Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author. WORK PATTERNS IN RESEARCH ORGANISATIONS:

# A CASE STUDY

OF SOME SOCIAL ASPECTS OF SCIENTIFIC KNOWLEDGE DEVELOPMENT

A thesis presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy at

Massey University

Richard Lubomir Hes 1980 This thesis involved an investigation of some social aspects of scientific knowledge development. In particular, it focused on the "work patterns" of problem solvers and the "effects" research organisations have on them. The proposed theories were tested in one government research organisation.

The "work patterns" of problem solvers were defined in terms of three stages of work (the Work Programme Development, the Idea Generation of specific projects, and the Problem Solving of these specific projects). It was hypothesised and substantiated, using the log-linear modelling technique, that each stage of work is associated with a distinctive pattern of communication, conceptualised in terms of six dimensions (sources of information, types of information, circumstances and modes of information transfer, and the effects of the information). It was shown that the Work Programme Development occurs in response to information, passively received, from external sources during formal circumstances. Ideas for specific projects are generated on the basis of scientific information acquired from journals. In solving specific projects, problem solvers actively consult internal sources, in informal circumstances.

The "effects" of organisations on the work patterns of problem solvers were considered by investigating the effects of (a) three organisational properties (analytic, structural, and global) on internal flows of communication, and (b) those environmental properties on external patterns of communication which could have been investigated in a case

(ii)

study situation. Hypotheses were derived from the resource dependence theory of organisations which was proposed by Pfeffer and Salancik (1978).

The investigation of the effects of the research organisation on the internal flows of communication used locally optimal tests and showed that all three properties of organisations influence the formation of these communications. Internal communications occurred mainly within structural and global constraints, and among people who had similar attributes (analytic properties). Some evidence was found that close physical proximity, which had a strong influence on internal communication, could be overcome by colleague networks, which formed among people with similar analytic properties (autonomy, work related orientations and socially recognised work competence). Informal networks also played an important role in the formation of colleague networks.

The investigations of the effects of the research organisation on the patterns of external communication indicated that the vast majority of information which was received from external sources came from other research organisations, and the amount declined with increasing distance from the focal organisation. The very limited communication with the client communities was not geographically constrained.

Implications for research administrators were discussed. Consistent with attitudes of the respondents toward the roles of research administrators, the findings of this study suggest that the most important role of research administrators should be in facilitating communication, contacts, and the provision of resources.

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#### CHAPTER 1

## INTRODUCTION

This thesis concerns the social construction of knowledge. In particular, it focuses on the effects of research organisations on the work of problem solvers within them.

Since the late sixties, the main attention in the sociology of science has shifted from investigating the work of scientists in their organisations to exploring the social and cognitive developments within the scientific community as a whole (Ben-David 1971, 1978). These explorations focus on the relationships among the organisational and national boundaries-free aggregate of scientists (the "scientific community"), and ignore the effects of organisations which employ scientists and provide their support services.

Although these studies provide some understanding of the social construction of scientific knowledge, I argue that this is inadequate as the effects of work organisations need to be specifically considered in attempts to understand one of the major influences on the work of scientists today. Scientists, and problem solvers in general, do not work in "perfect" labour and product markets, but within "collective entities which impede the free flow of information, men and materials" (Whitley 1977:23). Work organisations can be considered as just such

5.8

entities. The relationships among relevant organisations, which include work organisations, form a social structure which can be imagined as being superimposed on the social structure of scientists within the scientific community. However, because the relevant organisations also include those in the economy, the political system and other institutions, work organisations of problem solvers can also be seen as the locus of exchange between the scientific community and other communities in a society. The work organisations of problem solvers are thus important phenomena. The investigation of them will enable further understanding of how scientific knowledge develops, and is used in society.

This study looks at the effects of research organisations on the work patterns of problem solvers. Work organisations in general, and research organisations in particular, are considered as complex structural phenomena which are constrained by their organisational environments and which, in turn, constrain the work of their employees. Specifically:

- (i) Research organisations are considered as the collective entities within which problem solvers work.
- (ii) Through their own dependence on other organisations, research organisations are constrained by both scientific and extra-scientific influences.
- (iii) Either purposefully or by chance, research organisations bring together a variety of information which then affects the direction of work, the selection of specific projects, and the "puzzle-solving" activities of problem solvers; in

short, research organisations affect the construction of scientific knowledge.

In this study, the work patterns of problem solvers were defined in terms of "stages of work" and "information environment" particular to each stage. These two elements constitute the work patterns of problem solvers. In general, "stages of work" mean stages in the process of projects. "Information environment" means a set of communicated information considered by the problem solvers as significantly influencing their work. Each "information" within the information environment is characterised by several dimensions of communication. I argue that each stage of work depends on a different structure of communication. Communications thus affect the work of problem solvers and consequently the development of knowledge. Effects of research organisations on the communications of problem solvers were then studied.

## PROBLEM AREA OF THE STUDY

Because the raison d'etre of this study was a combination of theoretical and practical issues concerning knowledge development, each of these issues will be addressed in turn. Both considerations lead to the same conclusion: a need to investigate the effects of research organisations on the work of their employees, and thus the way scientific knowledge is created.

# Theoretical issues

The sociology of science concerns the social process whereby new scientific knowledge is created and becomes legitimised and accommodated within the structure of existing knowledge [1]. This field within sociology thus addresses the social aspects of knowledge development (Storer 1966, 1968, Ben-David and Sullivan 1975, Cole and Zuckerman 1975, Ben-David 1978, Beaver 1978).

Two distinct but complementary perspectives were employed within the sociology of science to throw light on the problem of scientific knowledge creation. These can be called "internalist" and "externalist". Internalists examine the work of problem solvers among other problem solvers in isolation from organisations and other social influences, whereas externalists look at the influences of various institutions on science (Basalla 1968, Johnston and Robbins 1977, Beaver 1978, MacLeod 1977, Barnes 1974, Wuthnow 1979) [2]. Of the two traditions, the internalists have recently built a theory of knowledge development (Ben-David and Collins 1966, Mullins 1972, 1973, Mulkay et al 1975, Mulkay 1973, 1975, 1976, Cole and Zuckerman 1975, Zuckerman 1978, Moravcsik 1977, Whitley 1976, 1977), which is important to the understanding of the relationships among problem solvers. The "internalist" theory can be briefly outlined in three points:

 (i) Knowledge is created through patterned growth of explorations in marginal problem areas, on the edges of major scientific work.

(ii) During this growth, "associations" of communicators are

formed, and their participants

- (a) set paradigmatic controls on potential new members[3], and
- (b) place demands for recognition on knowledge consolidators, who are usually the members of established social structure of science.
- (iii) Knowledge consolidators impede the growth of explorations in the problem areas through failing to recognise and reward certain types of new work which fall outside the mainstream of scientific discourse.

The theory, above all, shows that:

- (i) the process of knowledge creation can be understood only in relation to knowledge utilisation, and
- (ii) communication is the basis of interaction between and among knowledge creators and knowledge consolidators.
   Communication has, indeed, been termed the bloodstream of science (Storer 1968).

The internalist theory is, however, inadequate. It can be criticised from three interrelated points of view.

First, the theory has been developed following major advancements in the measurement of citations (Price 1965a, 1965b, Price and Gursey 1975, Elkana et al 1978). It is, therefore, based mainly on data obtained from published articles. Consequently, the theory fails to take into account the importance of the actual, on-going work patterns of

scientists and other problem solvers involved in the creation of knowledge.

Second, attempts to use the theory to predict the behaviour of scientists at the bench level have failed (McAlpine and Bitz 1973), and have resulted in a call for knowledge production to be understood as taking place within the context of work organisations (Bitz 1974:107). But with few exceptions (e.g. Friedkin 1978), the call remains unanswered; the effects of work organisations on knowledge development have not been investigated [4].

Third, internalist theory ignores the extra-scientific effects of society on knowledge development. This neglect occurs even though literature in the externalist tradition shows that the development of science takes place in a close association with developments in other social institutions in the society, especially the economy and the political system (Bernal 1939, Ben-David 1968, 1971, Gruber and Marquis 1969, Ravetz 1971; Don Price 1962, 1965, Brooks 1968, Nelkin 1975) [5].

However, the externalist literature lacks a systematic exploration of the relationships between society, the scientific community, and the work of problem solvers (Merton 1970, 1977, Mulkay 1977). But, unlike the internalists, the externalists maintain that the structure of scientific work, and problems investigated by scientists, are determined by the interactions between science and other institutions in society.

The persisting parallel explorations in the internalist and externalist traditions signify on the one hand the independence of the scientific community, and on the other hand its dependence on other communities in

the society. The relationship between the scientific and other communities in the society can thus be said to be symbiotic (Hawley 1950) [6]. Research organisations can then be viewed as structures through which such symbiotic exchanges take place.

# Problems investigated in this study

On the basis of the brief review of literature presented above, I argue that it is necessary to reconcile the externalist and internalist traditions (as did Johnston and Robbins 1977). Attention must be given to the effects of work organisations on the actual work of scientists and other problem solvers associated with the work of scientists.

Therefore, I suggest that the theory of knowledge development, based on the internalist theoretical tradition, can be usefully extended by:

- (i) focusing on the actual work of problem solvers, and
- (ii) redefining the socio-political context of the problem solvers in terms of their work organisations.

Instead of investigating the patterns of relations among scientists by looking at citation patterns, this study focuses on the actual work patterns of problem solvers involved in the process of knowledge creation. Further, rather than limiting the context of work to the scientific community (and the cognitive structure associated with it), it is the general argument of this thesis that the environment of problem solvers consists of a collection of organisations. And while one of these is the work organisation, it is also the case that these

#### work organisations:

- (i) are constrained by other organisations in their environments, and, in turn,
- (ii) constrain the work of their employees.

As a result, work organisations affect knowledge development. Thus although internalist model builders assume that "new problem areas are regularly created and associated social networks formed" (Mulkay 1975:520), I also argue that work organisations mediate these processes. In this study, the effects of research organisations in particular will be considered.

# Practical issues in science policy

It has often been argued that science has an important part to play in improving the quality of life. However, studies of science utilisation point out that, on average, about 20 years elapse between a scientific advance and its application to goods and services in society (e.g. Langrish et al 1972, Isenson 1969, Price 1969, Toulmin 1969, Rothwell 1974, Mench 1974) [7].

New Zealand spends about 0.8% of its GDP on scientific research (OECD 1979:42). In 1975, this amounted to about \$95 million (OECD 1979). A science policy based upon the quest for the most socially effective and efficient expenditure must be based upon answers to questions such as: Should there be increasing cooperation or/and coordination of research? Should scientists work on pure or on applied problems only? Should

multidisciplinary research be encouraged? What should be the relationship between science, politics and the economy?

To answer such questions, it is necessary to learn how science and scientists work. Within the area of science policy the quest cannot be limited to the scientific community alone; the study of science and scientists should also include:

- (i) the environment of innovation [8], and
- (ii) the relationship between the researchers and their work organisations.

These were also the conclusions reached in the exploration of literature, discussed in the previous sections.

Thus, this study focused on:

- (i) the effects of research organisations on the work patterns of their own employees, and
- (ii) the relationships between research organisations and their organisational environments.

