondent is informed of the purpose of the study. In an indirect interview the purpose is concealed." (p.183)

The difference between "structured" and "unstructured" interviews derives from the degree of freedom the interviewer has in modifying the interview schedule. As explained by Cox III (1978):

"A structured interview is completely standardized so that all respondents are asked the same question in the same fashion. In an unstructured interview the questioning process is adapted to fit the individual respondent." (p.183).

Nevertheless as argued by Tull and Hawkins (1980):

"Both structure and directness represent continuums rather than discrete categories" (p.113).

Figure 5.1 shows the various interviewing strategies which are commonly employed in survey methods. The particular strategy which one adopts depends on the nature of the research, and one's orientation. For example, if one believed that if respondents were told the purpose of the study they might be unwilling to answer the questions, or withhold vital information, or give misleading answers, then one might be inclined to conceal the purposes of the research from the respondents.

In this particular study we had no reason to believe that if respondents were told the purposes of the research they would be unwilling to co-operate, or withhold vital information, or give misleading answers; hence direct interviews were adopted.

On the question of "structure", we believed that OR being a relatively new subject, clearly defined and carefully worded questions organised in some particular order would be more appropriate for our purpose. Since the interview was conducted by the researcher personally, flexibility was built into the interview schedule such that, depending on the response to a particular question, the interviewer could omit certain other questions or probe some responses more deeply when necessary. As argued by Chisnall (1973),

"Flexibility is,...an important attribute of the interviewing process,..." (p.137).

Against the background already discussed, a "loosely" structured interview schedule or questionnaire was designed to be used for direct interviewing in a face to face situation as a means of collecting data during the study.

Figure 5.1 Interviewing Strategies

Is the Purpose of the Interview concealed from the Respondents?

		NO	YES
Are all of the Respondents Treated in a Standardized Fashion?	YES	I Direct/ Structured	III Indirect/ Structured
	NO	II Direct/ Unstructured	IV Indirect/ Unstructured

Adapted from Cox III (1979) p.133.

The Questionnaire Design:

The choice of the technique for data collection together with the selection of the interviewing strategy naturally influenced the process of the questionnaire design. The design of a questionnaire is a fairly complex issue, as underscored by Cox III (1978),

"the questionnaire is a promotional device as well as a measurement device" (p.196).

Hence the particular questionnaire which was used in this study was the product of prolonged cogitation aimed at balancing the "promotional" aspects against the measurements which the instrument was primarily designed to make. It is appropriate to say here that the "promotional" aspects, if any, that existed in the questionnaire which was used in this study was purely incidental, that is, having interviewed a respondent about OR, one hoped that the respondent had naturally become better informed about OR.

In designing the questionnaire, factors such as the need to develop rapport easily with the respondent, to need to maintain his interest and co-operation throughout the duration of the interview, and the primary objective of soliciting the relevant information were carefully considered. In other words, questionnaire attractiveness, interviewing duration, and the ease with which the respondent could supply the information demanded were among the factors considered as suggested by Tull and Hawkins (1982) and Cox III (1978). For as Luck et al (1982) have argued the total purpose of a questionnaire is:

"to obtain the specific quantitative and qualitative information with tolerable accuracy and completeness." (p.182).

#### Question Structures:

In designing a questionnaire, two broad alternative question structures can be adopted in order to achieve one's objectives namely: open-ended questions, and closed-ended questions.

##### (i) Open-Ended Questions:

In open-ended questions, as argued by Luck et al (1982), and by Tull and Hawkins (1980), the questions are structured, but the responses are unstructured, that is, respondents are at liberty to supply whatever information they consider to be pertinent and in whatever words they choose. Responses to open-ended questions are generally subject to probing where necessary.

The advantages of open-ended questions include the fact that they are less likely to put answers into mouths of respondents in that the respondent is not influenced by pre-stated set of response categories, they tend to solicit a wider variety of responses thereby enriching the data collected in complex investigations, and the responses tend to capture more accurately the real views of the respondent. Tull and Hawkins (1980) have argued that open-ended questions are

"particularly suitable for exploratory and problem-identification research" (p.272).

The disadvantages of open-ended questions include the fact that they tend to be inappropriate for self-administered questionnaires (e.g. mail questionnaire), they tend to measure respondent articulateness as argued by Dohrenwend (1965), they tend to be more liable to introduce interviewer effects as Collins (1970) have argued, and in general, the responses are more difficult to code or categorise for the purposes of analysis.

(ii) Closed-Ended Questions:

In closed-ended questions, both the questions and the responses are structured, that is, the responses are selected from a number of response options presented to the respondent. In fact the chief distinguishing feature of these type of questions lies in the response format. Cox III (1979) and Luck et al (1982) have argued that five types of closed-ended question structures are generally employed in survey techniques namely; dichotomous questions, multiple-choice questions, rating scales, Likert scales, and semantic differential scales. In these types of questions the respondent is often presented with some categories of response options from which to indicate his preference, that is, the respondent is neither free to supply whatever information he considers to be relevant nor is he free to use whatever words he chooses.

The advantages of closed-ended questions include the fact that the responses are standardized and hence tend to be much easier to code or categorise for the purposes of analysis, the questionnaires are much easier to administer, much easier to complete, and they are in general more suitable for self-administered questionnaires (e.g. mail questionnaires).

The disadvantages of closed-ended questions include the fact they tend to inhibit the respondent in that he has no freedom to supply information which he may consider to be relevant, furthermore he is not free to use whatever words he chooses. Closed-ended questions generally cannot accommodate accurately individual views. As Hunt et al (1964) discovered while interviewing political elites in the U.S.A., France and Austria, respondents protested strongly against the restrictions imposed by the response categories provided. Hunt et al reported:

"There were complaints that such devices were 'too brutal', that they provided no opportunity for considering 'nuances', or that respondents had 'personal positions' with regard to politics that would not fit into the categories provided."

Other disadvantages of closed-ended questions include their inability to cope effectively with policy matters and problems of top management decision making as argued by Heany (1965), Mintzberg (1975), and by Sayles (1970).

Paramount in our minds during the design of the particular questionnaire which was used in this study was the need to ensure that the questions asked solicited the desired responses. Since we believed that OR was a relatively new subject with which senior administrators may not be familiar, the question structures were such that respondents were generally not inhibited in that they were at liberty to release information which they believed was pertinent and they had the freedom to express themselves in whatever words they chose. The question structures were such that they were able to capture the wide variety of views that one believed existed in such a complex organisation and on such a complex issue as the introduction of OR - a new and relatively unknown activity. In addition, the question structures were such as would permit the real views of the respondents to be assessed. In essence, in the light of the foregoing arguments and in recognition of the particular complexities inherent in the study, open-ended question structures were employed in the questionnaire which was designed and used in this particular research.

#### **The Significant Factors Covered by the Survey Questionnaire:**

In trying to persuade the management of an organisation to introduce OR into its services, we believe that the decision makers in the organisation as well as the OR scientists would require some basic information in order

to enable them to make the right decisions. In designing the particular questionnaire which was employed in this study we concentrated our enquiry on factors which we believed to have pragmatic significance and pertinence in the process of the introduction of Operational Research (OR) into organisations, the Nigerian Civil Service in this particular case. These factors which were originally the product of abstract reasoning on our part were later tested against the experiences of practising OR scientists and those of managers who employ OR services in their organisations. These factors were covered in the actual questionnaire under five broad key headings namely; (see Appendix I for the questionnaire used in the study).

1. Environment in which Operational Research would be practised.
2. Existing knowledge about Operational Research.
3. Previous consultancy experience.
4. Availability of computer.
5. Preferred mode of introducing Operational Research.
6. Problems in introducing Operational Research.

#### The Sample Demography:

Having selected survey techniques for the study, it was decided that the problems of the introduction of OR into the civil service in Nigeria would be studied in relation to all the civil service units in the federation, that is, the study universe would include the civil service units in the nineteen States in the federation as well as the Federal Civil Service Unit. In view of the enormous monetary costs involved and the constraints of time imposed by the research schedule, a combination of purposive and judgment sample was employed to limit the sample size to the Federal Civil Service Unit and five State civil service units namely; Lagos State, Oyo State, Kwara State, Benue State, and Plateau State civil service units.

The five States were selected to reflect the politics-cum-geographical configuration of Nigeria. (See Figure 5.2 for a map of Nigeria).

In each of the sample, the target population were senior civil servants and the study population were administrative officers preferably. A complete enumeration was taken in each sample with the permanent secretaries as the sample frame.

#### THE PROBLEMS OF GAINING ACCESS:

Particular attention would be given to the problems of gaining access to the respondents because of its implications for further research in this area.

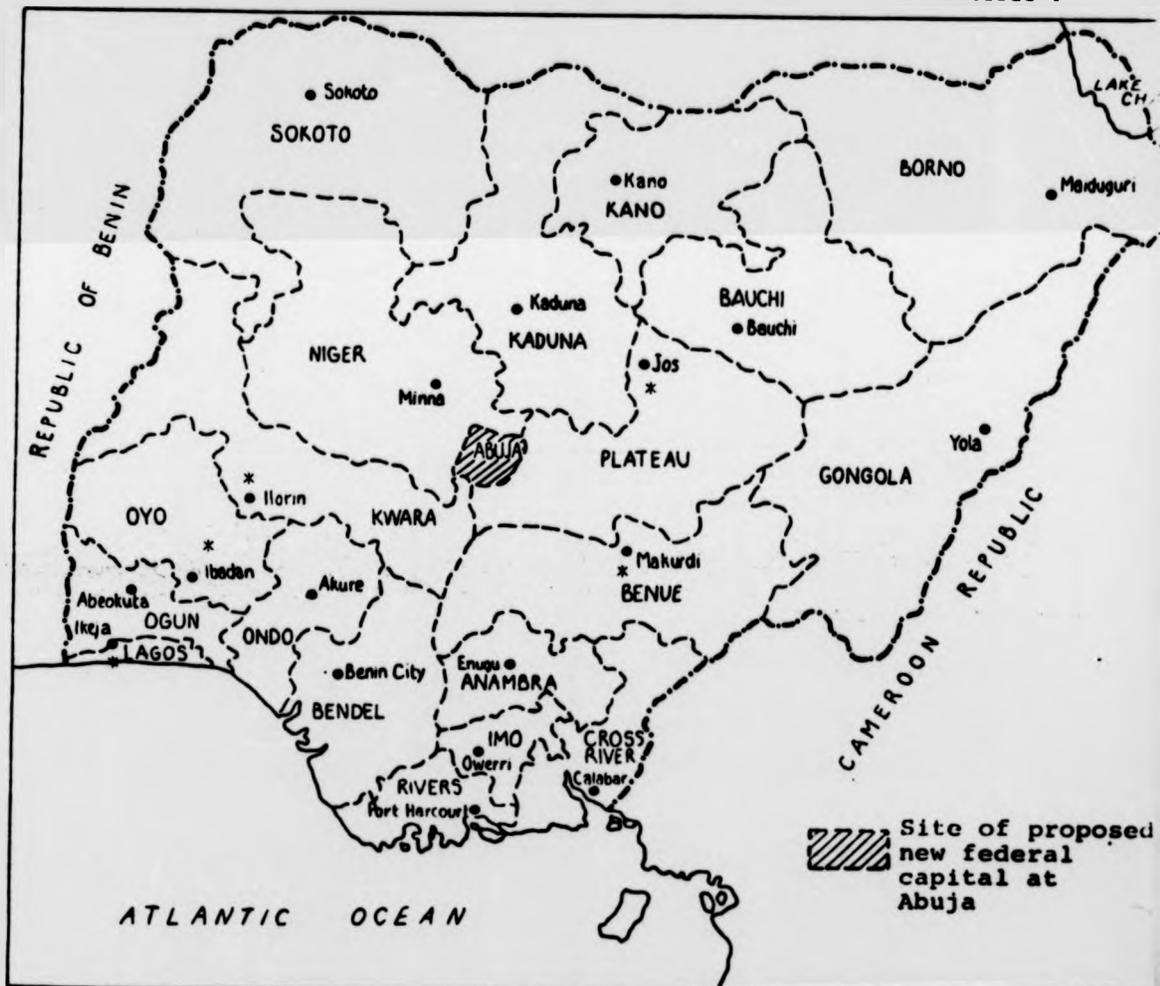
Gaining access to the appropriate respondents in a sample often constitute a main problem in survey research. Becker and Meyers (1975) who interviewed some bureaucrats in the USA suggested walking "right into the bureaucrats' office" without prior notification. Denitch (1972) in his study of opinion leaders in six sectors of Yugoslav society discovered that senior civil servants were more difficult to access and that the largest number of complaints came from them. Denitch remarked:

"There was considerable difference in access to the six sectors of the study. The most difficult and cautious were the higher civil servants who, as perhaps the world over, seem to cultivate a gray anonymity combined with a reluctance to express any independence or original views".

Zuckerman (1972) who interviewed forty-seven nobel laureates in science started by writing "lengthy letters explaining the nature of the investigations", but soon discovered that "the laureates themselves did not indulge in lengthy communications".

Figure 5.2

**NIGERIA : SHOWING STATE BOUNDARIES AND STATE CAPITALS**  
States where interviews were conducted are marked with an asterisk.



Scale : approximately 1 inch to 160 km.

Source: Metra Consulting (1981), p.2., Figure 1.1.

Unlike Zuckerman, Robinson (1960) in his attempt to gain access to the US Members of Congress simply sent a one-page letter to each of the selected Senators and Representatives briefly stating the purposes of the research, the sponsor and the possible duration of the interview. Nevertheless, Robinson reported considerable difficulties in gaining access to the American Congressmen. Jones (1960) had a similar experience with the Congressmen.

Hunt, Crane and Wahlke (1964) in their cross-cultural comparative research involving American, French, and Austrian politicians initially sent a letter to all the respondents on their list explaining the project and soliciting co-operation. In Austria, the letter alone was sufficient. In France however, gaining access proved to be a tough problem. Hunt et al noted:

"In France, more than three hundred letters were sent to prospective respondents. Yet it still required the utmost ingenuity and effort to track down a portion of those sought and to pin them down to an interview once they were found"

Letters, follow-up visits and even "loitering in the vicinity of the Palais Bourbon" were necessary before access could be gained to the respondents. Experience among American Legislators was similar to that in France, inter-personal contacts, friends, and even "working the floor" of the house were employed to gain access to the respondents.

In general, among the key points to note in writing a letter seeking to gain access to interview specialized respondents, particularly elites are the following:

- (1) Clearly state the purpose of the interview,

- (ii) Present a simple description of the project,
- (iii) Briefly state the purposes of the research and the importance of its findings,
- (iv) State the sponsors of the research, if any, and
- (v) State the nationality of the interviewer.

#### Gaining Access to Nigerian Senior Civil Servants:

Influenced by the experiences of earlier researchers and bearing in mind our particular case, since although there is a considerable knowledge and accumulated wisdom in Western industrialised societies about the art of gaining access and interviewing in general and in particular elites, not much can be found in the literature about the strategy and tactics of gaining access to and interviewing senior civil servants in the developing countries and in Nigeria in particular.

For our particular case, once the list was compiled, a one and quarter page letter was written to all the Heads of Service in the sample, a copy of the letter was also sent to each permanent secretary in the sample. The letter though general, was designed to be personal. It briefly stated:

- (i) the nationality of the research student and the specific request being made,
- (ii) the nature of the research,
- (iii) the research to that point in time and the necessity for the request for the interview,
- (iv) the nature of the interview requested and persons considered most appropriate as respondents,
- (v) the importance of the research to the Nigerian civil service, and
- (vi) the months when the interviews would take place.

Two annexes also accompanied the letter. Annex 1 briefly described Operational Research, introduced the ORASA Group, University of Warwick; and gave an outlined profile of the research supervisor who is also the signatory to the letter. Annex 2 gave outlines of some of the tentative conclusions of the research findings at that particular point in time. (See Appendix II).

The Follow-Up Letter:

As soon as a sizable number of replies accepting to co-operate were received, (by mid-May), an itinerary was drawn up. Specific letters were then written to all the permanent secretaries in each of the ministries from where a letter of co-operation had been received thanking them for their willingness to co-operate. The letter gave the particular date and time when the research student would call on the permanent secretary to conduct the interview. The duration of the researcher in the particular area was clearly stated.

With these arrangements completed, the author proceeded to Nigeria in the first week of June 1983 to conduct the interviews. The result of the interviews is discussed in the following chapter.

CHAPTER SIX  
THE CUSTOMER

Introduction:

In this chapter we discuss the results of the interviews conducted in the Nigerian Civil Service in order to increase our understanding of the administrators, and the situation with regards to some essential factors which we believed to be pragmatically significant and pertinent to the introduction of OR into the government. The questions were addressed to senior civil servants, the potential customers of OR scientists, in their natural work environment during a personal interview. A summary of findings is provided.

In the analysis which follows, the interview responses are discussed under nine sectional headings reflecting nine essential factors which we believed to be of pragmatic significance and pertinence to the introduction of OR into the civil service. Each section begins with introductory statements indicating why the particular factor was measured, followed by identification of the particular questions discussed in that section. Analysis of the responses are then made in details with reference to particular questions asked. The section is brought to a close by discussions of the main conclusions which are drawn from the analysis of the responses.

SOME TACTICAL PROBLEMS:

Preceding the detailed analysis of the interviews some interesting tactical problems which one believes could be important in future research in this area would be briefly discussed.

The Initial Response:

As stated in Chapter Five a letter of request to interview senior government officials in connection with the introduction of OR into the Nigerian Civil Service was sent to the Permanent Secretary in one hundred and sixty-four ministries in six Civil Service Units (C.S.U.) in Nigeria. At the time the author travelled to Nigeria to conduct the interviews replies indicating willingness to co-operate were received from approximately fifteen percent of the sample. Similar positive replies were later received from approximately nine percent of the sample but they arrived too late. Overall, approximately twenty-three percent of the sample wrote indicating their willingness to co-operate.

Table 6.1 shows the response rate. "Early Replies" are those received before the author travelled, "Late Replies" are those received after the author had travelled. Positive-"+Ve"- replies are those who indicated a willingness to co-operate, while negative-"-Ve"- replies are those who for some stated reasons could not grant the interview.

Table 6.1 The Response Rate

Civil Service	Number of Permanent Secretaries Written to	Early Replies Percent		Late Replies Percent		Total Percent	
		+Ve	-Ve	+Ve	-Ve	+Ve	-Ve
FEDERAL	38	15.79	2.63	7.89	5.26	23.68	7.89
LAGOS STATE	19	5.26	-	5.26	-	10.52	-
OYO STATE	34	8.82	-	5.88	-	14.70	-
KWARA STATE	29	24.14	-	6.90	-	31.04	-
BENUE STATE	26	23.08	-	11.54	3.85	34.62	3.85
PLATEAU STATE	18	5.56	-	16.67	-	22.23	-
Total	164	14.63	0.61	8.54	1.83	23.17	2.44

#### The Amplifier:

Starting from an uncertain position regarding the response to our request to interview senior civil servants bearing in mind the experience in the transport study (Chapter Four), the "remarkable high response" of approximately fifteen percent was considered a great achievement and a good omen. Hence the possibility of increasing the response rate was anticipated, as such an amplifying device was built into the research instrument.

In order to produce a multiplier effect on the response rate, the last question to be asked was whether there was anyone else that could be spoken to on the subject (See Appendix I, Q.7). In approximately ninety-seven percent of the interview the respondent suggested someone else and actually assisted in contacting the prospective respondent. So effective was this device that in all the C.S.U.s selected for data collection, more prospective respondents were available than could be interviewed within the allocated duration of the interviews.

This enabled the useful response rate to rise from the initial fifteen percent approximately to twenty-three percent approximately, covering in sum total nearly all the ministries one would find in a particular C.S.U.

Table 6.2 shows the number of ministries and Statutory Corporations in each C.S.U. where interviews were conducted and the number of senior civil servants interviewed in each case.

Table 6.2 Number of Ministries and Corporations Visited in each C.S.U.

Civil Service	Number of Government Ministries Visited	Number of Statutory Corporations Visited	Number of Senior Officers Interviewed
FEDERAL	7	-	11
LAGOS STATE	2	-	5
OYO STATE	7	1	15
KWARA STATE	7	1	12
BENUE STATE	8	1	10
PLATEAU STATE	4	-	6
Total	35	3	59

The First Letter of Request:

An important factor in the success of the amplifier mechanism is the letter of request written about three months earlier. In all the cases where one respondent referred the author to another prospective respondent in a different ministry, the prospective respondent soon confirmed that his ministry had received the letter of request and in some cases apologised for their inability to reply promptly. But now that the research student was standing right there before him there was no reason why the student must not be assisted, particularly when a sister ministry had already granted the student interview. After a brief delay to enable the prospective respondent to obtain clearance from the permanent secretary or other appropriate officials of the ministry, the interview was always granted.

In one particular case only, did it take three call backs spread over five days before the clearance was finally given to the official to grant the interview.

Respondent Control:

An important advantage of personal interview is the high degree of control the interviewer has over the choice of respondents.

Although it was stated in Chapter Five that the target population were administrative officers, the letter of request only suggested nominating a senior official with experience of the ministry. As a result, in some ministries Grade Level zero nine (GL09) or Grade Level ten (GL10) officers were nominated from either the administrative or the professional cadre to be interviewed.

From the experience gained in interviewing the first seven respondents who included administrative and professional officers on Grade Level sixteen (GL16) down to Grade Level zero nine (GL09), it became clear to the author that the most useful data would be collected from interviewing:

- (i) Officers on Grade Level fifteen (GL15) and above.
- (ii) Officers in the administrative cadre.
- (iii) professionals who were heads of their departments.

These principles guided the rest of the interviews although officers on other grades were interviewed where it was not possible at the time of call for the more senior officers to grant the interview.

Table 6-3 shows the seniority of the officers interviewed and the number interviewed in each of the C.S.U.s sampled.

Table 6.3 Seniority of Officers Interviewed According to Grade Level (GL).

Civil Service	GL17 <sup>1</sup>	GL16	GL15	GL14	GL13	<sup>11/</sup> GL12	GL10	GL09
FEDERAL	1	3	3	-	-	2	1	1
LAGOS STATE	-	-	2	1	-	1	-	1
OYO STATE	1	-	12	2	-	-	-	-
KWARA STATE	2	-	7	1	1	1	-	-
BENUE STATE	4	-	1	4	1	-	-	-
PLATEAU STATE	1	-	2	-	-	-	1	-
Total	9	3	26	10	2	4	2	2

1. Permanent Secretaries in all the C.S.Us are classified as Grade Level seventeen (GL17) Officers.

#### Difficulties in Making Appointments:

Since appointments were fixed in advance without prior approval by the prospective respondents (this was because of the distance and state of communication involved), it was anticipated that there could be problems. Because of the tight time constraints imposed on the survey particularly by the impending general election in Nigeria at the time, the interview schedule was designed such that call back was almost impossible. This is a point made much more difficult by the poor state of telephone communication in Nigeria and by the traffic situation in most Nigerian urban centres.

In general, it was our experience that although no prior approval was received from the prospective respondents before the date and time of their interviews were fixed, where the letter communicating the appointment reached the respondents at least two weeks before the author arrived, the interview was granted in approximately sixty percent of the cases.

#### Use of Tape Recorder:

Note taking and tape recording were the two methods employed simultaneously during the interviews. No particular negative effect was observed as a result of the use of the tape recorder. On the contrary before the small portable cassette recorder which was used was placed on the table, most respondents expressed the fear of being secretly recorded. "I hope you are not hiding a recorder under your suit" one respondent queried just before the cassette recorder was brought out of the interviewer's brief case.

In general the use of the tape recorder in particular proved to be beneficial. Respondents were observed to take the survey seriously, were thoughtful and tended to be more precise in their discussions. They talked without inhibitions such as would have occurred if they had to pause for the interviewer to write all that was being said. Respondents in the most senior grades were particularly eloquent and showed total disregard to the presence of the cassette recorder.

Our experience is similar to that of Zuckerman (1972) who interviewed the nobel laureates in science. On the use of tape recorder during the interview, Zuckerman noted:

"The usual disadvantage of recording - its tendency to provoke anxiety and inarticulateness - were not experienced with most respondents".

#### The Exceptions:

When the interviewer placed the cassette recorder on the table, respondents were always told before the start of the interview that if they objected to the use of the cassette recorder either for the whole length of the interview or for any part of the interview they can turn it off. It was

explained to the respondent that the main reason for using the cassette was to save his time.

Only one respondent objected to the recording of the interview either through the use of the cassette recorder or by note taking. He was later persuaded to allow note taking during the interview. The interview turned out to be interesting lasting for nearly two hours. No particularly divergent views were expressed by this respondent on any of the questions asked.

Similarly only one respondent was observed to be visibly nervous during the interview. Midway through the interview the respondent exclaimed: "I hope you are not a C.I.A. agent". After attempts were made to calm him the interview was resumed but was later terminated prematurely by the respondent. It is not clear whether his uneasiness had had anything to do with the recording, since the author offered to turn off the recording, but the respondent objected.

The third noticeable incident during the interviewing was when a respondent turned off the cassette recorder in order to make the remark "in our society what matters is not right but the political might one can wield". This in any case is a view expressed in some ways by over eighty percent of the respondents.

#### Background Information:

This survey was conducted in the months of June and July 1983. Two important events taking place at the time are worth mentioning although none of them was observed to have any direct effect on the survey.

- (i) The interviews were conducted at a time of intense political campaigns in preparation for the general elections scheduled to

take place in August and September 1983.

- (ii) Civil Servants in some of the Civil Service Units in the country had not been paid their regular salaries for some months at the time of the interview.

**Participation:**

On the whole thirty-five ministries and three government corporations participated in the survey. Fifty-nine senior civil servants were interviewed in all. Table 6.2 shows the breakdown of the number of ministries and government corporations that participated in each of the selected Civil Service Units. Also indicated on the table is the number of senior civil servants interviewed in the respective Civil Service Units.

Table 6.3 shows the seniority of the officers interviewed according to their Grade Level (GL) and the number of each category of officers interviewed in each Civil Service Unit.

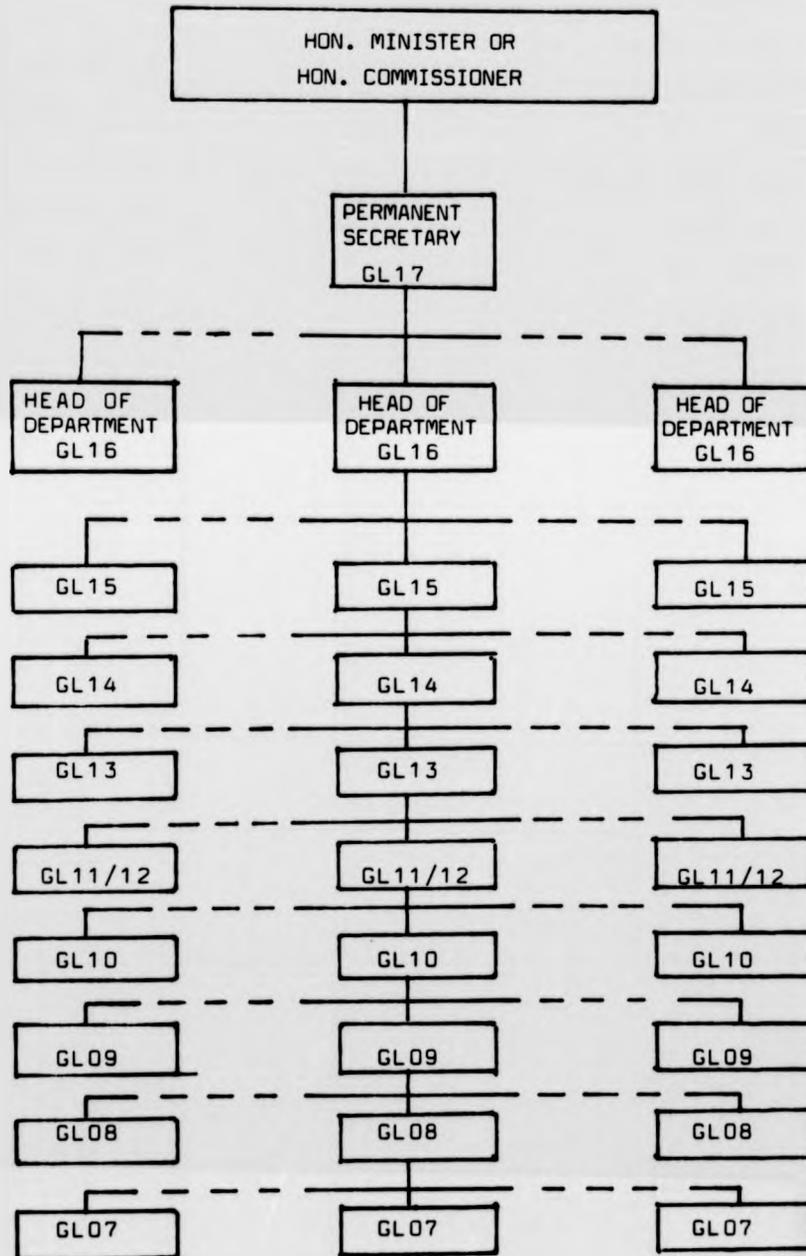
Figure 6.1 shows a generalised and simplified organisational structure of a typical ministry in any of the Civil Service Units covered by the survey.

The following are the Civil Service Units (C.S.U.) in which interviews were conducted during the survey.

- (i) The Federal Civil Service,
- (ii) Lagos State Civil Service,
- (iii) Oyo State Civil Service,
- (iv) Kwara State Civil Service,
- (v) Benue State Civil Service, and
- (vi) Plateau State Civil Service.

In addition to the interviews conducted in the main Civil Service, the author also visited the Nigerian Institute for Social and Economic Research (NISER), the University of Ibadan Consultancy and the Nigerian Institute for Strategic and Policy Studies, in order to ask questions regarding their involvement in the application of scientific method in problem-solving in the Civil Service.

Figure 6.1 A Generalised and Simplified Organisational Structure of a Typical Ministry in the Civil Service in Nigeria.



## ANALYSIS OF THE INTERVIEWS:

### Introduction:

The purpose of the interview was to increase our understanding of the administrators, and the situation with regards to factors which we believed to be pragmatically significant and pertinent to the process of the introduction of Operational Research (OR) into the civil service in Nigeria, a developing country. In the analysis which follows the data collected during the interviews are discussed in the context of the purposes of the particular questions asked, and in the light of the global objectives and purposes of the research.

In analysing the interview responses one has found it necessary to classify the data under nine essential factors which one has discerned from the data as having pragmatic significance and pertinence in the process of the introduction of OR into the civil service in Nigeria. As McGrath (1964) has argued:

"...the field study investigator imposes a "strong" structure after, rather than before, he collects his data..." (p.555)

In this case the interview responses are discussed under nine headings reflecting the nine essential factors which were discernible to the author to have pragmatic significance to the introduction of OR into the Nigerian Civil Service. Each section begins with introductory statements indicating why the particular factor was measured, followed by identification of the particular questions discussed in that section. Analysis of the responses to the questions are then discussed in details with reference to the particular questions asked. The section is brought to a close by discussions of the main conclusions which are drawn from the analysis of the responses.

The interview responses are analysed under the following nine sectional headings which are based on the nine essential factors which the author has discerned from the data.

1. Work for OR scientists to do in the civil service.
2. Availability of funds in the ministry to support OR investigations.
3. Decision making and power structure within the ministries in the civil service.
4. Availability of trained and experienced OR personnel within the civil service.
5. Existing knowledge in the civil service about Operational Research.
6. Existing experiences in the civil service in working with consultants in general.
7. Availability of computer or computer terminals in the ministries in the civil service.
8. Preferred mode for the introduction of OR into the government.
9. Problems perceived by senior civil servants as pertinent to the introduction of OR into the government.

1. Work for OR Scientists to do in the Civil Service:

In this section we discuss problem areas where OR scientists working in government can seek to influence government activities by undertaking studies in problem areas which are of strategic importance to government. Although it is generally recognised that there is much work that OR scientists can do in government in developing countries (Ackoff 1968, Morse and Brown 1976), the actual work done in the government and the problems the administrators have have never been thoroughly investigated by OR scientists. It is therefore not surprising for example, that what one finds in the literature on OR applications in the developing countries tend not to truly reflect the problems which are of major

concern to governments in the developing countries (see Chapter Two).

Based on extensive interviews conducted in the Nigerian civil service during which senior administrators described in details the work they do and the problems they experience, we shall now suggest problem areas in the government where we believe OR projects which can make substantial contributions to the quality of decision making in the civil service can be initiated.

It is worth emphasising that before particular projects can be arranged discussions with appropriate officials would be necessary. It is not within the scope of this research to arrange specific projects on which OR investigations may be conducted. Furthermore the turbulence in the environment would make such endeavour worthless before government was actually prepared to commission such studies and before OR scientists were available to undertake the studies.

In the analysis which follows real live problem areas which were of major concern to government and on which we believe OR contributions of substance can be made are suggested. As emphasised by Rivett (1984) and Ackoff (1974) worthwhile OR studies should be directed at the "muddles" or "messes" of real live problems. From the various suggestions made by respondents about areas where they would expect OR assistance in the civil service it is one's view that OR scientists who are to work in the civil service may have to be prepared to find their way through the "muddles" or "messes" of real life. Whereas it might be possible that some of the problems mentioned by the respondents may not be suitable for OR investigations, it is difficult to say which problems may not be suitable for OR investigations in the light of the history of OR. As Beer (1970) argued OR is:

"...using science to solve problems in the conduct of affairs - whether at the tactical or the strategic level, whether the problems were about activities on the ground or policies in the head."

In undertaking OR in the civil service in a developing country such as Nigeria one must be weary of the techniques approach to doing OR, as Beer (1973) rightly warned "let us take care that scientific insight is not obfuscated by its own technique."

In the analysis which follows project ideas are discussed in nine ministerial sectors in the civil service covering agriculture, water resources, transportation, education, finance, trade and industry, health, economic planning, and miscellaneous sectors. The project ideas suggested need to be followed up at the appropriate time; that is, when government and OR scientists are both ready to start actual OR investigations in the civil service.

#### Analysis of the Responses:

Although the interviews were conducted in the order contained in the questionnaire, the analysis in this section is based on the responses to questions Q1 (a-d) and Q2 (b-e) (See Appendix I for details of the questions asked). Based on the responses to these questions we suggest the following sectors of the civil service and discuss real live problems in the sectors on which we believe OR studies which could be of substance and significance to government can be undertaken.

#### (i) Agriculture:

Agriculture in Nigeria is still predominantly in the hoe and cutlass stage. Whereas this subsistence agricultural practice was sufficient in the past to sustain the population, rapid population growth, rural-urban migration by the young, and other environmental

factors have necessitated the massive importation of food in the last couple of years thereby placing heavy burdens on the nations foreign exchange. In order to combat this rather unhealthy situation since the country is blessed with good agricultural land (see F.O.A. 1966), successive governments since the 1970s have promoted various "green revolution" programmes the impact of which is yet to be felt within the nation.

Government being aware of the urgent need to produce more food locally has made agriculture one of its priority areas in its programmes for national development. In order to accelerate research and development in the agricultural sector, government effort has been directed at five key areas namely; root crops, grains, tree crops, dairy and poultry, and fisheries farming. Government is interested in modernising farming in each of these areas.

Given the well known contribution of OR in agriculture (see Chapter Two), one believes that OR studies can be initiated in this sector covering a number of problem areas. In one's view there is an urgent need for a thorough scientific evaluation of government "green revolution" programmes so that the options which are available to government in order for it to achieve its objectives in the most efficient manner can be clearly spelt out before it thereby enabling government to make better decisions. This is a problem on which one believes OR scientists can make vital contributions in finding solutions. Other problem areas include effective fertilizer usage, effective use of available agricultural machinery, the introduction of high yield variety grains, improved cropping patterns, design and manufacture of improved agricultural implements, farm management, storage systems, improving fishing tech-

niques, dairy and poultry production, selection of livestock to breed, distribution and marketing of agricultural products, and the evaluation of agro-allied industries.

(ii) Water Resources:

Water is an essential commodity yet it is a rear commodity in many developing countries, the development of water resources being yet in its infancy. As argued by Wionczek (1962) the development of water resources is closely linked to agricultural development. The same is true in industrialisation and in the improvement of the basic standard of living of people (Sikka 1973). A large percentage of diseases contracted by people in the developing countries have their origins in the use of contaminated water.