A BRIEF OVERVIEW OF THE MAIN ARGUMENTS ADVANCED IN THE STUDY

# A theory of work patterns [9]

In this study, work patterns of problem solvers have been defined as the formation and development of interrelated ideas (problems, projects, themes, work programmes) that evolve in response to communication. These ideas develop in stages. In this study, the focus was on three such stages:

Work Programme Development --> Idea Generation --> Problem Solving WD IG PS

I argue that different stages are likely to require different types of communication. Table 1.1 summarises the hypothesised relationships between these stages of work and dimensions of communication considered in the study.

Dimensions of Communication	Stages of W WD IG		PS
Sources	External	Written Mat.	Internal
Types	'ALL'	SC + TEC	SC,TEC + ADMIN
Modes	Passive	Passive	Active
Circumstances	Formal	Discussion	Informal
Effects	-	-	-

Table 1.1							
Summary	of	hypotheses	cor	ncerning	work	patterns	
		of probl	Lem	solvers			

The stage of Work Programme Development is likely to be associated with mainly external sources, all considered types of information, a passive mode of information transfer and formal circumstances.

The Idea Generation stage is likely to be associated with mainly written materials, scientific and technical types of information, and also with . a passive mode of information transfer and those circumstances which involve a discussion of the written messages.

The Problem Solving stage is likely to be associated with mainly internal sources, scientific, technical and administrative types of information, an active mode of information transfer and informal circumstances.

Effects of information on the work of problem solvers were not considered to be significantly associated with any particular stage. I argue that all categories of the dimensions of communications considered in the study are important in the work of problem solvers, but that their importance varies with the stages of work.

This theory of work patterns is more fully discussed in Chapter 3.

A theory of research organisations, their organisational environments, and their effects on work patterns [10]

A resource dependence perspective was used as the framework for studying the relationships between organisations, their environments and the work patterns of their employees (Pfeffer and Salancik 1978). It is a perspective which enables an understanding of the social processes in organisations in terms of three broad cyclical steps, shown in Diagram 1.I.



First, according to this perspective, research organisations depend upon resources outside the organisation. Depending on the scarcity and necessity of these resources, external organisations exert power over the research organisation. The sum of power exerted by different organisations is the "environmental contingency" of the research organisation. Second, this environmental contingency is reflected in the distribution of power among problem solvers in the research organisation. On the basis of the ability to deal with the external relations, a dominant coalition forms and administrators are selected in the organisation. Third, once selected these administrators shape the external environment. The shaping of the external environment alters the environmental contingency, and thus the whole process ensues again.

Two aspects of the above theory are of a particular importance in this study.

First, through attempts to shape the external environments, the administrators facilitate interactions between their employees and the

employees of other selected organisations. Thus, the administrators influence the Work Programme Development stage of work, because that stage is dependent upon communication with external organisations.

Second, administrators shape not only the external environment, but also the internal organisational structure. Through shaping the internal structure of research organisations, the administrators affect internal communication, and thus influence the Problem Solving stage of work.

This theory of organisation is discussed more fully in Chapter 4 which also includes a statement of hypotheses which are derived from the theory.

### LIMITATIONS OF THE STUDY

Due to the limitation of resources necessary to carry out a large scale enquiry, it was decided to conduct an exploratory case study which aimed at testing the applicability of the theories constructed in one particular complex research organisation - a government research laboratory. Characteristics of that organisation and its environment are outlined in Chapter 2.

As a case study approach is limited, some interesting derivations from the theories could not be investigated and are, therefore, subjects for further enquiry. For example, the effects of different external organisational influences on the structure of research organisations were not examined.

Thus, this study aims to explore plausible relations between variables

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in an attempt to test and develop theories about work patterns, work organisations, and the effects of these organisations on the work patterns.

## SUMMARY AND OUTLINE OF THE THESIS

This study concerns an aspect of the process of knowledge development.

Unlike recent studies in the sociology of science, however, it investigates the work patterns of "knowledge developers" (problem solvers), and the effects their employing organisations have on them.

The thesis was logically divided to deal with two problems:

- (i) Problem I: the social construction of work patterns, and
- (ii) Problem II: the effects of research organisations on these work patterns.

Chapters 3, 5.I, and 6 address Problem I. Chapters 4, 5. II, and 7 address Problem II. The organisation of the thesis is illustrated by the following diagram:

## Diagram 1.II

Organisation of the written report

PROBLEM I

PROBLEM II



The present research is a case study which attempts to test the utility of theoretical frameworks developed to describe and explain social processes in a research organisation. The focal organisation was a research division of a government department. A description of this organisation, a necessary preface to the elaboration of relevant theoretical and methodological matters, follows in the next chapter. NOTES

[1] Although changing over time, it can be assumed that at any one particular time such a hierarchy exists (Hagstrom 1965, Hargens 1975, Gieryn 1978), and consists of concepts such as the following:

Research area



[2] The internalists attempt to map out knowledge development by focusing on factors internal to the scientific community. The externalists look at the relationship between the scientific community and other institutions in the society; they examine the effects of the context of scientific activity on that activity and their product: knowledge development. Thus, the distinction between internalist and externalist literature in the sociology of science is akin to the distinction between closed and open perspectives employed in the sociology of organisations (see Chapter 4).

The classification of literature in sociology of science into externalist and internalist should not be confused with categories external and internal (as used in Chapter 3) which concern intraand extra- organisational sources of communication.

- [3] In this study, "paradigms" refer (in Kuhn's 1970 sense) to cognitive rules, set out by the proponents of a particular perspective, which determine the relevant problems for investigation, suitable techniques for solution of the problems, and the acceptability of the results. The proponents of a perspective whose rules are recognised and complied with, are frequently termed the "invisible college" of that perspective (Price 1969a, Crane 1972).
- [4] This is rather surprising, since the internalist tradition in the sociology of science emerged from investigating scientists in their organisations (Ben-David 1971, Ben-David and Sullivan 1975). However, in the late sixties, the main attention in that tradition has shifted to exploring the social and cognitive developments within the scientific community as a whole, and the investigating of work organisations of scientists and engineers has become absorbed in the general area of management studies (Ben-David 1971, Ben-David 1978:202). In turn, literature in the management studies of science lacks an overall perspective which would explain frequently contradictory reported findings (see Chapters 3 and 4).
- [5] As Whitley (1977:23) pointed out, the internalist knowledge development theory implied:

"'Perfect' labour and product markets ... so that aside from the benevolent state providing adequate facilities and staff there are no collective entities impeding the free flow of information, men and materials."

A similar criticism of the internalist theory of knowledge development was advanced by Gaston (1975).

Surely, knowledge "utilisation" entails also the acceptance of knowledge and its accommodation into the goods and services in society at large. Therefore, it can be expected that, in turn, society is likely to affect knowledge development.

- [6] Symbiotic relationships which denote a mutual dependence between unlike units (Hawley 1950), indicate that the relationships between science and other institutions are just as important as the relationships within science and the scientific community itself. It is suggested that science is "nested" in society.
- [7] Mench (1974) who studied the relationship between science and its utilisation in industry noted that the lag varies between 1 to 100 years. Although he found the lag shortening in the present century, he explained this by efforts of those industries that are in their existence fully dependent on science (such as electronics).
- [8] The environment of innovation was defined in terms of four major classes of actors (the professional community, the organisation, the client communities, and the political system - see Chapter 4). As defined in this study (and literature on technology transfer), the environment of innovation excludes culture, family and other important social factors other definitions may include.
- [9] For explanation of the terms used, see Chapter 3.
- [10] For explanation of the terms used, see Chapter 4.

### CHAPTER 2

## DESCRIPTION OF THE RESEARCH ORGANISATION STUDIED AND ITS ENVIRONMENT

The research organisation which is the subject of the present research is one of the 22 divisions of the Department of Scientific and Industrial Research (DSIR), a government department. This particular Division is engaged in agricultural and biological research. Its relevant environment consists of other organisations in Agricultural and Biological (A & B) research in New Zealand and overseas, organisations in agricultural extension and the farming community in New Zealand (clients in the economy), and the New Zealand political system (see Chapter 4). Other salient feature of this environment are discussed below by way of providing an outline of the New Zealand situation [1].

A recent cross-national survey of expenditure and manpower utilisation in science (OECD 1979) reported that, compared with most other OECD countries surveyed:

- (i) more research in New Zealand was financed by the government,
- (ii) more research in New Zealand was carried out in government laboratories, and
- (iii) a greater proportion of monetary and manpower resources were spent on A & B research.

These characteristics reflect the fact that agriculture occupies a central place in New Zealand's economy and, as well, substantiate the need to investigate the patterns of work in government laboratories engaged in A & B research. This is further evidenced by suggestions that there is much room for improvement in the implementation of scientific advances of A & B research in the economy (Crouch and Chamala 1975, Callaghan 1957, Squire and Hughes 1973, Atkinson 1976).

Broadly speaking, government expenditure on A & B research is allocated upon the advice of the National Research Advisory Council (NRAC), among 33 major A & B research organisations [2]. Of these A & B organisations, 23 are research divisions of four government departments; others are research associations or institutes. The major research organisations, which are located in several centres, administer a large number of experimental stations, as well as substations which are spread throughout New Zealand (see a map shown in Chapter 7). The 10 divisions of the DSIR engaged in A & B research constitute about 30% of the major research organisations in that area of research.

The DSIR consists of 22 divisions and is, therefore, the largest research "organisation" in New Zealand. Although its Head Office controls the allocation of resources (both material and human) and regulates patterns of expenditure and staffing, control of projects is delegated to the individual divisions (Robertson 1972, 1973). The divisions can thus be viewed as a cluster of semi-independent research organisations, which are integrated under the umbrella of the DSIR.

was considered as a research organisation, all other divisions of the DSIR, the Head Office of the DSIR and all other relevant organisations in the scientific community, agricultural extension, the farming community and the political system were considered to be part of the organisational environment of the research organisation in focus.

The rest of this chapter outlines the characteristics of this research organisation. In particular, it deals with:

- (i) some characteristics of the organisation in comparison with some research organisations in New Zealand and overseas;
- (ii) characteristics of the members of the organisation which were derived from information collected through two questionnaires; and
- (iii) an overview of the "projects" being undertaken by workers in the organisation.

## COMPARATIVE FEATURES OF THE ORGANISATION

The main characteristics of the research organisation were assessed by focusing on the history, size, age and education structures of the organisation and comparing these with other organisations which have been studied in similar research overseas, and with the 33 research organisations engaged in A & B research in New Zealand.

The findings of this aspect of the research are summarised in Table 2.1. In terms of the selected characteristics, the organisation studied here appears, in many respects, to be unique rather than typical.
### Table 2.1 Characteristics of the organisation studied compared with other research organisations \*

Selected ch	aracteristics						
Relative typicality (1)	Relative uniqueness (2)						
<ul> <li>a Number of scientists in an administrative unit</li> <li>b Arrangement into sections</li> <li>c History marked by turbu- lence, challenges, and achievements</li> </ul>	<ul> <li>a Small number of scientists #</li> <li>b Large number of scientists in a geographical locality</li> <li>c Small ratio of scientists to science technicians **</li> <li>d Fast growth 1970-1977 **</li> <li>e Recent changes in the thrust of activities</li> <li>f Responsibility to maintain and develop a large scale national technological facility</li> <li>g Young mean age and age distribution of scientists ##</li> <li>h Old mean age and age distribution of science technicians ##</li> <li>i Low educational attainment by science technicians and high educational attainment by scientists ## **</li> <li>j No substations</li> </ul>						

\* Unless otherwise stated, the organisations included in the comparison were the major research organisations in A & B research in New Zealand
 (1) Relative typicality was defined as a closeness to an average

(2) Relative uniqueness was defined as a deviation from average
 \*\* The uniqueness was greater than the mean + 1 S.D.
 # In comparison with previous studies overseas
 ## In comparison with other divisions of the DSIR only.

### A brief history

Although its origins can be traced to a post World War II section in one DSIR division, the research organisation studied became a Division of the DSIR on April 1st 1962, with the staff of 16 (Atkinson 1976:123-124).

The upgrading of DSIR sections to divisional status as well as their subsequent developments can be said to be the histories of the Directors of the divisions (Atkinson passim, but especially Chapter 7, Cameron 1974). In the main, histories of these divisions have been characterised by turbulence, challenges and also achievements. These were certainly features of the history of the organisation which was the focus of the present research.

The key to the development of the Division was the building of a national technological facility worth over a million dollars; specifically a complex of controlled Climate Rooms. Although these were officially completed for the Royal visit in 1970, the tables of yearly use indicate that the use of the Climate Rooms as a national facility did not properly begin until 1973 (Warrington 1973, Hardacre 1975). A process of development which has in a number of important respects been plagued by problems over the years has, some seventeen years later, become a research facility which has a better performance than similar laboratories overseas (Warrington 1974:18, Atkinson 1976:124). This achievement was mainly the result of the perseverance and determination of the Director. However, other staff also contributed to the final success by deploying their special skills and indeed their physical

labour to the tasks at hand.

For the scientists and science technicians working in the Division, the "productive role" of the organisation began only upon the completion of the facility, following a radical change in the organisation's formal structure, and a change in the Directorship.

Thus, the history of the organisation investigated in the present research differed from the histories of other DSIR divisions in that its full development involved:

(i) construction of a large scale national facility,

(ii) comparatively recent adoption of a productive role, and

(iii) fairly recent radical change in formal structure.

In these respects, the organisation studied was unique.

### Size

#### ----

The organisation was regarded as small by the respondents and Head Office personnel. Of the 54 people surveyed, 28 were scientists, 23 science technicians, and 3 members of the administrative staff.

In relation to organisations investigated in similar studies overseas, the size was indeed small. The average size of organisations studied previously was 124 professionals (Allen 1977:146, Hall 1974).

However, in relation to the 33 A & B research organisations in New Zealand, the picture is not as simple. Because, unlike other DSIR divisions, the organisation studied had no substations, it is

instructive to consider the sizes of organisations as administrative and geographical units. (The former includes all staff on payroll; the latter focuses on the concentration of staff in the major locality.) As an administrative unit, the organisation studied was fairly typical of A & B research organisations in New Zealand: 28 scientists compared with median 27.9 scientists of all organisations compared. However, the organisation studied concentrated more scientists in one locality than did a majority of all the organisations compared: 28 scientists compared with the median of 20.8 scientists.

### Rate of growth

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In terms of the increases of the staff levels between 1970 and 1977, the organisation studied was the fastest growing A & B division of the DSIR; moreover, it was among the three fastest growing A & B research organisations in New Zealand.

# Ratio between science technicians and scientists

By 1977 the Division was one of two organisations with the lowest ratio between science technicians and scientists. In comparison with other divisions of the DSIR, there were fewer science technicians per scientist (0.6 compared with the mean ratio of 1.18).

### Age structure

Because of difficulties in locating the appropriate figures for all A & B research organisations, the age structure was compared with A & B divisions of the DSIR only.

Not only were the scientists in the organisation studied younger on average (31.5 years compared with 38.2 mean years for all A & B divisions), but a study of the distribution of age groups indicated that the overall age structure was younger than in other A & B divisions of the DSIR.

The age structure of science technicians was, however, the opposite of the pattern found for scientists. Science technicians in the organisation studied were on average older than science technicians in all A & B divisions of the DSIR (35.4 years compared with 33.6 mean years).

### Staff qualifications

In 1977, 64% of scientists in the organisation studied had doctorates. This was the third highest proportion of doctorates in the A & B divisions (the mean was 47%), and among the top quarter of all organisations considered (the mean was 45.4%).

Science technicians, on the contrary, had the lowest proportion of people with certificates or degrees, compared with other A & B divisions of the DSIR (11% as compared with the mean of 31.9%).

#### OTHER SOCIO-POLITICAL CHARACTERISTICS

In this study, some socio-political characteristics of the organisational members were examined. These characteristics were studied in relation to the four major classes of actors:

A. the professional community,

B. the organisation,

C. the client communities, and

D. the political system.

The characteristics studied can be divided into three major categories:

(i) past experience (in A, B, C, D),

(ii) social "centrality" of the members (in A,B,C,D), and

(iii) attitudes (toward A,B,C,D).

This section of the chapter presents descriptive statistics of aggregate data on the characteristics in each of the above categories, other than those reported later in the major analyses.

### Work related past experience

About 20% of the respondents attained their highest secondary education (usually UE or its equivalent) overseas, and 40% each in the North and South Island of New Zealand. Respondents educated in the North Island went to schools spread throughout the island; a large number of those educated in secondary schools in the South Island went to schools in Nelson.

About 25% of the respondents had Bachelor's degrees, 18% Master's, and 37% had PhD; about 20% were holders of certificates and diplomas. Although approximately a quarter of the respondents completed their highest tertiary education overseas, the largest single group (36%) did so at Massey University, New Zealand.

Typically the respondents had worked on average six years in the Division under investigation; however, the median length of employment was five years and the mode three years.

About two-thirds of the respondents were born in New Zealand. The next largest groups came from the UK (16%) and the Netherlands (8%). On average, the respondents were brought up in cities (places with population sizes between 20,000 - 100,000 persons); and in lower-middle class families.

Whilst about 65% of the respondents had a farming experience of less than one year, 10% had between one and five years of such experience, and about 25% had farm experience of longer than 10 years.

The average age of respondents was 31.5 years. Typically, respondents were married, with semi-professional or professional working spouses, and with one child.

Centrality of the respondents in the four systems (professional, organisational, client, and political)

The centrality of the organisational members in the organisation includes the person's placement in the communication networks, formal structure, pattern of decision making, colleague network, informal network and the merit list. All these characteristics are fully analysed in the main analysis and need not to be discussed here.

In the professional community, the respondents were, on average, members of one professional society. About 10% of the respondents were members of four or more of these societies. However, only 15% of the respondents had held some elected office in these societies in the past three years.

Whilst the respondents normally attended about two conferences in the past three years, almost 30% did not attend any. At the other extreme, 14% of respondents went to more than six. About 80% of the conferences attended were held in New Zealand; others were in Australia, the United Kingdom and North America.

In comparison with attendance at professional conferences, only 10% of the respondents participated in meetings with persons in agricultural extension, and 12% in meetings with the farming community.

A vast majority (over 80%) belonged to two voluntary associations in the local community. About 60% also held office in these organisations. These figures suggest that the respondents were fairly active in the local community; however, the majority of them went to public meetings only "sometimes".

The highest political voting preference expressed by respondents was for the Labour Party, though the preference was, on average, weak.

## Attitudes towards the four systems

The major tool for assessing the respondents' attitudes toward the four systems was the Orientations Test which is described elsewhere in this report (Chapters 4, 5, and 7).

Four other attitudinal tests were carried out. The first studied the

Diagram 2.I Respondents' preferences for work team organisation



Diagram 2.II Respondents' preferences for work team composition



respondents' attitudes toward the likely users of their work. As might be expected, the respondents considered that the most likely users of their work would be scientists [3]. Agricultural extension personnel and persons in the farming community were not, in the main, considered to be likely users [4].

The second test addressed team work, the third responsibilities of persons occupying high administrative positions and the fourth studied the respondents' views of their organisation. The results of these tests are described below because they represent a summary statement of respondents' preferences regarding the structure of their work and organisation.

## Attitudes toward team work

Most respondents (95%) prefer to work in teams rather than alone.

Diagrams 2.I and 2.II summarise the observed mean preferences for a team approach to the organisation and the composition of work teams, respectively [5].

Both diagrams show little difference in preferences expressed by scientists and science technicians. The differences which were observed can be attributed to the indifference of science technicians rather than to differing points of view.

As shown in Diagram 2.I, the respondents prefer to work in "ad hoc" teams which would be set up by a contributing member, irrespective of whether the teams were set up to solve scientific or practical

### Diagram 2.III Respondents' attitudes toward people occupying the positions of Director, section leaders and those without administrative duties



problems.

The respondents did not wish to be located in any permanently established teams.

The respondents expressed some caution in their response to the involvement of administrators in setting up research teams. The phrase "it depends" perhaps best describes the hesitancy that characterised replies to this question.

As shown in Diagram 2.II, the preferred team member should be of similar, if not a higher degree of competence and be, preferably, "competent" in a different research area to that of the team member. Persons in the agricultural extension and the farming community were considered unsuitable for membership in "scientific" teams. They may well be the suppliers of practical problems (and this was highly valued by the respondents), but this appeared to be as far as any further exchanges of ideas should go. The respondents considered that client groups have no place in the solving of the problems, nor are the results of scientific and technical work directed toward them.

### Roles of administrative positions

Diagram 2.III summarises attitudes toward people occupying the positions of Director, section leaders, and those without administrative duties [6]. As shown in the diagram, scientists and technicians see their role as resolving work-related problems and organising their work, whereas the role of administrators, they considered, was to facilitate communication, contacts, and the provisions of other resources such as

space, equipment, funds and personnel.

Respondents' views of their organisation

The examination of the respondents' views of their organisation involved a test based upon instruments developed by Cotgrove and Box (1970) and Pearson (1977). The results are summarised in Table 2.2 [7].

The table shows that most of the items included in the questionnaire were considered important in the work of the respondents. The respondents reported that the quality and quantity of human and material resources, which can be reasonably easily manipulated to ends desired by the individuals and recognised and rewarded by the organisation, to be most important. The "external relations", particularly with the economy were considered by respondents to be least important.

Two factors which were between the two extremes addressed "administrative procedures" (Factor II) and "structural relations at DSIR" (Factor III).

Diagram 2.IV shows the mean scores of each item on the importance scale, plotted against mean scores on the satisfaction scale.

Table 2.2 Respondents' ranks on importance and satisfaction scales

1.00

ITEM	DESCRIPTION	RI	RS	FACTOR	MEAN SC.+
17 23* 22 24 3* 20 4* 1	Relations between scientists and science technicians Quality & quantity of support personnel Autonomy Quality & quantity of material resources System of promotions and rewards Library system DSIR administrative procedures Recruitment policy	1 2 3 4 7 9 17 24	2 7 4 5 26 6 25 23	I	3.835 s.d.=.475
19 16 26 18* 2 33 30	Buildings: Interior Arrangement of sections Contact with NZ colleagues Buildings: General Salaries Feedback Opportunity to extend formal education	8 10 11 13 16 18 23	8 10 16 3 20 19 13	II	3.444 s.d.=.188
32* 14 15 31 9 21* 7* 27* 6 5* 8 13	Opportunity to extend experience Size Arrangement of positions Opportunity to attend conferences Relations between staff and centre off. Publication policy Relations between staff and ADG's Contact with overseas colleagues Head Office policies on application Head Office forward planning and dir. Relations between staff and HO admin. Receptiveness to public issues	5 6 14 15 20 21 22 26 27 29 30	12 1 14 15 9 29 33 28 30 22 21	III	3.278 s.d.=.337
10 25 11 <b>*</b> 12 28 29	Relations between staff and other DSIR divisions Output by others Liaison with Agr. Extension Liaison with the Farming community Contact with extension personnel Contact with farmers	12 25 28 31 32 33	17 18 32 31 27 24	IV	2.905 s.d.=.377

Notes to the table are shown overleaf .....