The problem of making good quality water readily available to the masses of the population for domestic, agricultural and industrial usage is one that governments at all levels in Nigeria take seriously. This is an area where one believes OR scientists can assist government. In the last couple of years numerous technologies have been adopted by the various governments to solve the problem of making good quality water readily available. We believe that OR scientists can assist in the evaluation of these technologies so that government can be advised on the best options available to it in solving this great problem.

Additional problem areas where OR studies would be valued include determining the water needs for specific population centres, urban areas and rural communities; financing water projects, the collection of essential data necessary for water resources planning, and the local production of water accessories such as water pumps, pipes, tanks etc.

(iii) Transportation:

Public transport is considered by many to be a basic necessity comparable to education, health services and housing but like most essential services in Nigeria it is a big problem area (see Adeniyi 1963, Hays 1969, Tijesinghe 1976). This is a sector where one believes OR can easily make its mark since even the smallest improvement would be easily noticed by government and the general public.

Particular problem areas where OR studies could be initiated include planning of public transport for specific towns, cities, and whole communities; management of public transport, daily travel patterns in particular cities, towns and communities; provision of parking spaces in cities and towns (see Dodson 1969), bus routing and scheduling, and maintenance of public transport. For inter-urban transport project ideas see Chapter Four.

(iv) Education:

This is a sector where government has made massive investments. Problem areas where OR assistance could be vital include funding of educational institutions, manpower planning, collection of data needed for educational planning, determination of number, size and mix of schools required to meet the needs of particular areas (e.g. local government area or whole State), planning of courses offered in technical colleges, and location of schools and allocation of students to them.

A particular problem area which has been of major concern to education planners and administrators is that of linking education to national development. We believe that OR scientists can assist

in studying the linkages between education and national development and hence assist in the formulation of policies to bring this about. During the interviews, many administrators expressed their frustration over the lack of significant development in the scientific, technological and social fields despite massive government investments in education at all levels and in all fields. In one's view this is a problem area where government would be willing to receive OR assistance.

(v) Finance:

Particular problem areas which were of expressed concern to many administrators and professionals in the finance ministries include efficient collection of revenues, preparation of annual budgets, control of government expenditure, auditing of vouchers and receipts, and the operation of government treasuries.

In one particular State visited the treasury was like a marketplace, contractors and all sorts of people thronged the treasury like mobs in order to collect whatever they were owed by government. The deputy Accountant General in the State cited that as a case where he believed if OR could help it would be "greatly appreciated". He also mentioned the case of fraud which he said was very rampant and of great concern to the government, he questioned if OR people could not help to devise means of reducing the incidence of fraud in the service. These are problem areas where one believes OR studies can be initiated after careful discussions with the appropriate officials.

(vi) Trade and Industry:

This is the arm of government charged with the responsibility for

developing programmes for industrial development of the country or State. It undertakes feasibility studies of industrial projects, give guidelines on the location of industries, manage government industrial projects, negotiate partnership for government industrial projects, organise trade fairs and exhibitions, and advise industrialists and investors on opportunities available (e.g. in the country or in the State).

The administrators in this sector are presently assisted mostly by economists, industrial engineers and marketing specialists. We believe that there is scope here for OR assistance in this sector. Particular problem areas where OR studies could be initiated include developing planning models, conducting feasibility studies, investigating the industrial potentials of whole areas, and some aspects of trade fairs and exhibitions which are organised regularly by governments.

(vii) Health:

This is a sector where OR contribution is generally well known (see Boldy 1981, Shuman et al 1975, Stimson and Stimson 1972, Luck et al 1971). OR applications in this vital sector is yet to be substantial in the developing countries (see Chapter Two). We believe that health services like transportation, is a sector in the Nigerian civil service where OR studies can easily make impact on the government and on the general public.

Among the problem areas where OR studies could be organised are: the reduction of queue lengths in hospitals, clinics and other health institutions; the reduction of the through-put-time in hospitals, health manpower planning, allocation of government resources

among health institutions, general health services planning, location of health services, more effective use of epidemiological services, the collection of data for health services planning, and the development of effective health policies.

(viii) Economic Planning:

Work in this vital sector of the civil service is presently undertaken mostly by economists. In the light of the work done in this sector described to the author during the interviews, one can see areas where OR assistance can greatly enhance the quality of advice given to government from this sector. OR scientists can assist in developing planning models which may be used in the formulation of government policies and in mapping out government development programmes.

A particular problem area which was of major concern to planners and administrators in the planning ministries was that of getting accurate data, this being essential for planning. Since 1963 there has been no accurate population census in Nigeria. This problem of conducting an accurate census is a particular area where a number of administrators expressed their readiness to receive OR assistance. Although census is a hot political issue in Nigeria, one believes that the technology to enable the country to undertake an accurate census already exists. In one's view, this is a problem area where OR scientists can offer substantial assistance. Planning without reliable data presents enormous problems as outlined by Stolper (1966) based on experience in Nigeria.

Other problem areas where one believes OR assistance could be vital include national manpower planning, computation of G·D·P, inflation

rates, commodity prices etc; making government revenue forecasts, and devising strategies for the effective implementation of government development programmes. The wide gap which often exists between government development programmes and their implementation was a problem area in which many administrators expressed great concern. (See Rondinelli 1979, 1978, Rondinelli and Jones 1975). We believe that OR as an applied science can offer vital assistance in this major problem area.

(ix) Miscellaneous Sectors:

As mentioned elsewhere (see Annex 2, Appendix II), OR is a well-established and widely used activity in government departments in the United Kingdom and in the U.S.A., as well as in many other countries in the developed world. Many major OR studies have been undertaken in most ministries in the U.K. and in the U.S.A. (See Chapter Three). We believe that the range of problems for which OR could be usefully applied is no less in the Nigerian Civil Service than in the U.K. or the U.S.A. and its potential value is no less.

From the analysis of work done in the ministries it is one's conclusion that OR studies of some sort which could be of significance to government can be arranged in virtually all the ministries in the civil service. Other sectors in the government where one believes OR assistance can be arranged include defence, police affairs, judiciary and justice, lands, employment, establishment, housing, urban and town planning, mineral exploration, and the public corporations (e.g., telecommunications, post office, electricity, airways, railways, ports and waterways, insurance, banking etc.).

## 2. Availability of Funds in the Ministries to Support OR Investigations:

In this section we examined the situation regarding availability of funds to support OR investigations. Questions were asked against the background of the uncertainty about which mode would be most preferred by the administrators for the introduction of OR into the government. For example, if the establishment of a corporation on the lines of the RAND corporation in the U.S.A. or the extensive use of external OR consultants (Modes (ii) and (v), page 43, 44), were overwhelmingly preferred then the availability of funds in individual ministries to support OR investigations could be critical to the problem of the introduction of OR into the civil service.

In the analysis which follows views expressed in response to questions Q1 (e-f) and Q3(j) were taken into consideration. (See Appendix I for details of actual questions asked).

### Analysis of Responses:

When respondents were asked if they have funds allocated for consultancy services (Q1(e)) approximately forty-nine percent claimed that funds were allocated for studies in connection with the work done in the ministry; approximately fifty-one percent admitted to having no such allocations but that "funds could be found" if there was the need to engage the services of any consultants.

When asked about the percentage of project costs which would be allocated to consultancy services (Q1(f)), the responses varied as follows:

- (i) don't know - approximately forty percent.
- (ii) about five percent of particular project cost - approximately six percent.
- (iii) about five percent of annual vote is allocated to consultancy

services - approximately thirty percent.

(iv) more than five percent of annual vote is allocated to consultancy services - approximately twenty-four percent.

Later on in the interview however when respondents in the ministries where consultants have not been used in the last couple of years were asked for reasons why consultants have not been used, the overwhelming response was "there is no fund to commission research". In the light of their earlier admission that "funds could be found" for consultancy services where necessary, it is one's view that the real reason could be that the administrators in these ministries were simply being evasive or at best being somewhat overconfident as might be seen from the following response by one very senior official:

"you get someone to do research when you are at a dead end or have lack of knowledge, lack of skill to perform a given function, then you look for that skill... I know my basic needs, I have no need for consultants."

In conclusion, analysis of the responses to questions asked in this section revealed in one's view that funds to undertake specific studies may not be a primary constraint to undertaking OR studies in the civil service. The real problem could be that of identifying areas where OR studies could be of value in the ministries, as argued by Baldwin (1976), this is a task which only trained OR scientists can undertake effectively.

### 3. Decision Making and Power Structure within the Ministries in the Civil Service:

Understanding the decision making processes in the civil service is essential to the successful introduction (and practice) of OR into the government. (see interview with Mr. Turner). In this section we attempted to find out who makes the decisions, how are the decisions made, who are

the principal actors and what is the relationship between the civil service and the politician. In the analysis which follows the responses to questions Q1(y-n) are taken into consideration. (see Appendix I for details of the particular questions asked).

#### Analysis of the Responses:

In response to questions in this section respondents mostly reiterated well known decision making procedures in the civil service namely; decision making in the civil service is hierarchial, officers may comment along the line but the final decision on administrative matters are taken by the permanent secretary while the minister (or commissioner in the States) takes the final decision on policy matters. Depending on the gravity of the case some decisions may be taken by the President (or governor in the States), at the Executive Council, or in the Senate (or House of Assembly in the States). (see Longe 1975, 1980i, 1980ii).

On how and where day to day decisions are made (Q1(g-j)), the practice varied between ministries. In some ministries for example, the permanent secretary is advised by a standing committee on certain issues, in particular on important issues where the permanent secretary is required to advise the minister (or commissioner), a common practise was for the permanent secretary to hold a meeting with heads of divisions in order to take their views into consideration before advising the minister (or commissioner).

Asked on the one whose views will count the most in the ministry on particular issues (Q1(m)), respondents differed widely in their views. Some expressed the view that there was no one single individual in the ministry with a veto power. "Its team work, decision making is not a one man affair" one respondent explained. One director in a federal

ministry likened the decision making situation to a cybernetic system. "Its like a cybernetic system, objective agreement is what counts most" he emphasised. Some respondents were of the view that "the professional views count very seriously", they argued that the permanent secretary as an administrative officer depends on the professionals. Some of these respondents maintained that the views of the permanent secretary was final but that "he relies heavily on service chiefs" (i.e., directors and heads of departments). It is the view of some respondents that the minister (or commissioner) was the person with the last say on all matters in the ministry.

On the relationship between the permanent secretary and the minister (or commissioner), the response was generally a reiteration of well known positions in the civil service (see Longe 1979, 1980:iii). The permanent secretary was generally regarded as the accounting officer of the ministry, he is the principal adviser to the minister (or commissioner), he is responsible for the day to day management of the ministry and, he works with the minister (or commissioner) to implement party policies as they apply to his particular ministry. The minister (or commissioner) was regarded as the chief executive of the ministry, he is the representative of the party in power and he is in the ministry to see to the implementation of the party manifestos as it applies to the particular ministry. The minister or commissioner is the ministry's link to the President (or Governor) and to the Executive Council.

It is one's conclusion based on the analysis of responses to questions asked in this section that except for minor routine decisions, decision making power basically rests with the permanent secretary and the minister (or commissioner) in a ministry. Under these circumstances, how OR is integrated into the existing structure of government is important and

needs to be carefully considered during the introduction of OR into the civil service. In one's view it would not be sufficient to just train civil servants on how to undertake OR investigations or on how to use OR techniques. (see Luck 1979, Clayson 1980). One believes that the establishment of the OR function in the civil service such that it fits "neatly" into the existing decision making or power structure is a complicated matter and merits careful evaluation. (see Radnor et al 1968, Rubenstein 1960, Rubenstein et al 1967, Tansik et al 1971, Kornhauser 1962).

If the impact of OR is to be felt in the government, it is one's view that OR's position in the civil service has to be such as would allow it to directly influence the tactical, strategic and policy decisions which are made by government. The experience of OR scientists in the British and the American civil services, and in the public corporations in these countries lends credence to this point of view. Under the existing structure in the civil service, it is one's view that OR would be most effective if the head of OR reports directly to the permanent secretary.

As argued by Rivett and Ackoff (1963), the OR Society U.K. (1968), and the panel appointed by the National Academy of Sciences (1975), for OR to be effective it must report at high levels in the organisation (e.g., one step below the chief executive or directly to him). In the particular case of the Nigerian civil service, it is one's conclusion from the analysis of the decision making process and the power structure in the ministries, that the permanent secretary as the principal adviser to the chief executive in a ministry is the most appropriate officer to whom the head of OR should report. This will ensure that government enjoys the full benefits of OR services in the civil service just as

argued by Rivett and Ackoff (1963) in the case of the reporting level of OR in industrial organisations. Furthermore the suggested arrangement is relatively consistent with the level at which OR reported in government during its pioneering days as reported by Waddington (1973).

#### 4. Availability of Trained and Experienced OR Personnel Within the Civil Service:

The question of finding OR scientists of the right calibre and experience is one which was examined in this section. As recommended by the OR Society U.K. (1963) to the Fulton Committee on the Civil Service, the selection of the right calibre of OR staff is essential to the success of OR in government. Although it is generally believed that there is a pool of trained OR staff in Nigeria, where they are and what they do is generally not well known. For example Adegbeyemi and Longe (1976) could not find any reasonable OR activity in industries in Nigeria. In this section we attempted to find out if there were some trained OR scientists engaged in OR services in the government. The question of how staff, particularly senior staff are recruited into the civil service was also examined in this section. In the analysis which follows, the responses to questions Q1(o) and Q2(f,g) are considered. (see Appendix I for details of questions).

#### Analysis of Responses:

When asked if there was any one in the ministry doing OR or trained in OR, the response was simply "none". To the question on how staff are recruited, respondents explained that junior staff (GL01 to GL06), were directly recruited into the ministry while senior staff (GL07 and above) were recruited by the Civil Service Commission. When respondents were further questioned about how the Commission gets to know their particular staff needs, it was explained that personnel needs were determined at the time of the annual budget. Request for new staff would have to

be approved by the Establishment Division.

One's conclusion from the analysis of the responses to questions posed in this section is that there are a substantial number of Nigerians who have been trained in OR but who might not be practising the science at least full-time, many are known to be in the universities as might be expected based on Ackoff (1974). The absence of trained OR scientists in the civil service indicates that during the introduction of OR into the government, there could be a problem of lack of OR scientists with experience in civil service problem solving among indigenous trained OR scientists. As Sagastie (1972), Smith (1973), and Bandyopadhyay and Varde (1960) have bitterly criticised, indigenous OR scientists have not been able to demonstrate their ability to apply OR in real-live problem solving in the developing countries. Thus we could be in a situation where the administrator as well as the OR scientist are both learners, a rather shaky ground in one's view for a pioneering OR activity.

In general a supply problem exists in one's view during the introduction of OR into the civil service. An added complexity being that of finding personnel of the right calibre to train in OR and where to train them. As already pointed out (see Annex 2 Appendix II), OR staff need to be formally trained in the use of OR techniques and in the methodology of undertaking OR investigations, besides, they must have a suitable personality for the job. Some respondents tried to exploit this problem, for them the supply problem was a good defence against the introduction of OR into the government. This could be seen from the query raised by one respondent when he retorted:

"Do you have institutions in this country where people can be trained? Another problem is the right material to be trained, is not everybody that can be used."

As has been already mentioned (see Annex 2 Appendix II), if a substantial number of Nigerians who have been trained in OR can be identified and attracted into the government, they might be able to play a vital part in solving the supply problem. Nevertheless as argued by Rivett and Ackoff (1963), Morse and Brown (1975), the OR Society U.K. (1968) and by the panel appointed by the National Academy of Sciences (1976), the recruitment of the right calibre of OR staff is critical to the successful introduction of OR into an organisation. This is a problem which one believes merits careful examination (see Chapter Seven).

#### 5. Existing Knowledge in the Civil Service About Operational Research:

Given that until a fact is known it can not be effectively applied as argued by Streat (1960), we were interested in knowing how much awareness existed in the civil service about OR. We believed that this knowledge will enhance our understanding of the problems of the introduction of OR into the government. In this section we explored through direct questioning the degree of awareness which existed in the civil service about the subject of Operational Research (OR). In the analysis which follows this awareness is discussed based on the responses to question (Q2(a-e)). (see Appendix I for details of particular questions).

#### Analysis of Responses:

From the analysis of the responses to the leading question, Q2(a), one was persuaded that OR was generally not widely known. Some respondents admitted total ignorance about OR, for example one respondent when asked to say what he knew about OR (Q2(a)) promptly replied: "I don't know it at all", another asked to be educated: "I don't know, I want you to enlighten me".

Some respondents confused OR with activities such as Organisational

Dynamics (O & D), work study, or some social research. For example, one respondent when asked about OR retorted: "Operational Research, I think they have a long way to go with this Work Study analysis..." Another replied:

"Operational Research, I have not carried out one myself, I think Operational Research is supposed to be that aspect of research where the researcher goes to stay in the organisation or in the community and see how particular business which he is carrying out research on is being carried out, in fact he becomes a participant observer."

Some respondents, perhaps trying not to admit ignorance of the subject or being over confident, supported their description of OR by claiming to know what OR is or by claiming to have learnt some techniques of OR some years past even though their description of OR left one in doubt about their awareness of OR. For example, one respondent declared:

"Operational Research as is so-called has to do with exploration of various ways that you enhance efficiency in the performance of one's job... I know much about it, I know its scope, I know its usefulness..."

Another respondent claimed:

"Well, it's a long time that I have read this Operational Research, I think I read about Operational Research in 1964, it's a long time ago, I only know that it's a way of finding how to improve the performances of duties, that's all I know about it as of now, improvement of performance of duties."

The questions relating to where OR might be applied in the ministry (Q2(b-d)), were generally not asked. Flexibility of personal interviewing and the flexibility built into the interviewing instrument allowed the interviewer to skip questions which he felt were inappropriate

following the response to a preceding question. Hence in most cases respondents were given a brief description of OR and then asked if they could think of areas where OR might be usefully applied in their ministry (Q2(e)).

Since the subject was relatively new to most respondents, many were unable to say much while some simply kept silent. In order to maintain the respondent's enthusiasm and keep the interview going, some examples of successful OR investigations were briefly described to respondents in order to break the silence. One of the examples being always closely related to the work done in the particular ministry (see Chapter Two). In all cases respondents were able to suggest some problem areas in their ministry or in the government at large where they believed OR assistance could be of significance.

Analysed on a three point scale, the awareness which existed about OR in the civil service may be summarised as follows:

- (i) OR Not Well Known: Respondents in this category either admitted (often before they were asked) that they did not know much about Operational Research or attempted vaguely to recall something learnt or heard sometime past which they considered to be Operational Research, others simply made intuitive guesses about what Operational Research is.

By far the largest number of respondents belong to this class, approximately ninety-three percent of the respondents can be said to know little or nothing about OR.

- (ii) OR Known: Respondents in this class clearly demonstrated a higher

degree of awareness of the subject than the first class of respondents. These respondents recalled taking courses on which some "OR techniques" were taught, although generally they could not say confidently what OR is or of what particular benefits the techniques learnt have been to them. Approximately seven percent of the respondents are in this category.

(iii) OR Well Known: These were respondents who did a particular course in Operational Research (OR), Management Science (MS), or Systems Analysis (SA), and hold an academic qualification in it, or who were engaged in the practise of OR, MS or SA. No such respondent was discovered during the interviews, that is they constituted zero percent of the respondents.

It is one's conclusion from the analysis of the existing knowledge about OR in the civil service that a problem of ignorance about OR exists. One believes that for OR to be successfully introduced into the civil service something would have to be done about this problem particularly as it affects the decision to introduce OR. In one's view, there is the need for some sort of OR education in the civil service particularly at the higher levels of government from where the decision to get OR started in the government may have to come.

6. Existing Experiences in the Civil Service in Working With Consultants in General:

In this section we tried to explore the experiences which existed in the civil service in working with consultants in general, either foreign or indigenous, management consultants or engineering consultants (Q3(a-b)). OR being a consulting activity which generally demands active client participation, we were interested in knowing the extent to which civil servants were involved in studies undertaken for govern-

ment by consultants (Q3(c)). We were also interested in knowing whether the consultants were foreigners or Nigerians. We believed that this knowledge would enhance our understanding of the problems of the introduction of OR. As argued by Ackoff (1968) and Morse and Brown (1976) for a nation to succeed in solving its own problems it must train its own indigenous problem solvers. Other problems examined in this section included the process of recruiting consultants to undertake jobs in the civil service (Q3(f)). This being of particular interest because such understanding might be useful if the mode adopted for the introduction of OR into the civil service is some sort of corporation. The other problem area explored in this section was the situation regarding the implementation of the findings of consultants who have worked for government. This is a point of particular interest since implementation is what brings the benefits of studies to the client. Although the studies undertaken in the government might not be OR studies, the attitude of government in general to the implementation of studies undertaken in the civil service could be a pointer to what OR scientists working in government may expect. Analysis of the responses to the various questions asked in this section will now be presented. (see questions Q3(a-h), Appendix I for details of particular questions asked.)

#### Analysis of Responses:

Analysis of the responses to the questions in this section revealed that some measure of experience existed in the civil service in working with consultants in general. Consultancy services have been offered to government in the problem areas of engineering designs, feasibility studies, staff reorganisation, manpower utilization, demographic surveys and other data collection surveys.

Some ministries had a policy whereby one or two members of their staff

were assigned to work with the consultants, to actively participate in the studies, in the writing of the report and in the implementation of the recommendations. As one respondent explained:

"One or two of our staff are attached to the consultants, and we ensure that they participate in the writing of the report, so that they can lead in the implementation. As a rule, there must be active participation of our staff in all consultancies undertaken for the ministry."

In spite of the above response it would be misleading to believe that a number of civil servants have now acquired the art of problem solving since in general expertise in the areas where consultancies were offered is seldom available in the government as Okoli (1982i) has revealed. In some other ministries the situation was different, in these cases "project briefs" were given to the consultants, no member of staff participated directly in the study, when the report was submitted, it was appraised in the ministry and recommendations were made to the government. As one respondent explained:

"Once a project has been given to a consultant the ministry does not involve itself in it, the consultants are paid for the job, it's like subletting. It was given out because the ministry was unable to handle it, there is therefore no need for a member of staff to be with the consultants. What the ministry does is to appraise the report and make final recommendations to the permanent secretary."

The consultancy services were generally undertaken by foreign consultants, local consultants (this include university based consultants, government research institutions, and indigenous consulting firms), and by civil service Management Consulting Units (where they exist). Approximately fifty-two percent of the studies cited during the interviews were undertaken by foreign consultants, approximately twenty-nine percent by local consultants and approximately nineteen percent by the civil service

Management Consulting Units. The process of recruiting the consultants varied among the ministries, while some invited open tender, some kept a register of consultants, others simply invited quotations from known consulting firms when there was need for their services.

In the implementation of the studies, analysis of the responses indicated that approximately seventy-nine percent of the studies cited during the interviews were said to have been fully or partially implemented, approximately six percent were not implemented due to lack of funds while approximately five percent failed to be implemented due to reasons such as change of government or change of policy (examples of turbulence in the environment).

From the analysis of the responses in this section, it is one's conclusion that unlike the situation in the British and the American civil service, there is paucity of experience in working with OR scientists in the civil service in Nigeria. This implies that during the introduction of OR into the government learning may proceed slowly. Some measure of experience in working with consultants in general nevertheless exists in the civil service from which OR may indirectly profit. Although it would be misleading to relate the experience directly to participation in OR studies, it does however represent some degree of encouragement for OR work in the civil service when the activity gets started in the government. The minority of cases where government involvement in the studies was only limited to giving "project briefs" and appraisal of the completed reports do not augur well for government since it denies the civil service of valuable and in some cases rare experiences. For OR work especially it could be unhelpful. As argued by Morse and Bacon (1967), active involvement by administrators could expedite implementation. The points made by Morse and Bacon is worth underscoring, they declared:

"A report is not a successful solution to an operational problem. The true success, the implementation of the recommendations, is much more likely if, in addition to the report, a few members of the administrative staff have worked closely with the consulting team so that they understand the main outlines of the analysis and the reasons for the conclusions." (p.13).

The other point from the foregoing analysis which should be of concern to government is the high level of work being done by foreign consultants. In one's view, it is in the better interest of the nation that government should develop its own indigenous problem solving capabilities. A similar point was made by a panel appointed by the government in 1979 to look into this sort of problems (Okoli 1982i, 1982ii). The existing Management Consulting Units while making vital contributions in this direction are severely handicapped by a number of factors, prominent among which are the problems of staffing, organisation, and remunerations.

The existing Management Consulting Units in the civil service are generally staffed with personnel who are not trained in the sciences, this severely limits their capabilities with regard to methodology and the range of problems which they can effectively tackle. They are in general administrative officers. This means that officers upon whom government has invested enormous resources in training to do consultancy work, seldom have the time to do such work. Some of the officers interviewed believed that the establishment of a special cadre for these group of administrative officers might help to ease the problem. The other limiting factor is the sheer frustration experienced by the staff due to what they saw as low remunerations paid to them compared to what their colleagues in the private sector earns.

It is one's conclusion from the analysis of the responses to questions in this section that for government to successfully tackle the problems of development it must develop indigenous problem solving capabilities

within the civil service. The problems confronting the government cannot be effectively and efficiently solving by depending on foreign expertise nor can it be satisfactorily solved by sheer ad hoc decision making. As pointed out by Morse and Brown (1976), external help is not good enough, and as emphasised by the OR Society U.K. (1968), the major policy and strategic problems which often confront governments need to be tackled by using scientific method. It is one's view that the introduction into the government, of Operational Research (OR), an interdisciplinary problem solving activity which is based on scientific method, is a solution to this problem.

As pointed out elsewhere (see Annex 2, Appendix II), we believe that the Nigerian Civil Service has the management sophistication which would enable them to make effective use of OR investigations. For example, all the respondents interviewed by the author during the study, had at least a first degree or equivalent, while approximately ninety percent had post graduate degrees or diplomas in addition. And without exception, every one of the respondents had undergone a number of intensive short courses of some sort organised in institutions locally or abroad. We believe that the effective use of OR implies a degree of sophistication on the part of the administrators concerned and in their willingness to explore alternatives. In our view, the Nigerian senior administrator is no less willing to explore alternative solutions to a problem than his counterparts elsewhere nor is he any less sophisticated. Hence we are persuaded that the introduction of OR into the government would be an effective solution to the problem of developing problem solving capabilities within the government based on application of scientific method.

7. Availability of Computer or Computer Terminals in the Ministries in the Civil Service:

Computer is an invaluable tool in OR studies, hence in this section we

investigated the situation with regards to computer availability in the civil service in general and in particular ministries. "Do you have a computer in this ministry?" (Q4(a)), was the leading question addressed to all respondents during the interviews. Where a computer was available questions were asked about the means of accessing it (Q4(b,c)), availability of computer staff (Q3(d)), how the computer is actually used in the ministry (Q4(e)), and the use of computers in consultancy studies undertaken for government (Q3(i)). The analysis which follows is based on the responses to questions Q4(a-e) and Q3(i). (See Appendix I for details of particular questions).

#### Analysis of Responses:

"There is no computer in this ministry" was the general response to the leading question in this section (Q4(a)). In all the five State civil service units where interviews were conducted during this research, no computer or computer terminal was available. The Federal Civil Service was the only place where a mainframe computer was available in the Federal Office of Statistics and a mini-or micro-computer in the Federal Ministry of National Planning. The computers were operated by computer staff and there were no terminals assigned to any office.

Although a large computer is an invaluable tool in OR studies, in one's view the absence of computer should not prevent the introduction of OR into the civil service. Even in the industrialised countries OR was being done before computers became available. As Beer (1970) warned we should not "let our understanding vanish down the nearest data-drain to be lost in the viscera of a vast digital computer." What one believes may be necessary is for the OR group to have access to a large modern computer.

In one's view the increasing use of micro-computers with the opportunities they introduce for application in non-routine situations has created a major new field of application for OR. Therefore for the day to day use of the young OR group in the short term, mini-computers or even powerful micro-computers may be preferred to hand-held calculators. Besides private firms which provide computer services, computers are now available in a number of universities in Nigeria, so that the problem of computer availability may not be as bad as it may appear at first particularly to someone who was trained in the developed countries where computer and computer terminals are readily available.

8. Preferred Mode for the Introduction of OR into the Government:

In this section we explored the mode preferred by the senior Nigerian public administrators for the introduction of OR into the civil service. Often when the problems of the introduction of OR into organisations are discussed, the views and preferences of the administrators and managers into whose organisations the introduction of OR is proposed tend to be ignored. (see OR Society U.K. 1968, Morse and Bacon 1967, Rivett and Ackoff 1965, National Academy of Sciences 1973, White 1975, Radnor et al 1968, Rubenstein 1960).

We believe that in the introduction of OR into an organisation, in particular the civil service in a developing country, it is essential to engage the senior administrators in discussions on the mode which is most likely to lead to success from their own point of view as the potential customers of OR services. In introducing a new activity such as OR into organisations, particularly in developing countries we believe that one needs to proceed warily being careful not to impose a mode on the organisation, since little is known at present about the best mode for OR activity in government or in industry. One believes that the

mode by which OR is introduced into the civil service in a developing country could be a determining factor in whether the programme succeeds or fails.

In this research three possible approaches by which a government might introduce OR into its services were presented to fifty-nine senior Nigerian public administrators among whom were nine permanent secretaries. The approaches which were presented to the administrators will now be discussed and the responses analysed. (see Appendix I, Q5).

Modes/Question:

There are a number of possible ways by which a government can introduce Operational Research into its services, for example:

- (i) A government may set up a department which will provide Operational Research Services to all ministries in the government,
- (ii) A government may establish a corporation which will provide Operational Research Services for government ministries only, and
- (iii) A government may establish Operational Research groups in selected ministries to provide Operational Research Services.

Which of these approaches do you think is best for you?

Analysis of Responses:

Analysis of the responses to this question revealed that senior civil servants had strong preferences on the mode by which they believed government should introduce OR into the civil service. Some respondents believed that the establishment of a Central OR group would serve the purposes of government better. One such respondent argued:

"I think a Central Operational Research Service would be better, because if you have a crop of scientists attached to various ministries they may be working at cross-purposes."

Strong cases were made for the establishment of a corporation by some respondents. One such respondent passionately made the following case:

"One would prefer a Bureau of Management Consultancy for the government, the reasons are, they can hire more competent experts, give neutral independent view, make practical recommendations, and prevent biases. A group within the government may allow fear of the boss to affect its recommendations, and it may not be able to see problems from the outside. One prefers a corporation."

There were respondents who believed that the location of OR groups in some selected ministries would be preferred by government. A respondent with this persuasion argued:

"It is very difficult to say which approach is better, because you have to take many factors into consideration; if you have an omnibus organisation, such an organisation has to be well staffed with people of various disciplines serving such organisation. Whereas on the other side, if you base it in the ministry it means you will have to make such an organisation part of that particular ministry. So you can talk in terms of the advantages and disadvantages of each of them. One is likely to be less expensive than the other, but frankly speaking you may discover that government may not need to set up such organisation in all ministries, but honestly I don't think government needs to set up an omnibus organisation for the entire civil service, may be government can say, okay, which are the co-ordinating ministries in the entire service, and just set it up in such ministries."

There were respondents who preferred hybrid modes. One such respondent who preferred the combination of a corporation and the location of OR units in the ministries presented his argument thus:

"I have a feeling that I will tend to combine two, in the sense that I will first choose this idea of Corporation, that is, if the Corporations are going to charge the ministries or departments for whom they do these researches. Then I will also at the same time support or buy the idea that some people trained somehow in Operational Research should be posted to some ministries, so that at least some basic data on the operations of the ministry could be collected and stored, because it is very cumbersome, even if there is Operational Research Corporation to be invited to solve a problem and sometimes some basic information are not just available to solve that problem. I feel that some people trained somehow in Operational Research methods should be posted to certain ministries..., Ministry of Works, Housing, Agriculture, Health, Rural Development, and Co-operatives, that is why I talk of combination. If you decide to set up Operational Research Units for each ministry, you may be spreading too thinly the resources you have for research. If you colate all the resources together in a place, make it a department of government, purely civil service affairs, the result, I am not castigating the civil service, the result may not come out as fast as you want. So the idea of Corporation is quite acceptable to me, but at the same time there should be some sort of combination, such that some people trained somehow in Operational Research should be attached to ministries so that information could grow, be stored and grow so that when the Corporation comes to do a job for a ministry it has some basic information to rely upon, this is how I feel."

There were those who preferred a combination of all three approaches.

One such respondent made the following case:

"I like to say, in practice you discover that it is a combination of all these which is most suitable, I am not saying that is the best, what is most suitable may not be the best, I am sure you know your administrative theory, the optimal point is not to be attainable. I say this because if you commission a few people to devote themselves to Operational Research, that is a parastatal. Unless of course they have intense exposure to the civil service system and don't intend to lose sight of what is expected of them, their perception of the civil service may not be used, it may not be in tune with reality. On the other hand, once you get ministry dotted with Operational Research experts, they get swalled up in the system."

For some respondents, the civil service was not yet ripe for OR. One such respondent gave the following cautious response:

"I think the best approach for our kind of set up will be the location of these units within the various departments...but what I am saying is that at the present, at best on balance, what we have is just Operational Research in its pure rudiments, not the full fledged kind of thing that you will call confidently Operational Research... You take everything on balance, the time for full fledged Operational Research is probably not yet, it is not far off, but is certainly not yet..."

For some respondents there was no need for OR in government. A respondent who was of this disposition retorted:

"You get someone to do research when you are at a dead end or have lack of knowledge, lack of skill to perform a given function, then you look for that skill. I have too much around that needs to be done, too much of what I know needs to be done which I cannot do, basic rudimentary problems, not because I do not know the way to get the resources... I know my basic needs... I have no need for consultants, government does not need Operational Research."

A summary of the modes preferred by the respondents and the principal arguments adduced in support of them is as follows (see Table 6.4):

(i) "A Central OR Group with staff to locate in the ministries". This mode was preferred by approximately thirty-nine percent of the respondents. Approximately twenty-two percent of the most senior respondents favoured this mode. The principal arguments advanced in favour of this mode were:

- (a) the manpower problem tends to be more manageable,
- (b) the cost of establishing the group could be less,
- (c) the group could be used by government to serve other purposes,
- (d) it prevents the scientists from working at cross-purposes.

(ii) "A government Corporation to serve both the public sector and the

private sector, and have staff attached to ministries." This approach was favoured by approximately twenty percent of the respondents. Approximately eleven percent of the most senior respondents favoured this mode. Among the principal arguments adduced in favour of the approach were:

- (a) it is most likely to achieve better and quicker results,
- (b) it will be divorced from bureaucratic processes,
- (c) it can give independent and unbiased assessment and recommendation,
- (d) it will be able to hire more competent staff.

(iii) "OR groups located in selected ministries." This mode of introducing OR into the civil service was the choice of approximately thirty-six percent of the respondents. Approximately forty-five percent of the most senior respondents favoured this mode. Some of the strong arguments advanced in favour of this mode were:

- (a) it will be free from bureaucratic processes,
- (b) it is easily accessible,
- (c) it can give quick response to call for assistance,
- (d) it will be able to give better attention to the problems in the ministry.

(iv) "A combination of the three approaches." This suggestion was supported by less than two percent of the respondents. Approximately eleven percent of the most senior respondents favoured this mode. No proper argument was advanced in its favour except that "it may be the most suitable approach although may be unattainable in practice."

(v) "It's not yet time for OR to be introduced into the civil service."

This argument was advanced by less than two percent of the respondents. None of the most senior respondents favoured this point of view. Although no strong arguments were put forward in support of this position, its proponents just had "the feeling that time was not yet ripe" for OR in the civil service.

(vi) "Government does not need OR". This position enjoyed the support of less than two percent of the respondents. Approximately eleven percent of the most senior respondents favoured this point of view. It was the view of the supporters of this position that they know what their needs are and as such they do not need OR assistance.

Table 6-1 Preferred mode for the introduction of Operational Research into the civil service in Nigeria.

MODE	Respondents in favour. Percent	Permanent Secretaries in favour. Percent
(i) A Central OR Group with staff to locate in ministries	39 (23)	22 (2)
(ii) A government Corporation to serve both the public sector and the private sector, and have staff attached to ministries	20 (12)	11 (1)
(iii) OR Groups located in selected ministries	36 (21)	45 (4)
(iv) A combination of the three approaches	<2 (1)	11 (1)
(v) It's not yet time for OR to be introduced into the civil service	<2 (1)	0 (0)
(vi) Government does not need OR	<2 (1)	11 (1)

Note: Actual number of respondents in favour of mode is shown in parenthesis.