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- \* Items with a high difference between ranks on importance and satisfaction scales
- RI Rank on the importance scale
- RS Rank on the satisfaction scale
- + Mean of all items which loaded highly on the factor

Although the rating on the satisfaction scale was, generally, lower than on the importance scale, there was a high rank-order correlation between the two scales (r = .74). The less important an item, the greater was the respondents' dissatisfaction with the state of the item. This means that respondents were reasonably satisfied with those items which they considered important, and dissatisfied with the states of those items which they considered unimportant. Exceptions to this pattern are clearly visible in Diagram 2.IV, and are summarised in Table 2.3.

Table 2.3 Items with high differential between mean scores on importance and satisfaction scales

RI* ITEM	DESCRIPTION	IMPORTANCE SCORE	SATISFACTION SCORE
13 18 20 21 2 23 5 32 7 3 17 4 21 7 22 27 27 5 28 11	Buildings: general Publication policy Support personnel Extend Experience Rewards and Promotions HO administrative procedures Relations with ADG's Contact with overseas colleagues HO planning and direction Liaison with Agr. Extension	medium low high high high medium low low low	high high medium nedium low low very low very low very low very low

\* Rank on the importance scale

Relative to their importance, the respondents seemed to have been satisfied with the standard of accommodation and the system of



Mean Diagram 2.IV scores of "organisational" conditions ranked importance scale in comparison with the item mean score on the satisfaction scale the item's ор the

publication policies. (They were also highly satisfied with the size of their organisation.)

The scores for quality and quantity of support personnel and the opportunity to extend experience, although considered reasonably satisfactory suggested that there was much room for improvement.

The last six items in the table feature a score below "3" which indicated dissatisfaction. These items covered the DSIR context of work and the relations between the organisation and the economy. An item concerning the administrative system of rewards and promotions (excluding salary) was considered very important, but very unsatisfactory. This finding clearly has significant policy implications [8].

#### OVERVIEW OF PROJECTS

I now turn to a consideration of the projects under way within the organisation. Table 2.4 summarises the numbers of projects reported on by the respondents in the study.

In total, the respondents were involved in 454 projects. At the beginning of the study, the total number of projects was 322. On average, each respondent was involved in 6 projects, but the range was 1 - 14 projects. During the study, 132 projects were added and 115 terminated [9]. There was, then, a core of 207 projects which remained on the project schedule for the organisation throughout the study.

	Total No.of	Ent Res	Entries per Respondent					
	322	x	s.d.	range				
Entered at 28.4.1977 Added during study Concluded during study Dropped during study	322 132 91 24	6.0 2.4 1.7 0.4	3.12 3.09 2.36 1.23	1 - 14 0 - 14 0 - 10 0 - 7				
Total entered (1+2 lines)	454							

Table 2.4 Summary of projects entered by the respondents

All 454 projects entered by the respondents were juxtaposed and overlayed. As a result, 226 projects entered subsequent analysis and are described below [10].

The projects which were subsequently analysed can be described in terms of the distinction between research, development and service types of work, which has been used frequently in previous studies (Rosenbloom and Wolek 1970, Cotgrove and Box 1970, Whitley and Frost 1973). To avoid unnecessary complexity, however, this distinction was not used further in this study.

Over 60% of all projects were in research, 12% in service activities and about 14% of projects concerned developmental activities. Hybrids, which can be defined as projects in more than one major type of activity, accounted for about 10% of all projects analysed.

# Distribution of project stages

Diagram 2.V shows that a majority of projects were at the Problem Solving stage; the others, in descending order, were at the Idea Generation stage, the Concluding stage and the Project Proposal stage. The data thus indicate that during the study there were more projects at the pre-problem solving stages than there were at the concluding stage. Thus over the course of the present research, there appeared to be no apparent problems in replacing a concluded project with a new one.

The fact that the Project Proposal stage appeared the least number of times indicates that during the course of the research, there was likely to be a low degree of rigorous formal control over the work of the respondents. This lack of formal control of projects was confirmed in interviews [11].

## Project characteristics in terms of facilities used

Diagram 2.VI shows an overall bias toward the use of specialised in-house equipment. This equipment was used more extensively than any other class of major facilities. The use of farm plots featured the least.

# Characteristics of projects in terms of communications

On average, 4.7 items of information were introduced into the work for each project. This level of communication input was similar for the work of all occupational groups, persons working in different types of activities (research, development, service), and "work areas" which were



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Diagram 2.V Distribution of project stages .





examined in the Information Flow Questionnaires (Appendix A). This indicates that where the work of organisational members is conceptualised in terms of problem solving activities (whatever the type of problem solving activities), people are likely to require a similar degree of information to carry out their work. This point, which is contrary to the findings of previous studies, will be explained later in Chapter 6.

### The process of projects

The results from the present research suggest that the characterisation of projects as linear processes (that is proceeding from IG to PP to PS to C stages) was rather simplistic. During the study, only 24% of project stages changed in a linear fashion, whereas 64% remained the same throughout the study and 0.6% were dropped and reinstated later. Further, many projects featured more than one stage. Because projects had this dynamic quality, constraints were introduced into the present investigation which made the analyses required more complex than had been expected at the outset.

The results from an examination of the ratio between unchanged and changed statuses of project stages in terms of communication input are shown in Diagram 2.VII. This diagram reports the proportions between changed and unchanged statuses of the four stages. In response to communication input, there was a smoother transition of projects at the Project Proposal and Concluding stages, whereas a backlog of projects tended to occur at the Idea Generation and Problem Solving stages. Since there was no formal control of projects, and there were more ideas on

Diagram 2.VII Project stages: proportions of changed and unchanged project stages



new projects than there were projects concluded, the "problem" area appears to be the Problem Solving stage. There appears to be a need to aid the problem solvers in the actual problem-solving activity, in order to overcome a work blockage.

In general, the use of facilities did not change as projects changed from one stage to another. Consequently, the role of facilities in the work of problem solvers was not investigated further.

#### SUMMARY AND CONCLUSION

This chapter presented a description of the organisation studied and briefly outlined its environment.

Although the organisation studied appeared small in relation to organisations investigated in similar overseas studies, its size did not differ significantly from other organisations engaged in Agricultural and Biological (A & B) research in New Zealand. The organisation investigated in the present research had, however, a greater growth rate, a lower ratio between science technicians and scientists who were younger and better qualified, and an older, lower qualified population of science technicians than analogous research organisations in New Zealand. The organisation studied appeared to be, in many respects, unique rather than typical. Inferences based upon the findings of the study must, therefore, be drawn with caution.

Somewhat unexpectedly, other findings showed that the members of the organisation studied were brought up in cities, in lower middle class

families and, on average, had little direct farm experience.

It appeared that the members were involved in professional and non-work related voluntary organisations (more so in the latter than the former), but cared little for participation in client communities and politics. Some of these points were confirmed in an analysis of the respondents' attitudes.

Whilst the client communities were seen as necessary to provide research problems, their representatives were considered to have no place in the research teams. Also, members of client groups were not considered to be the likely users of the results of the respondents' work. The formation of external relations with the client communities was considered to be the least important aspect of work. These results appear to be consistent with administrative practices which simply tend to ignore these relations.

Yet the respondents believe that some liaison with client communities is essential; moreover, they expressed some dissatisfaction with the practices of administrators in this matter. From the point of view of respondents, the role of administrators was construed as facilitating communication, contacts, and the use of resources, including the elaboration of links with the client communities. This can, indeed, be expected because a review of the innovation environment in New Zealand agriculture is likely to indicate that a member of an A & B research organisation attempting to cooperate with actors in other classes is likely to face a maze of organisations and relations which are confounded by diverse conflicts.

The respondents saw their primary role as the solving of problems; and they desired to carry out their tasks with as little administrative interference as possible. They also saw their important role in setting up of research teams; and they desired flexible structures to do so.

Overall, respondents appeared to be generally satisfied with arrangements for matters which they thought were highly important. They were reasonably satisfied with the amount of autonomy they had and the availability of human and material resources they needed to exercise the autonomous decisions which they wished to make in their work. They were, however, very dissatisfied with the administrative system of rewards and promotions which they regarded as a very important part of their work.

The data indicated that respondents were engaged in several projects, simultaneously. On average, the respondents were working on six projects, with the majority of these projects at the Problem Solving stage. The projects under way at the time the present research was carried out featured an extensive use of specialised in-house equipment. The transition of work from one stage to another was more complex in the research setting of this study than was anticipated. This result represents a difficulty which is not infrequently encountered, when an investigation seeks to map the "real" world. Nevertheless, there was evidence to suggest a relationship between communications input and projects. This relationship was studied more closely in the analyses of the present research.

NOTES

- [1] For more details on each major class of actors see New Zealand Official Yearbook, Agricultural Statistics, Lloyd 1974 (for some reviews of New Zealand's agriculture); Mclintock 1966:13-16, Gibbs 1979, Hercus 1970, Dale 1979, Gidley 1977, Squire and Hughes 1973 (for some reviews and bibliographies on agricultural extension); Jackson 1973, Cleveland 1972 (for some reviews of the New Zealand system of government); and Callaghan 1957, Atkinson 1976, Hoare 1976, Dick 1957 (for some reviews of New Zealand's science and the relationship between the four classes of actors).
- [2] For the purpose of the comparisons carried out in this study, any organisation in Agricultural and Biological research noted in the List of Research Workers in Agricultural Sciences in the Commonwealth 1978 and which was headed by a Director was considered a major A & B research organisation (the list may thus differ from DSIR's traditional definition of which divisions constitute the A & B sector).
- [3] The mean attitude score was 3.2 on a scale 1-5; 5 being the highest.
- [4] The mean attitude score was 2.4 on the same scale as in footnote [3].
- [5] The instruments and the scales are shown in Questionnaire II, Questions 13a and 13b. The tests used were published in Glueck and Thorp (1971).
- [6] The instruments and scales are shown in Questionnaire II, Questions 14 and 14a. The tests were adapted from Glueck and Thorp (1971).
- [7] The instruments are shown in Questionnaire III. Table 2.2 which summarises the findings shows the number of each item (corresponding to the one in the questionnaire) and its description, the rank of each item on the importance and satisfaction scales and some descriptions of the factor analysis which was carried out to find the dimensions of the importance scale. The items in the table are arranged in order of the factors. Asterisked items are further discussed later in the text.

The responses to the question requesting the respondents to evaluate the importance of each item were factor analysed. A four factor Varimax solution was found interpret the data best.

Whilst the use of factor analysis can be considered inappropriate here, it was used merely to group together "similar" items on an other than purely intuitive basis. The results were not used to make claims for theoretical nor methodological validity of the tests.