One's conclusion from these analysis is that respondents in general preferred OR groups lodged within the administrative structures of government namely; in the ministries. (see (i) and (iii) above). While some respondents preferred the groups to be centrally administered, others, permanent secretaries in particular, preferred autonomous ministerial OR groups (see (i) and (iii), Table 6.4). In general, the "arche-types" found among Peruvian public administrators by Sagastic (1972), were in the minority (see (iv)-(vi), Table 6.4).

The preferences expressed by the Nigerian public administrators is in contrast to the suggestions put forward by the panel appointed by the National Academy of Science (1975) that governments in developing countries should start with a "prototype" OR group, or the suggestion put forward by Morse and Bacon (1967) that governments should start by using external OR consulting firms. As argued by Tomlinson (1980, 1974), more serious work tends to be done by the OR groups located within the management structures of an organisation (or in-house OR groups), than by those occasionally called in from the outside (external OR consulting firms).

In one's view the location of OR groups within the ministries and free from external control, in other words, OR groups accountable within the ministerial unit, offers more advantages to the users of OR services and to OR scientists working in the civil service. The location of OR groups in some selected ministries initially may enable government to reap the benefits of its investments quicker since OR may be able to make its mark on government sooner. OR scientists in particular ministries would be able to understand the problems of that particular ministry more readily and make the necessary infrastructural arrangements such as the collection of appropriate data. The scientist would be seen

as staff of the ministry and not as "outsiders on a witch hunt", this will enable the scientists to interact more effectively with the staff and interest the staff in the assistance which OR can offer. This cordial relationship may help to eliminate or at least minimise resistance and animosity which could develop when radical recommendations are made.

The advantage of this recommendation is borne out by the experiences of administrators and OR Scientists in the British and in the American civil service respectively. In both of these governments, OR groups are located within the ministerial units and are accountable within the ministries where they are located (see Chapter Three). Administrators and OR Scientists in the British civil service rejected the recommendations of the OR Society (1960) that the OR groups in the ministries should merge into one unit under one ministry (Management Services Department) on the grounds that they believed more useful work would be done if the OR scientists were lodged within the various ministries in the government. Experience since the war years tend to have persuaded administrators as well as OR scientists in the civil service in the U.K. and in the U.S.A. that OR would be more effectively done if there were some OR scientists located within the various administrative units in the government. The in-house group could liaise with large external OR consulting firms such as the RAND Corporation in the U.S.A. or with other relatively smaller external OR consulting firms.

In general one believes that the location of OR groups in selected ministries and making them accountable within the ministries will generate better understanding of the role of the scientists, give the scientists better insights into the problems of the particular ministry, enable the scientists to develop better work programmes, and encourage

the OR scientists to specialise quickly. This question of specialisation is particularly important, modern OR activity spans almost every known area of human decision making problems (see International Abstracts Operations Research). It would be of a great advantage to government if indigenous OR Scientists could quickly develop expertise in important sectors such as agriculture, health services, transportation, education, housing, urban and rural development, economic planning and development, industrial development, finance, water resources, police affairs, defence, banking, and the public corporations.

In this regard it would be important for OR Scientists working in the civil service to have forums for interaction among themselves. This would create avenues for mutual co-operation and for intellectual exchanges. This can be achieved through holding regular meetings of OR scientists working in particular geographical locations or those working on related problems. An additional avenue for interaction could be through publications which are designed to inform and to enlighten both practitioners and administrators alike about OR activities in the civil service.

In general, this conclusion is in agreement with our earlier conclusion (see Annex 2, Appendix II), we believe that the best method of introducing OR into the Nigerian Civil Service would be to establish small OR teams in some selected ministries in the government. Given the administrative structure in the civil service, in one's view, effective results can only be obtained when specialist OR Units are lodged within the management teams and are seen as part of the overall management function of a department or ministry. In this way a basic requirement for successful OR activity which is the active support of senior administrators and the active cooperation of managers for whom original studies are

undertaken might be easier to obtain.

9. Problems Perceived by Senior Civil Servants as Pertinent to the Introduction of OR into the Government:

The attitudes of senior civil servants to the introduction of OR into the civil service is very important we believe. In this section we sought to understand their attitudes by asking respondents to discuss what they saw as the problems in the introduction of OR into the civil service. It was an opportunity for respondents to express their fears, doubts, and feelings on the prospects for the introduction of OR into the government. The analysis which follows is based on the responses to question Q6 on the questionnaire. (See Appendix I, Q6 for details of question).

Analysis of Responses:

The general attitude of respondents to the introduction of OR into the civil service was a mixture of euphoria and cautious enthusiasm. For some it was good news, something long expected; others had their doubts, a "will it work here" sort of feeling. In general the attitude of the senior Nigerian public administrators is similar to that experienced by Walsham (1978) and Satter and Walsham (1975) among Kenyan public administrators. The "arche-types" found by Sagasti (1972) among Peruvian public administrators were the exception among the Nigerian public administrators (see section 8).

In relation to getting OR started in the civil service, a number of problem areas were discussed, prominent among which are the followings:

- (1) Manpower: Many respondents doubted if a reasonable number of experienced scientists trained in OR were available locally and wondered about where people could be trained and who could be

trained. One respondent queried:

"Do you have institutions in this country where people can be trained? Another problem is the right material to be trained, is not everyone that can be used."

- (ii) Funding: The problem of finding funds to enable OR activity to get started in the government was raised by a large number of respondents. This fear was expressed by one respondent thus:

"Well, as far as we are concerned in introducing such a service we want to be aware of the cost of such services. Where the cost appears to be on the high side, the government may not go for it."

- (iii) Education of the civil service about OR: Since OR was generally not widely known, many respondents felt there was the need for government to be educated about OR. This would be important in getting OR started in the government as one respondent emphasised:

"Government have not yet realised the value of Operational Research, it depends on individuals who appreciate it. What is required is a thorough education of the public sector, so that government can budget for Operational Research."

- (iv) Resistance by Conservative Officers: A number of respondents feared that conservatives, those who may have their positions challenged, and those who may lose by way of prestige when confronted by scientific method may resist the introduction of OR into the civil service. This fear was epitomised by a respondent when he declared:

"Conservatives may resist the introduction of scientific services into government decision making. The O & M and Management Consulting services have not been well received. The needs are actually there, but people's minds are not

prepared to receive scientific aids. Civil servants are timid, fearful and guided by rule."

(v) Lack of Data: The absence of data in the government is a problem which many respondents perceived could severely handicap OR activities in the civil service. This is a well known problem in developing countries (See Elshafei 1976, Bandyopadhyay 1980).

(vi) The Need to Effectively "Sell" the Idea of OR to Government: "Selling OR" has always been a problem to practitioners even under very favourable conditions, that is, in environments where OR is relatively well known (see Beer 1970, Ranyard 1984). The need to get the message clearly and successfully across to government is therefore more acute in the developing countries, environments where OR is relatively not widely known.

One "service chief" who was interviewed during this research lamented at the inability of experts with brilliant ideas to persuade governments to give their ideas a chance. He complained that often the benefits were never properly explained to government. The need to convincingly "sell" the idea of OR to government was underscored by a respondent when he emphasised:

"I think before we can introduce such a thing we are bound to create some awareness on the part of government, the need for it first, then if you sell that idea and it is bought, that is, convince them, then it means..."

(vii) Political Might: Over eighty percent of the respondents saw this as perhaps the most formidable obstacle very likely to be in the way of the use of scientific method in government decision making. Some respondents felt that because of deep rooted vested interests,

the implementation of OR studies may prove difficult (see Ackoff 1977). One respondent expressed the view that the true test of scientific method could be the "ability of Operational Research to break through the strong hold of politics" which another respondent claimed was "directing the affairs of the ministries", such that "any other condition, be it scientific, social, or economic was out of the way".

Analysis of the responses to questions in this section leads one to conclude that while some respondents saw the problems discussed above as challenges to the introduction of OR and hence believed that they could be overcome, others saw the problems as obstacles which would make the introduction of OR into the government impossible. On the particular problem of political factors, Mitchell (1960) has in fact argued that Operational Research (OR) is sensitive to political considerations. And a similar point was also made by Mr. Turner (see Chapter Three) in respect to the practice of OR in government.

In one's view what is needed is the "will" on the part of government to solve the various problems raised by the respondents. One believes that government has the power to solve the problems if it so wishes. Nevertheless since the problem of "will" is closely linked to the problems of government being fully persuaded of the values of OR, one's principal conclusion from analysis of the problems of the introduction of OR into the Nigerian Civil Service is that the real problem may be that of persuading government about the usefulness of OR to decision making in the civil service. In other words, there is a need for some form of OR education at the highest levels of decision making in the government. Once government is fully persuaded of OR, one believes that the problems of funding, manpower, general education of the civil service about OR, data

collection, and even the dreaded problem of the abuse of political might would be easier to solve.

Summary of Findings Regarding the Essential Factors:

The analysis of the responses to questions on the situation with regards to nine essential factors which we believed to be of pragmatic significance and pertinence to the introduction of OR into the civil service in Nigeria revealed that:

1. A number of OR projects which could be of significance to government can be identified in nearly all the ministries in the civil service.
2. Ministries can find funds to commission OR investigations into aspects of their work if the officials could be persuaded of the values of such investigations.
3. Except for tactical decisions, the major strategic and policy decisions in the ministries tend to be made at the levels of permanent secretaries and ministers (or commissioners in the States).
4. The supply of trained and experienced OR personnel of high calibre, an essential prerequisite for successful OR, could be a problem during the introduction of OR into the civil service.
5. OR is generally new to the civil service. A problem of ignorance regarding OR exists in the government about which something must be done in order to expedite the process of getting OR started in the government.
6. It is essential for government to develop scientifically based indigenous problem solving capabilities within the civil service in order for it

to be able to effectively and efficiently tackle the major strategic and policy problems confronting the nation. One believes that the introduction of OR is a solution to this problem.

7. Computers were not commonly available in the civil service, only in the Federal Office of Statistics was there a computer in the Federal government; in the States there were no computers in the government.
8. On the mode for the introduction of OR into the government, civil servants generally preferred OR groups lodged within individual ministries in the government.
9. Civil servants were generally enthusiastic about the introduction of OR into the government, although it was largely feared that funding, manpower, opposition from conservative officers, and the abuse of political power could pose serious threats to the use of scientific method in the government. There was also widespread recognition that government needs to be more fully educated about OR.

to be able to effectively and efficiently tackle the major strategic and policy problems confronting the nation. One believes that the introduction of OR is a solution to this problem.

7. Computers were not commonly available in the civil service, only in the Federal Office of Statistics was there a computer in the Federal government; in the States there were no computers in the government.
8. On the mode for the introduction of OR into the government, civil servants generally preferred OR groups lodged within individual ministries in the government.
9. Civil servants were generally enthusiastic about the introduction of OR into the government, although it was largely feared that funding, manpower, opposition from conservative officers, and the abuse of political power could pose serious threats to the use of scientific method in the government. There was also widespread recognition that government needs to be more fully educated about OR.

CHAPTER SEVEN  
THE POTENTIAL SUPPLY

The Background:

Even though no attempts were made in this research to determine and assign weights of statistical as well as pragmatic significance to any of the factors which are generally believed to be pragmatically significant to the introduction of OR into an organisation, it is certain that some factors are more relevant than others. One such factor which we could not resist paying particular attention to was the question of staffing - the selection of scientists for OR training, or for OR work in the civil service.

As recommended by the Operational Research Society, United Kingdom (1968) to the Fulton Committee on the Civil Service, the selection of the right calibre of scientists is essential to the success of OR in the civil service. The Society recommended:

"Operational research needs to be done well or not at all, and it is correspondingly important to recruit staff of the right calibre."

It's almost well known that the typical civil service when confronted with a problem such as finding staff for a new activity in the service employs criteria which may not necessarily be the most efficient and most effective in selecting personnel for the activity. For example, a typical criterion for selecting staff for training for a new activity is length of service; another is the sheer wish of a particularly favoured staff to transfer to the new service, in which case a frustrated staff or worse still an inefficient and ineffective staff may see the creation of the new activity as an avenue for escape.

The problem of staffing becomes more complicated when one is thinking about an activity such as Operational Research about which little is yet known in the civil service in Nigeria. OR is a scientific activity, traditionally it is more successfully undertaken by scientists working in the company of professionals from other non scientific disciplines.

Finding staff for such activity from within a civil service where there already existed a core of scientists such as is the case in most industrialised countries may not pose serious problems. But in a civil service such as in Nigeria where scientists are located in some highly specialised sections of particular ministries, (unless of course one adopts the wider definition of the civil service such as provided in the 1970 Constitution for example), finding staff of the right calibre from within the service could present serious problems, particularly because the success of OR in the civil service depends to a reasonable degree on the staff charged with the practice of OR in the civil service.

Even if one takes a wider view, that is to say scientists would be recruited from the general adult population of Nigeria the problem would not be resolved, for as Streat (1950) questioned, every good scientist may not succeed as an OR practitioner. Streat asked:

"Is any good scientist qualified to succeed in operational research or does it call for qualities other than pure scientific attainments? If so, what qualities?" (p.133)

Confronted with this problem, a number of questions arose in our minds: Are OR scientists a distinct group of professionals? If so, what characteristics most significantly delineates them? How can such characteristics be scientifically measured? How does one distinguish a potential OR scientist from the average adult, and more importantly,

from any other scientist? These and other related questions drove us into isolating the problem of the potential supply of OR scientists for rigorous investigations in the interest of the successful introduction of OR into the civil service and public corporations.

Our first inclination was to turn to advertisements for OR personnel in order to find out the factors which were perceived as the most significantly distinguishable characteristics of OR scientists by employers of OR scientists. What light we got from the advertisements and what followed on from there are the subjects discussed in the following sections of this chapter.

#### SELECTION OF OR SCIENTISTS

A study of advertisements for OR scientists shows that they are often couched in such broad generalities that they are of little use in evaluating candidates for OR appointments. A careful study of one hundred and forty advertisements for OR scientists put out by a number of employers over a period of twenty-eight months indicated that employers were basically interested in five principal requirements when identical phrases were grouped together. These were:

- (i) A good first degree in a numerate discipline. This was demanded in approximately seventy-three percent of the advertisements.
- (ii) Formal qualifications in Operational Research, or Management Science. Approximately forty-three percent of the advertisements contained this demand.
- (iii) Well developed communications and interpersonal skills. In approximately forty-one percent of the advertisements this was demanded.

(iv) Ability to apply creative, critical and practical approach to problem solving. This was a condition for appointment in approximately thirty-four percent of the advertisements.

(v) At least one year experience in OR/MS. This demand was contained in approximately seventy-seven percent of the advertisements.

These requirements failed to specify the particular ways in which the prospective OR scientist could be distinguished from the general adult population, members of other scientific disciplines, and members of other professional groups. As guidelines they do not increase one's power to select Operational Research Scientists in the most effective and most efficient manner.

In fact the advertisements leave one with the impression that recruitment officers are unsure of the characteristics which are really responsible for success in OR. Hence young OR scientists are allowed to experiment for about a year or more wherever they can be initially accepted after which the recruitment officer can then use their performance over that period to test for their suitability or otherwise for the particular appointment (a case of risk aversion? See (v) above).

The other factor which is highly emphasised in selection procedures is numerate ability or general intelligence (see (i) above). This is rather unfortunate because it does not tell us much since most people who go into OR are relatively intelligent anyway. Furthermore as Blum and Naylor (1968) pointed out, it is generally recognised that most people fail in their job not because they are technically incompetent but because they may not possess the right personality for the job. Blum and Naylor declared:

"...it has been unequivocally determined that in many occupations the people with the highest scores on an intelligence test are not necessarily the most successful employees..." (p.101)

Gaudet and Carli (1957) who administered questionnaires on a number of top executives in order to gather data on executives whom the top executives had fired estimated that four out of five executives fail due to personality problems ("personality lacks") than for lack of technical competence ("knowledge lacks").

Blackett (1950) expressing a view on the most important qualification required in an OR worker listed among other things the ability to take a broad view of a problem, some knowledge of statistical methods, a high degree of general intelligence, and enthusiasm. But concluded

"...above all, the right personality is vital..."  
(p.15).

Similarly Tippett (1950) expressing an opinion in response to a question on what training an OR person should receive suggested technological training with elements of statistics and scientific method, but remarked in closing

"...the chief requirement being the mental outlook - the personal qualities - which will count for more than half of his qualifications" (p.79)

That a successful OR worker requires something more than his pure scientific training has long been the subject of speculation. The point made by Streat (1950) in this respect is worth underscoring:

"Is any good scientist qualified to succeed in operational research or does it call for qualities other than pure scientific attainments? If so, what sort of qualities? Is there anything essential to true operational research in the

partnership of different sciences? Those questions were prompted by my own strong feeling that there was something more than pure scientific qualifications in the men who had most succeeded in contributing to efficiency by operational research." (p.133)

Although it is generally recognised that a right personality is essential to the successful practice of OR, the personality profile of OR workers has never been scientifically determined. We believe that for the job of introducing OR into the developing countries to be properly done, it is important and necessary that only the right calibre of people should be enlisted.

The foregoing paragraphs highlighted the need for a scientific way of meeting the demand and supply of OR scientists, particularly in the process of the introduction of OR into the developing countries. There is clearly a need for a better understanding of the qualities which distinguish the OR scientist from other members of the scientific community, other professional groups, and in particular from the general adult population. One needs to be able to describe in more precise terms the calibre of people in OR and those with the highest probability of succeeding in OR in relation to the average adult, and members of other occupations.

To assist in this process we propose, using an instrument which is based on scientific foundation and one which is widely used world-wide for personality studies, to construct a personality profile of OR scientists and, to suggest how this additional information might be used to enhance the effective and efficient selection of persons for OR work. In order to do this, the Sixteen Personality Factor Questionnaire (16PF), a psychometric instrument for measuring the sixteen primary source traits which the instrument designer believes to be the underlying structures of personality was employed to study the traits which most significantly

distinguish OR scientists from the general adult population. (See ~~Ca~~cell, Eber and Tatsouka, 1970).

Before proceeding to the construction of the 16PF profile, a brief discussion about personality and personality assessment in general would be in order.

#### DEFINITION OF PERSONALITY:

There is no universally agreed definition of personality among personality scientists. Sarason (1966) pointed out that

"the existing definitions of personality could fill a volume" (p.13)

Often personality is defined in terms of the problems being studied.

Hall and Lindzey (1957) reviewed personality theories and concluded

"...no substantive definition of personality can be applied with any generality" (p.9)

Similarly, Pervin (1980) concluded his review of personality theories by observing that

"there is no one right or wrong definition of personality" (p.5).

Webster Universal Dictionary defined personality as:

"Sum of mental and moral qualities which make up the distinctive character of an individual; characteristic combination of such qualities found in a single individual".

Allport (1961) declared that

"personality is the dynamic organisation within the individual of those psychophysical systems that determine his characteristic behaviour and thought" (p.28).

Hilgard (1962) said:

"...the term personality is used to mean the configuration of individual characteristics and ways of behaving which determines an individual's unique adjustments to his environment. We stress particularly those personal traits that affect the individual's getting along with other people and with himself. Hence personality includes any characteristics that are important in the individual's personal adjustment, in his maintenance of self-respect." (p.447).

For McClelland (1951) personality is

"the most adequate conceptualization of a person's behaviour in all its detail that a scientist can give at a moment in time" (p.69).

Guilford (1959) defined personality as a person's "unique pattern of traits" and he defined a trait as

"any relatively enduring way in which a person differs from others" (p.5,6).

For Eysenck (1953)

"personality is the more or less stable and enduring organisation of a person's character, temperament, intellect and physique which determines his unique adjustment to the environment" (p.2).

Sarason (1966) simply took a philosophical view of personality. He declared:

"We shall consider personality as an area of investigation rather than as an entity, real or hypothetical." (p.15)

Castell (1950) declared:

"Personality is that which permits a prediction of what a person will do in a given situation" (p.2-3).

Pervin (1980) said

"personality represents those characteristics of the person or of people generally that account for consistent patterns of response to situations" (p.6)

#### ASSESSMENT TECHNIQUES:

A number of techniques exist for the assessment of personality. The assessment devices are often related to the particular theory and definition of personality adduced by the designers. Hence Hall and Lindzey (1957) were able to say

"we submit that personality is defined by the particular empirical concepts which are a part of the theory of personality employed by the observer" (p.9)

And Pervin (1980) wrote:

"a definition of personality reflects the kinds of problems to be studied and reflects the methods to be used in studying these problems" (p.5)

A large number of test devices for the assessment of personality are regularly reviewed in Buros' Mental Measurement Yearbooks. Most of the instruments are used for psychopathology and with normal (non-psychiatrically disturbed) subjects. Some instruments such as the Minnesota Multiphasic Personality Inventory (MMPI) were primarily intended for the assessment of psychopathology. Some instruments such as the Sixteen Personality Factor Questionnaire (16PF) are based on quantitative techniques, in particular multivariate factor analysis. In general there is some correlation in the scores measured by the various personality assessment devices available to test users.

The following tests are among the most widely used instruments in personality assessment. Indicated in parentheses are the number of scores measured by the particular instrument. The Minnesota Multiphasic Personality Inventory (14 scores), the California Personality Inventory (18 scores), Edwards Personal Preference Schedule (15 scores), Guilford-Zimmerman Temperament Survey (10 scores), Gordon Personal Profile and Gordon Personal Inventory (4 scores each) and, the Sixteen Personality

Factor Questionnaire (22 scores, 16 primary and 6 secondary), (Buros 1978).

As mentioned earlier, the problems investigated by a personality scientist and the instrument he designs for the assessment of personality are a reflection of his definition of personality. For our purpose, Cattell's definition: "personality is that which permits a prediction of what a person will do in a given situation", the problems he investigated - the discovery of "the number and nature of a minimally sufficient set of factors from which essentially all of human behavior may be predicted" (Walsh 1978, p.1081), his emphasis on the "whole person" and, the methodology employed seemed to have more relevance than most other approaches to personality assessment. Hence in our study of the traits which account for success in OR, the Sixteen Personality Factor Questionnaire was used.

#### THE SIXTEEN PERSONALITY FACTOR QUESTIONNAIRE (16PF):

The Sixteen Personality Factor Questionnaire (16 PF) is a psychometric instrument designed by Cattell for measuring the sixteen primary source traits which Cattell has determined scientifically as being the underlying structures of personality. (More primary source traits have now been recognised by Cattell, Cattell and Delhees, 1973). The 16PF questionnaire covers a large dimension of personality as Adcock (1965) acknowledged in his review of the instrument:

"No other test covers such a wide range of personality dimensions and never before have the dimensions been so meticulously determined" (p.197).

The comprehensiveness of Cattell's research was also underscored by Pervin (1980):

"The research has touched on every one of the dimensions we have outlined as relevant to personality theory - structure, process, growth and development, psychopathology, and change" (p.269).

Bolton (1978) concluded his review of the Sixteen Personality Factor Questionnaire by noting that:

"No other personality measuring instrument has a more substantial scientific foundation. Nor has any instrument undergone a more thorough examination by critics." (p.1030).

A large number of reviews of the 16PF have been undertaken since its introduction in 1949. While some recommend the instrument others do not, for example, Walsh (1978) at the end of his review of the 16PF came to the following conclusion:

"It is impossible to recommend the 16PF in an unqualified manner for any use, from the most basic research to the most pragmatically oriented applications." (p.1033).

In spite of disagreements among reviewers, the 16PF is one of the most widely used instruments for personality assessment. It has been used in large cultural studies, the reliability and validity of the test is well documented, profiles of samples from a wide variety of occupational, clinical and cultural populations are available. (Cattell, Eber and Tatsuoka 1970, Karson and O'Dell 1976, Krug 1951). Buros (1978) recorded 1515 citations, applications and reviews of the 16PF. The 16PF was one of the battery of tests administered by Belbin (1981) in his study of personality mix essential for successful management teams.

The primary source traits measured by the 16PF questionnaire are listed in terse forms in Table 7.1. The special names given to the traits by Cattell are shown in parentheses.

The Cross-Cultural Validity of 16PF Tests And the Universality of the Personality Traits:

The influence of culture and national differences on attitudes, values, and personality is well known and generally recognised in particular by industrial and personality psychologists and by management scientists. For example significant differences in attitudes have been shown to exist among managers from different cultural backgrounds and in different countries. (Weinshall 1977, Hofstede 1980).

In the realm of the Sixteen Personality Factors which are measured by the 16PF Questionnaire, significant and systematic differences have been shown to exist among different sex groups (Cattell 1948), social groups (Cattell 1957), national groups (Jalota 1957), national sub-cultural groups (Meredith 1935, Meredith and Meredith 1966), persons with different value and belief systems (Morris 1956, Butt 1966), and among different age groups (Sealy and Cattell 1966). As an instrument for the assessment of personality the 16PF is highly sensitive to cultural and national differences as pointed out by Cattell et al (1970).

But as an instrument which is based on scientific foundations, the 16PF "have substantial scientific universality" as argued by Cattell et al (1970, p.14). The 16PF has been demonstrated to measure essentially the same personality traits in the cultures where it has been tested. As argued by Cattell et al (1970), a number of factors have been "demonstrated to retain their conceptual validities as unitary source traits in other cultures" (p.14). In essence, the basic underlying structures of personality which are measured by the 16PF can be identified and measured in persons from all cultures but items which measure particular personality factors need to be carefully determined in each culture.

For example, in most cultures into which the 16PF have been translated,

the personality trait B - intelligence - could not be accurately measured because translators have had difficulties in effectively translating the relevant items into their particular languages. (Cattell et al 1970). Nevertheless, standardisations (or Norms) of the 16PF are now available in a number of different countries. For example, the 16PF is now in use in India, Finland, Brazil, France and Czechoslovakia. (See Cattell et al 1970 for details)

In the particular case of Nigeria, it is known that a number of senior Nigerian civil servants and others who have attended the Henley Management College in the last couple of years have taken the 16PF test. Discussions with staff at the College suggest that no apparent significant differences have been observed in the scores by these Nigerians compared with persons from other countries.

In general, for practical purposes, it is the recommendations of the test designer (Cattell et al 1970), that before using the 16PF for serious work among persons of different cultures and nationality it is advisable to construct specific standardisations (or Norms) which are based on the particular population. Where the questionnaires have been translated into another language or where new items have been adopted, it is strongly recommended that factor checks should be carried out before the instrument comes into use. Besides this necessary precautions, the cross-cultural validity of the 16PF Test and the universality of the personality traits measured by the test is well documented. (Cattell et al 1970).

**Criticisms of Psychometric Instruments:**

Like all measuring instruments, psychometric instruments in general and in particular the 16PF has its short comings. A common criticism of questionnaires generally is that they are susceptible to distortion and deliberate faking. The particular criticism of the 16PF is that the instrument is based on the mathematical techniques of multivariate factor analysis which some argue is a method of data reduction but which Cattell holds to as being able to reveal the basic dimensions or underlying structures of personality. (Overall 1964, Mischel 1968). Some psychologists have queried the mathematical complexity of the method. (Holtzman 1962, Luborsky 1953) and some others have quibbled about their inability to replicate Cattell's trait factors. (Eysenck 1977, Guilford 1975, Howarth 1972).

Table 7.1 The primary source traits covered by the Sixteen Personality Factor Questionnaire.

Low Sten Score (Sten of 1, 2, 3)	High Sten Score (Sten of 8, 9, 10)
Reserved, detached, aloof, stiff (Sizothymia)	- A - Outgoing, warmhearted, easygoing, participating (Affectothymia).
Dull, low intelligence (Lower scholastic mental capacity)	- B - Bright, high intelligence (Higher scholastic mental capacity)
Affected by feelings, emotionally less stable, easily upset, changeable (Lower ego strength)	- C - Emotionally stable, mature, faces reality, calm (High ego strength)
Humble, mild, easily led, docile, accommodating (Submissiveness)	- E - Assertive, aggressive, competitive, stubborn (Dominance)
Sober, taciturn, serious (Desurgency)	- F - Happy-go-lucky, enthusiastic (Surgency)
Expedient, disregards rules (Weaker superego strength)	- G - Conscientious, persistent, moralistic, staid (Stronger superego strength)

Table 7.1 (continued)

Shy, timid, threat-sensitive (Threctia)	- H - Venturesome, uninhibited, socially bold (Parmia)
Tough-minded, self-reliant, realistic (Harria)	- I - Tender-minded, sensitive, clinging, overprotected (Premsia)
Trusting, accepting conditions (Alaxia)	- L - Suspicious, hard to fool (Protension)
Practical, "down-to-earth" concerns (Praxernia)	- M - Imaginative, bohemian, absent- minded (Autia)
Forthright, Unpretentious, genuine but socially clumsy (Artlessness)	- N - Astute, polished, socially aware (Shrewdness)
Self-assured, placid, secure, complacent, serene (Untroubled adequacy)	- O - Apprehensive, self-reproaching, insecure, worrying, troubled (Guilt proneness)
Conservative, respecting traditional ideas (Conservativism of temperament)	- Q <sub>1</sub> - Experimenting, liberal, free-thinking (Radicalism)
Group dependent, a "joiner" and sound follower (Group adherence)	- Q <sub>2</sub> - Self-sufficient, resourceful, prefers own decisions. (Self-sufficiency)
Undisciplined self-conflict, lax, follows own urges, careless of social rules (Low self-sentiment integration)	- Q <sub>3</sub> - Controlled, exacting will power, socially precise, compulsive, following self- image (High strength of self- sentiment)
Relaxed, tranquil, torpid, unfrustrated, composed (Low ergic tension)	- Q <sub>4</sub> - Tense, frustrated, driven, overwrought (High ergic tension)

## THE SIXTEEN PERSONALITY FACTOR QUESTIONNAIRE PROFILE OF BRITISH OR SCIENTISTS:

In order to prepare the author for this phase of the research he was given an intensive training in the general administration and interpretation of psychology tests. This was necessary in order to ensure that the tests were properly administered to the respondents and that the construction and interpretation of the profile were carefully done.

### The Tests Administered:

In constructing the 16PF personality profile of British OR scientist, Form A and Form B of the questionnaires were administered to all the respondents. This is in line with the test designers recommendation that:

"in research situations and in all cases where maximum precision is needed, it is suggested that, wherever possible, at least two forms be used (e.g. A + B or C + D)". (Cattell, Eber and Tatsouka 1970, p.9).

Form A and Form B were particularly advocated for use with elite respondents such as OR scientists.

### Participation:

The questionnaires (Form A and Form B) were administered to fifty-six OR scientists in the U.K.<sup>1</sup> The respondents were OR scientists who voluntarily offered to take the tests following appeal for volunteers to participate in the study. The appeal was made through regional OR Groups, large OR Groups, a regional OR conference, a national OR Conference and, an international OR Conference. (See Appendix III for the letters used in the appeal to enlist respondents).

1. An attempt to internationalise the study did not materialise because Form As which were administered to five respondents at an international conference in Vienna, Austria could not be used for reasons stated in the text.

The sample consisted of fifty male OR scientists and six female OR scientists with an age mean and standard deviation of 35.82 and 11.12. It included academics as well as practitioners, the mean and standard deviation of the number of years spent in OR are 8.55 and 6.35. The sample included one-man-band OR scientists as well as OR scientists having responsibility over large numbers of staff. The mean and standard deviation of the number of staff reporting to the respondents are 7.23 and 19.05. (See Table 7.2a and 7.2b for summary of participation).

Table 7.2a Participation in the study of the 16PF profile of British OR Scientists: number of usable response.

	Male	Female
Number of respondents who completed Form A and Form B	50	6
Number of respondents who completed Form A only	5	-
Total Useable Response	50	6

Table 7.2b Participation in the study of the 16PF profile of British OR Scientists: Age, experience and responsibility of respondents.

	Mean	Standard Deviation
Age of respondents	35.82	11.12
Number of years in OR	8.55	6.35
Number of staff reporting to respondent	7.23	19.05

**Scoring:**

The test results were manually scored using the scoring stencils provided for that purpose. In order to evaluate and interpret the "raw scores", they have to be converted to "Standard ten (Sten) Units" using an appropriate norm.

Since the tests were conducted in the U.K., the norm used in converting the raw scores to Sten units was the "British General Population Male + Female: Form A + Form B." (Saville 1972).

Figure 7.1 is a plot showing the 16PF test profile of OR scientists based on the norms for the British general adult population. Shown alongside the plot are the mean scores and standard deviations in sten units.

#### Significant Personality Differences Between the British General Adult Population and OR Scientists:

In order to identify the personality factors which distinguishes OR scientists from the general adult population, the raw score means and standard deviations of OR scientists were compared with the raw score means and standard deviations of the general population in a two-tailed Student's t-test. (See Table 7.3).

The test results showed that in relation to the British general adult population, OR scientists are distinguishable at the five percent level of significance or above on nine of the sixteen personality factors. OR scientists tended to possess more intelligence (B,  $p < 0.001$ ), emotional stability (C,  $p < 0.001$ ), and dominance (E,  $p < 0.001$ ), show less conformity (G,  $p < 0.001$ ), and sensitivity (I,  $p < 0.002$ ), possess more imagination (M,  $p < 0.001$ ), show less shrewdness (N,  $p < 0.001$ ) and insecurity (O,  $p < 0.001$ ) and possess more radicalism ( $Q_1$ ,  $p < 0.001$ ), tend to be less tense ( $Q_4$ ,  $p < 0.02$ ).



Table 7.3 Significant Personality Differences Between OR Scientists and the British General Adult Population. Scores are in "Raw Units"

	A	B	C	E	F	G	H	I	L	M
OPERATIONAL RESEARCH SCIENTISTS	Mean 18.77	20.91	32.68	28.11	27.64	21.30	26.41	18.59	17.20	29.61
	S.D. 5.54	2.12	6.44	6.49	9.57	6.27	11.04	6.34	6.03	5.77
BRITISH GENERAL ADULT POPULATION	Mean 19.64	14.41	29.43	22.05	26.34	24.71	25.36	21.32	16.80	22.36
	S.D. 5.83	3.47	6.97	7.60	8.92	5.69	10.50	6.38	5.03	5.81
MEAN DIFFERENCES (Positive if OR higher)	-0.87	6.50	3.25	6.06	1.30	-3.41	1.05	-2.73	0.40	7.25
T VALUE	1.10	13.94	3.45	5.91	1.07	4.41	0.74	3.16	0.58	9.21
SIGNIFICANCE OF DIFFERENCE,	NS <sup>1</sup>	** <.001	+ <.001	+ <.001	NS	* <.001	NS	<.002	NS	+ <.001
	N	D	Q <sub>1</sub>	Q <sub>2</sub>	Q <sub>3</sub>	Q <sub>4</sub>	AGE	SEX	N	
OPERATIONAL RESEARCH SCIENTISTS	19.29	16.93	24.23	19.68	23.19	23.39	35.8	M + F	56	
	4.22	7.00	4.01	5.67	7.24	9.11	11.1			
BRITISH GENERAL ADULT POPULATION	21.65	22.53	17.68	20.05	24.00	26.28	38.2	M + F	2012	
	4.80	8.20	4.98	5.69	5.93	9.04	15.8			
MEAN DIFFERENCES (Positive if OR higher)	-2.36	-5.60	6.55	-0.37	-0.81	-2.89	-2.4			
T VALUE	3.64	5.06	9.75	0.48	0.88	2.36	1.57			
SIGNIFICANCE OF DIFFERENCES,	<.001	<.01	<.001	NS	NS	ζ.02	NS			

\* + means OR scientists scored HIGHER, - means OR scientists scored LOWER, 1 NS means Not Significant.

#### 16PF TEST PROFILE AS A PREDICTOR:

A primary objective of the personality study was the desire to provide a more satisfactory instrument which is based on scientific method and which can be used in the selection of OR scientists. With this perspective in view we now discuss how the 16PF, an instrument based on scientific foundation can assist in the selection of OR scientists.

An important and basic assumption in profile-matching for determining an individual's suitability to enter a particular occupation is that the mean profile of people who have stayed long in the particular occupation and who are generally believed to be satisfying the demands of that occupation and who are also believed to have adjusted to the particular demands of that occupation represent in a sense an "ideal" pattern for selecting new entrants into that particular occupation. (Cattell, Eber and Tatsuoka 1970). That is not to say of course, that the people presently engaged in the particular occupation whose mean profile is used as a guide present the best profile for effectiveness in the particular occupation. The profile is in error, only to the extent that the biases and prejudices, and limitations of the prevailing methods of recruitment into the particular occupation failed to attract "better" individuals into that occupation.

There are basically two major approaches to profile-matching (Cattell, Eber and Tatsuoka 1970).

- (1) Type Placement Method. Under this method, which is based on discriminant techniques, the profile of the prospective entrant to the particular occupation is matched on the sixteen personality factors to test for the entrants "belongingness" to, or "adjustment" in the particular occupation; in other words, is the candidate a "member" of that group?

(ii) The Effectiveness Method. In this method, which is based on linear (or multiple) regression techniques, the sten scores of the candidate on the sixteen personality factors are multiplied by appropriate loadings or weights on each of the sixteen personality factors in order to test for the probability of success in the particular occupation.

In the following sections, Type Placement Method is used to describe an approach to profile comparison. By comparing an individual's 16PF profile with that of the "standard", the individual's belongingness or otherwise to the group can be tested objectively. This comparison can be done using coefficient of pattern similarity,  $r_p$  (Cattell 1949). Pattern analysis is a complicated problem in profile comparison and there are a number of methods suggested for tackling the problem (Guion 1965). Mosel and Roberts (1954) after comparing several methods concluded that

"Cattell's (1949) coefficient of pattern similarity,  $r_p$ , agreed best with commonsense judgements" (Guion 1965, p.175).

This method of profile comparison would be discussed in the following sections.

Another method of comparing 16PF profiles is that presented by Krug (1981). In Krug's approach, the second-order scores derived from the 16PF primary scores are calculated on the four factors: extraversion, anxiety, tough poise, and independence. The scores on these four second-order factors are then converted into a four-digit pattern code using some rules which are provided. The pattern code is then compared with a corresponding one from among the 81 patterns provided by Krug in order to get the interpretation of the particular profile.

According to Krug, the set of 81 pattern codes provided

"represents a reasonably exhaustive sample of most variations in 16PF profiles one is likely to encounter in practice." (p.22).

Since the 16PF profile of OR scientists is not among the occupational profiles provided in Krug the method is not directly relevant to the purposes of this research. We shall now discuss profile comparison based on Type Placement Method using pattern similarity coefficient,  $r_p$ .

#### Comparison of 16PF Profiles:

Pattern similarity coefficient  $r_p$ , presents mathematico-statistical properties useful for grouping people into types, and for making a number of comparisons of personality profiles such as individual-to-individual comparison, individual-to-group comparison, and group-to-group comparison. (Cattell 1949, Horn 1961, Cattell and Couter 1966).

As Cattell et al (1970) pointed out:

"...for many situations, the pattern similarity coefficient is the best thing available; for, in general, a person can be considered well adjusted to a job in proportion to his resemblance to those in it" (p.144)

#### Individual-to-Group Comparison of 16PF Profile:

Pattern similarity coefficient  $r_p$ , is perhaps the most widely used technique in adjustment placement of candidates into occupations. It allows the personality profile of the individual to be compared with the mean profile of the occupation.

By computing the individual's pattern similarity coefficient, tests can be conducted to determine how significantly the individual's profile resembles that of the group. An important advantage of this approach is that it tests for the adjustment of the "whole" person rather than for

his similarity on a few factors of personality.

The pattern similarity coefficient is calculated in an individual-to-group comparison by using the formula (Cattell et al 1970, p.141):

$$r_p = \frac{(4K + \sum D^2) - \sum d^2}{(4K + \sum D^2) + \sum d^2}$$

where:

d = difference in sten score on each factor between the individual's score and the group mean,

D = difference between the group mean sten score on each factor and the general population mean, 5.5,

K = Median of the chi-squared distribution with degrees of freedom equal to the number of personality factors measured (sixteen in the 16PF)

The pattern similarity coefficient  $r_p$ , takes values varying from +1 to -1 with "0" indicating no resemblance. The significance of  $r_p$  can be evaluated using Horn's table (Horn 1961).

In interpreting  $r_p$  values, it should be understood that the higher the value, the stronger the resemblance.

Group-to-Group Comparison of 16PF Profile:

Later on in this chapter, the profiles of five occupations which have some affinity with DR would be compared on a factor by factor basis using Student's t-test. As useful as such a comparison is, it has the disadvantage that it tends to portray a "mechanistic" picture of the occupation's profile in that it emphasises similarities and differences on

particular factors rather than on the occupation's profile as a whole unit. An interesting comparison is the group-to-group comparison. In this case the occupation's profile is treated as a homogeneous group, that is, the mean profile can be thought of as the profile of an "ideal" person representing the particular occupation.

In a group-to-group comparison,  $r_p$  is calculated using the formula (Cattell et al 1970, p.311):

$$r_p = \frac{4K - \sum W_j d_j^2}{4K + \sum W_j d_j^2}$$

where:

K = median of the chi-squared distribution with degrees of freedom equal to the number of factors measured (sixteen in the 16PF)

$W_j$  = Weight or loading on personality factor j. given in Table 7.4

$d_j$  = difference in factor j between the mean profiles of the occupations.

Based on this formula the following  $r_p$  values were computed in the comparison of the profiles of the five occupations each with the profile of OR scientists.

(i) OR Scientists Versus Accountants (England and Scotland)

$$r_p = -0.055 \text{ (NS)}^1$$

(ii) OR Scientists Versus Business Executives

$$r_p = -0.114 \text{ (NS)}$$

(iii) OR Scientists Versus Research Scientists

$$r_p = -0.024 \text{ (NS)}$$

1. NS means Not Significantly related using Horn's table as in Cattell et al (1970).

(iv) OR Scientists Versus Sales Managers

$$r_p = -0.038 \text{ (NS)}$$

(v) OR Scientists Versus Social Workers

$$r_p = -0.049 \text{ (NS)}$$

These results show that even at the ten percent level on Horns table, the profession or occupation of Operational Research bears no significant resemblance to any of these five occupations. In other words, OR is clearly on the basis of the 16PF test profile a distinct and homogeneous psychologically selected group. (See t-test results of profile comparisons later).

Male Versus Female OR Scientists: 16PF Profile Comparison:

Although the data available on female OR scientists is small in number, since the population of female OR scientists is generally small, we wish to make use of the data available to us if only to encourage further research in the area.

The pattern similarity coefficient  $r_p$ , computed for the female members of the OR profession suggests that as a group the females significantly resemble the males at beyond the five percent level of significance on Horn's table of significance.<sup>1</sup>

Male OR Scientists Versus Female OR Scientists

$$r_p = 0.345 \text{ (} p < 0.05 \text{)}$$

1. This is good, for example the resemblance between female Employment Counsellors and male Employment Counsellors is significant at only about ten percent,  $r_p = 0.24$ . (Cattell et al 1970 p.312).

Table 7.4 Weights for use in making comparisons among occupational groups.

PRIMARY SOURCE TRAIT	
	A B C E F G H I L M N O Q <sub>1</sub> Q <sub>2</sub> Q <sub>3</sub> Q <sub>4</sub>
W	1 2 1 1 1 2 2 1 3 4 1 1 2 2 4 3

Sources: Cattell et al (1970) p.312.

ASSESSMENT OF PERSONS FOR OR WORK BASED ON THEIR 16PF PROFILES:

By using discriminant analysis (as in Type Placement Method) and linear (or multiple) regression techniques (as in the Effectiveness Method) and by combining the discriminant function with the linear regression model, the sixteen personality factor test profile of a prospective OR scientist can be used to assess respectively:

- (i) The probability of the candidate's membership or belongingness to the community of OR scientists,
- (ii) The probability of the candidate's effectiveness or success as an OR scientist and,
- (iii) The joint probability of membership and effectiveness in Operational Research.

Obtaining the data, -criteria of effectiveness or success in OR-, necessary for calculating the factor weights or loadings for the linear (or multiple) regression model, and for constructing the effectiveness specification equations is a matter for further research. When the data becomes available the models proposed by Cattell et al (1970) and Rulon et al 1967, can be used to build a particular model for making these predictions in respect of candidates entering the OR profession.

For the purposes of selecting OR scientists which is the main thrust of this study, the pattern similarity coefficient  $r_p$ , computed using the individual-to-group comparison equation is useful, as an aid to decision making, and to guide in the selection of a candidate for OR work taking into consideration all relevant variables in the selection process.

In order to do this, the pattern similarity coefficient  $r_p$ , of the prospective candidate should be computed so as to test the degree to which the candidate's 16PF test profile significantly bears resemblance to that of OR scientists. We believe that this additional information is critical and essential to the effective and efficient selection of OR scientists.

#### 16PF PROFILE OF BRITISH OR SCIENTISTS BASED ON AMERICAN GENERAL POPULATION:

A large number of 16PF profiles are published in the "Handbook for the 16PF" (Cattell, Eber and Tatsuoka 1970) and in "Interpreting 16PF profile patterns" (Krug 1981). These profiles were based on the American general population norm and on a standard age of thirty years. Since a profile based on a particular norm cannot be meaningfully compared with that which is based on a different norm, a profile of British OR scientists was first constructed based on the American general population as a prelude to comparing the profile with those of some selected occupational groups.

#### 16PF Profile of British OR Scientists Based on American General Population Norm:

In order to compare the 16PF profile of British OR Scientists with the American population, the raw scores of each respondent was age corrected to thirty years before the norms for the American general population was entered into in order to obtain the sten scores. The age correction was effected by applying the quadratic age correction equation and the age

For the purposes of selecting OR scientists which is the main thrust of this study, the pattern similarity coefficient  $r_p$ , computed using the individual-to-group comparison equation is useful, as an aid to decision making, and to guide in the selection of a candidate for OR work taking into consideration all relevant variables in the selection process.

In order to do this, the pattern similarity coefficient  $r_p$ , of the prospective candidate should be computed so as to test the degree to which the candidate's 16PF test profile significantly bears resemblance to that of OR scientists. We believe that this additional information is critical and essential to the effective and efficient selection of OR scientists.

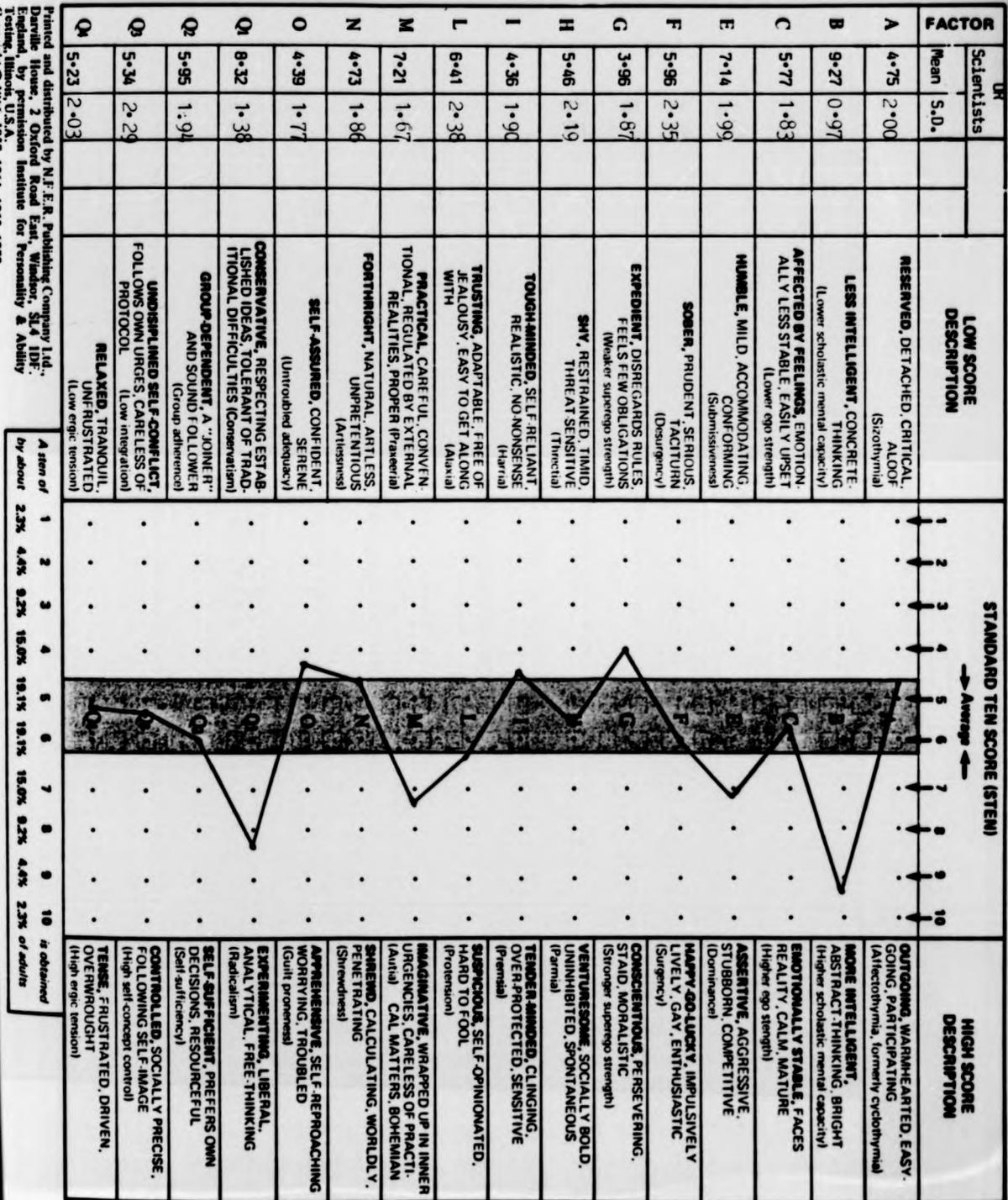
#### 16PF PROFILE OF BRITISH OR SCIENTISTS BASED ON AMERICAN GENERAL POPULATION:

A large number of 16PF profiles are published in the "Handbook for the 16PF" (Cattell, Eber and Tatsuoka 1970) and in "Interpreting 16PF profile patterns" (Krug 1981). These profiles were based on the American general population norm and on a standard age of thirty years. Since a profile based on a particular norm cannot be meaningfully compared with that which is based on a different norm, a profile of British OR scientists was first constructed based on the American general population as a prelude to comparing the profile with those of some selected occupational groups.

#### 16PF Profile of British OR Scientists Based on American General Population Norm:

In order to compare the 16PF profile of British OR Scientists with the American population, the raw scores of each respondent was age corrected to thirty years before the norms for the American general population was entered into in order to obtain the sten scores. The age correction was effected by applying the quadratic age correction equation and the age

Figure 7-2 16PF Test Profile of British OR Scientists.  
(Based on American General Population Norm)



Printed and distributed by N.F.E.R. Publishing Company Ltd.,  
Dunblair House, 2 Oxford Road East, Windsor, SL4 1JF.  
Reprinted by permission Institute for Personality & Ability  
Testing, Illinois, U.S.A.  
Copyright © 1946, 1957, 1961, 1962, 1979.

16 PF TEST PROFILE

correction coefficients (b1, b2) for general adult males and females respectively as recommended in the "Tabular Supplement" (IPAT 1976).

Figure 7.2 is a plot showing the 16PF test Profile of British OR Scientists based on the norm for American general population. Male + Female, Form A + Form B, and based on age thirty years. The mean sten scores and standard deviations for each personality factor is shown alongside the plot.

**Significant Personality Differences between British OR Scientists and the American General Adult Population:**

In order to portray the personality factors on which British OR Scientists are delineated at the five percent level of significance or above from the American population, a two tailed Student's t-test was applied to the raw score means and standard deviations of the two populations (see Table 7.5).

The test results showed that British OR Scientists were distinguishable from the American population on the same factors as with the British population; the exceptions being on the personality factors A, C, L, and Q4; these are the personality factors on which the British OR Scientists were not significantly different from the American population. This result is in line with the main findings of Saville (1972).

Student's T-test comparison between the 16PF test profile of British OR scientists based on the British general population norm and the 16PF test profile based on the American general population norm showed no significant difference on any one of the sixteen personality factors at the five percent level of significance or above.

Table 7-5 Significant Personality Differences Between OR Scientists and the American General Adult Population. Scores in Raw Units.

	A	B	C	E	F	G	H	I	L
OPERATIONAL RESEARCH SCIENTISTS (Age corrected) S.D.	19.52	20.91	33.93	29.30	28.75	21.39	27.95	18.16	16.70
AMERICAN GENERAL ADULT POPULATION	21.62	14.08	32.71	24.05	27.49	26.66	28.00	22.02	14.42
MEAN DIFFERENCES (Positive if OR Higher)	-2.10	6.83	1.22	5.25	1.26	-5.27	-0.05	-3.86	2.28
T VALUE	2.48	13.66	1.06	5.30	1.23	6.78	0.03	4.28	3.07
SIGNIFICANCE OF DIFFERENCE, P	<.02	+* <.001	NS <sup>1</sup>	+ <.001	NS	-* <.001	NS	<.001	+ <.01

	M	N	O	Q <sub>1</sub>	Q <sub>2</sub>	Q <sub>3</sub>	Q <sub>4</sub>	Age	Sex	N
OPERATIONAL RESEARCH SCIENTISTS (Age corrected) S.D.	30.57	18.77	14.93	24.23	19.68	23.55	21.79	30	M + F	56
AMERICAN GENERAL ADULT POPULATION	25.20	20.60	20.39	17.22	18.35	24.09	23.29	30	M + F	1710
MEAN DIFFERENCES (Positive if OR Higher)	5.37	-1.83	-5.46	7.01	1.33	-0.54	-1.50			
T VALUE	5.99	2.98	4.54	10.30	1.66	0.63	1.15			
SIGNIFICANCE OF DIFFERENCE, P	+ <.001	<.01	<.001	+ <.001	NS	NS	NS			

\* + means OR Scientists scored HIGHER, - means OR Scientists scored LOWER, 1 NS Means Not Significant.

COMPARISON OF 16PF PROFILE OF BRITISH OR SCIENTISTS WITH FIVE OTHER OCCUPATIONS:

In order to establish the distinction in personality profile between OR scientists and occupations with whom OR has some affinity, the 16PF test profile of OR scientists is compared on a two-tailed Student's t-test with the 16PF test profile of five occupations chosen from among the scientific professions, the decision making professions, and the problem solving professions.

Table 7.6 shows the full details of the two-tailed t-test comparisons of the personality profiles. The occupations are listed in alphabetical order and not in order of the professional groups referred to in the foregoing paragraph.

Figures 7.3 to 7.7 show plots of the profiles of the occupations individually superimposed in broken line upon the profile of OR scientists which is in unbroken line. The means and standard deviations in sten units are shown alongside the plots in each case.

Since the objective of the personality study is to suggest a more efficient and a more effective way of selecting scientists for the introduction of OR into the developing countries in particular and into the OR profession in general, our primary interest in comparing the profiles of the occupations is to unravel what clearly delineates the groups. Of particular interest also are the similarities between the profiles. In the discussions which follow however, emphasis would be placed on what significantly distinguishes the occupations.

The grouping of the occupations is as follows:

- (i) Scientific Professions
  - (a) Research Scientists
- (ii) Decision-making professions
  - (a) Business Executives
  - (b) Sales Managers
- (iii) Problem Solving Professions
  - (a) Accountants (England and Scotland)
  - (b) Social Workers

The personality profiles compared in this discussion are those of the male members of the occupations only. For this reason the norm applied in constructing the 16PF profile of OR scientists for the purpose of this comparison is the American general population male, Form A + Form B.

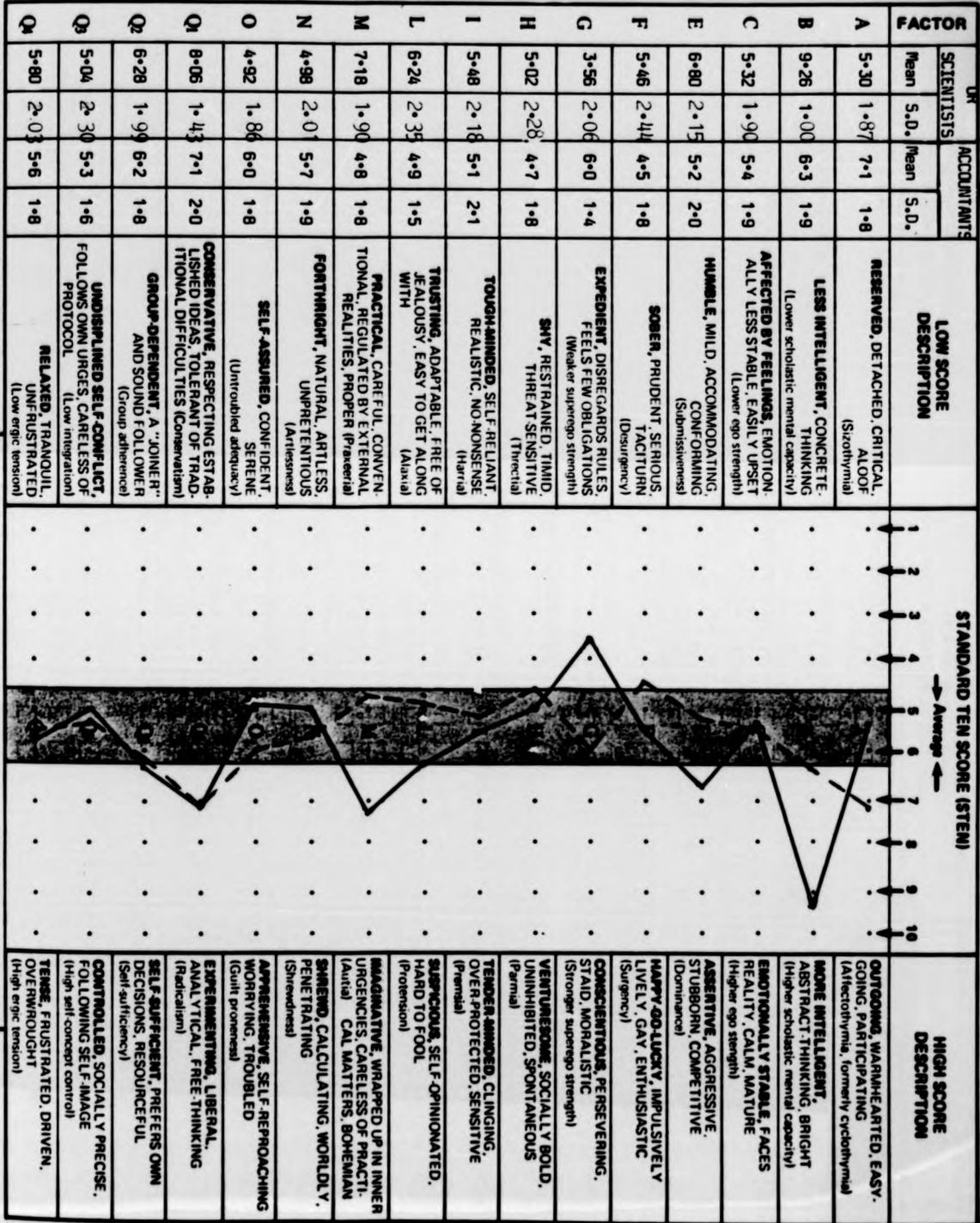
Figure 7-8 shows a plot of the profile of male OR scientists based on age thirty years and on the American general population male, Form A + Form B. The means and standard deviations of the sten scores are shown alongside the plot.

In order to encourage further research in constructing a 16PF profile of female OR scientists we present here the profile of the female members of our sample. The number available (six female OR scientists) for constructing this profile is far too small for any objective statement to be made.

Figure 7-9 shows a plot of the 16PF test profile of female OR scientists. The mean sten scores and the standard deviations are shown alongside the plot. Figure 7-10 shows a plot of the profile of female OR scientists in broken line superimposed on the profile of male OR scientists which is in unbroken line. The means and standard deviations are shown alongside the plots.

Figure 7.3 16PF Test Profiles of British OR Scientists<sup>1</sup> and Accountants, England and Scotland<sup>2</sup>

1. OR Scientists - Unbroken line (Male, 50)
2. Accountants - Broken line (Male, 90)



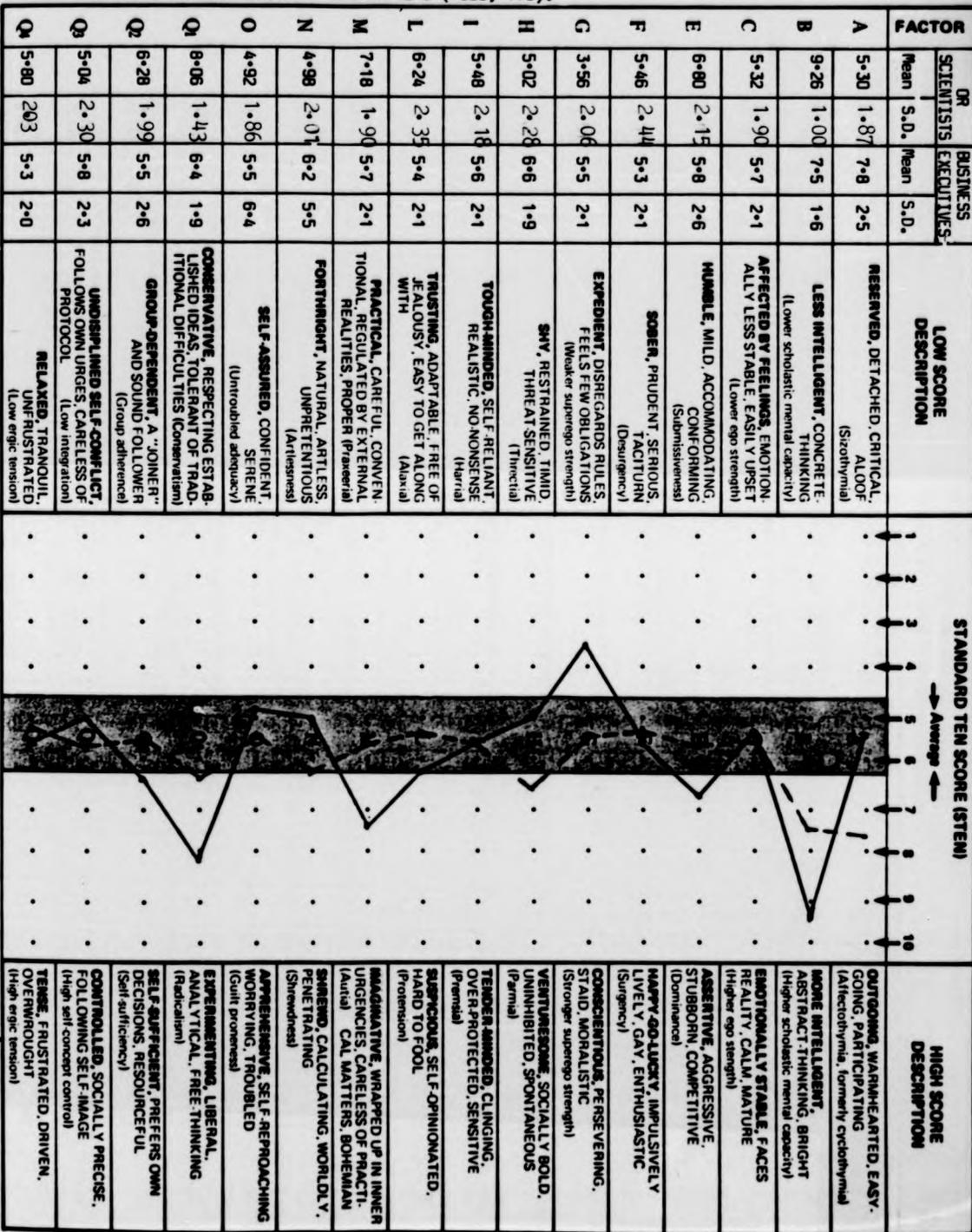
Printed and distributed by N.F.E.R. Publishing Company Ltd., Davville House, 2 Oxford Road East, Windsor, SL4 1DF, England, by permission Institute for Personality & Ability Testing, Illinois, U.S.A. Copyright © 1956, 1957, 1961, 1962, 1979.

A sten of 1 2 3 4 5 6 7 8 9 10 is obtained by about 2.3% 4.4% 9.2% 15.0% 18.1% 19.1% 15.0% 9.2% 4.4% 2.3% of adults

16 PF TEST PROFILE

Figure 7-4 16PF Test Profile of British OR Scientists<sup>1</sup> and American Business Executives<sup>2</sup>

1. OR Scientists - Unbroken line (Male, 50)
2. Business Executives - Broken line (Male, 178).



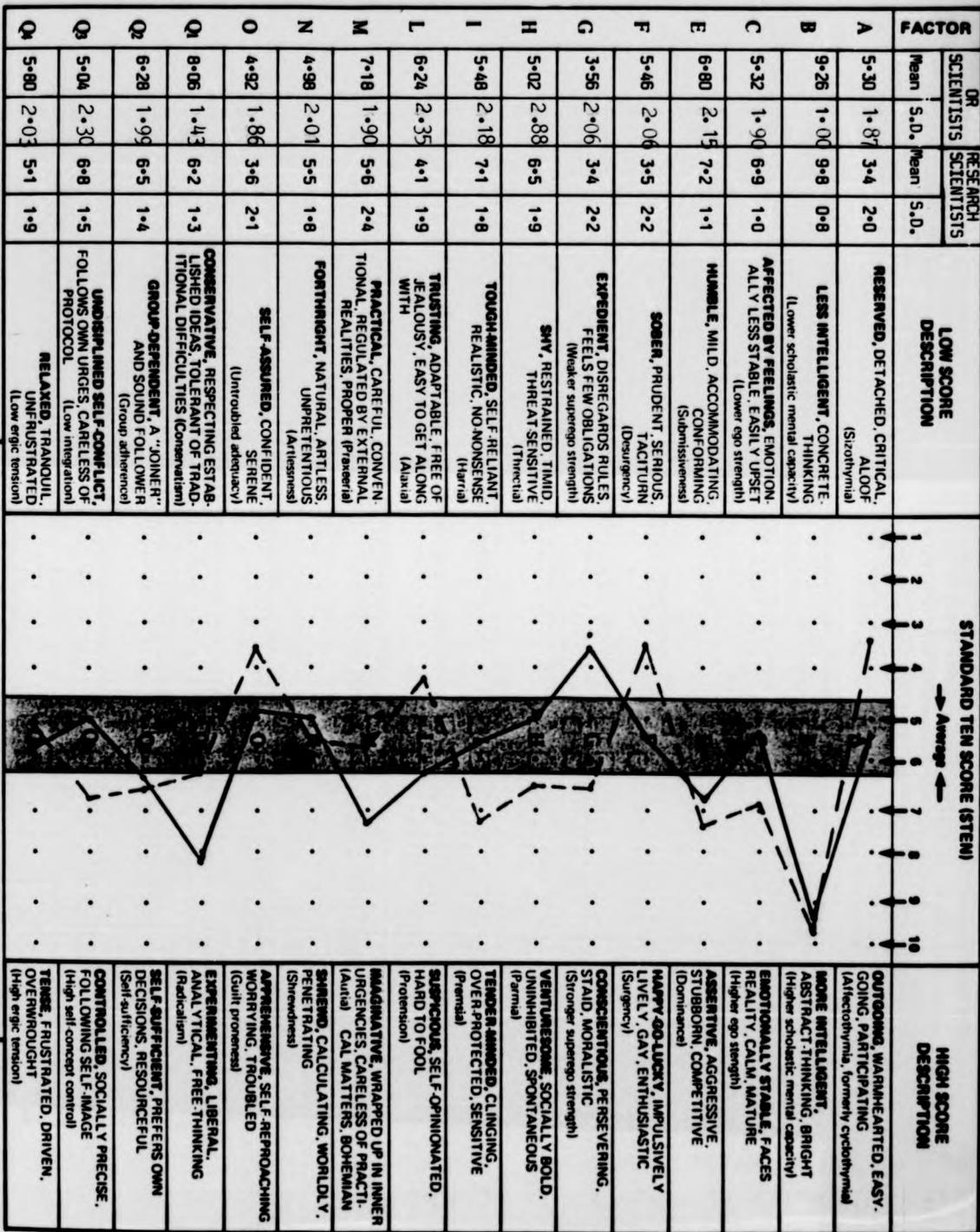
Printed and distributed by N.F.E.R. Publishing Company Ltd., Davville House, 2 Oxford Road East, Windsor, SL4 1DF, England, by permission Institute for Personality & Ability Testing, Illinois, U.S.A. Copyright © 1956, 1957, 1961, 1962, 1979.

A stem of 1 2 3 4 5 6 7 8 9 10 is obtained by about 2.3% 4.6% 9.2% 15.0% 19.1% 19.1% 15.0% 9.2% 4.6% 2.3% of adults

16 PF TEST PROFILE

Figure 7-5 16PF Test Profile of British OR Scientists<sup>1</sup> and American Research Scientists<sup>2</sup>

1. OR Scientists - Unbroken Line, (Male, 50)
2. Research Scientists, Broken line, (Male, 144)

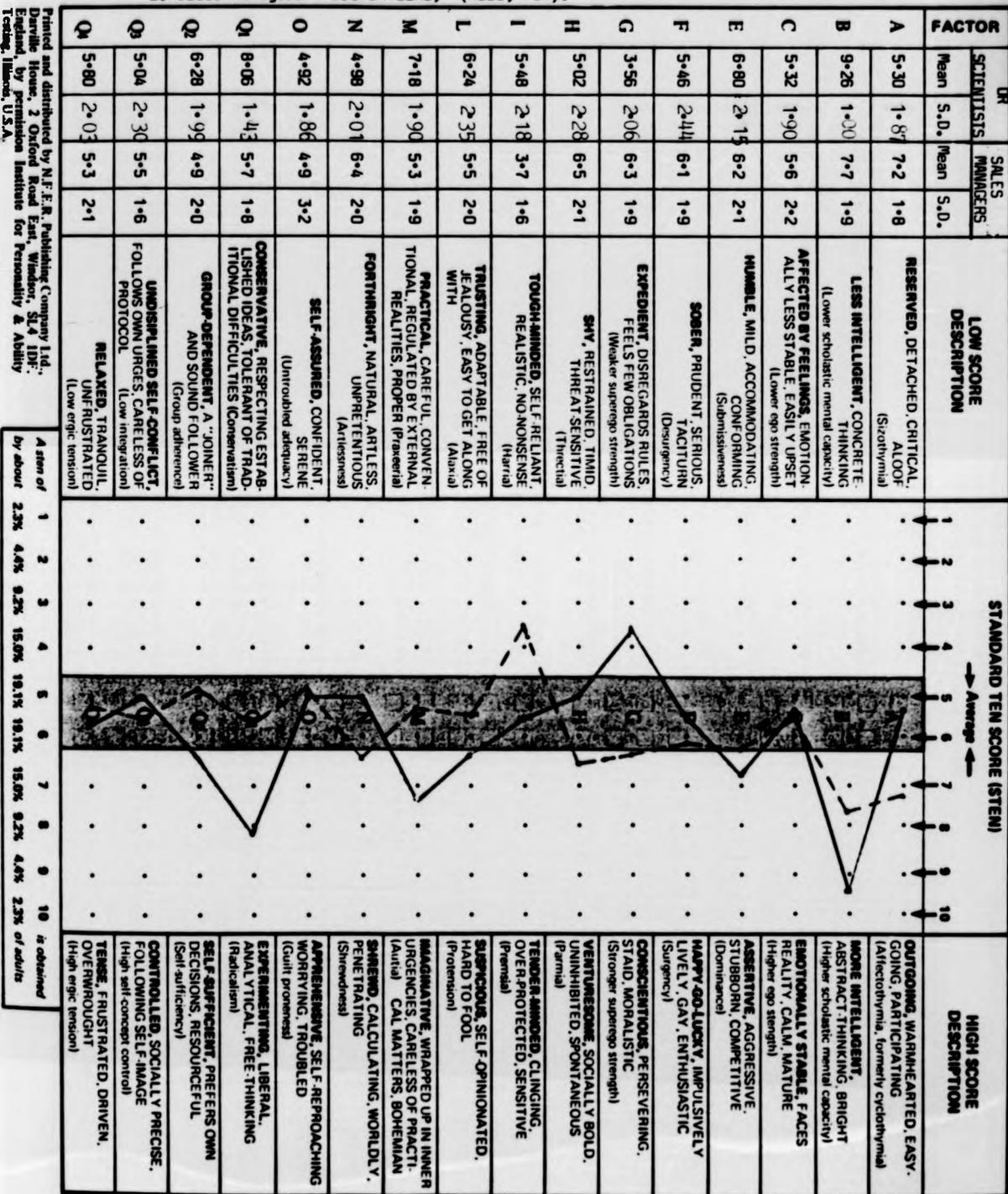


Printed and distributed by N.F.E.R. Publishing Company Ltd., Davville House, 2 Oxford Road East, Windsor, SL4 1DF, England, by permission Institute for Personality & Ability Testing, Illinois, U.S.A.  
Copyright © 1956, 1957, 1961, 1962, 1979.