[8] A detailed analysis of responses of scientists and science

technicians (not shown here) showed no statistically significant difference between the evaluations made by the two occupational groups. This overall agreement then tends to confirm Hagstrom's (1965) notion that science technicians tend to adopt the norms and values of scientists. The differences which were found indicated that scientists accentuated the need for an elaboration of the external relations. Science technicians appeared to be more dissatisfied with the organisational and administrative procedures which indicated that they were acutely aware that although their attitudes were similar to those of scientists, the Public Service codes treat the two occupational groups differently.

- [9] Of the 115 projects which were terminated during the study, 91 (79%) were concluded and only 24 (21%) were dropped. Of these 24 dropped projects, 13 (54%) were terminated due to the departure of a team leader. These changes affected only a small number of persons, but resulted in extensive changes in their workloads. Eight projects (33%) were temporarily suspended due to pressure of other work, and two were transferred to other persons. One project was dropped because it was found to duplicate the work of another person within the organisation. The reasons given for dropping a project indicate that, during the study, there were hardly any administrative "surgeries" on the work of the respondents.
- [10] Projects in the areas of administration and committees were excluded from the analysis; projects of joint nature were combined; and other projects which were considered too trivial to be studied separately were grouped.
- [11] In the past, there were two systems of formal control of projects (discussions at professional staff meetings and set up panels). Both systems were said to have "fizzled out". It was commented that while especially the first system was working, "it was good". However, as soon as some proposals were not discussed, the system collapsed. As it was put: "there is only one reason to have proposals .. (to discuss them) .. not to file them away in a filing cabinet .. which is pointless". The difficulties with maintaining a formal project control system are extensive. As suggested, "all staff are expected to submit proposals to the Director concerning major projects" (Triennial Review 1978/79:5). However, just what constitutes these major projects in view of the process of idea development outlined in Chapter 3 is, understandably, problematic.

CHAPTER 3

A THEORY OF WORK PATTERNS OF PROBLEM SOLVERS IN RESEARCH ORGANISATIONS

This analysis of knowledge creation begins by looking at work patterns of problem solvers.

A survey of relevant literature concerning the work of scientists and engineers shows an inconclusive state of affairs. Because of the lack of a sufficiently integrated perspective, the field features studies with contradictory findings and no theory which would reconcile these differences. Hence, the various work patterns are not adequately explained.

Research and development, the major types of work activities in research organisations, have been studied whilst investigating both the work of scientists (Merton 1938, Crane 1972, Storer 1966, Hagstrom 1965) and industrial scientists/engineers (Allen et al 1966, Marquis and Allen 1966, Marcson 1960, Strauss and Rainwater 1962, Kornhauser 1962). A major similarity between otherwise different systems of work (Toulmin 1969, Price 1969b, Sklair 1973) was found in problem-solving activities. This similarity is the starting point of analyses carried out in this chapter. In the present study, work patterns are considered in terms of problem-solving activities. People engaged in this type of work are simply termed problem solvers. I will argue that problem solving takes

place in stages, and that each stage in the problem-solving process is characterised by a specific form of communication. Consequently, this chapter looks at:

- (i) Stages of work,
- (ii) Structure of communication, and
- (iii) Relationships between the stages of work and structure of communication.

In this thesis, I attempt to provide a wider perspective by trying to integrate the study of work patterns of scientists and engineers with sociological studies of the process of knowledge development.

I begin with the notion of work stages.

#### I. WORK STAGES

In the literature, problem-solving activity was considered as the formulating and solving of projects. The process was said to begin by some recognition of a problem or a research possibility that becomes defined, solved and concluded and finally either accepted or rejected by some users (Johnston 1974, Myers and Marquis 1969, Goldhar 1974, Gruber and Marquis 1969, Rao and Rao 1973, Frischmuth and Allen 1969).

Thus, problem-solving activity was considered as a linear process which can be characterised in terms of four stages:

(i) Idea Generation (IG): a particular problem is defined in response to some need, or by the recognition that it is technically feasible to solve an existing problem (Goldhar 1974, Gruber and Marquis 1969, Langrish et al 1972).

- (ii) Project Proposal (PP): occurs when the demand and the appropriate technical approach are put together (Goldhar 1974).
- (iii) Problem Solving (PS): frequently termed the "puzzle-solving" stage (Kuhn 1970, Johnston 1974), it consists of the actual activities aimed to solve or resolve the initial problem (Gruber and Marquis 1969, Johnston 1974).
  - (iv) Concluding (C): the project is wound up and the results (whether positive or negative) "leave" the organisation. This may occur in various forms of "technical information"; either as embodied in the crude state of ideas, or in the literature, or in hardware (Johnston 1974:78).

The linearity of the problem-solving process can be illustrated as follows:

IDEA GENERATION --> PROJECT PROPOSAL --> PROBLEM SOLUTION --> CONCLUDING (IG) (PP) (PS) (C)

Such a pattern typifies the problem-solving process in a single project. However, each problem solver may be involved in several projects simultaneously. Indeed, some researchers have noted that because of the paramount importance which can be attributed to the choice of research problems (Gieryn 1978, Zuckerman 1978), professional problem solvers tend to routinise their work by paying attention to several projects at the same time (Hargens 1975). This then helps to reduce the possibility of "disastrous frustration" which may occur when a "scientist invests all his intellectual and psychological resources in one research topic" (Stinchcombe quoted by Hargens 1975:60). The overall work pattern for any given problem solver can thus be characterised as follows:

#### AT TIME T

PROJECT	1						/	IG	-	->	PP	>	PS	>	C
PROJECT	2					IG	>	PP	-	->	PS	>	С		
PROJECT	3			IG	>	PP	-   ->	PS	-	->	С				
PROJECT	4	IG	>	PP	>	PS	-   ->	С							

A problem solver may then be working, simultaneously, on the solution of a number of projects (PS stage) and preparing drafts of one or two papers with a view to publication (C stage). Another project with which s/he is involved my be awaiting a decision on funding (the PP stage); further projects may still be in the process of formulation (the IG stage).

The work of problem solvers involved with several projects simultaneously is likely to have a different structure from the "one-project" situation. Whilst past studies focused mainly on work involving single projects (Baker et al 1967, Fisher 1979), this study concerns the investigation of a work organisation in which problem solvers are carrying out a number of projects, simultaneously. The study thus re-examines the definition of problem-solving activities. In essence, I will argue that problem-solving activities concern not only the processes of projects, but also a broader issue: the development of work programmes within which the processes of projects take place. Even the "one-project" situations can be seen to be part of a work programme. In these instances, one project follows another; a logical connection exists between projects. Because previous investigations have generally neglected consideration of this issue, some contradictory findings shown in the empirical studies completed to date could not be explained. The argument is as follows.

Because the involvement with several projects at any one time may mean that the choice of a research problem in one project is related to the choices of problems in other projects [1], it is possible to suggest that several projects, consisting of several problems, are likely to form around a single work theme. Moreover, several work themes are likely to to form the work programme of problem solvers. Consequently, the work of problem solvers can be considered as the formation and development of inter-related "ideas". The structure of these "ideas" is illustrated in Diagram 3.I.

Diagram 3.I The structure of ideas in the work of problem solvers



In the above scheme, work programmes refer to the sum of problem solvers' work activities which may consist of one or more work themes. Work themes describe those ideas which denote work areas from which projects are derived. Themes expand and decline in emphasis as the work interests of problem solvers change. Work projects are ideas in the form of specific tasks which are to be resolved. They have a definite beginning and an end. Problems are the smallest components of work and address not only the "problem" investigated in a project, but also the choice of theories, methodologies, the operation of instruments, procedures for writing up results, and so on. [2]

Whereas the above concepts address the structure of "ideas" at any one time, the present investigation focused on the processes of these "ideas", over time. The process of projects has already been discussed as occurring in four stages. Further concepts, however, need to be introduced to explicate the developments of work themes and work programmes. (Work problems were discarded from analysis in this study.)

Mulkay (et al 1975) discussed work themes in terms of three stages. A ----work theme is in either an exploratory, growth, or decline stage depending upon the quality and quantity of problem solvers' networks.

Work programmes can be considered using the life cycles of the problem solvers (Hill et al 1974, Hill 1976). For example, there is some -----evidence to suggest that natural scientists achieve high productivity at about age 30.

However, for simplicity, I focus on "Work Programme Development (WD)", which is defined as the process whereby the choice of work themes alters the direction of work programmes. This concept thus addresses the processes of work themes and work programmes from the point of view of individual problem solvers. The present formulation argues that Work Programme Development is an important stage in the process of knowledge

creation, prior to and different from the stages of projects. It constitutes a metaphysical "weltanschauung" upon which all projects are based. Although such "weltanschauung" includes what Kuhn (1970) termed paradigms, it is much more. It is what problem solvers consciously and unconsciously consider paradigms, as well as the results of perceptions of developments in the society at large. That research programmes within which research "problems" are selected, are affected by such "weltanschauung" is also a conclusion recently reached by Crothers (1979) and Mulkay (1979). For example, during the time in which the present research was carried out, energy issues became paramount in New Zealand. Such demands strengthened some scientists' willingness to further develop work themes related to energy farming. Another example involved a scientist whose concern with the problem of food production in third-world countries resulted in his determination to study alternative supplies of those fertilisers which would be "at a price the world could afford". The actual studies were, of course, carried out within scientific paradigms.

Later in this chapter I will show that the definition of the work of problem solvers, which includes the Work Programme Development stage, enables a theoretical reconciliation of some contradictory findings in the literature.

In sum, I argue that Work Programme Developments and the various stages of projects constitute the work activities of problem solvers who work on a multiplicity of projects. Thus, under this new formulation, the process of these stages of work can be illustrated as follows:
Stages of work

WD PROJECT 1 (IG -> PP -> PS -> C) PROJECT 2 ( " ) PROJECT n ( " )

Although for different projects different stages occur simultaneously, and problem solvers are likely to define and re-define the direction of their work continuously, these stages can logically be considered as categories which exclusively exhaust the work activities of problem solvers; they are stages of work.

Previous research has, however, focused mainly on the communication patterns of problem solvers working on projects at two major project stages: Idea Generation, and Problem Solving. For simplicity, this study did so too; the two other stages in the processes of projects (Project Proposal and Concluding stages) were discarded from analyses. The focus of this study was thus on three work stages, as illustrated below.

Work Programme Development --> Idea Generation --> Problem Solving

#### II. STRUCTURE OF COMMUNICATION

Having discussed the stages of work, this section of the theoretical formulation examines the importance of communication in the work activities of problem solvers and addresses the structure of such communication. In the next section I will suggest that each stage of work is likely to be associated with a particular structure of communication. Because of the complexity inherent in the discussion of communications, the analysis is divided into four sections:

- (i) An introduction to the notion of "information matrix",
- (ii) The definition of "significant information" which comprises the information matrix,
- (iii) The structure of the information matrix, and
- (iv) A discussion of the dimensions of the information matrix adopted in this investigation.

1. INTRODUCTION

Each stage of work evolves on the basis of communication.

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At the Idea Generation stage, a project can be generated by either of two communicated stimulii: awareness of either a problem or of a technology.

A Project Proposal cannot be formulated without communication about both the problem and the technology to be employed.

At the Problem Solving stage, previous studies found that the higher the number of alternatives considered, the higher was the projects' success rate (Allen 1969). Such alternatives were considered following communications of their existence. It is also generally accepted that as new information comes to hand, the Problem Solving stage involves a redefinition of the initial problem (Johnston 1974:80).

Even at the Concluding stage, the appropriate format for presenting results needs to be the subject of communication, because the requirements of different journals may vary.

Thus, each stage occurs in an information environment which affects it. This environment can be mapped. To avoid confusion which may arise out of using the concepts of "information environment" and "organisational environment", the information environment will be termed "information matrix" (Johnston 1974).

The next two sections examine what constitutes the information matrix and its structure.

#### 2. DEFINITION OF SIGNIFICANT INFORMATION

Goldhar (1974) defined the information matrix as follows:

"...the entire process of a project can be defined as an "organisation" of many diverse bits and pieces of both new and existing technical and market information."

A similar, but in some respects less satisfactory, definition was advanced also by Johnston (1974:80).

The definition indicates that the information matrix consists of new and existing information; that is information newly communicated to the

problem solvers, as well as information problem solvers already possess. This study focuses only on information newly communicated to the problem solvers because this is the information found to be most directly influential on their work. As previous studies indicated, knowledge which problem solvers already possess tends to influence only their preparedness to seek and consider various information stimulii (Allen and Marquis 1964, Allen et al 1968).

#### ----

The definition also points out what kind of information counts. This is of a fundamental methodological importance. One may imagine that the information matrix comprises "bits and pieces" of information which are in the environment of problem solvers. This means that information given by a person can be seen as the sufficient condition for that information to belong to the information matrix. Many previous studies partially constructed the information matrix of problem solvers investigated on such a basis (Allen and Cohen 1969, Shotwell 1971, Frost and Whitley 1972, Hall 19<sup>-1</sup>). In these studies, the criterion for accepting a piece of information into the information matrix was that the exchange of information was mutually acknowledged by both its sender and receiver.

However, Goldhar (1974) and Johnston (1974) suggest that the information which counts is that which is perceived as significant by the problem solvers, that is the receivers, alone. It is the information that is "organised" by the problem solvers which is important, whether or not its giver was conscious of giving it. As Rodgers (1951:503) noted in a textbook of social psychology:

"As experiences occur in the life of individual, they are either (a) symbolised, perceived and organised into some relation to self, or (b) ignored, because there is no perceived relationship

to the self-structure, or (c) denied symbolisation, or given a distorted symbolisation, because the experience is inconsistent with the structure of the self."

Thus, in this study, the information matrix was constructed on the basis of significant information, that is information which problem solvers considered likely to influence their work [3]. In testing the theory of work patterns advanced in this chapter, significant information was treated as the unit of analysis.

### 3. STRUCTURE OF THE INFORMATION MATRIX

Information items in the information matrix differ along several dimensions. Having determined what constitutes the information items, I now turn to discuss the structure of the information matrix. I begin by reviewing studies which have investigated communication among problem solvers, because these are the most relevant for the problem at hand.

Early studies of the patterns of communication among problem problems were succinctly summed up by Burns (1969:43) in his aphorism "The mechanism of technological (information) transfer is one of agents, not agencies". Information exchanges were most efficient, he suggested, in oral and in informal circumstances. Recent research is summarised in Table 3.1.

The table shows that the information matrix is a complex phenomenon which consists of many dimensions; it entails the whole process of communication.

		Tab	ole	3.1	
Summary	of	research	on	communication	among
		proble	em s	solvers	

Studies	Major Variables Considered	Findings
Allen 1966,1968,1977, Allen and Cohen 1969, Frost and Whitley 1971, Whitley and Frost 1973, Utterback 1971, Baker et al 1967, Hall 1974	sources of information	Internal oral sources are generally more important than external oral or written sources
Johnston and Gibbons 1975, Hagstrom 1965, Menzel 1970, Shotwell 1971	11	External oral and written sources are more important than internal sources
Myers and Marquis 1969, Walsh and Baker 1972, Pruthi and Nagpaul 1978, Johnston and Gibbons 1975, Katz and Tushman 1979	types of information	administrative types of information are important; previous other studies cited above focused on tech- nical type of infor- mation alone
Walsh and Baker 1972, Hall 1974	circumstances of transfer	Formal circumstances (meetings) are important Other studies over- emphasised importance of informal circumstances
Myers 1970, Rothwell and and Robertson 1973, Hall 1974	mode of transfer	Both active and passive modes of transfer found important. Other studies failed to differentiate (see also under project stages)
Wolek 1970	information complexity	The greater the info. complexity, the greater the use of oral sources; the lesser such complex. the greater the use of sources written
	contin	ued overleaf

Table 3.1 continued .....

Studies	Major Variables Considered	Findings
Myers 1970, Utterback 1971, shown also in Rothwell and Robertson 1973, Fisher 1979	project stages	The less advanced the stage, the greater the use of written sources. The more advanced the stage, the greater the use of oral sources. Also, the less advanced the stage, the greater the passive persual of information. The more advanced the stage, the more active persual of information
Baker et al 1967	"	Idea Generation stage is associated with the extensive use of external oral sources
Pelz and Andrews 1966, Smith 1970, Katz and Tushman 1979,Connolly 1975, Conrath 1973, Johnston and Gibbons 1975	target of information (task complexity*)	The higher the task complexity, the higher the communication needs
Fisher 1979	task "newness" (routiness)	The newer the task, the greater the reliance on external sources; the more "rou- tine" the task, the greater the reliance on internal sources

\* In past literature, this variable was also termed task uncertainty and found also related to environmental uncertainty (Lawrence and Lorsch 1967, Duncan 1973, Gailbraith 1973).

Following the discussion of those dimensions of communication which were considered in this study, the last part of this chapter deals with the relations between them and the stages of work. The discussions draw heavily on the information presented in Table 3.1.

### 4. DIMENSIONS OF THE INFORMATION MATRIX ADOPTED IN THIS STUDY

Although there appears to be little agreement as to what communication is (Dance 1970), this study adopted a simple but, it is argued, an effective definition of communication: the transmission and reception of information by the use of symbols (Berelson and Steiner 1964:254, Williams 1968:17). Given this definition, the process of communication can be viewed as comprising six dimensions. These dimensions can be outlined, very generally, by the following sequence of questions: Who communicates, what, with whom do they communicate, through what channels, how, and with what effect? Thus, in this study, the focus was on the following six dimensions of the information matrix:

- (i) the sources of information,
- (ii) the types of information,
- (iii) the receivers (targets) of the information,
- (iv) the circumstances of information transfer,
- (v) the modes of information transfer, and
- (vi) the effects of the information on the receivers.

The dimensions shown above cover nearly all the variables considered in previous studies [4].

### 4.1. Sources of information (Who communicates?)

The sources of information are people or written material that provide the information.

This study focused on three sources of information, based upon a two-dimensional classification which is shown in Table 3.2.

Oral Written Internal X External X X

Table 3.2 Sources of Information

X indicates that the cell forms a category of sources of information accepted in this study.

In past studies, each dimension was used in different studies (Allen 1969, Johnston 1974; Rosenbloom and Wolek 1970, Goldhar 1974) [5]. For conceptual clarity the two dimensions were combined. However, as no contribution to the role of internal written sources was expected, only a three-fold classification of sources of information was made. For brevity, these sources will be termed as follows:

- (a) internal (implying oral),
- (b) external (implying oral), and
- (c) written (implying external).

4.2. Types of information (What is communicated?)

Types of information focus on the contents of the information communicated.

The present study focused on five basic types of information, defined on

the basis of the field of activity from which the information arose (as in Walsh and Baker 1972, Pruthi and Nagpaul 1978, Katz and Tushman 1979). As shown in Table 3.3, the five basic types were grouped into two major categories. The two broad types of information examined address the "total" pool of information received by the respondents.

Table 3.3 Types of Information

Broad types	Basic types
scientific/technical	scientific client technical
organisational/administrative	organisational administrative

Scientific/technical information was defined as information of a scientific/technical nature which is likely to affect the content of work [6].

Scientific information is information covering scientific findings and/or data and/or methods which derive from a scientific discourse.

Client information is information which expounds conditions and/or methods found or used by client communities.

Technical information is information not covered by the above categories which is, however, likely to affect work in the way stressed by the generic definition of scientific/technical information.

Organisational/administrative information was defined as information

which is likely to affect the form or organisation of work.

Organisational information concerns forecasting and planning activities.

Administrative information is information which details the availability of manpower, time, and other resources.

4.3 Receivers of information (With whom does communication take place?) Previous research focused on the communication patterns of a variety of problem solvers grouped according to certain characteristics of the tasks they worked on. Whilst some looked at broad occupational groupings (Rosenbloom and Wolek 1970, Cotgrove and Box 1970, Whitley and Frost 1973), others investigated the different communication patterns of problem solvers in different research areas (Herzog 1975, Hargens 1975). Yet others looked at the association between communications and stages of work (Myers 1970, Utterback 1971). Results from these and similar studies were summarised in Table 3.1.

The present study focused on two such characteristics:

- (i) Stages of work, as discussed at the beginning of this chapter, and
- (ii) Occupational groups, defined in terms of the following categories:
- (a) scientists,
- (b) science technicians, and
- (c) administrative staff.

As shown in Table 3.4, the circumstances of information transfers were conceptualised differently for the exchanges of oral information and the receiving of written messages.

	Oral	Written
Informal Formal	X X	
Pointed out Not Pointed out		X X

Table 3.4 Circumstances of information transfer

X denotes the categories of circumstances of information transfer for oral and written communications.

Informal denotes circumstances when exchanges of oral information were not pre-arranged.

Formal means those circumstances when exchanges of oral information took place at pre-arranged regular or irregular meetings.

"Pointed out" information from written material indicates that the information was discussed before it was received.

When information from written material was not "pointed out" to problem solvers by others, the problem solvers presumably evaluated the written message independently.

# 4.5 Modes of information transfer (How does communication occur?)

Modes of information transfer denote the extent to which information was sought by problem solvers (Rothwell and Robertson 1973, Hall 1974).

In this study, a distinction was made between two modes of information transfer:

- (a) active, and
- (b) passive.

Information was acquired passively if it was volunteered to the respondent in oral exchanges or gathered through regular reading or more or less randomly from the literature. Conversely, the active mode of acquisition occurred when an item of information was sought from others or by a purposeful search of literature.

# 4.6 Effects of information (What happened?)

The effect of information was defined in terms of the receiver's perceived importance of the information (Hall 1974, Johnston and Gibbons 1975). Given this definition, it was necessary to attempt to measure the importance of information items to problem solvers. Self-perceived importance was measured on a three-step Likert-type scale which defined the weight respondents attached to the information.

III. RELATIONSHIPS BETWEEN STAGES OF WORK AND DIMENSIONS OF COMMUNICATION

A determination of the relationships between the stages of work and other dimensions of communication is the major focus in the construction of a theory for analysing the work of problem solvers. To recapitulate, the focus was on three stages of work: Work Programme Development (WD), Idea Generation (IG), and Problem Solving (PS). As shown in the previous section, the stages of work are really a part of the structure of the information matrix (Receivers of information). Other dimensions of the information matrix were: Sources of information, Types of information, Circumstances of information transfer, Modes of information transfer, and Effects of the information. Occupational groups, a special variable, constituted, together with the stages of work, the "Receivers" of information.