16 PF TEST PROFILE

Figure 7-6 16PF Test Profile of British OR Scientists<sup>1</sup> and American Sales Managers<sup>2</sup>

1. OR Scientists - Unbroken line, (Male, 50).
2. Sales Managers - Broken line, (Male, 137).



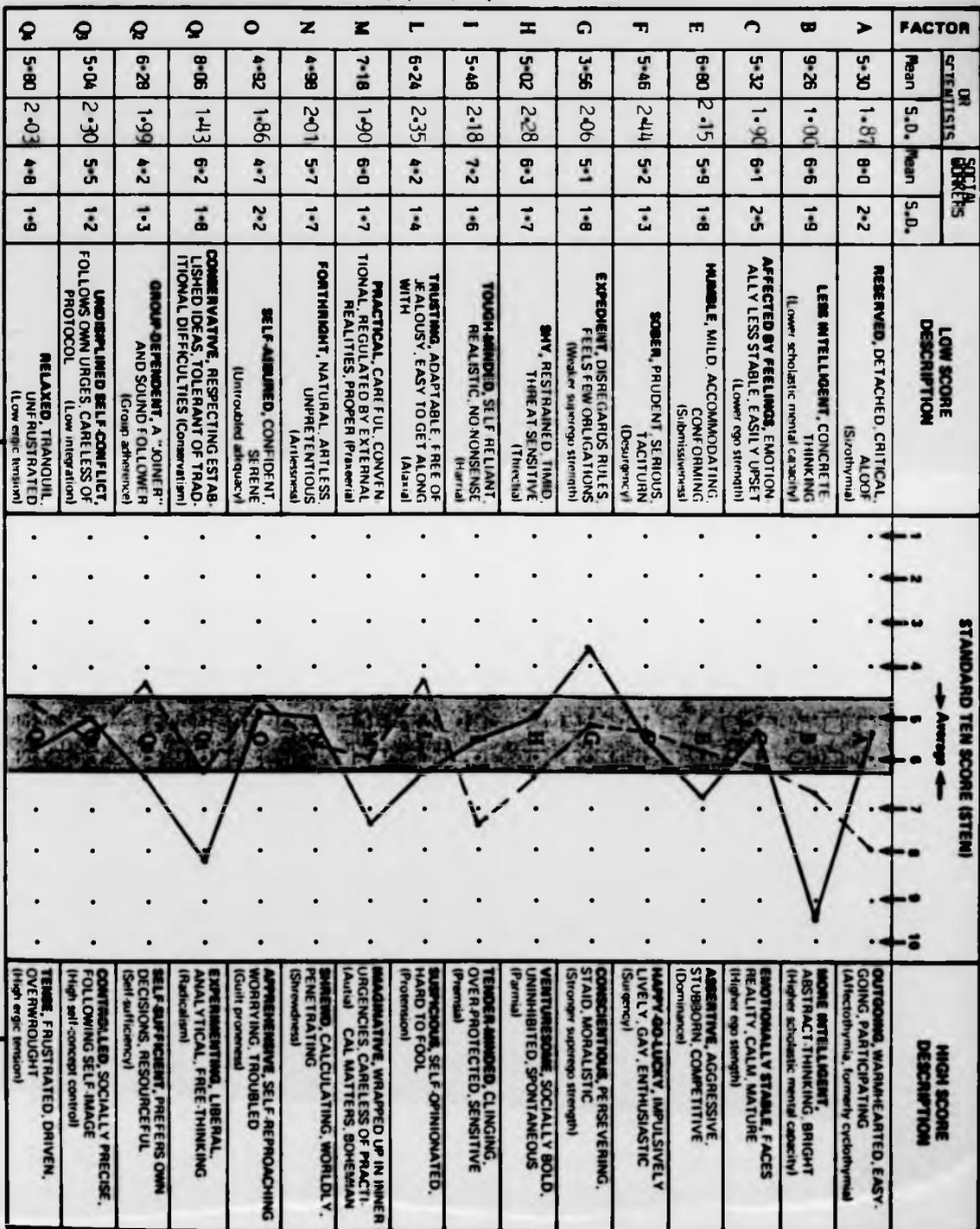
Printed and distributed by N.F.E.R. Publishing Company Ltd.  
 Denville House, 2 Oxford Road East, Windsor, SL4 1DJ.  
 England, by permission Institute for Personality & Ability  
 Testing, Illinois, U.S.A.  
 Copyright © 1946, 1957, 1961, 1962, 1979.

A stem of 1 2 3 4 5 6 7 8 9 10 is obtained by about 2.3% 4.4% 9.2% 15.0% 19.1% 19.1% 15.0% 9.2% 4.4% 2.3% of adults

16 PF TEST PROFILE

Figure 7-7 16PF Test Profile of British OR Scientists<sup>1</sup> and American Social Workers<sup>2</sup>

- 1. OR Scientists - Unbroken line, (Male, 50)
- 2. Social Workers - Broken line, (male, 81).



Printed and distributed by N.F.E.R. Publishing Company Ltd., Dunstable House, 2 Oxford Road East, Windsor, SL4 1DR. England. By permission Institute for Personality & Ability Testing, London, U.S.A. (Copyright © 1956, 1957, 1961, 1962, 1979.)

16 PF TEST PROFILE

Figure 7-8 16PF Test Profile of British OR Scientists - MALE.  
(Based on American General Population Norm-Male)

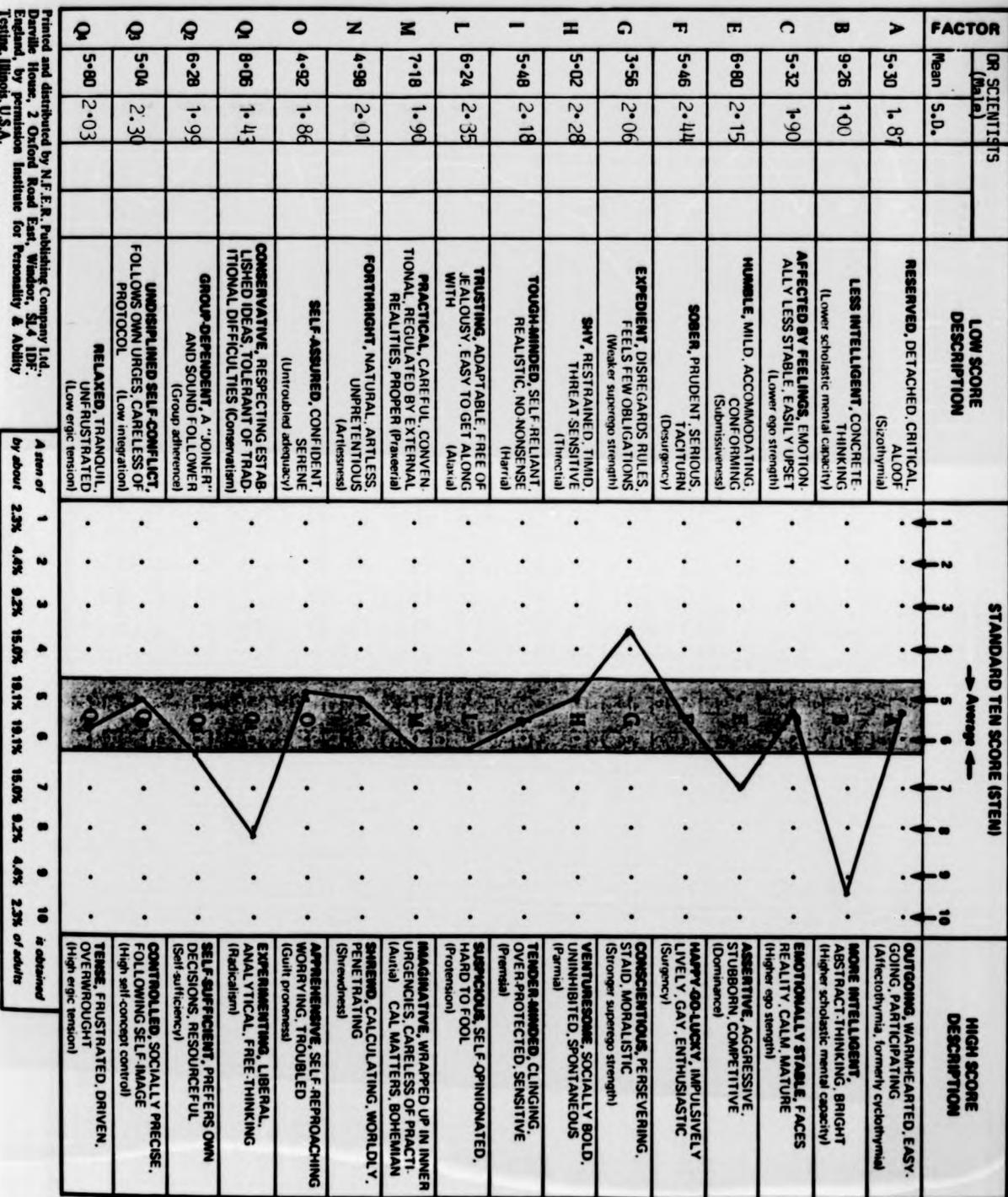
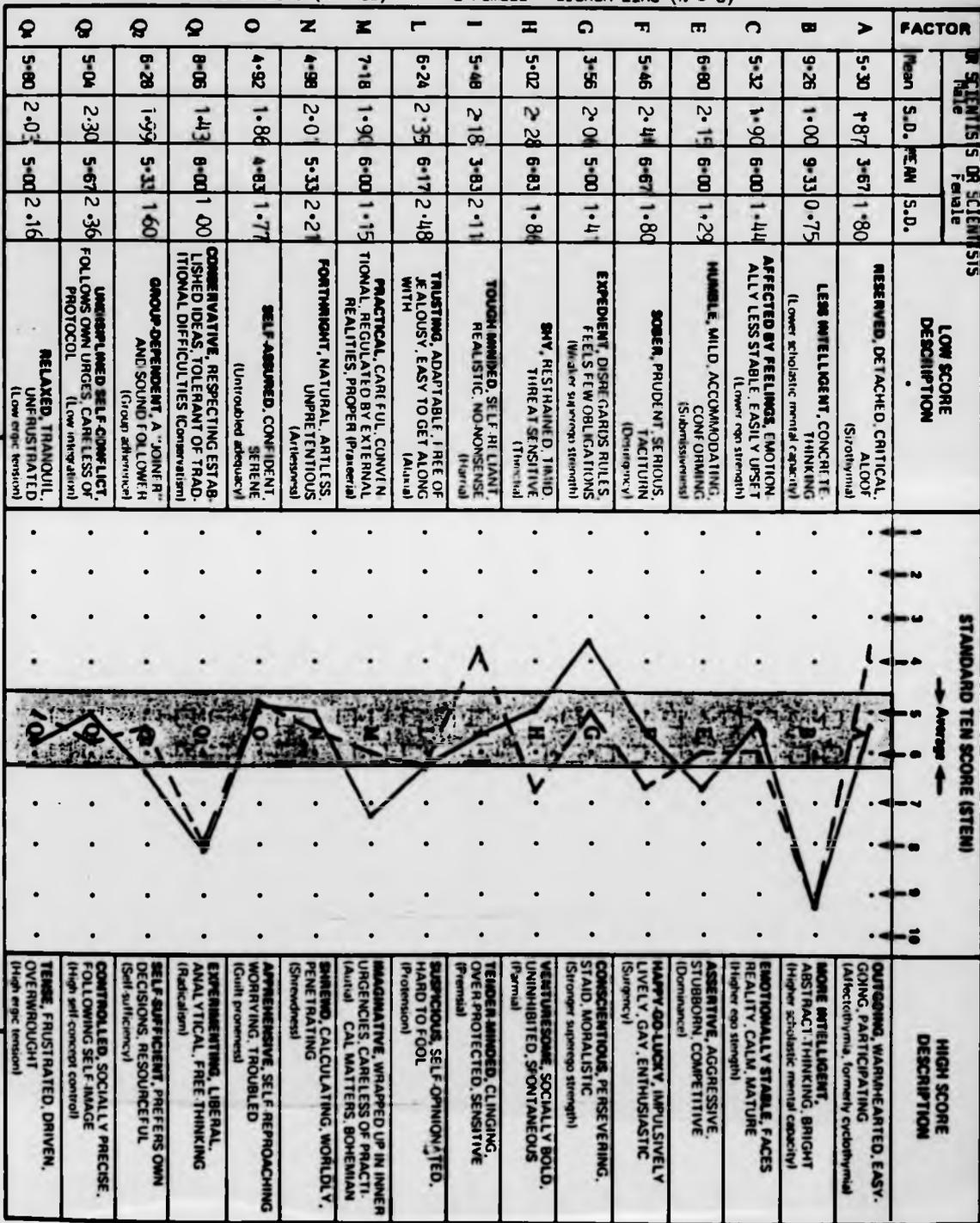




Figure 7-10 16PF Test Profile of British OR Scientists, Male<sup>1</sup> and Female<sup>2</sup> (Based on American General Population Norm).

1 Male - Unbroken Line (N = 50)      2 Female - Broken Line (N = 6)



Printed and distributed by N.F.E.R. Publishing Company Ltd., Daventry House, 2 Oxford Road East, Windsor, SL4 1DF, England, by permission Institute for Personality & Ability Testing, Illinois, U.S.A. Copyright © 1976, 1957, 1961, 1962, 1979.

A stem of 1 2 3 4 5 6 7 8 9 10 is obtained by about 2.5% 4.8% 8.2% 15.0% 18.1% 18.1% 15.0% 8.2% 4.8% 2.5% of adults

16 PF TEST PROFILE

Table 7-6 Student's T-Test comparisons of 18PF Occupational Profiles. Means and Standard deviations in Stem Units. Only five percent level of significance or above is considered.

OCCUPATION	PERSONALITY FACTOR														SEX	N			
	A	B	C	E	F	G	H	I	L	M	N	O	Q <sub>1</sub>	Q <sub>2</sub>			Q <sub>3</sub>	Q <sub>4</sub>	
OR SCIENTISTS	Mean	5.30	9.26	5.32	6.80	5.46	3.56	5.02	5.48	6.24	7.18	4.98	4.92	8.08	6.28	5.04	5.80	M	50
	S.D.	1.87	1.00	1.90	2.15	2.44	2.06	2.28	2.18	2.35	1.90	2.01	1.86	1.43	1.99	2.30	2.03		
ACCOUNTANTS (ENGLAND AND SCOTLAND)	Mean	7.10	6.30	5.40	5.20	4.50	6.00	4.70	5.20	4.90	4.80	5.70	6.00	7.10	6.20	5.30	5.60	M	90
	S.D.	1.80	1.90	1.90	2.00	1.80	1.40	1.80	2.10	1.50	1.80	1.90	1.80	2.00	1.80	1.60	1.80		
Mean Differences (Positive if OR Higher)	T Value	-1.80	2.96	-0.08	1.60	0.96	2.44	0.32	0.38	1.34	2.38	-0.72	-1.08	0.96	0.08	-0.26	0.20		
	Significance of Difference	5.59	10.24	0.24	4.42	2.65	8.31	0.91	1.01	4.11	7.35	2.10	3.36	2.99	0.24	0.78	0.60		
BUSINESS EXECUTIVES	Mean	7.80	7.50	5.70	5.80	5.30	5.50	6.60	5.60	5.40	5.70	6.20	5.50	6.40	5.50	5.80	5.30	M	178
	S.D.	2.50	1.60	2.10	2.60	2.10	2.10	1.90	2.10	2.10	2.10	2.10	2.00	1.90	2.60	2.30	2.00		
Mean Differences (Positive if OR Higher)	T Value	-2.50	1.76	-0.38	1.00	0.16	-1.96	-1.58	-0.12	0.84	1.48	-1.22	-0.58	1.66	0.78	-0.76	0.50		
	Significance of Difference	6.57	7.38	1.15	2.49	0.46	5.80	4.96	0.35	2.43	4.49	3.66	1.84	5.73	1.96	2.06	1.56		
P	Mean	<.001	<.001	NS	.02	NS	<.001	<.001	NS	.02	<.0	<.001	NS	<.001	.05	.05	NS		
	S.D.	<.001	<.001	NS	.02	NS	<.001	<.001	NS	.02	<.0	<.001	NS	<.001	.05	.05	NS		

\* + means OR Scientists scored HIGHER; - means OR Scientists scored LOWER; 1 NS Means Not Significant.

Table 7-6 (continued)

		A	B	C	E	F	G	H	I	L	M	N	O	Q <sub>1</sub>	Q <sub>2</sub>	Q <sub>3</sub>	Q <sub>4</sub>	SEX	N
RESEARCH SCIENTISTS	Mean	3.40	9.80	6.90	7.20	3.50	3.40	6.50	7.10	4.10	5.60	5.50	3.60	6.20	6.50	6.80	5.10	m	144
	S.D.	2.00	0.80	1.00	1.10	2.20	2.20	1.90	1.80	1.90	2.40	1.80	2.10	1.30	1.40	1.50	1.90		
	Mean Difference (Positive if OR Higher)	1.90	-0.54	-1.58	-0.40	1.96	0.16	-1.48	-1.62	2.14	1.58	0.52	1.32	1.86	-0.22	-1.76	0.70		
	T Value	5.88	3.85	7.46	1.69	5.27	0.45	4.50	5.18	6.44	4.49	1.71	3.94	8.49	0.85	6.16	2.02		
Significance of Difference	† <.001	† <.001	† <.001	NS	† <.001	NS	† <.001	† <.001	† <.001	† <.001	† <.001	NS	† <.001	† <.001	NS	† <.001	† <.05		
SALES MANAGERS	Mean	7.20	7.70	5.60	6.20	6.20	6.30	6.50	3.70	5.50	5.30	6.40	4.90	5.70	4.90	5.50	5.30	M	137
	S.D.	1.80	1.90	2.20	2.10	1.90	1.90	2.10	1.60	2.00	1.90	2.00	3.20	1.80	2.00	1.60	2.10		
	Mean Difference (Positive if OR Higher)	-1.90	1.56	-0.28	0.60	-0.64	-2.74	-1.48	1.78	0.74	1.88	-1.42	0.02	2.36	1.38	-0.46	0.50		
	T Value	6.32	5.53	0.80	1.72	1.88	8.53	4.17	6.08	2.13	5.99	4.29	0.04	8.35	4.18	1.54	1.45		
Significance of Difference	† <.001	† <.001	NS	NS	NS	† <.001	† <.001	† <.001	† <.001	NS	† <.001	† <.001	NS	† <.001	† <.001	NS	NS		
SOCIAL WORKERS	Mean	8.00	6.60	6.10	5.90	5.20	5.10	6.30	7.20	4.20	6.00	5.70	4.70	6.20	4.20	5.50	4.80	M	81
	S.D.	2.20	1.90	2.50	1.80	1.30	1.80	1.70	1.60	1.40	1.70	1.70	2.20	1.80	1.30	1.20	1.90		
	Mean Difference (Positive if OR Higher)	-2.70	2.86	-0.78	0.90	0.26	-1.54	-1.28	-1.72	2.04	1.18	-0.72	0.22	1.86	2.08	-0.46	1.00		
	T Value	7.21	9.14	1.89	2.58	0.79	4.50	3.67	5.19	6.23	3.69	2.19	0.59	6.20	7.24	1.50	2.85		
Significance of Difference	† <.001	† <.001	NS	† <.01	NS	† <.001	† <.001	† <.001	† <.001	† <.001	† <.001	† <.05	NS	† <.001	† <.001	NS	† <.01		

Significant Personality Differences Between British OR Scientists and Five Occupations: T-test comparisons of 16PF Test Profiles

The similarities and differences in the 16PF test profiles of the five occupations compared with that of British OR scientists will now be discussed on each of the sixteen personality factors measured by the 16PF test. For each of the factors the level of significance and the direction of the difference is presented in Table 7.6.

FACTOR A. Reserved Versus Outgoing

At the five percent level of significance or above, OR scientists diverge significantly from all the five occupations on this trait. OR scientists and in particular research scientists tend to be reserved relative to the four other occupations.

Research scientists are among the lowest ranking occupations on Factor A while social workers and business executives are among the highest ranking occupations.

FACTOR B. Low Intelligence Versus High Intelligence

In relation to all the occupations only research scientists tend to possess higher intelligence than OR scientists ( $p < 0.001$ ).

FACTOR C. Emotionally less stable versus Emotionally stable

OR scientists tend not to be as emotionally stable in relation to research scientists. With the other four occupations OR scientists are not significantly dichotomised.

FACTOR E. Humble Versus Assertive

OR scientists tend to be more assertive in relation to three of the five occupations. With the other two occupations OR scientists are not significantly distinguishable - research scientists and sales managers.

FACTOR F. Sober Versus Happy-go-Lucky

OR scientists tend to be less sober in relation to research scientists, and accountants (England and Scotland). With the other three occupations OR scientists are not significantly delineated.

FACTOR G. Expedient Versus Conscientious

OR Scientists are not identifiable from research scientists on this factor. In relation to the remaining four occupations OR scientists tend to be more expedient while the four occupations tend to be more conscientious.

FACTOR H. Shy Versus Venturesome

OR scientists are not distinguishable from accountants (England and Scotland). Relatively, OR scientists tend not to be as venturesome as the other four occupations.

FACTOR I. Tough-minded Versus Tender-minded

OR scientists are not significantly different from accountants and business executives. Research scientists and social workers tend to be more tough-minded in relation to OR scientists while sales managers tend to be more tender-minded.

FACTOR L. Trusting Versus Suspicious

OR scientists are not significantly different from just only the

sales managers on this trait. In relation to the four other occupations, OR scientists tend to be less trusting.

FACTOR M. Practical Versus Imaginative

OR scientists tend to be more imaginative than all the occupations.

FACTOR N. Forthright Versus Astute

OR scientists tend not to be as astute as four of the occupations only. With the research scientists OR scientists are however not significantly different.

FACTOR O. Self-assured Versus Apprehensive

OR scientists differ significantly from research scientists and accountants on this factor; with the other three occupations OR scientists are not significantly different. OR scientists tend not to be as self-assured as research scientists, although not as apprehensive as accountants.

FACTOR Q<sub>1</sub>. Conservative Versus Experimenting

In relation to all the five occupations OR scientists tend to be more experimenting.

FACTOR Q<sub>2</sub>. Group dependent Versus Self-sufficient

OR scientists are not significantly dichotomised from two of the five occupations; with the other three occupations OR scientists are significantly delineated. OR scientists tend to be self-sufficient in relation to sales managers, social workers and business executives.

FACTOR Q<sub>3</sub>. Undisciplined Self-conflict Versus Controlled

OR scientists are distinguishable from business executives and research scientists; with the three other occupations OR scientists are not significantly different. OR scientists tend not to have as much control over their emotions and general behaviours in relation to research scientists and business executives.

FACTOR Q<sub>4</sub>. Relaxed Versus Tense

On this personality factor OR scientists are distinguishable from two of the five occupations. Research scientists and social workers tend to be less tense in relation to OR scientists; others are indistinguishable.

SUMMARY OF THE PERSONALITY PROFILE OF OR SCIENTISTS:

Although the uniqueness of using 16PF personality profiles in the selection of candidates for any work lies in the realisation that the "whole person" rather than some traits is being considered in the selection, it is desirable in interviewing situations to be aware of the particular features of the personality profile which most significantly distinguishes the group of particular interest from the rest of the population and other related professions. In assessing the degree of resemblance of an individual's profile to those in a particular profession, the pattern similarity coefficient  $r_p$ , offers reliable data upon which judgement can be based.

A summary of the principal features of the personality profile of OR scientists in relation to the general adult population and the occupations whose profiles have been compared with OR scientists in this thesis is presented on all the sixteen factors covered by the 16PF test in Table 7.7.

In general the profile of OR scientists is that of a profession relatively high on intelligence (B+), a prerequisite for any high level performance; reasonably strongly assertive and stubborn (E+), a quality necessary for carrying the profession through those times when new and seemingly untried methods or solutions have to be implemented, this quality is supported by the strong tendency to break rules easily (G-). A high degree of scepticism and being hard to fool (L+) seem to be a major reason for the success of OR scientists in problem solving coupled with being highly imaginatively creative and unconventional (M+). A strong willingness to experiment with problem solutions (Q<sub>1</sub>+) and high self-sufficiency (Q<sub>2</sub>+) are all qualities essential for successful high level problem solving and desirable in a profession dedicated to creating change.

Whereas some of these properties may appear similar to phrases found in advertisements for OR scientists, it is doubtful how much of the richness of these primary source traits is captured by the prevailing methods of recruitment. We believe that the use of the sixteen personality factor test profile will enhance the selection of scientists more endowed with these essential personality traits.

#### OR Scientists Versus Research Scientists: A 16PF Profile Comparison:

Sincere OR scientists are generally recruited from the scientific community, the particular personality characteristics which essentially distinguishes OR scientists from the rest of the scientific community are worth identifying in order to assist in the effective recruitment of OR scientists.

The 16PF test profile of OR scientists compared with that of research scientists shows that OR scientists are distinguishable on eleven of the sixteen personality factors at above the five percent level of significance on Student's t-test. The pattern similarity coefficient,  $r_p$ ,

computed in a comparison of the 16PF test profile of research scientists to that of OR scientists is  $r_p = -0.024$ .

These two tests results suggest that OR scientists are a distinct and homogenous psychologically selected group within the scientific community. Specifically, in relation to research scientists OR scientists tend to be happy-go-lucky, suspicious, more imaginative and experimenting and, less reserved, emotionally stable, venturesome, tender-minded, self-assured and self-controlled.

Table 7.8 shows a summary of the factors delineating the two groups.

Table 7.7 Key features of OR scientists on the 16PF test in relation to the general adult population and five selected professions.

PRIMARY SOURCE TRAIT	MOST OF THE FIVE PROFESSIONS (RELATIVE TO GENERAL POPULATION) <sup>1</sup>	OR SCIENTISTS (RELATIVE TO GEN. POP.)
A	Tend to be strongly outgoing and participating. Research scientists tend to be strongly reserved.	Tend not to be significantly different from the average adult.
B	Tend to be high on intelligence. Research scientists tend to be very much higher than the average adult and most professions.	Tend to be very much higher than the average adult and most professions.
C	Tend not to be significantly different from the average adult. Research scientists though, tend to be fairly emotionally stable.	Tend not to be significantly different from the average adult.
E	Tend to be fairly assertive and competitive. Research scientists tend to be strongly assertive and stubborn.	Tend to be strongly assertive and stubborn in relation to the average adult and most professions
F	Tend not to be significantly different from the average adult. Research scientists and to a lesser extent Accountants, tend to be sober and serious.	Tend not to be significantly different from the average adult.
G	Tend to be mildly conscientious, and rule bound. Research scientists tend to be strongly expedient and break rules easily.	Tend to be strongly expedient and break rules easily.
H	Tend to be fairly uninhibited and venturesome. Accountants to a very much lesser extent.	Tend not to be significantly different from the average adult.
I	Tend not to be significantly different from the average adult. Research scientists and social workers tend to be strongly tender-minded and sensitive. Sales managers tend to be strongly tough-minded and self-reliant.	Tend not to be significantly different from the average adult.
L	Tend not to be significantly different from the average adult. Research scientists and social workers however tend to be mildly trusting and free from jealous tendencies relatively speaking.	Tend to be very much more sceptical, hard to fool and suspicious.

1. The mean sten score for the general adult population is 5.5

Table 7.7 (continued)

M	Tend to be mildly imaginatively creative.	tend to be highly imaginatively creative and unconventional.
N	Tend to be somewhat socially aware.	Tend to be mildly unpretentious.
O	Tend to be polarised between tending to be mildly self-reproaching and tending to be mildly self-assured. Research scientists tend to be strongly more self-assured.	Tend to be mildly self assured.
Q <sub>1</sub>	Tend to be fairly experimenting and free-thinking. Accountants relatively more so.	Tend to be highly experimenting and free-thinking.
Q <sub>2</sub>	Tend to be fairly accustomed to going their own way. Sales Managers and Social Workers tend somewhat to go with the group.	Tend to be fairly accustomed to going their own way.
Q <sub>3</sub>	Tend not to be significantly different from the average adult. Research scientists tend to be fairly more self-controlled.	Tend not to be significantly different from the average adult.
Q <sub>4</sub>	Tend not to be significantly different from the average adult. Social Workers tend to be mildly more relaxed.	Tend not to be significantly different from the average adult.

Table 7-8 Summary of 16PF test profile comparison between OR scientists and research scientists.

PRIMARY SOURCE TRAIT	OR SCIENTISTS IN RELATION TO RESEARCH SCIENTISTS	RESEARCH SCIENTISTS	T-test LEVEL OF SIGNIFICANCE
A	less reserved	reserved	$p < 0.001$
B	less intelligent	high intelligence	$P < 0.001$
C	less emotionally stable	emotionally stable	$p < 0.001$
E	NS <sup>1</sup>	assertive	-
F	happy-go-lucky	sober	$p < 0.001$
G	NS	expedient	-
H	less venturesome	venturesome	$p < 0.001$
I	less tender-minded	tender-minded	$p < 0.001$
L	suspicious	trusting	$p < 0.001$
M	more imaginative	imaginative	$p < 0.001$
N	NS	forthright	-
O	less self-assured	self-assured	$p < 0.001$
Q <sub>1</sub>	more experimenting	experimenting	$p < 0.001$
Q <sub>2</sub>	NS	self-sufficient	-
Q <sub>3</sub>	less self-controlled	self-controlled	$p < 0.001$
Q <sub>4</sub>	less relaxed	relaxed	$P < 0.05$

1. NS means Not Significant.

CHAPTER EIGHT  
CONCLUSIONS AND RECOMMENDATIONS

**Introduction:**

In this chapter a summary of the research is presented, and a general theory on the introduction of Operational Research into organisations is discussed. Based on the general theory some conclusions are drawn on the particular problems of the introduction of Operational Research into the Nigerian Civil Service, and some recommendations are made on how the problems might be solved. A suggestion is made on area for further research on the problems of OR in developing countries.

**THE RESEARCH SUMMARY**

This research was concerned with the problems of the introduction of Operational Research into developing countries. The particular area investigated was the problems of the introduction of OR into the Civil Service in Nigeria. The purpose of the research was to increase our understanding of the administrators, and their problems, and the situation with regards to factors which are basic and pragmatically significant to the introduction of OR into an organisation.

In the preliminary stages of the research, a comprehensive literature survey was conducted on OR in developing countries. The literature revealed the application of OR approaches in a large number of problem areas throughout the developing countries. But there was little evidence of implementation or management involvement in the studies. A list and a summary of problem areas where OR approaches were applied in water resources, agriculture, health and social welfare, industry, sectoral and national planning and, transportation was provided showing analytical and quantitative models developed and the country or region where the study was conducted.

On the particular problems of the introduction of OR into organisations, paucity of literature was revealed by the survey. A summary of some of the approaches suggested for getting OR started was presented. A review of OR in government services in the developed countries was undertaken in order to gain useful insights into the specific problems of getting OR set up in the civil service. The review included an interview with a senior OR Scientist in the British Civil Service. A summary of the various modes which can be adopted in the introduction of OR in a civil service was provided.

With that completed the introduction of OR into some sectors of the civil service in Nigeria was thought of in order to provide a specific case in which the problems of setting up OR can be studied. The Nigerian Railways Corporation (NRC) was chosen for this purpose. In order to initiate the dialogue necessary for identifying projects perceived by the management as significant and on which OR assistance can be arranged, a list of projects related to problem areas in rail transportation was prepared and sent to officials of the appropriate Federal ministry. This was to get the dialogue started as a prelude to the discussion on the introduction of OR into NRC. The lack of effective response suggested that more fundamental work was necessary before the question of the introduction of OR into specific ministries and public corporations could be considered.

Following that realisation the research efforts were directed onto trying to increase our understanding of the administrators, their work, their problems, and the situation with regards to factors which are basic and pragmatically significant to the introduction of OR into an organisation.

This was done by conducting extensive interviews among senior civil servants in Nigeria covering the Federal Civil Service and the civil service in five States. The interviews showed that OR was not well known in the Civil

Service, that civil servants had preferences in the mode of introducing OR into the Civil Service, that OR projects of some sort could be arranged in nearly all the ministries and public corporations, and that there could be problems with finding staff of the right calibre and experience in the introduction of OR into the civil service. In order to assist in finding solutions to the problems of staffing in particular, a psychometric instrument which is based on scientific foundation was used to increase our understanding of the traits which account for success in OR. Although some cautions would be required in using the particular test instrument in Nigeria, we believe that understanding the personality factors which are essential for successful OR work is an important contribution to knowledge and to the particular problems of the selection of staff for OR work in the Nigerian Civil Service.

The main conclusions of the research will now be examined first by discussions on a general theory on the introduction of OR into organisations.

#### A GENERAL THEORY ON THE INTRODUCTION OF OPERATIONAL RESEARCH (OR) INTO ORGANISATIONS:

The primary purpose of this study was to increase our understanding on the problems of the introduction of Operational Research (OR) into developing countries. Our particular interest being in the introduction of OR into the civil service in Nigeria. We believe that this research has bridged some important gaps in our knowledge regarding the problems of the introduction of OR into organisations done in a planned and systematic manner. This study represents the first attempt based on scientific method to understand the administrators, their work and their problems in connection with the introduction of OR into the civil service in Nigeria. This unique study we believe has made original contributions vital to our understanding of the problems of the introduction of OR into organisations in general.

In fact, based on analysis of data collected during the study, a general theory on the introduction of Operational Research into organisations can now be discussed.

As asserted by Mintzberg (1975)

"A theory may be defined simply as a coherent system of propositions that purports to explain a phenomenon."

In this section we discuss factors which we believe explain the introduction of OR into organisations. Often theories emerge from problem solving as argued by Poper (1974), and as discussed in Chapter five theories do emanate from the results of surveys undertaken to increase one's understanding of a phenomenon. In a developing field such as the problems of a planned and systematic introduction of OR into organisations deep understanding can at best be gained only from studying the problems in the real world where the decisions are made on whether to introduce OR or not to introduce OR into particular organisations.

Analysis of data collected on factors which one believed to be pragmatically significant and pertinent to the introduction of OR into an organisation during face to face interviews conducted in the Nigerian Civil Service has led one to the conclusion that certain factors are central to the successful introduction of OR into any organisation. One believes that the introduction of OR into an organisation is a policy decision, and in one's view the response of the decision makers in an organisation to the issue of whether to introduce OR into the organisation or not depends on five essential factors namely:

1. AWARENESS - the degree of awareness and understanding which exists about Operational Research at the highest levels (and to lesser extents at

other levels) of decision making in an organisation. Implicit in this factor is the ability and willingness of the decision makers in the organisation to apply the results of scientific investigation to decision making problems in the organisation.

2. APPLICABILITY - the range of decision making problems in an organisation which are amenable to scientific method of enquiry.
3. MODALITY - the status which the decision makers in an organisation are willing to accord to Operational Research in the management structure of the organisation.
4. AVAILABILITY - the availability of OR scientists of the right calibre and experience who can successfully tackle the decision making problems which confront the decision makers in the organisation.
5. FINANCEABILITY - the willingness and ability of an organisation to pay the price of acquiring the best available expertise (personnel and otherwise) needed in order to effectively tackle the decision making problems which confront the organisation.

#### SOME CONCLUSIONS REGARDING THE INTRODUCTION OF OR INTO THE NIGERIAN CIVIL SERVICE:

Considered in the light of the general theory on the introduction of Operational Research into organisations which was discussed in the foregoing section, the following conclusions have been drawn on the particular problems of the introduction of OR into the civil service in Nigeria.