# Sources of information and stages of work

As shown in Table 3.1, the role of information sources has, in the research undertaken to date, attracted the widest attention. But, as the table also indicates, these studies have generated contradictory findings. The present approach argues that these apparently contradictory findings can be explained by looking at:

- (i) the conditions under which the findings can be considered applicable, and
- (ii) the work patterns of problem solvers which consist not only of stages of projects but also the Work Programme Development

#### stage of work.

The initial attempt to explain some of the contradictions involves specifying the conditions under which different findings apply. To do so, let me restate and elaborate the relevant findings shown in Table 3.1.

The findings summarised in Table 3.1 show that in general,

- (i) the greater the information complexity, the greater the importance of oral communication; and conversely, the lower the information complexity, the greater the importance of written material (Wolek 1970),
- (ii) the less advanced a project stage, the greater the importance of written material; and conversely, the more advanced the project stage, the greater the importance of oral sources (Fisher 1979) [7].
- (iii) the more routine a task is, the greater is the likelihood of the importance of internal sources; conversely the less routine, the "newer" a task is, the greater is the likelihood of the importance of external sources.

The third point can be considered as an expression of a condition for the validity of the two other points. Hence, under the condition of working on routine tasks, written material is likely to be the most important source of information in the Idea Generation (IG) stage. In the Problem Solving (PS) stage, oral internal sources are likely to be, under the same conditions, most important.

This is consistent with intuitive expectations. Projects, it has been noted (Goldhar 1974) come into being as a fusion of simple ideas. These are found in journals which report solutions to problems. As Gordon (1968 in Wolek 1970:234) suggested:

"The most elegant solution to a given problem is one where the solution is the simplest in proportion to the complexity of the variables involved."

Journals in areas with which a problem solver is acquainted are most likely to provide the problem solver with the least complex messages. Consistently, Scott (1962) noted:

"The main function of the literature is not that of a reference source but as a primary source of stimulation".

In the Problem Solving stage, the information complexity increases. At that stage, problem solvers face a variety of problems. When working on routine tasks, internal sources are likely to be consulted, as these are associated with the lowest "cost" of information transfer through repeated use (Allen 1968:227).

Under different conditions, different work patterns can occur. In circumstances of non-routine tasks, problem solvers are likely to turn to external sources in an attempt to untangle complex information. As the cost of information transfer increases, there will appear to be no alternative to the problem solver but to engage in the exchange across the boundary of the research organisation.

Thus, the specification of the conditions under which information exchanges take place, as was done above, tends to explain some of the contradictory findings in the literature (compare e.g. Allen 1968 with Johnston and Gibbons 1975, shown in Table 3.1.).

In attempting to explain other contradictions in the relevant findings, it can be argued that these can only be interpreted by defining the work of problem solvers in terms of stages which include the one which is prior to the stages of projects.

As also shown in Table 3.1, some studies pointed out that the generation of projects is associated with a significant and extensive use of external oral sources (Baker et al 1967). Because these are oral sources, the findings imply a high task complexity. This is because the use of oral sources was found to be associated with high task complexity (see above). Yet, such findings are contradictory to those discussed above.

A resolution of this contradiction can be found if it is suggested that there is a work stage which is prior to the generation of projects: the Work Programme Development. It is suggested that this is a different situation, where problem solvers face high task uncertainty and high information complexity. Work at this stage, therefore, requires oral communication. On the basis of Baker's (et al 1967) findings, I suggest

The definition of stages of work, where two distinctive stages are prior to the Problem Solving stage, thus enabled a resolution of further contradictions in the literature.

In sum, there are three major stages in the work of problem solvers: Work Programme Development (WD), Idea Generation (IG), and Problem Solving (PS).

The sources of information are likely to have differential impact upon the three stages. Where problem solvers are working on "routine" problems (as it was expected in the organisation studied), it is hypothesised that:

- 1.1.1 : In the Work Development stage, information from external oral sources is likely to be more influential than information from internal oral sources and written materials.
- 1.1.2 : In the Idea Generation stage, information from written materials is likely to be more influential than information from internal and external oral sources.
- 1.1.3 : In the Problem Solving stage, information from internal oral sources is likely to be more influential than information from external oral sources and written materials.

These hypotheses are summarised in Diagram 3.II.

Diagram 3.II Relationships between sources of information and stages of work

Sources of Information			
Oral External (E) Oral Internal (I) Written Material (WM)	*	*	*
	WD Sta	IG ages of work	PS

\* The asterisk indicates the likely significant relationship.

## Type of information and stages of work

There is a dearth of evidence which would throw light on what types of information are important in the different stages of work. Previous studies merely documented the importance of scientific/technical and organisational/administrative types of information in the work of problem solvers (Walsh and Baker 1971, Pruthi and Nagpaul 1978, Katz and Tushman 1979). The importance of different types of information in the stages of work need to be deduced.

In the Work Programme Development (WD) stage, a problem solver needs to interpret a variety of stimulii. It has been suggested that to choose the "right" project, a problem solver has to interpret the developments in science and also in the socio-political community (Mulkay 1975, 1979, Merton and Gaston 1977). At the same time, a problem solver needs to be concerned about the availability of human and material resources which would facilitate the emploration of a particular theme. This point is illustrated by the example of another division of the DSIR which requires an answer to three questions before a new project can be approved: contribution to international science, contribution to New Zealand, and feasibility of the techniques envisaged by the proposed research.

Therefore, in the Work Programme Development (WD) stage, all types of information, that is scientific, client, technical, organisational and administrative, are likely to be important.

Judging from the reliance on written material in the Idea Generation (IG) stage, it appears that only scientific and technical types of information will be found to be important in this stage of work.

In the Problem Solving (PS) stage, the reliance on internal sources suggests that only three types of information will be important in this stage: scientific, technical, and administrative.

Thus, types of information are likely to have a differential impact upon the three stages of work, as the following hypotheses suggest:

- 1.2.1 : In the Work Programme Development (WD) stage, all types of information are likely to be influential; there will be no special emphasis on any single type of information.
- 1.2.2 : In the Idea Generation (IG) stage, scientific and technical types of information will be more influential than client, organisational and administrative types of information.
- 1.2.3 : In the Problem Solving (PS) stage, scientific, technical and administrative types of information will be most influential.

These hypotheses are summarised in Diagram 3.III.

Diagram 3.III Types of information and stages of work

Types of Information			
Scientific	*	×	*
Technical	*	*	*
Administrative	*		*
	WD	IG Stages of wor	PS

\* The asterisks indicate the cells which are likely to show significant relationship (at the WD stage, the full column of asterisks indicates that no single type will dominate).

Modes of information transfer and stages of work

Modes of information transfer denote the extent to which information is sought.

As shown in Table 3.1, previous studies indicate that the less advanced the project stage, the more likely is the search for information to be passive. The more advanced the project stage, the more likely are problem solvers to pursue information actively (Myers 1970, Rothwell and Robertson 1973, Fisher 1979).

This makes sense intuitively. In situations where several projects are being undertaken simultaneously, the principal task of problem solvers is likely to be solving problems arising from projects in hand. This is because solutions alone count in the distributions of rewards. Therefore, problem solvers are likely to spend most of their time on the Problem Solving stage of work; moreover, it is likely that they will actively seek out relevant information.

Although work at the Problem Solving (PS) stage is likely to result in the most time-consuming and the most active communication, work at the Idea Generation (IG) stage is likely to depend on a slow crystallisation of ideas, based on developments in the literature. The process is then likely to consist of a passive receiving of information which, as it were, becomes "queued" in the mind of the problem solver. From time to time these ideas are reinforced or replaced by new information. The same can be said about information which is likely to affect the Work Programme Development (WD) stage of work.

Thus, the mode of information is likely to have a differential impact upon the three stages of work. It is hypothesised that:

- 1.3.1 : In the Work Programme Development (WD) stage, a passive acquisition of information is likely to be more influential than an active mode.
- 1.3.2 : In the Idea Generation (IG) stage, a passive acquisition of information is also likely to be more influential than an active mode.
- 1.3.3 : In the Problem Solving (PS) stage, an active mode of information acquisition is likely to be more influential than a passive mode.

These hypotheses are shown in Diagram 3.IV.

Diagram 3.IV Modes of information transfer and stages of work



\* Asterisks indicate the cells which are likely to show significant relationship

Circumstances of information transfer and stages of work

The circumstances of information transfer denote the channels through which communication occurs.

Circumstances of information transfer which concern oral exchanges and written material will be discussed in turn.

From findings reported in previous studies it is suggested that formal meetings are likely to be more influential in the passive mode of oral information transfer, whereas informal oral exchanges are likely to be most influential in the active mode (Walsh and Baker 1972, Hall 1974). Because it was suggested earlier that the passive mode is likely to be associated with the Work Programme Development (WD) stage and the active mode with the Problem Solving (PS) stage, it is reasonable to anticipate that formal circumstances of information transfer will be associated with the Work Programme Development (WD) stage, and informal circumstances with the Problem Solving (PS) stage.

If science depends, to some extent, upon consensus among researchers

(Moravcsik 1977) then it can be expected that written material, important in the Idea Generation (IG) stage, is likely to be more influential in circumstances where ideas from these sources are pointed out to the problem solvers than in those circumstances where the information is merely read.

Consequently, it can be expected that circumstances of information transfer have a differential impact upon the three stages of work. Thus, it is hypothesised that:

- 1.4.1 : In the Work Programme Development (WD) stage, formal circumstances are likely to be more influential than informal circumstances.
- 1.4.2 : In the Idea Generation (IG) stage, "pointed out" literature is likely to be more influential than literature not "pointed out".
- 1.4.3 : In the Problem Solving (PS) stage, informal circumstances are likely to be more influential than formal circumstances.

These hypotheses are summarised in Diagram 3.V.

D Circumstances of informa	iagram 3.V tion transfer	and stages	of work
Circumstances of Transfer			
For Oral Transfer Informal Formal	           		*
For Written Transfer Pointed out Not pointed out		*	
	WD	IG ages of wor	PS

## Effects of information and stages of work

There is no reason to suggest that the perceived information importance will vary with the stages of work. Thus I argue that information received in each stage is likely to be considered equally important.

Thus, it was hypothesised:

1.5.1 : The effects of information are not likely to vary with stages of work.

### Occupational groups and communication

In discussing the dimensions of the information matrix, I pointed out that two variables were considered in the dimension of the "receivers" of the information: the "stages of work" and "occupational groups". Whereas the former was selected as the major dependent variable in the present study, occupational groups were treated as a "controlling", antecedent variable. The reasons for doing so become apparent from the argument which follows.

Previous studies have shown that the amount of communication differs with work activities of problem solvers (Ackoff and Halbert 1958, Herner 1954, McLaughlin et al 1965, Allen 1966). Ackoff and Halbert (1958), for example, found that research chemists spent on average 33.4% of their total work time on communication, whereas engineers spent only 20% of their total work time on communication. Such findings are consistent with findings from studies of organisations. This research indicates that task complexity is directly associated with the amount of communication required for the tasks (Lawrence and Lorsch 1967, Duncan 1973, Hall 1972, Hage et al 1971, Gailbraith 1973, Van de Ven et al 1976). It can thus be expected that scientists are likely to require a large amount of information. Science technicians, whose work can be imagined as being akin to the work of engineers, are likely to require less information than scientists. Administrative staff, whose work is assumed to be of the lowest task complexity, are likely to require even less information than science technicians.