##### 1. OR AWARENESS:

The research revealed that there was overwhelming evidence of ignorance concerning OR among senior civil servants. In our view something must

be done about this problem in order that OR might have a real chance of being introduced into the civil service. We believe that some basic understanding of OR at the very high levels of government is essential to the successful introduction of OR into the civil service. The sort of experiment undertaken by Luck (1979) in Indonesia would not be an effective solution in our view.

Operational Research is a revolutionary activity, without strong backing at the high levels of government it could be a fruitless exercise, if not impossible to effectively practice. Officers could withhold data or refuse to implement the results, just to mention these two problem areas. For OR to be effectively and successfully introduced into the civil service we believe would require a definite decision at very high levels of government similar to the decisions taken by the British government to use OR both during the war and after the war. This will ensure that OR has the necessary backing vital to its effectiveness in the civil service, that questions such as the role and function of OR in government, and the organisational structure of OR are well thought out, and that OR scientists working in government have a planned career path to follow as is the case in the British Civil Service for example. Merely recruiting OR scientists into the government or just developing OR skills in government officials as Luck (1979) experimented or as suggested by Clayson (1990) could lead to frustration on the part of OR scientists working in government, and destroy the moral and motivation which are necessary for success in a pioneering activity.

From analysis of the situation regarding this factor, it is a conclusion of this study that for OR to be effectively and successfully started and sustained in the civil service in Nigeria, some sort of OR education would be necessary at the very high levels of government in order to

increase the awareness and understanding which exists among the top policy makers in the government about Operational Research, and about its values to government in problem solving and in policy formulation.

## 2. APPLICABILITY:

Operational Research is a well-established and widely used activity in government departments in the U.K. and in the U.S.A., as well as in many other countries in the developed worlds. Major OR studies have been undertaken in most ministries in the U.K. The range of problems for which OR can be usefully applied is no less in the civil service in Nigeria than in the U.K. or in the U.S.A. and we believe its potential is no less. In fact as Morse and Brown (1976) have pointed out the problem in the introduction of OR into the developing countries is not with what OR will do. Morse and Brown noted:

"It seems reasonable to conclude that there is no lack of places where an OR Group can work."

From the description of work done in the ministries in the civil service in Nigeria, a wide range of potential OR application areas can be discerned. Our studies showed that in nearly all government ministries and public corporations, OR projects of some sort which would be perceived by administrators as being of significance to the government can be identified. We conclude that a number of the policy issues, strategic problems, and tactical matters which confront the Nigerian government are amenable to scientific method of investigation. In other words Operational Research is applicable to the general range of problems which the Nigerian civil service grapples with, and the quality of decision making could definitely improve with the introduction of Operational Research into the civil service. It is our belief that the Nigerian government would profit from the use of Operational Research in its civil service.

### 3. MODALITY:

There was convincing evidence that senior civil servants had strong preferences on the approach which government should adopt during the introduction of OR into the civil service. For example, our research findings suggested that the establishment of RAND-type corporations to undertake OR for government was not an approach most favoured by senior civil servants. Evidence from the research showed that OR groups located in the ministerial units was the most preferred approach among senior civil servants, in particular among permanent secretaries. While some senior officers would like such groups to be centrally administered, some others, permanent secretaries in particular believed that centralised control would introduce bureaucratic processes which could undermine the efficiency and effectiveness of OR activities in government. Some of these officers would prefer "own" groups or autonomous ministerial OR groups. This is a departure from the recommendations of the panel appointed by the National Academy of Sciences (1976) that a central OR group (or a prototype OR group) is the most suitable during the introduction of OR into governments in developing countries. In fact, it is in line with the traditional approach to OR in government as exemplified by the U.K. Civil Service and the American Civil Service.

We believe that there is some relationship between the status of OR in the management structure of an organisation and the kind of problems which OR is called upon to investigate. The question of the status of OR in the top management structure of an organisation is vital, we believe that this is one of the five essential factors which are responsible for the successful introduction and functioning of OR in an organisation. As the OR Society U.K. (1968) asserted in respect of the status of OR in the British Civil Service, low level OR undermines the benefits of OR in the government. Rivett and Ackoff (1963) have argued that to place

OR low in the management structure of an organisation was to rob the organisation of the benefits of having OR in the organisation. The particular points made by Rivett and Ackoff in this respect is worth underscoring; they argued:

"One of the greatest potential uses of OR in a company is at the top strategy-making level. Consequently, the OR man must have access to the directors (top managers) of the company concerned... To do anything else is to deny yourself the full dividends coming from using OR in your company... The advantage of such a setting in the company structure is that it gives a firm basis for the OR activity. It is well rooted in the structure of the company, it is forced into the front line of decision making and hence its work will have an immediate usefulness." (p.82).

Given that there are policy issues, strategic problems, and tactical matters in the government on which OR investigations can significantly contribute to improvements in the quality of decisions which government makes, it is our conclusion that in the introduction of OR into the civil service, the status of OR must be sufficiently high in the management structure of government in order that OR would be in a position to freely study these problems. We believe that in doing so government would derive maximum benefits from OR activities in the civil service.

#### 4. AVAILABILITY:

Although the problems of having persons with the right personality type in specific occupations has long been recognised (Blum and Naylor 1968, Gaudet and Carli 1957), and in particular for OR work (Blackett 1950, Streat 1950, Tippett 1950), the personality profile of OR scientists has never been determined in a scientific fashion. We believe that in starting OR in organisations, having OR staff of the right calibre and experience is essential and vital in order that the exercise may have a real chance of success. The importance of starting with qualified

staff was emphasised by Rivett and Ackoff (1963), the OR Society U.K. (1969), and by Morse and Brown (1976).

In this research we have determined using a psychometric instrument which is based on scientific foundation and which is the product of over thirty-five years of scientific research (Walsh 1973), the traits which are essential to successful OR work. This unique study, which is the first of its kind, has filled an important gap in our knowledge about OR scientists.

Our research findings showed that OR Scientists are a distinct and identifiable group of workers within the scientific community, among occupational groups, and within the general population. The 16PF test profile of OR scientists showed that they are a homogenous and psychologically selected group of persons. In our view, this understanding will assist in the selection of serving officers in particular for training in OR during the introduction of OR into an organisation.

Our studies have shown that availability of OR staff of the right calibre and experience in Nigeria could be a problem during the introduction of OR into the civil service in Nigeria. We are aware that a substantial number of Nigerians have trained in Operational Research in the last couple of years, if they could be identified, they might be able to ease the problem. But we believe that most of these OR scientists may be lacking in experience in real live problem solving since many of them were not known to be engaged in full-time practice of Operational Research. As Sagastic (1972), Smith (1973), and Bandyopadhyay and Varde (1980) have each criticised, OR scientists from the developing countries who have trained abroad often lacked experience in real live problem solving, particularly in solving problems of the kind which public

administrators and managers in the developing countries grapple with.

Our conclusion is that during the introduction of OR into the civil service in Nigeria, availability of indigenous OR Scientists of the right calibre and experience would be a problem. In order to assist in solving this problem the personality traits which are essential for OR work have been identified using a psychometric instrument so that appropriate serving officers could be recruited for OR training.

#### 5. FINANCEABILITY:

Evidence from the research showed that individual ministries in the Nigerian Civil Service could find funds to permit studies of some kinds to be undertaken for them. This might be seen from the consultancy studies commissioned by government ministries and public corporations. On the particular case of the introduction of OR into the civil service, the impression we got from the interview responses was that government would be willing to budget for OR, if it was persuaded of its value. In other words subject to certain conditions being satisfied financeability might not be a problem. Our conclusion on this factor is that the situation regarding it can only be satisfactorily resolved when there is more understanding among the policy makers in the government about the values of OR to the government.

#### SOME RECOMMENDATIONS ON THE INTRODUCTION OF OPERATIONAL RESEARCH INTO THE NIGERIAN CIVIL SERVICE:

Based on the conclusions discussed in the foregoing section, we make the following recommendations on the introduction of Operational Research into the civil service in Nigeria.

##### 1. OR Education for the Most Senior Decision Makers:

OR is an "assistance" given to one confronted with the problems of

decision making. For a decision maker to benefit most from the assistance, it is essential for him to have reasonable confidence in the assistance. This means that it is necessary for the decision maker to have some basic understanding of what OR is, what it does and who does it, its value to government in policy formulation, analysis of strategies and resolution of tactical problems, and how OR can be introduced into the civil service.

As pointed out by Streat (1950) in connection with the introduction of OR into British industries, unless there is this understanding the assistance may be worthless. Streat declared:

"It seems to me a pregnant and dramatic truism that until a fact is understood it has no dynamic impact on human affairs. The moment it is understood it begins forthwith to affect life and conduct in a vivid and vital fashion." (p.9).

In view of the prevailing problem of ignorance about OR, something has to be done in order for the introduction of Operational Research into the civil service to mature. In our view, the most senior decision makers - political leaders, civil servants, and managers of government corporations - should be given some form of OR education in order to enhance their understanding of OR, what it does, how it is done, who does it, how it can assist them, and how to set up OR in the government.

OR education for decision makers in this category is a complex matter. It is not just a matter of giving them an academic introduction to OR through say formal academic courses such as MBA or Diploma/M.Sc. in OR for example, since the intention is not to make them OR workers. In fact as pointed out by Jackson (1959) top executives do not have the disposition for activities such as Operational Research. Similarly

the use of literature for this purpose is inappropriate since busy executives are less likely to have time to study and digest the contents of such materials. Word of mouth or personal involvement could have served the purpose to some extent if OR was already being done in the government. But since we are dealing with a situation where little or no OR is being done, OR education through word of mouth or personal involvement cannot be an effective solution to the problems of getting OR started in the Civil Service.

We believe that for OR to be effectively introduced into the Civil Service it would require a definite decision by government. This will ensure that the function of OR, its position in the structure of government and other related questions are carefully examined. To just recruit OR scientists into the government without giving due thought to these and other related questions could lead to frustrations on the part of OR scientists or hinder their effectiveness.

The kind of OR education we recommend is that which will provide the basis for the decision maker to act and assist in developing in him the "will" necessary in order to take the decision to introduce OR into government. It could take the form of seminars to which ministers, commissioners, permanent secretaries, and general managers of public corporations are invited. Such seminars would include experienced OR practitioners of distinction and a few notable OR scholars. This will bring together all the key elements vital to getting OR started and essential to successful OR practice in the civil service and in public corporations. As Morse and Brown (1976) pointed out, in order to get OR started it is important that OR users and OR practitioners know about the existence of each other. Morse and Brown noted:

"Two elements have to be brought together for the process to be started: an administrator who wants to use OR and a capable or potentially capable, OR director who wants to develop a group. Both kinds of people need to know about OR and about each others' existence."

There are problems involved in the implementation of this recommendation. Three which are particularly central to the successful implementation of the recommendation are the problems of finding sponsorship for the seminars, the problems of developing appropriate programmes for the seminars since often seminars on OR tend to dwell on "mathematics" rather than on problem solving, and the problems of how to persuade the top policy makers in the government - ministers, commissioners, permanent secretaries, and managers of public corporations - to attend the seminars. Finding solutions to these and other problems is beyond the scope of these research.

2. Staffing: Collecting a Team Composed of the Right Calibre of Personnel:  
A common problem when starting OR in an organisation is that of staffing. Collecting a team which is composed of the right calibre of staff is vital to the successful introduction of OR. In general an OR team would include physical scientists, engineers, mathematicians, economists, behavioural scientists, social scientists, computer scientists and programmers, and staff with indepth knowledge of the organisation - an experienced administrative officer for example. An important precondition in OR team formation is the ability of the staff to work together as a team. A common suggestion on staffing when introducing OR into an organisation is to start with a small number of scientists (between three and six) and allow the team to grow. (Rivett and Ackoff 1963, Morse and Brown 1976).

Although no OR scientist was discovered in the Civil Service in Nigeria

during our investigation it is generally believed that in Nigeria there exists a pool of trained OR scientists with various disciplinary backgrounds from which one can draw in order to form an initial OR team. The main problem there is that most of these OR scientists have little or no experience in real live problem solving.

Our recommendation is that for an initial period of say three years, experienced foreign OR scientists should be employed to work with indigenous trained OR scientists. The experienced foreign OR scientist will have three basic roles namely;

- (i) to undertake OR in the government,
- (ii) to pass on his experience to qualified but relatively inexperienced Nigerian OR scientists, and
- (iii) to provide on the job training for experienced but non OR trained staff.

In order to assist in the recruitment, particularly internal recruitment of experienced staff of the right calibre for training in OR, we have identified the personality traits which are responsible for success in OR using a psychometric instrument - the Sixteen Personality Factor Questionnaire (16PF). The research showed that a suitable candidate for OR work would in addition to having scientific training be someone with a high degree of general intelligence, be reasonably strongly assertive and stubborn, one who may easily disregard organisational rules, practices, traditions and conventional ways of doing things, and one who is suspicious and hard to fool. Such candidate would be one who is highly imaginatively creative, interested in intellectual matters and have a strong willingness to try new solutions to problems, and be highly independent-minded but not necessarily dominant in his relationship with others.

These are qualities the research has revealed as essential for successful high level problem solving, for carrying the OR scientist through those times when new and seemingly untried methods and solutions have to be implemented, and in a scientist dedicated to creating change.

Having staff of the right calibre is essential to successful OR as pointed out by the OR Society U.K. (1968) in their Memorandum to the Fulton Committee on the Civil Service. The Society noted: "Operational research needs to be well done or not at all, and it is correspondingly important to recruit staff of the right calibre and experience." As Streat (1950) questioned, every good scientist may not succeed in OR. Streat queried:

"Is any good scientist qualified to succeed in operational research or does it call for qualities other than pure scientific attainments? If so, what sort of qualities?" (p.133).

We believe that the use of appropriate testing instruments would greatly enhance the selection of individuals with the right personality trait for OR work. As Blum and Naylor (1968) pointed out, it is generally recognised that most people fail in their job not because they are intellectually incompetent but because they may not possess the right personality for the particular job. Blum and Naylor declared:

"...it has been unequivocally determined that in many occupations the people with the highest scores on an intelligence test are not necessarily the most successful employees..." (p.101).

Gaudet and Carll (1957) similarly showed that many people fail in their jobs due to personality problems. In the practice of OR, having a personality suitable for the job is vital to success as pointed out by Blackett (1950) and Tippet (1950) respectively. In order to assist

in the recruitment of candidates with the necessary personality requirements for OR work, a Sixteen Personality profile of OR scientists was constructed during this research. Although the use of this instrument (the 16PF) would be a vital aid in the selection of persons for OR work, we feel that its use in Nigeria should proceed with caution until appropriate norms are available.

#### SUGGESTION FOR FURTHER RESEARCH:

The problems of the introduction of Operational Research into organisations in general and in particular in the developing countries is an under-developed area of Operational Research, but it is a daunting area of research. It calls for dedication and courage. One of the worst handicaps of this research was that the problem was investigated far away from its environment in Nigeria. One looks forward to the day that research of this kind would be undertaken in the developing countries.

A particularly important area in which research results could dramatically affect in a positive direction the processes of the introduction of OR into the developing countries, especially Nigeria, will now be suggested so as to encourage daring OR scientists and other interested researchers to come and help us in the developing countries.

#### The Training of OR Scientists in Developing Countries, Especially in Nigeria:

This is a research that one believes is urgently needed. As argued by Sagasti (1972), Smith (1973), and by Sandhyopadhyay and Varde (1980), OR scientists from the developing countries who have been trained in the developed countries (perhaps like most other professionals trained in the developed countries) do have difficulties in applying their knowledge readily and effectively to problems in the developing countries. In this enquiry the researcher should among other questions seek to find answers

to how OR scientists from the developing countries can be trained in order for them to be able to tackle the problems of development facing the developing countries. In other words, how can the teaching of OR particularly in institutions in the developing countries, be made relevant to solving the problems of development facing the developing countries?

The research should investigate how scientists in the developing countries through training in Operational Research can be mobilized in a crusade for national development such as suggested by Ackoff (1963) and prevent the universities from becoming a haven into which trained OR scientists can escape and from there transmit their "irrelevant knowledge" to others as feared by Ackoff (1974).

The study will attempt to develop a programme which will firmly link OR training done particularly in the developing countries to problem solving in the real world in which governments, industries, and businesses function. One believes that a well designed training programme for OR scientists in the developing countries is an important step in the process of the introduction of OR into the developing countries especially Nigeria.

#### CONCLUDING REMARKS:

How soon the Nigerian Civil Service acquires OR expertise and employs the expertise in government policy, strategic, and tactical decision making depends to a large extent on how soon the recommendations of this research are duly implemented.

We conclude by noting that the introduction of Operational Research into the civil service in Nigeria is a vision which we sincerely hope will come to pass. In the words of an old prophet we declare that:

"...the vision is yet for an appointed time, but at the end it shall speak, and not lie: though it tarry, wait for it; because it will surely come, it will not tarry." (Habakkuk 2:3).

## BIBLIOGRAPHY

- ABALU, G.I.  
"An Optimization Model for Evaluating Tree Crop Development Projects",  
Nigerian Journal of Economics and Social Studies, 17, 1975, 19-34.
- ABALU, G.O.I.  
"A Note on Crop Mixtures Under Indigenous Conditions in Northern  
Nigeria," Journal of Development Studies, 12, 1976, 212-220.
- ABEL, D.J., K.P. STARK, C.R. MURRY and Y.M. DEMOULIN.  
"A Routing and Scheduling Problem for a Rail System: A Case Study,"  
Journal of the Operational Research Society, 32, 1981, 767-774.
- ABKIN, M.H., T.J. MANETSCH, T.W. CARROLL, M.L. HAYENGA, D.R. BYERLEE,  
A.N. HALTER, K. CHONG and G.L. JOHNSON.  
"A Generalised System Simulation Approach to Agricultural Development  
Planning and Policy Making," in M.A. Cuenod and S. Kahne (Eds.) Systems  
Approaches to Developing Countries, International Federation of Automatic  
Control, 1973, 97-107
- ABKIN, M.H. and T.T. MANETSCH.  
"A Development Planning-Oriented Simulation Model for the Agricultural  
Economy of Southern Nigeria, IEEE Transactions on Systems, Man and  
Cybernetics, 2, 1972, 472-486.
- ACKOFF, R.L.  
"National Development Planning Revisited," Operations Research, 25, 1977,  
207-218.
- ACKOFF, R.L.  
"The Role of Research in Underdeveloped Countries," Operations Research,  
16, 1968, 717-729.
- ACKOFF, R.L.  
Redesigning the Future. Wiley, New York, 1974.
- ACKOFF, R.L.  
Creating The Corporate Future, Wiley, New York, 1981.
- ACKOFF, R.L.  
"Unsuccessful Case Studies And Why," Operations Research, 8, 1960,  
259-263.
- ACKOFF, R.L.  
"A Black Ghetto's Research on a University," Operations Research, 18,  
1970, 761-771.
- ACKOFF, R.L. and L. PRITZKER.  
"The Methodology of Survey Research," International Journal of Opinion  
and Attitude Research, 1951, 313-334.
- ADEGBEYEMI, E.O. and D. LONGE.  
"Operations Research Techniques," Management in Nigeria, Journal of the  
Nigerian Institute of Management, April 1976, 22-26.
- ADCOCK, C.J.  
Review of the MMPI, in O.K. Buros (Ed.), The Sixth Mental Measurements  
Year Book, Gryphon, Highland Park, 1965, 313-316.

- ADINIJI, K.  
 "Nigerian Municipal Bus Operations," Transportation Quarterly, 37, 1983,  
 135-143.
- AGTMAEL, A.W.  
 "Evaluating the Risks of Lending to Developing Countries," Euromoney,  
 (April 1976), 16-30.
- AKOM, A.A.  
 "An Integrated Mass Transportation System for Kumasi, Ghana,"  
Transportation Quarterly, 38, 1984, 59-68.
- ALDRED, K.  
 "The Treasury Financial Information System," Management Services in  
 Government, 34, 1979, 90-102.
- ALEXANDER, N.J.B.  
 "Problems of Increasing the Capacity of Existing Railways in Africa,"  
The Courier, No. 56, 1979, 95-98.
- AL-KAZILY, J.  
 "Modeling Containerized Shipping for Developing Countries,"  
Transportation Research-A, 16A, 1982, 271-283.
- ALLPORT, G.W.  
Pattern and Growth in Personality, Holt, Rinehart & Winston, New York,  
 1961.
- ANASTOS, D., A. BEDOS and B. SEAMAN.  
 "The Development of Modern Management Practices in Saudi Arabia,"  
Columbia Journal of World Business, Summer 1980, 81-92.
- ANDERSON, A.M. and M.D. EARLE.  
 "Diet Planning in the Third World by Linear and Goal Programming,"  
Journal of the Operational Research Society, 34, 1983, 9-16.
- ANDERSON, D.  
 "Models for Determining Least-Cost Investments in Electricity Supply,"  
Bell Journal of Economics and Management Science, 3, 1972, 267-299.
- ATTANASI, E.D.  
 "Design of Exploration and Minerals-Data-Collection Programs in  
 Developing Areas," Socio-Economic Planning Science, 15, 1981, 347-352.
- AUERBACH, L.S.  
 "Child Birth in Tunisia Implications of a Decision-Making Model,"  
Social Science and Medicine, 16, 1982, 1499-1506.
- AYODELE, A.S.  
 "The Technological Choice of Decision Making Process: An Example from  
 Nigeria - The Kainji Hydro-Electric Technology: A Multi-Purpose  
 Development Technology," Socio-Economic Planning Science, 16, 1982, 9-14.
- BALDWIN, P.  
 "The Use of Operational Research and Systems Analysis in Government  
 Decision-Making," Management Services in Government, 33, 1978, 5-19.
- BALL, R.  
 "Some Problems in University Planning in Developing Countries," in  
 K.B. Haley (Ed.) Operational Research '75, North-Holland Publishing  
 Company, Amsterdam, 1976, 601-616.

- BANDYOPADHYAY, R.  
"Operational Research in Development Banking in India," European Journal of Operational Research, 2, 1978, 8-25.
- BANDYOPADHYAY, R.  
"OR Applications in Industry and Problems of Industrialisation of a Developing Economy with Special Reference to India," Journal of the Operational Research Society, 31, 1980, 769-780.
- BANDYOPADHYAY, R. and S.D. VARDE.  
"OR Education and Developing Economies with Special Reference to India," The Journal of the Operational Research Society, 31, 1980, 675-687.
- BANERJEE, B.P.  
"A Working Plan for Programming and Sustaining the Growth of Small Scale Industries Around Calcutta," in M. Ross (Ed.) Operational Research '72, North-Holland Publishing Company, Amsterdam, 483-489, 1973.
- BARNETT, D., B. BLAKE and B.A. McCARL.  
"Goal Programming via Multidimensional Scaling Applied to Senegalese Subsistence Farms," American Journal of Agricultural Economics, 64, 1982, 720-727.
- BARR, H. and D. DALTON.  
"Modelling a National Superannuation Scheme," in K.B. Haley (Ed.) Operational Research '75, North-Holland Publishing Company, Amsterdam, 1976, 617-631.
- BARRETT, A.D. and M.B. PESCOD.  
"Water Supply in Developing Countries: Improving on Current Practice," Journal of Water Engineers and Scientists, 36, 1982, 323-337.
- BARROS, O. and A. WEINTRAUB.  
"Production Planning in the Dairy Industry in Chile," in K.B. Haley (Ed.) Operational Research '78, North-Holland Publishing Company, Amsterdam, 1979.
- BARROS, O.H.  
"Design of a Distribution System for Sea Products," in K.B. Haley (Ed.) Operational Research '75, North-Holland Publishing Company, Amsterdam, 1976.
- BARZELAY, M. and S.R. PEARSON.  
"The Efficiency of Producing Alcohol for Energy in Brazil," Economic Development and Cultural Change, 31, 1982, 131-144.
- BAZARAA, M.S. and A. BOUZAHER.  
"A Linear Goal Programming Model for Developing Economies With an Illustration from the Agricultural Sector in Egypt," Management Science, 27, 1981, 396-413.
- BEER, S.  
"Operational Research as Revelation," Journal of Operational Research, 21, 1970, 9-21.
- BECKER, T.M. and P.R. MEYERS.  
"Empathy and Bravado: Interviewing Reluctant Bureaucrats," Public Opinion Quarterly, 38, 1975, 605-613.
- BELBIN, R.M.  
Management Teams. Why They Succeed Or Fail, Heinemann, London, 1981.
- BENITO, C.A.  
"Peasants' Response to Modernization Projects in Minifundia Economies," American Journal of Economics, 58, 1976, 143-151.

- BENKHELIFA, B., P. COIDAN, M. CUENOD and A. SCHARLIG.  
 "Approach to the Optimal Localization of Cement Plants and Cement Distribution Centres in Developing Countries," in M.A. Cuenod and S. Kahne (Eds.) Systems Approaches to Developing Countries, International Federation of Automatic Control, 1973, 347-358.
- BENNETT, V.L., D.J. EATON and R.L. CHURCH.  
 "Selecting Sites for Rural Health Workers," Social Science and Medicine, 16, 1982, 63-72.
- BENYOUSSEF, A. and A.F. WESSEN.  
 "Utilization of Health Services in Developing Countries - Tunisia," Social Science and Medicine, 8, 1974, 287-304.
- BENYOUSSEF, A., J.L. CUTLER, M.P. LEVINE, T. PHAN-TAN, R. BAYLET, H. COLLOMB, S. DIOP, B. LACOMBE, J. RAVEL, J. VAUGELADE and G. DIEBOLD.  
 "Health Effects of Rural-Urban Migration in Developing Countries - Senegal," Social Science and Medicine, 8, 1974, 243-254.
- BHATIA, R.  
 "Technological and Locational Choices in Petroleum and Fertilizer Industries: A Multiprocess Inter-Regional Programming Model for India," Indian Economic Review, 11, 1976, 1-59.
- BHATNAGAR, S.C.  
 "Implementing Linear Programming in a Textile Unit: Some Problems and a Solution," Interfaces, 11, 1981, 87-91.
- BHATNAGAR, S.C.  
 "A Framework for Designing an MIS for Health Delivery System in Rural India," Socio-Economic Planning Science, 16, 1982, 15-19.
- BHENDE, V.P.  
 "Development Planning in Underdeveloped Countries," Management Science, 10, 1964, 796-809.
- BIFFEN, J.  
 "Management and Control of Public Expenditure," Journal of the Operational Research Society, 31, 1980, 1059-1061.
- BINNIE, C.J.A. and D.M. FINLAYSON.  
 "Nile Delta Fish Farm Project," Journal of the Institution of Water Engineers and Scientists, 36, 1982, 129-143.
- BISWAS, A.K.  
 "Environmental and Water Development in Third World," Journal of the Water Resources Planning and Management Division of the American Society of Civil Engineers, 106, 1980, 319-332.
- BISWAS, S.  
 "Waiting Time, Employment Generation and Rate of Outturn," Indian Economic Review, 11, 1976, 159-180.
- BIZIEN, Y.  
 "A Model Relating to the Impact of Rural Development Projects on Population Change," Socio-Economic Planning Science, 13, 1979, 159-174.
- BLACKETT, P.M.S.  
 "Operational Research" in Operational Research: Its Application to Peace-Time Industry, The Manchester Joint Research Council, 1950, 11-16.

- BLASK, J.K.  
 "A Survey of Country Evaluation Systems in Use," in S.H. Goodman (Ed.) Financing and Risk in Developing Countries. Praeger Publishing, New York, 65-70.
- BLUM, M.L. and J.C. NAYLOR.  
Industrial Psychology. Its Theoretical and Social Foundations. (Revised Edition), Harper and Row, New York, 1968.
- BLUMSTEIN, A. and R. LARSON.  
 "Models of a Total Criminal Justice System." Operations Research, 17, 1969, 199-232.
- BOLDY, D.  
Operational Research Applied to Health Services. Groom Helm, London, 1981.
- BOLTON, B.F.  
 Review of the 16PF, in O.K. Buros (Ed.), The Eight Mental Measurement Yearbook. Gryphon, New Jersey, 1978, 1078-1080.
- BOWLES, S.  
 "The Efficient Allocation of Resources in Education," Quarterly Journal of Economics, 81, 1976, 189-219.
- BOWONDER, B.  
 "The Myth and Reality of High Yielding Varieties in Indian Agriculture," Development and Change, 12, 1981, 293-313.
- BOWONDER, B.  
 "Impact Analysis of the Green Revolution in India," Technological Forecasting and Social Change, 15, 1979, 297-313.
- BOWONDER, B.  
 "Appropriate Technology: A Systems View," Human Systems Management, 2 (No. 2), 1981, 95-100.
- BOYD, A.T. and P.R. FOURACRE.  
 "Land Transport Planning in Algeria - The Short Term Solution," in M.A. Cuenod and S. Kahne, (Eds.) Systems Approaches to Developing Countries. International Federation of Automatic Control, 1973, 295-304.
- BRASCH, J.J.  
 "Sales Forecasting Difficulties in a Developing Country," Industrial Marketing Management, 19, 1978, 354-360.
- BRAY, J.  
 "Decision-Making in Government," Operational Research Quarterly. Special Conference Issue, 1968, 25-35.
- BUDHU, G. and A.G. HOBEIKA.  
 "Transportation Investment in Less-Developed Countries: The case of Guyana," Transportation Research Record 747. Transportation Research Board, National Academy of Sciences, Washington D.C. 1980, 93-97.
- BUROS, O.K. (Ed.)  
The Eight Mental Measurements Yearbook. Gryphon, New Jersey, 1978.
- BUTLER, F.E.R. and K. ALDRED.  
 "The Financial Information Systems Project," Management Services in Government. 32, 1977, 77-87.
- BUTT, D.S.  
 "Value and Personality Dimensions: Their Constancies and their Relationships." Psychological Reports. 1966, 19, 1115-1124.

- BUTTERFIELD, D. and A.A. KUBURSI.  
 "Investment Planning and Industrialization of the Syrian Arab Republic: A Simulation Exercise," UNIDO: Industry and Development, No. 6 1981, 65-85.
- BYERLEE, B., C.K. EICHER, C. LIEDHOLM and D.S.C. SPENCER.  
 "Employment-Output Conflicts, Factor-Price Distortions, and Choice of Technique: Empirical Results from Sierra Leone," Economic Development and Cultural Change, 31, 1983, 315-336.
- CABRAAL, R.A.  
 "Production in a Sri Lanka Coconut Mill Using Parametric Linear Programming," Interfaces, 11, 1981, 16-23.
- CALKINS, P.H.  
 "Nutritional Adaptations of Linear Programming for Planning Rural Development," American Journal of Agricultural Economics, 63, 1981, 247-254.
- CARRUTHERS, I.D.  
 "Constraints and Strategic Choices in Water Supply Investment," in M.A. Cuenod and S. Kahne (Eds.) Systems Approaches to Developing Countries Internatioal Federation of Automatic Control, 1973, 225-234.
- CARTER, E.C., H.S. CHADDA and P.H. SCHONFIELD.  
 "A Comparison of Transportation Planning in Developed and Developing Countries," Transportation Quarterly, 33, 1984, 69-85.
- CARTER, R.D., J.G. HAMILTON and P.J. WILLIAMS.  
 "Corporate Planning in Developing Economies," Long Range Planning, 6, No. 2 1973, 2-5.
- CATTELL, R.B.  
"Personality", McGraw-Hill, New York, 1950.
- CATTELL, R.B.  
Personality and Motivation Structure and Measurement, New York, World Book, 1957.
- CATTELL, R.B.  
 "The Primary Personality Factors in Women Compared with those in Men," British Journal of Psychology, 1943, 1, 114-130.
- CATTELL, R.B.  
 " $r_p$  And Other Coefficients of Pattern Similarity," Psychometrika, 14, 1949, 279-298.
- CATTELL, R.B., H.W. EBER and M.M. TATSUOKA.  
Handbook For The Sixteen Personality Factor Questionnaire (16PF), Institute For Personality and Ability Testing, Champaign, Illinois, 1970.
- CATTELL, R.B. and K.H. DELHEES.  
 "Seven Missing Normal Personality Factors in the Questionnaire Primaries," Multivariate Behavioural Research, 8, 1973, 173-194.
- CHACKO, G.K.  
Management Information Systems, Petrocelli, New York, 1979.
- CHANG, J.Y.  
 "Traffic Conflict Technique in Taiwan, Taiwan," Transportation Engineering Journal of the American Society of Civil Engineers, 106, 1980, 99-110.
- CHARLES, C., D. BLANDFORD and R.N. JOISVENT.  
 "Import Substitution for Livestock Feed in the Caribbean Community," American Journal of Agricultural Economics, 64, 1982, 70-79.

- CHARNES, A., M.J.L. KIRBY and S.A. WALTERS.  
"Horizon Models of Social Development," Management Science, 17, 1970,  
9-165 - 8-177.
- CHI-FA, K.  
"Extension Work, Practical Applications and Theoretical Studies of Some  
Methods of Seeking the Optimum in China," in K.B. Haley (Ed.) Operational  
Research '75, North-Holland Publishing Company, Amsterdam, 1976, 3-11.
- CHISNALL, P.M.  
Marketing Research: Analysis and Measurement, McGraw-Hill, London, 1973.
- CHRISTIAN, B., D. RAY, A. BENYOUSSEF and T. TANAHASHI.  
"Health and Socio-Economic Development: An Intersectoral Model,"  
Social Science and Medicine, 11, 1977, 63-69.
- CLAYSON, J.  
"How Relevant is Operational Research to Development? The Case of  
Kenyan Industry," Operational Research Quarterly, 31, 1980, 293-299.
- COLLINS, W.A.  
"Verbal Idiosyncracies as a Source of Bias," Public Opinion Quarterly, 34,  
1970, 416-422.
- CONLEY, D.M. and E.O. HEADY.  
"The Interregional Impacts of Improved Truck Transportation on Farm  
Income from Rice in Thailand," Journal of the Developing Areas, 15, 1981,  
543-560.
- CORNLISSSE, P.A. and J. KOL.  
"Price Policy, Price Consistency and Employment in Less Developed  
Countries," in K.B. Haley (Ed.) Operational Research '75, North-Holland  
Publishing Company, Amsterdam, 1976, 343-356.
- CORREA, H.  
"The Human Resources Approach to Manpower, Education and Income Distribution  
Planning," Socio-Economic Planning Science, 12, 1976, 135-143.
- COX 111, E.P.  
Marketing Research. Information for Decision Making. Harper & Row,  
New York, 1979.
- CROWFORD, E.W. and R.A. MILLIGAN.  
"A Multi-Year, Stochastic, Farm Simulation Model for Northern Nigeria:  
An Experimental Design Approach," American Journal of Agricultural Economics  
64, 1982, 723-737.
- CUNTO, E.  
"Scheduling Boats to Sample Oil Wells in Lake Maracaibo," Operations  
Research, 26, 1978, 183-196.
- DANIEL, R.R. and S.J. LLOYD.  
"Microbiological Studies on Two Oxfam Sanitation Units Operating in  
Bengali Refugee Camp," Water Research, 14, 1980, 1567-1571.
- DAVIG, W.  
"Industrial Buying Behaviour in Brazil," Industrial Marketing Management,  
9, 198, 273-280.
- DAVIS, P.  
"The Transfer of Systems Technology: Logistics Systems for Underdeveloped  
Countries," European Journal of Operational Research, 7, 1981, 232-241.

- de NEUFVILLE, R.  
 "Cost Effectiveness Analysis of Civil Engineering Systems: New York City's Primary Water Supply," Operations Research, 18, 1970, 785-804.
- DENITCH, B.  
 "Elite Interviewing and Social Structure: An Example from Yugoslavia," Public Opinion Quarterly, 36, 1972, 143-158.
- DHOLAKIA, N., R. KHURANA, L. BHANDARI and M.N. VORA.  
 "On Normative Policy Models in Developing Countries," Omega, 7, 1979, 359-360.
- DIAZ, A. and R. MARTINEZ.  
 "A Case study in the Improvement of the Sugar Cane Transport System," in M.A. Cuenod and S. Kahne (Eds.) Systems Approaches to Developing Countries, International Federation of Automatic Control, 1973, 175-179.
- DIXON, B.L. and W.H. CHEN.  
 "A Stochastic Control Approach to Buffer Stock Management in the Taiwan Rice Market," Journal of Development Economics, 10, 1982, 187-207.
- DODSON, E.N.  
 "Cost-Effectiveness in Urban Transportation," Operations Research, 17, 1969, 373-394.
- DOHRENWEND, B.S.  
 "Some Effects of Open and Closed Questions," Human Organization, 1965, 24, 175-184.
- DONALDSON, W.  
 "Enterprise and Innovation in an Indigenous Fishery: The Case of the Sultanate of Oman," Development and Change, 11, 1980, 479-495.
- DUE, J.F.  
 "The Problems of Rail Transport in Tropical Africa," Journal of Developing Areas, 13, 1979, 373-393.
- DUE, J.F.  
 "The Economic Viability of the Railways of Tropical Africa," Journal of Development Economics, 7, 1980, 263-272.
- DURSTINE, R.M. and R.G. DAVIS.  
 "Educational Planning in Developing Countries - A Positive Role for Operations Research," Operations Research, 17, 1969, 911-915.
- DYSON, T.P., C.L.G. BELL and R.H. CASSEN.  
 "Fertility, Mortality and Income-Change Over the Long-Run: Some Simulation Experiments," Journal of Development Studies, 14, 1977, 40-78.
- EASTER, K.W.  
 "Field Channels: A Key to Better Indian Irrigation," Water Resources Research, 11, 1975, 389-392.
- EMERSON, E.C., J. FIELD, P.R. FOURACRE and N.G. WILLIAMSON.  
 "A Systems Approach to Transport Planning in Algeria," in M.A. Cuenod and S. Kahne (Eds.) Systems Approaches to Developing Countries, International Federation of Automatic Control, 1973, 261-269.
- ELSHAFEI, A.N.  
 "O.R. in Developing Economies: Some Experience with Applying O.R. in Egypt's National Planning Studies," in K.B. Haley (Ed.) Operational Research '75, North-Holland Publishing Company, Amsterdam, 1976, 13-23.

- ELSHAFEI, A.N. and E.E. ELHADIDI.  
"Use of LP in Intergrated Planning - An Application from the Egyptian Industry," European Journal of Operational Research, 6, 1981, 279-285.
- EYSENCK, H.J.  
The Structure of Human Personality, Methuen, London, 1953.
- EYSENCK, H.J.  
"Personality and Factor Analysis: A reply to Guilford," Psychological Bulletin, 84, 1977, 405-411.
- FAJARDO, D., B.A. McCARL, and R.L. THOMPSON.  
"A Multicommodity Analysis of Trade Policy Effects: The Case of Nicaraguan Agriculture," American Journal of Agricultural Economics, 63, 1981, 23-31.
- FASS, S.  
"Water and Politics: The Process of Meeting a basic need in Haiti," Development and Change, 13, 1982, 347-364.
- FEDER, G., R. JUST and A. SCHMITZ.  
"Storage with Price Uncertainty in International Trade," International Economic Review, 18, 1977, 553-568.
- FEDER, G.  
"Farm Size, Risk Aversion and the Adoption of New Technology Under Uncertainty." Oxford Economic Papers, 32, 1980, 263-283.
- FEDER, G., R. JUST and K. ROSS.  
"Projecting Debt Servicing Capacity of Developing Countries," Journal of Financial and Quantitative Analysis, 16, 1981, 651-669.
- FEI, J.C.H. and G. RANIS.  
"A Model of Growth and Employment in the Open Dualistic Economy: The Cases of Korea and Taiwan," Journal of Development Studies, 11, No. 2 1975, 32-63.
- FILANI, M.O.  
"Some Critical Issues in Air Transport Planning in Nigeria," Nigerian Journal of Economic and Social Studies, 17, 1975, 49-62.
- FLAGLE, C.D.  
"Operations Research in the Health Services," Operations Research, 10, 1962, 591-603.
- FONG, C.O.  
"A Model for Analysis of the Malaysian Family Planning Programme," European Journal of Operational Research, 11, 1982, 133-144.
- FORCESE, D.P. and S. RICHER.  
Social Research Methods, Prentice-Hall, Englewood, Cliffs, New Jersey, 1973.
- FORSYTH, D.J.C. and R.F. SOLOMON.  
"Choice of Technology and Nationality of Ownership in Manufacturing in a Developing Country," Oxford Economic Papers, 29, 1977, 528-582.
- FRANKEL, R.J.  
"Systems Evaluation of Village Water Supply and Treatment in Thailand," Water Resources Research, 11, 1975, 383-388.

- FREDERIKSON, P.C.  
"Further Evidence on the Relationship Between Population Density and Infrastructure: The Philippines and Electrification," Economic Development and Cultural Change, 29, 1981, 749-758.
- FREEMAN, D.L. and R. KAREN.  
"The Farmer and the Money Economy: The Role of the Private Sector in the Agricultural Development of LDCs," Technological Forecasting and Social Change, 22, 1982, 183-200.
- FREIVALDS, J.  
"Bringing Space Down to Earth; Space Age Technology Transfer and the Developing Countries," Journal of Developing Areas, 8, 1973, 83-92.
- FRERICHS, R.R. and J. PRAWDA.  
"A Computer Simulation Model for the Control of Rabies in an Urban Area of Colombia," Management Science, 22, 1975, 411-421.
- FRIEND, J.K. and W.N. JESSOP.  
Local Government and Strategic Choice: An Operational Research Approach to the Process of Public Planning, Tavistock Publications, London, 1969.
- GANDHI, K.K., V.A. ZVONDOV and H. SINGH.  
"Development of a Driving Cycle for Fuel Economy in a Developing Country," Transportation Research-A, 17A, 1983, 1-11.
- GAUDET, F.J. and A.R. CARLI.  
"Why Executives Fail," Personnel Psychology, 10, 1957, 7-21.
- GAURISO, G., K. HAYNES, D. WHITTINGTON and YONIS.  
"Energy, Agriculture and Water: A Multiobjective Programming Analysis of the Operations of the High Aswan Dam," Environmental Planning, A12 1980, 369-379.
- GAZIS, D.C.  
"Future Major World Problems and Operations Research," in K.B. Haley (Ed.) Operational Research '78, North-Holland Publishing Company, Amsterdam, 1979.
- GEARING, C.E., W.W. SWART and T. VAR.  
"Determining the Optimal Investment Policy for the Tourism Sector of a Developing Country," Management Science, 20, 1973, 487-497.
- GERSHENBERG, I. and M.A. HASKELL.  
"The Distribution of Medical Services in Uganda," Social Science and Medicine, 6, 1974, 353-372.
- GHOSAL, R.  
"Operations Research in the Coal Industry in India," in D.B. Hertz and J. Melese (Eds.) The Proceedings of the Fourth International Conference on Operational Research, Wiley, 1966, 814-821.
- GLADWIN, C.H.  
"A View of the Plan Puebla: An Application of Hierarchical Decision Model," American Journal of Agricultural Economics, 58, 1976, 881-887.
- GLEN, T.M. and C.F. JAMES Jr.  
"Difficulties in Implementing Management Science Techniques in a Third World Setting," Interfaces, 10, 1980, 39-43.

- GLICKMAN, T.S. and S.V. ALLISON.  
 "Investment Planning for Irrigation Development Projects," Socio-Economic Planning Science, 17, 1973, 113-122.
- GOH, T.N.  
 "Quantitative Analysis of Some Decision Rules for Family Planning in an Oriental Society," Interfaces, 11, 1981, 31-37.
- GOLDBERG, M.D.  
 "Linking National-Level and Village-Level Energy-Planning in Developing Countries," Human Systems Management, 3, 1982, 195-200.
- GONZAGA, C.C., R.M. PERSIANO and S. CARNEIRO Jr.  
 "Optimal Planning of the Expansion of a Power Transmission System," in M.A. Ceunod and S. Kahne (Eds.) Systems Approaches to Developing Countries, International Federation of Automatic Control, 1973, 217-224.
- GOROON, R.L.  
Interviewing: Strategy, Techniques, and Tactics. Dorsey, Homewood, Illinois, 1969.
- GOULD, F.J. and M.J. MAGAZINE.  
 "A Mathematical Programming Model for Planning Contraceptive Deliveries," Socio-Economic Planning Science, 5, 1971, 255-261.
- GOYAL, S.K. and J.P. YADAV.  
 "Allocation of Doctors to Health Centres in Haryana State of India - A Case Study," Journal of the Operational Research Society, 30, 1979, 427-431.
- GRIBBIN, J.A.  
 "Potential Effects of Re-opening and Expanding the Suez Canal on the Shipment Cost of Crude Oil," Transportation Research, 9, 1975, 259-263.
- GUILFORD, J.P.  
"Personality". McGraw-Hill, New York, 1959.
- GUILFORD, J.P.  
 "Factors and Factors of Personality," Psychological Bulletin, 82, 1975, 802-814.
- GUION, R.M.  
Personnel Testing. McGraw-Hill, New York, 1965.
- GUPTA, J.D.  
 "Regional Land Use and Transportation Development Optimization Model for Delhi Region of India," Transportation Research Record 848, National Academy of Sciences, Washington D.C., 1982, 21-28.
- GUPTA, S.K. and M.S. KRISHNAMOORTHY.  
 "Government Services Workshop," in K.B. Haley (Ed.) Operational Research '75, North-Holland Publishing Company, 1976, 597-599.
- HAGAN, R.E. and J. WANG.  
 "Minimizing Canal Capacity for Irrigated Rice," Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, 103, 1977, 71-78.
- HAND, N.E.  
 "The Metropolitan Police M.S. Department," Management Services in Government 29, 1974, 153-163.

- HAISSMAN, I.  
 "Generating Skilled Manpower for Irrigation Projects in Developing Countries: A Study of North West Mexico," Water Resources Research, 7, 1971, 1-17.
- HALTER, A.N. and S.F. MILLER.  
 "Simulation in a Practical Policy-Making Setting: The Venezuelan Cattle Industry," in M.A. Cuenod and S. Kahne (Eds.) Systems Approaches to Developing Countries, International Federation of Automatic Control, 1973, 109-116.
- HALL, C.S. and G. LINDZEY.  
Theories of Personality, (Third Edition, Wiley), New York, 1957.
- HANNAH, L.M.  
 "Choice of Ground Water Irrigation Technology in Bangladesh," The Bangladesh Development Studies, 6, 1978, 55-70.
- HARAN, E.G.P.  
 "An Optimization Model for the Allocation of Resources in Family Planning Programs," Socio-Economic Planning Science, 13, 1979, 13-20.
- HAYS, A.M.  
 "The Importance of Passenger Transport in Nigeria," Nigerian Journal of Economic and Social Studies, March 1969.
- HAZELL, P.B.R. and C. POMAREDA.  
 "Evaluating Price Stabilization Schemes with Mathematical Programming," American Journal of Agricultural Economics, 63, 1981, 550-556.
- HAZLEWOOD, A. and I. LIVINGSTONE.  
 "Complementarity and Competitiveness of Large and Small-Scale Irrigated Farming: A Tanzanian Example," Oxford Bulletin of Economics and Statistics, 40, 1978, 195-208.
- HEANY, D.F.  
 "Is TMS Talking to Itself?," Management Science, 12, 1965, 8146 - 8155.
- HELLAND, J.  
 "Social Organisation and Water Control among the Borana," Development and Change, 13, 1982, 239-258.
- HERATH, H.M.G.  
 "Crop Mixtures Under Peasant Conditions: A Decision Theoretic Interpretation," Journal of Development Studies, 16, 1980, 322-331.
- HERATH, H.M.G., J.B. HARDAKER and J.R. ANDERSON.  
 "Choice of Varieties by Sri Lanka Rice Farmers: Comparing Alternative Decision Models," American Journal of Agricultural Economics, 64, 1982, 87-93.
- HILGARD, E.R.  
Introduction to Psychology, (Third Edition), Harcourt, Brace and World, New York, 1962.
- HILHURST, J.G.M.  
 "National Development Strategies and Regional Planning in Latin America: Some Reflections," Development and Change, 12, 1981, 525-545.
- HILL, H.  
 "Choice of Technique in the Indonesian Weaving Industry," Economic Development and Cultural Change, 31, 1983, 337-353.

- HINDLE, D.  
 "Management Science in Developing Countries: Adopting the Right Style," Omega, 6, 1978, 370.
- HOFFMAN, K.  
 "Alternative Energy Technologies and Third World Rural Energy Needs: A Case of Emerging Technological Dependence," Development and Change, 11, 1980, 335-365.
- HOFMEIER, R.  
 "The Political Economy of Transport Projects." Intereconomics, 66, 1980, 94-99.
- HOFSTEDE, G.  
Culture's Consequence: International Differences in Work-Related Values. Sage, London, 1980.
- HOLDGATE, M.W. (Chairman)  
Management Committee for the Science Group (Civil Service Department) - Review of the Scientific Civil Service. Cmd. 8032, Her Majesty's Stationery Office, London, 1980.
- HOLSEN, J.A.  
 "World Bank Techniques for Country Evaluation," in S.H. Goodman (Ed.) Financing and Risk in Developing Countries, Praeger Publishing, New York, 1973, 38-93.
- HOLTZMAN, W.H.  
 "Methodological Issues in P technique," Psychological Bulletin, 59, 1962, 248-256.
- HOWARTH, E.  
 "Factor Analysis has only just begun to fight - a reply to Lykken," Journal of Experimental Research in Personality, 6, 1972, 266-272.
- HUNT, W.H., W.W. CRANE and J.C. WAHLKE.  
 "Interviewing Political Elites in Cross-Cultural Comparative Research," American Journal of Sociology, 70, 1964, 59-65.
- ISAAC, S.L.  
 "Price, Competition, and Profits among Hawkers and Shopkeepers in Pendembu, Sierra Leone: An Inventory Approach," Economic Development and Cultural Change, 29, 1981, 353-373.
- IWAYEMI, A.  
 "An Investment Planning Model for the Electricity Sector in Nigeria," Socio-Economic Planning Science, 12, 1978, 285-292.
- JACKSON, H.M.  
 "To Forge a Strategy for Survival," Public Administration Review, 19, 1959, 159.
- JALOTA, S.  
 "Personality Factors. A Comparative Study of Average American and Indian College Adults," Science and Culture, 23, 1957, 22-23.
- JOHNSON, H.  
 "Welcome from M-I.T." in D.S. Hertz and J. Melese (eds.) The Proceedings of the Fourth International Conference on Operational Research, Wiley, New York, 1965.

- JOHNSON, J.  
The Economics of Indian Rail Transport, Allied Publishers,  
Bombay, India, 1963.
- JOHNSON, S.H. and T. CHAROENWATANA.  
"Economics of Rainfed Cropping Systems in Northeast Thailand,"  
Water Resources Research, 17, 1981, 462-468.
- JOHNSTON, K.H.  
British Railways and Economic Recovery. A Sociological Study  
of the Transport Problem, Clerke and Cockeran, London, 1949.
- JONES, C.O.  
"Notes on Interviewing Members of the House of Representatives,"  
Public Opinion Quarterly, 24, 1960, 404-406.
- JONES Jr., R.J.  
"A Model for Predicting Expropriation in Latin America Applied to  
Jamaica," Colombia Journal of World Business, Spring 1980, 74-80.
- KAMRANY, N.M.  
"The Three Vicious Circles of Underdevelopment: The Sahel-  
Sudan Case of West Africa," Socio-Economic Planning Science,  
19, 1975, 137-145.
- KANE, E.  
Doing Your Own Research. Basic Descriptive Research in the  
Social Sciences and Humanities, Turco Press, Dublin, 1983.
- KEMBALL-COOK, D. and D.J. WRIGHT.  
"The Search for Appropriate O.R.: A Review of Operational  
Research in Developing Countries," Journal of the Operational  
Research Society, 32, 1981, 1021-1037.
- KIRSHEN, P.H.  
"Water Supply Model for West Africa," Journal of the Water  
Resources Planning and Management Division, American Society of  
Civil Engineers, 105, 1979, 413-427.
- KORNHAUSER, W.  
Scientists in Industry: Conflicts and Accommodation, University  
of California Press, Berkeley, 1962.
- KOSHAL, R.K.  
"Economies of Scale in Railway Transport," Indian Economic  
Review, 5, 1970, 177-191.
- KUMAR, S.P.  
"Long-Term Planning for Indian Shipping," Long Range Planning,  
9, (No. 6), 1976, 63-68.
- LAHIRI, S.  
"Investment Planning for the Electric Power Industry in  
Northern India: A Spatial Programming Approach," Indian  
Economic Review, 12, 1977, 43-72.
- LAKSHMINARAYANA, V. and P. RAJAGOPALAN.  
"Optimal Cropping Pattern for Basin in India," Journal of the  
Irrigation and Drainage Division, American Society of Civil  
Engineers, 103, 1977, 53-70.

- LAMBO, E.  
 "An Optimization Simulation Model of a Rural Health Centre in Nigeria," Interfaces, 13, 1983, 29-35.
- LAWRENCE, G.E. and A.I. MUNDIGO.  
 "Realpop: A Mathematical Model for Resources Allocation in Population Programs - Results from a test in Dominican Republic Studies," Family Planning, 6, 1975, 54-63.
- LAWRENCE, C.E., A.I. MUNDIGO and C.S. REVELLE.  
 "Analysis of the Allocation of Resources in Family Planning Programs," Management Science, 20, 1973, 520-531.
- LEGASTO Jr. A.A.  
 "A Multiple-Objective Policy Model: Results of an Application to a Developing Country," Management Science, 24, 1980, 493-509.
- LEPSCHY, A., S. MILO and D. TORRIANO.  
 "Modelling Techniques for a System Engineering Approach of Water Use for Agricultural Purposes," in M.A. Cuenod and S. Kahne (Eds.) Systems Approaches to Developing Countries, International Federation of Automatic Control, 1973, 491-497.
- LEUNG, C.K.  
 "The Analysis and Interpretation of National Transportation Networks, with Special Reference to the Case of China," Third World Planning Review, 4, 1982, 177-191.
- LEVARY, R.R. and T.S. CHOI.  
 "A Linear Goal Programming Model for Planning the Exports of Emerging Countries," Journal of the Operational Research Society, 34, 1983, 1057-1067.
- LIETAER, B.A.  
 "A Planning Model for Underground Mines - An Application in a Developing Country," Omega, 15, 1977, 149-159.
- LINGARAJ, B.P.  
 "Production and Inventory Planning in the Beedi Industry," Interfaces, 10, 1980, 97-102.
- LIVINGSTONE, I. and A. HAZLEWOOD.  
 "The Analysis of Risk in Irrigation Projects in Developing Countries," Oxford Bulletin of Economics and Statistics, 41, 1979, 21-35.
- LLOYD, B.  
 "Are We Taking the World Development Problem Seriously? - An Overview of Recent Reports and Publications - Book Review Article," Long Range Planning, 12, 1979, 97-99.
- LONGE, G.A.E.  
 "The Management Challenges for the 1980's" Address to the Nigerian Association of Management Consultants, 1980iii, Establishment Division, Lagos.
- LONGE, G.A.E.  
 "Leadership in the Public Service," Lecture delivered at the Command and Staff College, Jaji, 1980ii, Establishment Division, Lagos.

- LONGE, G.A.E.  
 "Problems of the Public Service" Address to the Senior Executive Course No. 1 at the National Institute for Policy and Strategic Studies at Kuru, 1980i, Establishment Division, Lagos.
- LONGE, G.A.E.  
 "Preparing for Change to the Presidential System," Address given to a Seminar on the Role of the Higher Civil Service in the Presidential System of Government, 1979, Establishment Division, Lagos.
- LOW, A.R.C.  
 "Small Farm Improvement Strategies - The Implication of a Computer Simulation Study of Indigenous Farming in South-East Ghana," Journal of Development Studies, 12, 1976, 334-350.
- LOW, A.R.C.  
 "Decision Taking Under Uncertainty: A Linear Programming Model of Peasant Farmer Behaviour," Journal of Agricultural Economics, 25, 1974, 311-321.
- LUBORSKY, L.  
 "Intra-Individual Repetitive Measurements (P techniques) in Understanding Psychotherapeutic Change," in O.H. Merver (Ed.), Psychotherapy-theory and Research, Ronald, New York, 1953, 388-413.
- LUCK, D.J., H.G. WALES, D.A. TAYLOR, and R.S. RUBIN.  
Marketing Research, (sixth edition), Prentice-Hall, Englewood Cliffs, New Jersey, 1982.
- LUCK, G.M.  
 "Barefoot ORSA," in K.B. Haley (Ed.) Operational Research '78, North-Holland Publishing Company, Amsterdam, 1979.
- LUCK, G.M., J.-LUCKMAN, B.W. SMITH, and J. STRINGER.  
Patients, Hospitals and Operational Research, Tavistock, London, 1971.
- MADDOCK, C. and H. MORGAN.  
 "Assessing the Effects of New U.K. Coins," Management Services in Government, 36, 1981, 218-224.
- MADELEY, J.  
 "Getting the Trains to Run on Time...," Guardian, 15 April 1981, 8.
- MADHNA, L.C.  
 "Simulation and Analysis of Energy Demand for Passenger Automobiles in Australia," Transportation Research-A, 14A, 1980, 235-240.
- MAHALANOBIS, P.C. and M. MUKHERJEE.  
 "Operational Research Models Used in Planning in India," in J. Banbury and J. Maitland (Eds.) Proceedings of the Second International Conference on Operational Research, English Universities Press Ltd., London, 1961, 523-533.
- MAHMASSANI, H. and R. GAKENHEIMER.  
 "Budget Estimation for Transport Project Programming Under Uncertainty," Third World Planning Review, 5, 1983, 149-164.
- MALIK, M.A.K. and I. AHMAD.  
 "Forecasting Demand for Food in Libya - Using Confidence Limits," Long Range Planning, 14, 1981, 90-96.

- MANETSCH, T.J., M.L. HAYENGA, and A.N. HALTER.  
 "Simulation of Nigerian Development: Northern Region Model,"  
IEEE Transactions on Systems, Man and Cybernetics, 1, 1971, 31-43.
- MARTINEZ, R.  
 "Strategic Planning in the Planting and Cutting of Sugar Cane Varieties,"  
 in M.A. Cuenod and S. Kahne (Eds.) Systems Approaches to Developing  
 Countries, International Federation of Automatic Control, 1973, 169-173.
- MATZKE, G.  
 "A Reassessment of the Expected Development Consequences of Tsetse  
 Control Efforts in Africa," Social Science Medicine, 17, 1983, 531-537.
- MAYO, A.L. and A.G. BARRETT  
 "An Early-Warning Model for Assessing Developing-Country Risk," in  
 S.H. Goodman (Ed.) Financing and Risk in Developing Countries,  
 Praeger Publishing, New York, 1976, 81-87.
- MCCARTHY, S.J.  
 "Potential Applications of O.R. in Developing Countries - A Generalization  
 from Botswana," Journal of the Operational Research Society, 29, 1978,  
 167-170.
- MCCLELLAND, D.C.  
Personality, Sloane, New York, 1951.
- MCGRATH, J.E.  
 "Toward a 'Theory of Method' for Research on Organisations" in U.W. Cooper,  
 H.J. Leavitt, and M.W. Shelly New Perspectives in Organisation Research,  
 Wiley, New York, 1964.
- MELLALIEU, P.J.  
 "A Decision Support System for Corporate Planning in a New Zealand Dairy  
 Company," A Paper Presented at the Twenty-fifth Annual Conference of  
 the Operational Research Society, University of Warwick, England, 1983.
- MELLALIEU, P.J. and K.R. HALL.  
 "An Interactive Planning Model for the New Zealand Dairy Industry,"  
Journal of Operational Research Society, 34, 1983, 521-532.
- MEREDITH, G.M.  
 "Personality correlates to religious belief systems," Psychological  
 Reports, 1968, 23, 1039-1042.
- MEREDITH, G.M., and C.G.W. MEREDITH.  
 "Acculturation and personality among Japanese-American college students  
 in Hawaii," Journal of Social Psychology, 68, 1966, 176-182.
- MESAROVIC, M.D.  
 "Industrialisation of the Third World and What it Means For Industry  
 Today," Management Review, 70, 1981, 34-35.
- METRA CONSULTING.  
Nigeria: Business Opportunities in the 1980s, Metra Consulting, London  
 1981.
- METWALLY, M.H.  
 "Economic Multipliers for the Maltese Economy," Socio-Economic Planning  
 Science, 13, 1979, 1-5.
- MICHELL, T.  
 "Urban Transportation in Korea: Lesson for the World or a  
 Passing Phase?," Transportation Research Record 484, National  
 Academy of Sciences, Washington D.C., 1982, 15-20

- MICKLE, M.H. and W.G. VOGT.  
 "A Dynamic Sociological System Model," in M.A. Cuenod and S. Kahne (Eds.) Systems Approaches to Developing Countries. International Federation of Automatic Control, 1973, 475-480.
- MINHAS, B.S., K.S. PARIK and R.N. SRINIVASAN.  
 "Toward the Structure of a Production Function for Wheat Fields With Dated Inputs of Irrigation Water," Water Resources Research, 10, 1974, 383-393.
- MINTZBERG, H.  
Policy as a Field of Management Theory. Working-paper, Universite de Droit, d'Economie et des Sciences d'Aix-Marseille, Institut D'Administration Des Entreprises, Centre D'Etude et de Recherche sur les Organisations et la Gestion, Aix-En-Provence, April, 1975.
- MISCHIL, W.  
Personality Assessment. Wiley, New York, 1968.
- MITCHELL, G.H.  
 "Images of Operational Research," Journal of Operational Research Society, 31. 1980, 459-466.
- MITROFF, I.I. and R.H. KILMANN.  
Methodological Approaches to Social Science, Jossey-Bass Publishers, San Francisco, 1978.
- MOGHADAM, F.E.  
 "Farm Size, Management and Productivity: A Study of Four Iranian Villages," Oxford Bulletin of Economics and Statistics, 44, 1982, 357-379.
- MONNAN TEUIL, Y.  
 "Project of a Plan on the Dimensioning of the Habor Infrastructure," in M.A. Cuenod and S. Kahne (Eds.) Systems Approaches to Developing Countries, International Federation of Automatic Control, 1973, 311.
- MONTAZEMI, M. and D.J. WRIGHT.  
 "Mathematical Programming in Subsistence Agriculture," European Journal of Operational Research, 10, 1982, 346-350.
- MORRIS, C.  
Varieties of Human Value. University of Chicago Press, 1956.
- MORSE, P.N and A.A. BROWN.  
 "Operations Research in the Developing Countries - A Role for IFORS," in K.B. Haley (Ed.) Operational Research '75, North-Holland Publishing Company, Amsterdam, 1976, 111-124.
- MORSE, P.M. and L.A. BACON (Eds.).  
Operations Research for Public Systems, The M.I.T. Press, 1968.
- MORTAGY, A.K. and S.A. ELEITHY.  
 "Optimizing Transportation Service for Oil Exploration," Interfaces, 10, 1980, 13-21.
- MOSCARDI, E. and A. de JANVRY.  
 "Attitudes Roward Risk Among Peasants: An Econometric Approach," American Journal of Agricultural Economics, 59, 1977, 710-716.
- MOSEL, J.N. and J.B. ROBERTS.  
 "The Comparability of Measures of Profile Similarity: An Empirical Study," Journal of Consulting Psychology, 18, 1954, 61-66.
- MOSER, C.A. and G.KALTON.  
Survey Methods in Social Investigation, (2nd Ed.), Heinemann, 1971
- MUIR, M., M. DIZY and C. FAULKNER.  
 "Operational Research in Chile, " O.R.Q., 15, 164, 303-317.

- MWASE, N.  
 "The Supply of Road Vehicles in Tanzania: The Problem of Suppressed Demand," Journal of Transport Economics and Policy, 17, 1983, 77-89.
- MYERS, S.  
 "One Signalbox to Control All Lines" Railway Gazette International, December 1981, 1035-1036.
- NATIONAL ACADEMY OF SCIENCES.  
Systems Analysis and Operations Research: A Tool For Policy and Program Planning in Developing Countries. National Academy of Sciences, Washington, 1976.
- NELSON, M.  
 "Application of Management Science to Water Resources Planning in Latin America: Some Lessons," European Journal of Operational Research, 3, 1979, 6-12.
- NILSEN, S.E.  
 "The Use of Computer Technology in Some Developing Countries," International Social Science Journal, 13, 1979, 513-528.
- ODIFE, O.  
 "Decongesting Apapa Port," Management in Nigeria, Journal of the Nigerian Institute of Management, 11, 1975, 21-25.
- OGUNFOWORA, O. and E.O. HEADY.  
 "Integrating Short-Term Farm Enterprises with Perennial Tree Crops: An Application of Recursive Programming to a Tree Crop Settlement," Nigerian Journal of Economics and Social Studies, 15, 1973, 81-94.
- OGUNSANYA, A.A.  
 "Spatial Pattern of Urban Freight Transport in Lagos Metropolis," Transportation Research-A, 16A, 1982, 289-300.
- OKITA, S.  
 "Present Issues in Developing Countries and Future Challenge for Development," in K.B. Haley (Ed.) Operational Research '75, North-Holland Publishing Company, 1976, 49-61.
- OKOLI, E.J.  
 "Contracts Explosion," West Africa, No. 3387, 1982i, 1750-1751.
- OKOLI, E.J.  
 "Opening Up Tenders," West Africa, No. 3388, 1982ii, 1812-1813.
- OLANREWAJU, S.A.  
 "Some Determinants of the Operational Cost of the Nigerian Railways," Quarterly Journal of Administration, 11, 1979, 309-323.
- OLAYIDE, S.O., M.H. ABKIN and G.L. JOHNSON.  
 "Agricuture and the Growth of the Nigerian Economy: Results of Policy Simulation Experiments," Nigerian Journal of Economics and Social Studies, 15 1973.
- OLAYIDE, S.O., O. OGUNFOWORA and S.M. ESSANG.  
 "Effects of Marketing Board Pricing Policy on the Nigerian Economy: A Systems Simulation Experiment," Journal of Agricultural Economics, 25, 1974, 289-309.
- OLAYIDE, S.O. and S.O. OLOWUDE.  
 "Optimum Combination of Farm Enterprises in Western Nigeria: A Linear Programming Analysis," Nigerian Journal of Economics and Social Studies, 14, 1972, 63-76.

- OMORINBOLA, E.O.  
 "Predicting Depths to the Water Table in Deeply Weathered River Catchments in Nigeria," Journal of the Institution of Water Engineers and Scientists, 36, 1982, 191-204.
- OSAYIMWESE, I.  
 "Evacuation of Groundnuts in Nigeria: A Linear Programming Approach," Nigerian Journal of Economic and Social Studies, 15, 1973, 95-108.
- OSAYIMWESE, I.  
 "An Application of Linear Programming to the Evacuation of Groundnuts in Nigeria," Journal of Transport Economics and Policy, January 1974, 58-69.
- OVEN-THOMPSON, K., L. ALERCON and D.H. MARKS.  
 "Agriculture Vs Hydropower Trade offs in the Operation of the High Aswan Dam," Water Resources Research, 18, 1982, 1605-1613.
- OVERALL, J.E.  
 "Note on the Scientific Status of Factors," Psychological Bulletin, 61, 1964, 270-276.
- OZORO, O.  
 "A Mathematical Programming Model for Planning Training Opportunities in Relation to Manpower Targets for Development," Socio-Economic Planning Science, 12, 1978, 113-119.
- PAL, S.K. and B. BOWONDER.  
 "Marketing Challenges of Technical Industries in Developing Countries," Industrial Marketing Management, 8, 1979, 69-74.
- PALMER-JONES, R.W.  
 "Irrigation System Operating Policies for Mature Tea in Malawi," Water Resources Research, 13, 1977, 1-7.
- PANITCHPAKDI, S.  
 "Demand and Supply Elements in Educational Planning," Socio-Economic Planning Science, 11, 1977, 339-346.
- PARDOE, C.H.B. and I.F. WILLIAMSON.  
 "The Road to Cardiff - The Development of MOD's Dispersal Network," Management Services in Government, 34, 1979, 27-37.
- PATEL, N.R.  
 "Locating Rural Social Service Centre in India," Management Science, 25, 1979, 22-30.
- PATEL, R.R.  
 "Planning for Electricity Generation in India," Long Range Planning, 16, 1983, 61-65.
- PATIL, M.K., P.S. JANAHANLAL and D.N. GHISTA.  
 "Mathematical Simulation of Impact of Birth Control Policies on Indian Population System," Simulation, 41, 1983, 103-117.
- PENSON Jr. J.B.  
 "synthesis of Optimal Macro Production Plans in Planned Economies: A Syrian Example," Journal of Developing Areas, 16, 1981, 31-45.

- PERIN, R.K.  
 "The Value of Information and the Value of Theoretical Models in Crop Response Research," American Journal of Agricultural Economics, 58, 1976, 54-61.
- PERKINS, F.C.  
 "Technological Choice, Industrialisation and Development Experiences in Tanzania," Journal of Development Studies, 19, 1983, 213-243.
- PERRIN, R. and D. WINKELMANN.  
 "Impediments to Technical Progress on Small Versus Large Farms," American Journal of Agricultural Economics, 53, 1976, 888-894.
- PERVIN, L.A.  
Personality: Theory, Assessment, and Research, (Third Edition), New York, 1970.
- PICARDI, A.C. and A.M. SHORB.  
 "Simulating Saudi Arabia's Oil Export Strategy," Simulation, 40, 1983, 20-27.
- PIKE, J.G.  
 "The Planning of Water Resources Development in an Arabian Gulf State: Qatar, A Case Study," Journal of the Institution of Water Engineers and Scientists, 37, 1983, 75-88.
- PINKUS, C.E. and A. DIXSON.  
Solving Local Government Problems: Practical Applications of Operations Research in Cities and Regions, George Allen & Unwin, London, 1981.
- PIPER, I.  
 "New Lease of Life for the Railways," The Courier, No. 71, 1982, 43-44.
- POMAREDA, C. and R.L. SIMMONS.  
 "A Programming Model with Risk to Evaluate Mexican Rural Wage Policy," Operational Research Quarterly, 28, 1977, 997-1011.
- POPKIN, B.M., F.S. SOLON, T. FERNANDEZ and M.C. LATHAM.  
 "Benefit-Cost Analysis in the Nutrition Area: A Project in the Philippines," Social Science and Medicine, 14C, 1980, 207-216.
- POPPER, K.R.  
Conjectures and Reputations. The Growth of Scientific Knowledge, (Fifth Edition), Routledge and Kegan Paul, London, 1974.
- PRIEST, D.E.  
 "Enhancing the Developmental Impact of Rail Transit," Transportation, 3, 1980, 45-55.
- PRUZAN, P.M.  
 "The Bangladesh Grain Model," European Journal of Operational Research, 3, 1978, 110-121.
- RADA, J.F.  
 "The Micro Electronics Revolution: Implications for the Third World," Development Dialogue, 2, 1981, 41-67.
- RADNOR, M. and R.D. NEAL.  
 "The Progress of M.S. Activities in Large U.S. Corporations," Operations Research, 21, 1973, 427-450.

- RADNOR, M., A.H. RUBENSTEIN, and A.S. BEAN.  
 "Integration and Utilization of Management Science Activities in Organisations," Operational Research Quarterly, 19, 1968, 117-141.
- RADNOR, M., A.H. RUBINSTEIN and D.A. TANSIK.  
 "Implementation in Operations Research and R & D in Government and Business Organizations," Operations Research, 18, 1970, 967-991.
- RAILWAY GAZETTE INTERNATIONAL.  
 "Station Signalling Raises RAN Capacity," Railway Gazette International December 1981, 1036-1037.
- RAMANI, K.V.  
 "An Information System on Allocating Coach Stock on Indian Railways," Interfaces, 11, 1981, 44-51.
- RAMANUJAM, M.S.  
 "Requirements of Technical Manpower in India: 1965-66 to 1980-81," Indian Economic Review, 8, 1973, 101-124.
- RANGASWAMY, P.  
 "Risk-Aversion and Investment Gap," Indian Economic Review, 17, 1982, 223-239.
- RANBYRD, J.C.  
 "PR For OR" OR Newsletter, 13, 1984, 9.
- RAO, R.  
 "India - The Plan for Steel," Long Range Planning, 11, 1978, 22-28.
- RAO, T.V.S.R. and S. ACHARYA.  
 "Structure of Production Decisions of Small Scale Firms," Indian Economic Review, 10, 1975, 127-133.
- RASMUSEN, H.J.  
 "Transportation Mode Planning: A Case Study" European Journal of Operational Research, 2, 1973, 327-335.
- RHEE, Y.W. and L.E. WESTPHAL.  
 "A Micro Economic Investigation of Choice of Technology," Journal of Development Economics, 4, 1977, 205-273.
- RITZEN, J.M.  
 "Manpower Targets and Educational Investments," Socio-Economic Planning Science, 10, 1976, 1-6.
- RIVETT, P.  
 "A World in Which Nothing Ever Happens Twice," Journal of the Operational Research Society, 34, 1983, 677-683.
- RIVETT, P.  
 "Leave the Palaces of Mathematics and Help in the Muddles of Real Problems" OR/MS Today, 11, 1984, 5.
- RIVETT, P. and R.L. ACKOFF.  
A Manager's Guide to Operations Research. Wiley, New York, 1963.
- ROBINSON, J.A.  
 "Survey Interviewing Among Members of Congress," Public Opinion Quarterly, 24, 1960, 127-138.

- RONDINELLI, D.A.  
 "Planning Development Projects: Lessons from Developing Countries," Long Range Planning, 12, (No.3), 1979, 48-56.
- RONDINELLI, D.A.  
 "National Investment Planning and Equity Policy in Developing Countries: The Challenge of Decentralized Administration," Policy Sciences, 10, 1978, 45-74.
- RONDINELLI, D.A. and B.G. JONES.  
 "Decision-Making, Managerial Capacity and Development: an Entrepreneurial Approach to Planning," African Administrative Studies, No.13, 1975, 105-118.
- ROSE, C.J.  
 "Management Science in the Developing Countries: A Comparative Approach to Irrigation Feasibility," Management Science, 20, 1973, 423-438.
- ROSE GRANT, M.W. and R.W. HERDT.  
 "Simulating the Impacts of Credit Policy and Fertilizer Subsidy on Central Luzon Rice Farms, the Philippines," American Journal of Agricultural Economics, 63, 1981, 655-665.
- ROTH, G.J. and Y.ZAHAVI.  
 "Travel Time 'Budgets' in Developing Countries," Transportation Research-A, 15A, 1981, 87-95.
- ROUMASSET, J. and G.THAPA.  
 Explaining Tractorization in Nepal: An Alternative to the 'Consequence Approach'," Journal of Development Economics, 12, 1983, 377-395.
- ROWNTREE, B.S.  
Land and Labour: Lessons from Belgium, MacMillan, London, 1910.
- RUBENSTEIN, S.H.  
 "Integration of Operations Research into the Firm," Journal of Industrial Engineering, 11, 1960, 421.
- RUBENSTEIN, A.H., M. RADNOR, N.R. BAKER, D.R. HEIMAN, and J.B. McCOLLY.  
 "Some Organisational Factors Related to the Effectiveness of Management Science Groups in Industry," Management Science, 13, 1967, B-508 - B-518.
- RULON, P.J., D.V. TIEDEMAN, M.M. TATSUOKA and C.R. LANGMUIR.  
Multivariate Statistics for Personnel Classification. Wiley, New York, 1967.
- RUSSELL, W.  
 "Peterhead Bay Harbour - An OR Study into its Capacity for Tanker Traffic." Management Services in Government, 31, 1976, 81-87.
- RYCROFT, R.W. and J.S. SZYLIOVICZ.  
 "The Technological Dimension of Decision-Making: The Case of the Aswan High Dam," World Politics, 33, 1980, 36-61.
- SAATCIOGLU, O.  
 "Mathematical Programming Models for Airport Site Selection," Transportation Research-B, 16B, 1982, 435-447.
- SAATY, T.L.  
 "Scenarios and Priorities in Transportation Planning: Application to the Sudan," Transportation Research, 11, 1977, 343-350.

- SAATY, T.L.  
 "The Sudan Transport Study," Interfaces, 8, (Part 2), 1977ii, 37-57.
- SAATY, T.L. and L.G. VARGAS.  
 "Estimating Technological Coefficients by the Analytic Hierarchy Process,"  
Socio-Economic Planning Science, 13, 1979, 333-336.
- SAGASTI, F.R.  
 "Management Science in an Underdeveloped Country. The Case of  
 Operational Research in Peru," Management Science, 19, 1972, 121-131.
- SAGASTI, F.R.  
 "Operations Research in the Context of Underdevelopment: Some Case Studies  
 from Peru," Operational Research Quarterly, 25, 1974, 219-230.
- SAGASTI, F.R.  
 "Thoughts on the Use (and Abuse) of OR/MS in the Planning and Management  
 of Development (Or: Can OR/MS Help in the Planning and Management of  
 Revolutions)," Operational Research Quarterly, 27, 1976, 937-948.
- SAEED, K.  
 "Public Policy and Rural Poverty: A System Dynamics Analysis of a Social  
 Change Effort in Pakistan," Technological Forecasting and Social Change,  
 21, 1982, 325-349.
- SAHA, J.L.  
 "An Algorithm for Bus Scheduling Problems," Operational Research  
 Quarterly, 21, 1970, 463-474.
- SARASON, I.G.  
Personality: An Objective Approach, Wiley, New York, 1966.
- SARGENT, C.  
 "Utilization of National Health Maternity Services in a Northern District  
 of People's Republic of Benin," Rural Africana, No. 8-9, Fall-Winter  
 1980-81, 77-90.
- SARGIOUS, M.A. and J.J. SALINAS.  
 "Capital Budgeting of Mass Transportation Systems in Large Cities in  
 Developing Countries," in M.A. Cuenod and S. Kahne (Eds.) Systems  
 Approaches to Developing Countries, International Federation of Automatic  
 Control, 1973, 319-326.
- SARIN, S.  
 "Buying Decisions in Four Indian Organisations," Industrial Marketing  
 Management, 11, 1982, 25-37.
- SARKAR, N.K.  
 "A Simulation Model for Performance Evaluation of Developing Economies,"  
Developing Economies, 12, 1974, 56-73.
- SAVILLE, P.  
The British Standardisation of the 16PF. Supplement of Norms, Forms  
 A and 9, N.F.E.R. Publishing Company Limited, Berks, U.K. 1972.
- SAYLES, L.R.  
 "Whatever Happened to Management--Or Why the Dull Stepchild?,"  
Business Horizons, 13, 1970, 25-34.
- SCHLESINGER, J.R.  
 "Quantitative Analysis and National Security," World Politics,  
 15, 1963, 295-315.

- SEALY, A.P. and R.B. CATTELL.  
 "Adolescent Personality trends in primary Factors Measured On the 16PF and the HSPQ Questionnaires Through Ages 11-23," British Journal of Social and Clinical Psychology, 1966, 5, 1972-184.
- SEIVER, D.A.  
 "FREDONIA: A Simulation Model for Teaching Undergraduate Development Economics," Journal of Development Economics, 13, 1983, 103-107.
- SHAH, K.S. and K.V. RASTOGI.  
 "Systems Approach to Transportation Methods Between Jaipur and Delhi in India," in M.A. Cuenod and S. Kahne (Eds.) Systems Approaches to Developing Countries, International Federation of Automatic Control, 1973, 329-333.
- SHARKO, J., A.J. PENNINGTON and D.R. LIMAYE.  
 "Requirements for a World Oil Model," in M.A. Cuenod and S. Kahne (Eds.) System Approaches to Developing Countries, International Federation of Automatic Control, 1973, 359-363.
- SHARMA, P.N. and O.J. HELWEG.  
 "Optimal Design of Small Reservoir Systems," Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, 108, 1982, 250-264.
- SHIBA, S.  
 "Strategies For Transferring Operations Technology," in K.G. Haley (Ed.) Operational Research '75, North-Holland Publishing Company, 1976, 87-96.
- SHNEERSON, D.  
 "Investment in Port Systems: A Case Study of Nigerian Ports," Journal of Transport Economics and Policy, 15, 1981, 201-216.
- SHUMAN, L.J., R.D. SPEAS Jr., and J.P. YOUNG (Eds).  
Operations Research in Health Care: A Critical Analysis. The Johns Hopkins University Press, Baltimore, 1975.
- SIKKA, D.R.  
 "Guidelines for Systems Planning Investigations and Optimum Utilization of Water Resources and Norms in a Developing Area," in M.A. Cuenod and S. Kahne (Eds.) Systems Approaches to Developing Countries, International Federation of Automatic Control, 1973, 453-465.
- SINGH, I. and C.Y. AHUJ.  
 "A Dynamic Multi-Commodity Model of the Agricultural Sector. A Regional Application in Brazil." European Economic Review, 11, 1978, 155-179.
- SLATER, C.C. and G. WALSHAM.  
 "A Systems Simulation of the Kenyan Economy," Omeqa, 3, 1975, 557-567.
- SMITH, B.L.R.  
The RAND Corporation. Case Study of a Non Profit Advisory Corporation. Harvard University Press, Cambridge, U.S.A., 1966.
- SMITH, B.R.  
 "Modelling New Zealand's Energy System," European Journal of Operational Research, 4, 1980, 173-184.
- SMITH, D.V.  
 "Decision Rules in Change-Constrained Programming: Some Experimental Comparisons," Management Science, 19, 1973, 638-702.

- SMITH, J.D.  
"Management Science in Developing Countries," Management Science, 20, 1973, 255-256.
- SMITH, H.W.  
Strategies of Social Research, (Second Edition), Prentice-Hall, Englewood Cliffs, New Jersey, 1981.
- SOLTANI-MOHAMMADI, G.R.  
"Problems of Choosing Irrigation Techniques in a Developing Country," Water Resources Research, 8, 1972, 1-6.
- SPENCER, D.S.C. and D. BYERLEE.  
"Technical Change, Labor Use, and Small Farmer Development: Evidence from Sierra Leone," American Journal of Agricultural Economics, 58, 1976, 874-887.
- STICKNEY, R.E., P.C. ABBOTT and J.G. CHAMBERLIN.  
"Systems Approach to Nutrition Planning: Preliminary Considerations," in M.A. Cuenod and S. Kahne (Eds.) Systems Approaches to Developing Countries, International Federation of Automatic Control, 1973, 137-147.
- STIMSON, D., and R. STIMSON.  
Operations Research in Hospitals, Diagnosis and Prognosis, Hospital Research and Educational Trust, Chicago, Illinois, 1972.
- STONE, E.F.  
Research Methods in Organizational Behaviour, Goodyear Publishing Company, Santa Monica, California, 1978.
- STOLPER, W.F.  
Planning Without Facts: Lessons in Resource Allocation from Nigeria's Development, Harvard University Press, 1966.
- STREAT, E.R.  
Remarks in Operational Research: Its Application to Peace-Time Industry, The Manchester Joint Research Council, 1950.
- SUBRAMANIAM, S.  
"Planning Problems of State Road Transport - India," Long Range Planning, 9, 1976, 77-80.
- SUBRAMANIAM, S.  
"Corporate Planning in Indian Railways - A Case Study," Long Range Planning, 12, 1979, 91-96.
- SUBRAMANIAM, S. and C.K. SHARMA.  
"Corporate Planning in Domestic Airlines - An Indian Case Study," Long Range Planning, 8, 1975, 64-69.
- SUPER, M., H. de V. HEESE, D. MACKENZIE, W.S. DEMPSTER, J. Du PLESSIS and J.J. FERREIRA.  
"An Epidemiological Study of Well-Water Nitrates in a Group of South West African/Namibian Infants," Water Research, 15, 1981, 1265-1270.
- SZPIGEL, B.  
"Optimal Train Scheduling on a Single Track Railway," in M. Ross (Ed.) Operational Research '72, North-Holland Publishing Company, 1973, 343-352.
- TABULAR SUPPLEMENT NO. 1 TO THE 16PF HANDBOOK The Institute for Personality and Ability Testing, Illinois, U.S.A., 1970.

TANSIK, D.A. and M. RADNOR.  
"An Organisation Theory Perspective on the Development of New  
Organisational Functions" Public Administration Review, 13, 1971, 644-652.

THE CONSTITUTION OF THE FEDERAL REPUBLIC OF NIGERIA  
Daily Times, Lagos 1978.

THE COURIER  
No. 56, 1979, 80-112.

THE OPERATIONAL RESEARCH SOCIETY.  
Memorandum No. 102 Submitted to the Committee on the Civil Service,  
Under the Chairmanship of Lord Fulton. Cmnd 3638, H.M.S.O., London,  
Vol. 5(2), 1968, 703-709.

THOMAS, H. and R. REVELLE.  
"On the Efficient Use of the High Aswan Dam for Hydropower and Irrigation,"  
Management Science, 12, 1966, B-296 - B-311.

THORNBLADE, J.B.  
"A Checklist System: The First Step in Country Evaluation," in  
S.H. Goodman (Ed.) Financing and Risk in Developing Countries. Praeger  
Publishing New York, 1978, 73-80.

TINKER, J.  
"How Delhi Made the Buses Run on Time," New Scientist 9th January 1975,  
64-66.

TIPPETT, L.H.C.  
" 'Operational Research' in the Cotton Industry" in Operational Research  
Its Application to Peace-Time Industry, The Manchester Joint Research  
Council, 1950, 63-85.

TOMLINSON, R.C.  
"Operational Research and Systems Analysis: From Practice to Precept,"  
Philosophical Transactions, Royal Society London, A287, 1977, 355-371.

TOMLINSON, R.  
"Doing Something About the Future," Journal of the Operational Research  
Society, 31, 1980, 467-476.

TOMLINSON, R.C.  
"OR Is", Operational Research Quarterly, 25, 1974, 347-360.

TOMLINSON, R.C.  
Operational Research in the Public Service," in J. Lawrence (Ed.)  
Operational Research '69, Tavistock, London, 1970, 69-82.

TOMLINSON, R.  
"Some Dangerous Misconceptions Concerning Operational Research and  
Systems Analysis," European Journal of Operational Research, 7, 1981,  
203-212.

TULL, D.S. and D.I. HAWKINS.  
Marketing Research: Measurement and Method. A Text With Cases.  
(Second Edition), Macmillan Publishing Company Inc. 1980.

TURNER, T.P.  
"The Application of OR in Government," Management Services in Government,  
36, 1981, 29-37.

UNITED NATIONS.

Agricultural Development in Nigeria 1965-1980, Food and Agriculture Organisation, Rome, 1966.

VANERDEN, J.D. and S.A. WANDNER.

"The Demand for Tourism in Puerto Rico," Mid-Atlantic Journal of Business, 20, 1982, 1-12.

VAN REST, D.J.

"Systems Assessment of Improved Technology for the Coffee Industry in Puerto Rico," in K.B. Haley (Ed.) Operational Research '75, North-Holland Publishing Company, Amsterdam, 1976.

VENU, S.

"Corporate Planning in a Developing Economy: Indian Experience," Long Range Planning, 5, 1972, 29-35.

VERTINSKY, I.

"OR/MS Implementation in Valle, Colombia: A Profile of a Developing Region," Management Science, 18, 1972, 314-329.

VIDALI, J. and J. TRUESDELL.

"A Re-examination: Potential Effects of Re-opening and Expanding the Suez Canal on the Shipment Cost of Crude Oil," Transportation Research, 11, 1977, 391-395.

VRAT, P. and S.A. BABU.

"Inventory Control of Spares in a Transport Corporation - A Case Study," Omega, 17, 1979, 153-159.

WADDINGTON, C.H.

OR In World War 2. Operational Research Against the U-Boat, Elek, London, 1973.

WADDINGTON, R. and J.T. CROWTHER.

Science at War, Her Majesty's Stationery Office, London, 1949.

WALSH, J.A.

Review of the 16PF, in O.K. Buros (Ed.), The Eight Mental Measurement Yearbook. Gryphon, New Jersey, 1978, 1081-1083.

WALSHAM, G.

"Education in Operational Research for the Developing Countries," Journal of the Operational Research Society, 29, 1978, 299-306.

WALSHAM, G.

"Telephone Systems in the Third World: A Research Project," Journal of the Operational Research Society, 34, 1983, 225-231.

WARD, R.A.

"Operational Research in British Local Government," in J. Lawrence (Ed.) Operational Research '69, Tavistock, London, 1970, 135-145.

WARD, R.A.

Operational Research in Local Government, George Allen & Unwin, London, 1964.

WARE, G.O. and P.M. Dickert.

"A Management Planning Model for Delivery of Family Planning Services," Socio-Economic Planning Science, 10, 1976, 155-158.

- WEINSHALL, T.D. (Ed.)  
Culture and Management. Penguin, Harmondsworth, Middlesex, 1977.
- WEISS Jr., C.  
 "Mobilizing Technology for Developing Countries." Science, 203, 1979, 1083-1089.
- WELLENIUS, B.  
 "Some Recurrent Problems of Telecommunications in Developing Countries,"  
IEEE Transactions on Communications, Com-24, (No. 7), 1976, 723-728.
- WHITE, M.J.  
Management Science in Federal Agencies: The Adoption and Diffusion of  
 Socio-Technical Innovation, Lexington, Massachusetts, 1975.
- WHITE, M.J., M. RADNOR and D.A. TANSIK (Eds.)  
Management and Policy Science in American Government: Problems and  
 Prospects, Lexington, Massachusetts, 1975.
- WIENS, T.B.  
 "Peasant Risk Aversion and Allocation Behaviour: A Quadratic Programming  
 Experiment," American Journal of Agricultural Economics, 58, 1976, 629-635.
- WIESE, H.J.  
 "Tuberculosis in Rural Haiti," Social Science and Medicine, 8, 1974, 359-362.
- WIESS, D., P. DJHA, W. HILLESBRAND, H. SAUER, J. KENNEWEG, B. LANGEN, C. WILMSEN  
 and G. THOMA.  
 "Regional Analysis of Kosi Zone/Eastern Nepal: Working Method for Regional  
 Planning in Nepal," Socio-Economic Planning Science, 17, 1973, 213-282.
- WIJESINGHE, F.D.C.  
 "Traffic Problems in Nigeria - A Case for Private Enterprise,"  
Journal of Administration Overseas, 15, 1976, 141-149.
- WINSTON, G.C.  
The Appeal of Inappropriate Technologies: Self-Inflicted Wages, Ethnic  
 Pride and Corruption, Research Memorandum No. 68, Centre for Development  
 Economics, William College, Williamstown, Massachusetts, 1978.
- WIONCZEK, M.  
 "The Roots of the Mexican Agricultural Crisis: Water Resources Development  
 Policies (1920-1970)." Development and Change 13, 1982, 365-399.
- WOLGIN, J.M.  
 "Resources Allocation and Risk: A Case Study of Smallholder Agriculture  
 in Kenya," American Journal of Agricultural Economics, 57, 1975, 622-630.
- WOOD, T.W.  
 "The Economics of Mixed Cargo and Cruise Ship Traffic in a Port,"  
Journal of Transport Economics and Policy, 16, 1981, 43-53.
- WORTZEL, L.H.  
 "Marketing to Firms in Developing Asian Countries," Industrial  
 Marketing Management, 12, 1983, 113-123.

- WORTZEL, L.H. and H.V. WORTZEL.  
"Export Marketing Strategies for NIC and LDC-Based Firms,"  
Colombia Journal of World Business. Spring 1981, 51-60.
- WRIGHT, C.L., R.L. MEYER and F.E. WALKER.  
"Analysing Bottlenecks in Grain Transportation and Storage Systems:  
A Brazilian Case Study," Journal of Development Studies. 18, 1981,  
68-84.
- WUYTS, M.  
"The Mechanization of Present-Day Mozambican Agriculture,"  
Development and Change. 12, 1981, 1-27.
- WYLD, H.C. and E.H. PARTRIDGE.  
Webster Universal Dictionary. Harver, New York, 1975.
- ZUCKERMAN, H.  
"Interviewing an Ultra-Elite," Public Opinion Quarterly. 36, 1972,  
159-175.

APPENDIX I

INTRODUCING OPERATIONAL RESEARCH INTO THE DEVELOPING COUNTRIES:  
QUESTIONNAIRE FOR INTERVIEWING SENIOR CIVIL SERVANTS IN NIGERIA

INTRODUCTION

My name is Adamu Idama. I am the research student from the School of Industrial and Business Studies of the University of Warwick, England. Thank you for granting me this interview. We are currently studying the problems of introducing OPERATIONAL RESEARCH (OR) into the developing countries. We are examining the particular case of the introduction of OR in the Public Service in Nigeria. We have requested this particular interview with you so that we can understand what your responsibilities are and what value Operational Research would be to you. We assure you that views expressed during this interview are held in confidence.

ENVIRONMENT IN WHICH OPERATIONAL RESEARCH WOULD BE PRACTISED

- Q.1 a) In order that I can fully understand and appreciate your responsibilities, can you give me a brief description of the main work done in this ministry?
- b) What will you consider to be the key factors on which the success of your ministry will be judged?
- i) By your colleagues in other ministries.
  - ii) By the general public.
- c) Are studies in connection with the work of the ministry initiated in the ministry?
- d) Do you have particular set times when studies must be initiated?
- e) Do you have funds allocated for consultancy services in connection with your studies.
- f) About what percentage of the project cost would you say is allocated to consultancy services?
- g) Are decisions in connection with the activities of the ministry usually taken by the permanent secretary?

(If NO go to 1)

- h) How does he normally take the decisions, that is, for example, would he depend on recommendations from an officer in the ministry, or would he take the decision in a standing committee existing in the ministry?
- i) Where are such decisions taken?
- j) How are they taken, that is, for example, by a standing committee or by other means.
- k) ~~See attached sheet.~~
- l) ~~See attached sheet.~~
- m) Considering the planning and the execution of a particular project, whose views would count the most in the ministry?
- n) In taking decisions in connection with the activities of the ministry, what is the position of the permanent secretary in relation to the minister?
- o) Does the ministry recruit staff directly to meet its needs?

#### EXISTING KNOWLEDGE ABOUT OPERATIONAL RESEARCH

Q.2 a) Can you tell me what you know about Operational Research?

(If OR is UNKNOWN go to e))

b) Can you suggest any areas where OR might be applied in the ministry?

(If NO go to d))

c) What areas are these?

d) Are there any particular difficulties in identifying areas where OR may be applied?

e) Operational Research is the application of the methods of science to aid decision making. OR is applicable to a wide range of problems. In practice it is found to be most useful in dealing with problems that have some measure of uncertainty, or where the sheer complexity of the problem means that a detailed research is necessary.

Given what has been said, and what you have told me about the main work of this ministry, can you think of areas where OR might be usefully applied?

f) Do you have anyone doing OR in the ministry?

(If NO go to Q.3)

g) How was he trained?

PREVIOUS CONSULTANCY EXPERIENCE

Q.3 a) Have any consultancy projects been done during your time in this ministry?

(If NO go to j))

b) What kind of work was it?

c) What was your involvement in the project?

d) Was the consultancy undertaken by a team of civil servants?

(If YES go to g))

e) Who were the consultants?

f) How were they recruited?

g) Was the result implemented?

h) What were the difficulties in implementing the results?

i) Was a computer used on the project?

(Go to Q.4)

j) Is there any particular reason why consultants have not been used?

AVAILABILITY OF COMPUTER

Q.4 a) Do you have a computer in the ministry?

(If NO go to Q.5)

b) Do you have direct access to the computer?

(If NO go to e))

c) By what means, that is, for example, do you have a terminal assigned to your office?

(If NO go to e))

d) Do you have staff to operate it for you?

e) How do you use the computer?

PREFERRED MODE OF INTRODUCING OPERATIONAL RESEARCH

Q.5 a) There are a number of possible ways by which a government can introduce Operational Research into its service, for example:

- 1) A government may set up a department which will provide Operational Research service to all the ministries in the government.

- ii) A government may establish a corporation which will provide Operational Research services for government ministries only, and
- iii) A government may establish Operational Research groups in selected ministries to provide Operational Research services.

Which of these approaches do you think is best for you?

#### PROBLEMS IN INTRODUCING OPERATIONAL RESEARCH

Q.6 a) Introducing a new service into an existing organisation sometimes presents problems. Do you see any difficulties with introducing Operational Research in the government?

#### FURTHER LEADING

Q.7 Is there anyone else you suggest I should talk to on this subject?

#### FINAL REMARKS

Thank you very much. We would be very pleased to hear from you if we can be of further assistance to you in any way. That is the end of the interview.

SCHOOL OF INDUSTRIAL AND  
BUSINESS STUDIES

ROLFE C. TOMLINSON  
PROFESSOR OF SYSTEMS  
AND OPERATIONAL RESEARCH

14th March 1983



UNIVERSITY OF WARWICK  
COVENTRY CV4 7AL

TELEPHONE COVENTRY (0203) 24011

APPENDIX II

Dear Sir

I am writing to ask if you could arrange for one of my Nigerian research students, Idama Adamu, to have an interview with a senior official in your department.

Idama's research is concerned with the problems of introducing Operational Research (see Annex 1) into developing countries and in particular Nigeria. It is clear that governments in Europe and North America have gained a great deal - both in terms of financial saving and policy formulation - from the application of Operational Research, and Idama is trying to understand whether similar advantages could accrue in Nigeria and what would be needed to allow this to happen. A related question is to find out why the considerable number of overseas graduates who qualify in OR each year do not seem to practice the subject on their return home.

Idama has extensively studied the practical use to which OR has been put by government bodies in the UK and the US, and has developed some ideas as to its potential value in the Nigerian public service. He has now reached the point where he needs direct contact with the appropriate officials to test out these ideas. Following such interviews he would hope to be able to identify some problems to which OR could immediately be applied.

Idama has also examined the problems of establishing an OR team in a new area and is developing ideas as to the relative effectiveness of different ways of doing this. It is clear that effectiveness depends on the skill and experience of the administrative staff concerned, as well as on the training and experience of the investigational staff themselves and of the organisational relationship between them.

The interview would be using a structured questionnaire which we are preparing and which needs to be administered in person. Whereas it would be most valuable to us if you could give the necessary time yourself, we think it realistic to ask if you could nominate a senior official with experience of your department, and who has had contact with internal investigators or consultants (not necessarily in OR). Because the research is practically oriented, I would hope that the information that Idama would obtain from such interviews, and any suggestions that he may be able to make as a result of them, may be of direct value to your department, as well as being an important element in his PhD thesis.

In addition to the annex already referred to, which gives you some information about our group at Warwick University, I also enclose a summary discussion paper which indicates the ground that Idama has so far covered in his research.

cont ...

Our plan is for Idama to obtain this important additional information at the end of May or early in June. I would be grateful if you could arrange for an appropriate senior official to see him during this period. It would greatly assist in planning his visit if you could suggest a convenient time.

Thank you for considering this request, which I hope may lead to information of value to your department. If I, or my colleagues, can help in any way we would be glad to do so.

Yours faithfully

Rolfe Tomlinson

Enclosures: Annex I - Operational Research at Warwick  
Annex II - Summary of Conclusions to Date

### Operational Research

'The use of the scientific approach to help solve problems of decision making and policy formulation'. It draws on all branches of knowledge and makes extensive use of 'models' - which can be written statements, mathematical equations or computer formulations - to explore the consequences of alternative actions.

'Systems Analysis' is sometimes used in exactly the same sense as Operational Research (OR). At Warwick University the word ORASA is used to cover them both.

### The ORASA Group - Warwick University

The group is situated in the School of Industrial and Business Studies and teaches on undergraduate courses as well as being responsible for an MSc course in Management Science and Operational Research. It is one of a small number of groups recognised by the Science and Engineering Research Council for studentship and research awards in OR. Its research interests include strategic planning, decision support systems, management and control problems in the public service, stock management and the methodology of OR.

### Professor Rolfe Tomlinson

Professor Tomlinson was for many years Director of Operational Research at the National Coal Board, in charge of a team of 100 graduates covering every aspect of the Board's Operations. He was then Chairman of the

Management and Technology Area at the International Institute of Applied Systems Analysis for three years. He came to Warwick in 1980 as Professor of Systems and Operational Research.

Professor Tomlinson is a past-president of the UK OR Society and of the European Association of OR Societies, and has wide international experience in Europe (East and West), North America, Malaysia and Singapore, and Australia.

Introducing OR into Government Activities in Developing Countries

SUMMARY OF CONCLUSIONS TO DATE

1. OR is a well-established and widely used activity in government departments in the United Kingdom and in the US, as well as in many other countries in the developed world.
2. Although consultants are widely used in the construction of mathematical models used in OR, effective results are only obtained when specialist OR units are lodged within the management teams and are seen as part of the overall management function of a department.
3. The effective use of OR implies a degree of sophistication on the part of the administrators concerned and in their willingness to explore alternatives. It does not, however, require any direct knowledge of OR methodology or of computer operations.
4. Major OR studies have been undertaken in most Ministries in the UK. There are substantial teams in the Treasury, the Department of Health, Defence, the Home Office, and smaller but significant teams in many other departments.
5. The increasing use of micro-computers with the opportunities they introduce for application in non-routine situations has created a major new field of application for operational research.
6. There are many ways by which an operational research group may be started. Basic requirements are the support of a senior administrator

and the active cooperation of managers for whom the original studies are undertaken. From the OR side it requires a leadership of someone with experience of applying OR in practical situations as well as having an understanding of the way in which the department operates.

7. OR staff need to be formally trained in the use of operational research techniques and in the methodology of undertaking OR investigations. In personality they need to be able to mix with and be accepted by management personnel.
8. The range of problems for which OR could be usefully applied is no less in the Nigerian Civil Service than in the UK or the US and its potential value is no less. A wide range of potential applications have been identified, but discussions with appropriate experts are necessary before the real value can be gauged.
9. The Nigerian Civil Service has the management sophistication which would enable them to make effective use of investigations.
10. The best method of introducing OR into the Nigerian Civil Service would be to establish small teams in selected Ministries.
11. Particular care needs to be paid to the recruitment of appropriate staff and to ensure that they are given a suitable working environment. There are a substantial number of Nigerian students who have been trained in operational research who are not pursuing

the subject, at least on a full-time basis. If they could be identified, they might be able to play a substantial part.

Idama Adanu

March 1983

SCHOOL OF INDUSTRIAL AND  
BUSINESS STUDIES

ROLFE C. TOMLINSON  
PROFESSOR OF SYSTEMS  
AND OPERATIONAL RESEARCH



UNIVERSITY OF WARWICK  
COVENTRY CV4 7AL

TELEPHONE COVENTRY (0203) 24011

APPENDIX III

21st February 1983

To All Members of Midlands OR Society

Dear OR Society Member

The purpose of this letter is to invite you to Warwick University on March 16th to take part in a personality test for experienced OR workers. The date has been chosen because it was originally fixed for a Midland OR Society meeting and I hope that some members will have kept the date free in their diary.

There are two reasons for wishing to undertake these tests which are part of a research programme being undertaken by one of my PhD students, Idama Adamu, who is studying the problems of introducing OR into developing countries. One of the topics he has considered in the course of his research is the personality of the OR worker. A study of recent advertisements has confirmed the very strong emphasis that is given to certain personality requirements when recruiting OR staff. However, so far as we can find out these requirements have not been researched in any formal manner. He therefore wishes to undertake some personality tests of OR workers in the UK so that eventually the information obtained might be useful in his home country. This leads me to the second reason for our proposal, namely that we do not currently have such information for ourselves and this could be of value and interest in planning the future of our profession.

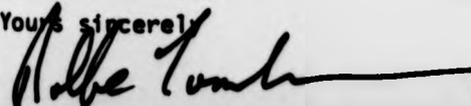
We have identified a test (PF16) that has been used extensively for examining the differences between different professional classes and this seems to measure the qualities traditionally associated with OR. Idama has had some initial training in the administration of psychological tests and a professional psychologist within our School has agreed to supervise the interpretation of the tests, which will take 1½ - 2 hours. Individual results would, of course, not be revealed.

The problem is to obtain the cooperation of a sufficient number of OR workers to provide a satisfactory sample. It is obviously impracticable to conduct all the tests on a one to one basis (they need to be supervised) and we are therefore looking for ways of getting volunteers together: hence this invitation. The tests will start at 4.30 p.m. in Room 2.81 (2nd Floor, Statistics Department), Social Studies Building and we hope that you could join us for a cup of tea in the entrance hall to the FME Building (part of the Social Studies Building) from 4.00 onwards. If you can come, please complete the attached slip and we will send you a University Site map.

Undertaking these tests is quite an interesting experience and would certainly provide scope for discussion after the event. I hope that I might see you then.

With best wishes.

Yours sincerely

  
248

Rolfe Tomlinson

University of Warwick  
School of Industrial and Business Studies

WHAT CONSTITUTES A GOOD OR WORKER?

At every OR conference there are protracted discussions as to what qualities are desirable for a good OR worker. Surprisingly, given the nature of our profession, no-one has seriously set out to measure this. This handout is an invitation to OR practitioners to provide some information.

If you read the OR job advertisements you will find that enormous emphasis is put on a variety of managerial and social skills (technical skills seem to be taken for granted). Are OR professionals, then, really more like managers than scientists, or do we come in some intermediary position? Can we say anything more precise about OR practitioners than the rather vague statements that appear in the advertisements or are expounded in the bar during a conference? There exist a number of personality tests that have been tried out on a wide range of professions, giving what is known as a typical profile for each profession. Nobody seems to have done this for OR and we feel that the gap should be filled.

It may be interesting to indicate how we got into this. A Nigerian research student at Warwick is examining the problems of introducing OR into developing countries, and Nigeria in particular. But if you do this you must consider supply as well as demand. The subject can only develop if there are people available who can develop it. If you are starting more or less from scratch, you have to take the problem of training very seriously and consider how to select the appropriate people for training; self-selection is not necessarily the best procedure. So Idama Adanu started to ask how he could identify people in his own country with the appropriate characteristics and looked to UK experience for guidance. What he has found has been a series of wise remarks, based on experience, but nothing that was remotely factual or scientific. There is a gap in our knowledge and if we fill it it will not only be useful to Idama and Nigeria, but also, hopefully, to ourselves.

The way that we hope to start filling the gap is by getting a sufficient number of OR practitioners to undertake a well-known personality test (PF16), which has been used extensively for examining the differences between different professional classes and where the profiles for these classes is well-known. Idama has had initial training in the administration of such tests, and a professional psychologist within the School of Industrial and Business Studies at Warwick has agreed to supervise the analysis of the tests. Confidentiality of individual test scores would, of course, be maintained. Equally there would be a feedback of results to the individuals concerned.

The tests, which take about 1½ hours, need to be taken in a group under supervision. Idama will do this supervision in person and will then be able to answer any questions about his research. We hope that you may be able to cooperate.

Rolfe Tomlinson  
March 1983

WHAT CONSTITUTES A GOOD OR WORKER?

This note is an invitation to OR workers attending the Operational Research Society Conference to assist in providing some information concerning the personal characteristics of a good OR worker - information which has not been collected before and which could be of value in developing the profession in the future. We hope that many professionals will be prepared to give a little time in this cause.

If you read the OR job advertisements you will find that enormous emphasis is put on a variety of managerial and social skills (technical skills seem to be taken for granted). Are OR professionals, then, really more like managers than scientists, or do we come in some intermediary position? Can we say anything more precise about OR practitioners than the rather vague statements that appear in the advertisements or are expounded in the bar during a conference? There exist a number of personality tests that have been tried out on a wide range of professions, giving what is known as a typical profile for each profession. Nobody seems to have done this for OR and we feel that the gap should be filled.

The way that we hope to start filling the gap is by getting a sufficient number of OR practitioners to undertake a well-known personality test (PF16), which has been used extensively for examining the differences between different professional classes and where the profiles for these classes is well-known. One of my research students has had initial training in the administration of such tests and a professional psychologist within the School of Industrial and Business Studies at Warwick University has agreed to supervise the analysis of the tests. Confidentiality of individuals' test scores would, of course, be strictly maintained. The tests, which last about 1½ hours, need to be taken in a group under supervision. Thus, in order to obtain the numbers necessary to provide a good average profile, they need to be conducted at a time when a number of OR workers are meeting together. Hence the request at this conference.

The tests will be held from 4.00 - 5.30 pm on Wednesday, 28th September. The rooms in which they will take place will be notified during the Conference. I hope that you will be able to help us in this way. If so, could you complete the slip below and hand it in at the Conference Desk when you arrive.

Rolfe Tomlinson  
June 1983

---

WHAT CONSTITUTES A GOOD OR WORKER - Personality Tests

I will take part in the personality test for OR workers to be held on 28th September from 4.00 - 5.30 pm.

Name: .....  
Organisation: .....  
.....

Attention is drawn to the fact that the copyright of this thesis rests with its author.

This copy of the thesis has been supplied on condition that anyone who consults it is understood to recognise that its copyright rests with its author and that no quotation from the thesis and no information derived from it may be published without the author's prior written consent.

2