But, whilst previous studies indicated that the quantity of information is likely to vary between different occupational groups, the research findings from previous studies provide no evidence to support the idea that the quality of their work patterns (the structure of their communication pattern) will differ also.

Intuitively, however, this appears to be unlikely. Indeed, some variation in the quality of work of the three occupational groups examined in this study can be expected. Here, I faced a dilemma. Whilst the hypotheses advanced in this chapter attempt to develop a theory for

explaining the work patterns of problem solvers, this may not be correct for all problem solvers. However, because the relevant research literature offers no guide to the differences, I decided to use the occupational groups as a "controlling", antecedent variable, because it was anticipated that such an approach might provide some data on relationships between the occupational groups and communications for further study. Such an analysis might, it was expected, throw some light on the relationships between the three occupational groups in the organisation investigated.

SUMMARY AND CONCLUSION

This chapter has attempted to develop a theory to describe and explain the work patterns of problem solvers. As such, it consists of the delineation of the major dimensions of work patterns and the specification of hypotheses concerning these dimensions.

Within this theoretical framework, the work of problem solvers was defined as the formation and development of ideas which evolve in response to information.

A review of the literature showed that information gathering is a part of the process of communication. Six dimensions of communication were discussed: sources and types of information, activities to which the information related, the circumstances and mode of information transfer, and the effect of the information on the receivers.

In constructing the theory of work patterns, the relationships between

stages of work and the other dimensions of communication were explored. Three important stages of work were considered in this study: Work Programme Development (WD), Idea Generation (IG) and the Problem Solving (PS). It was anticipated that communication has a differential impact upon the three stages of work. Thirteen hypotheses were formulated in an effort to investigate the utility of the theoretical framework. By way of recapitulation, the hypotheses are summarised in the following table (shown already in Chapter 1):

Dimensions of Communication	WD	Stages of Work IG	PS
Sources	External	Written Mat.	Internal
Types	"ALL"	SC + TEC	SC,TEC + ADMIN
Modes	Passive	Passive	Active
Circumstances	Formal	Discussion	Informal
Effects	-	-	-

Work Programme Development is likely to be associated with mainly external sources, all considered types of information, a passive mode of information transfer and formal circumstances.

The Idea Generation stage is likely to be associated with mainly written materials, scientific and technical types of information, and also with a passive mode of information transfer and those circumstances which involve a discussion of the written messages. The Problem Solving stage is likely to be associated with mainly internal sources, scientific, technical and administrative types of information, an active mode of information transfer and informal circumstances.

The hypotheses logically extend the task of delineating the roles of the various categories of the dimensions of communication, a task initiated by Johnston and Gibbons (1975). Unlike the arguments in some studies which suggest that some categories of variables are more important than others, the broad conclusion made on the bases of arguments advanced in this chapter is that each category of all variables considered is equally important in the work of problem solvers, although the degree of importance may well vary with the stages of work.

The theory of work patterns summarised above was assumed to be valid for all problem solvers. Whilst the main thrust of the theory is directed at the work patterns of problem solvers in general, intuitive expectations suggest that this may not be valid for all problem solvers. To explore the relationships between occupational groups, stages of work, and other dimensions of communication, occupational groups were, for the purposes of the present research, treated as "controlling", antecedent variable.

The next chapter deals with the second issue, "Problem II" of the study: how organisations affect work patterns; more specifically, the effects of organisations on oral communications. NOTES

- [1] This process which provides logical continuity of work is likely to occur given that problem solvers can exercise their autonomy.
- [2] Note that the concepts used here differ from those employed in describing the structure of knowledge (see Chapter 1 note 1). However, like the relations among the concepts in the structure of knowledge, the "ideas" are, more or less, in a dynamic state over time. Problems may become projects, projects may become themes; what may be considered as themes may in fact change into single projects.
- [3] For a more elaborate definition, see under "types of information" and footnote [6].
- [4] Information complexity, a variable which addresses the structure of the communicated message was considered in the formulation of hypotheses only. This is because previous research suggests that information complexity varies with the sources of information (Wolek 1970). These findings were not disputed in other studies and there was no reason to dispute them here.

The variable task complexity was considered whilst looking at the communication patterns of different occupational groups in the organisation studied.

- [5] The investigation of innovations in past studies also looked at sources termed "personal" which covered those items of information problem solvers possessed prior to the commencement of the innovation (Baker et al 1967, Myers and Marquis 1969, Langrish et al 1972, Johnston and Gibbons 1975). However, as noted earlier, this "source" was excluded from this study.
- [6] Formally, significiant scientific/technical information was defined as information of a scientific/technical nature which EITHER concerns an on-going project in any stage of its course and in that case leads to a change in opinion about the approach (approaches) considered in the solution to that project. This means that if one approach is at present slightly favoured over other approaches, then any scientific/technical information that will cause a change in this balance is considered as significant scientific/technical information;
  - OR concerns a work area. In this case information is significant if it is regarded as important for its present or potential use.
- [7] This generalisation is, however, valid only in the context of investigating the processes of projects consisting of two stages -Idea Generation and Problem Solution.

CHAPTER 4

A THEORY OF THE EFFECTS OF ORGANISATIONS ON ORAL FLOWS OF COMMUNICATION

The fundamental assumption underlying the theoretical analysis carried out in this chapter is that the transfer of oral information plays an important role in the work of problem solvers.

Past studies, which were reviewed in the previous chapter, indicated that most of the information used by problem solvers is likely to be received orally. The importance of written material, as was hypothesised, can be seen mainly as a stimulus to ideas in the Idea Generation stage of work.

The findings from previous studies indicated that organisational structure affects the flows of internal oral communications, and it was this basic perspective which was employed to investigate the factors which may be likely to influence these flows. However, unlike previous studies, the set of potential influences on the internal communication flows was derived from the organisational theory which is discussed below. Further, the choice of an "open system" theory of organisations enabled a more systematic investigation of the relationships between research organisations and their environments. The formulation of the theoretical framework provided a unified whole within which each hypothesised relationship could be located in relation to other

processes in organisations.

Thus, the adoption of the organisational theory not only allowed a more systematic investigation of the effects organisations have on internal communication flows, but it also guided the investigation of external communication patterns, and suggested how various findings could be interpreted.

It will also be shown that research organisations themselves, as well as outside organisations, constrain the process of knowledge development.

In particular, this chapter addresses:

- (i) a theory of organisations,
- (ii) this theory's applicability to research organisations,
- (iii) the effects of organisations on internal flows of oral communication (Part A), and

### A THEORY OF ORGANISATIONS

Some literature reviews in the sociology of organisations classify material on the basis of historical development in the field (Davis et al 1972, Pugh 1971, Perrow 1972). Others focus on the central variables that studies employ (Silverman 1970, Eldridge and Crombie 1974). Yet others differentiate studies according to the number of dimensions of organisations included in the analysis (Whisler 1970). All reviews, however, point to a gradual shift from the investigation of organisations as "closed" systems to the investigation of organisations as "open" systems; that is, from examining a limited set of factors internal to an organisation, to the investigation of the relationships between these internal factors and the environments of organisations (Scott 1975). This "open" system approach to organisations has been employed in the present study.

Early studies addressing the relationship between organisations and their environments, which suggested that organisations had no choice but to adapt to their environments (see e.g.Emery and Trist 1965), have been criticised as too deterministic (Child 1972, Pfeffer and Salancik 1978, Pfeffer 1978). More recently, however, increasing attention has been drawn to the re-examination of these relationships (Aldrich and Pfeffer 1976). These attempts have been called variously a political economy model, a dependence exchange, an ecology model, or the resource dependence perspective (Aldrich and Pfeffer 1976).

The resource dependence perspective (shown in Pfeffer and Salancik 1978, Pfeffer 1978) appears the most coherent statement of this trend. It is employed in this study because it sets out a framework which addresses the inter-relationships between organisations and their environments. Further, the theory allows a clear and relatively straightforward elaboration of the relationships within the organisation. This perspective then can be used to account for the ways:

(i) other organisations affect a research organisation, and(ii) research organisations in turn affect the work of their own

employees.

This resource dependence approach to the study of organisations, which is analogous to theories of oligopoly and the behavioral theory of the firm (Aldrich and Pfeffer 1976:84), can be outlined in terms of the three cyclical steps, shown below. (The theoretical framework itself will be elaborated and the terms defined in the next sections.)

In Chapter 1, the following diagram was used to illustrate the three cyclical steps:



(i) According to the resource dependence perspective, organisations depend upon resources outside the organisation. Depending on the scarcity and necessity of these resources, external organisations exert power over the

research organisation. The sum of power exerted by different organisations is the "environmental contingency" of the focal organisation.

- (ii) This environmental contingency is reflected in the distribution of power among people within the focal organisation. On the basis of the ability to deal with the external relations, a dominant coalition forms and administrators are selected within the organisation.
- (iii) The dominant coalition within the focal organisation responds to and shapes its environment and thus "enacts" the organisational environment ("environmental contingency"). In addition, however, the dominant coalition also shapes the internal organisational structure.

The processes associated with each of these steps are complex. As Stern (1979:613) pointed out:

"Conflict, coalition, and a considerable degree of indeterminancy are manifest at each step."

Thus, although the resource dependence approach to organisations suggests that the work of employees is affected by the environment of the organisation, the framework is not deterministic, especially since it attempts to account for some of the freedom enjoyed by employees. Pfeffer and Salancik (1978) term this discretionary power "strategic choice" (a term coined by Child 1972) [1].

### Definitions

In the resource dependence theory of organisations, organisations are defined as coalitions of varying interests, within the boundaries of the focal organisation (Pfeffer and Salancik 1978:259).

The dominant coalition within the focal organisation is a group of participants who have the ability to formulate constitutions, rules, procedures, and information systems that limit the potential power of others and ensure their own continuing control (Pfeffer and Salancik 1978:235). [2]

"Administrators" are defined as people who have been granted a formal authority to exercise power over other people within the organisation. Although the ideas of dominant coalitions and "administrators" must be understood as distinct concepts, it is assumed, for the purposes of the present study, that "administrators" occupy powerful positions in the dominant coalitions. In the ensuing discussion, therefore, the term "research administrators" has been used instead of the term "dominant coalition".

Environments are defined as sets of organisations of varying power, beyond the boundaries of the focal organisation.

Organisational boundaries are defined by the organisation's control over the activities of participants relative to the control which other social entities have over these same personnel and their activities (Pfeffer and Salancik 1978:259). [3]

According to the resource dependence perspective, organisational
structure comprises the interlocked activities and behaviour of social actors (Pfeffer and Salancik 1978). However, unlike the expositions of the relationships between organisations and their environments, Pfeffer and Salancik's discussion of organisational structure was limited. In the present study, a two-dimensional working definition of organisational structure was adopted. This definition was derived from two complementary theories of organisations.

March and Simon (1958:170) defined organisational structure as:

"those aspects of the pattern of behavior in the organisation that are relatively stable and that change only slowly".

The systems theoretician Walter Buckley (1967:128) addressed the concept of structure in terms of morphogenic processes which were defined as:

"sets of alternative actions, or tendencies to act in certain ways, associated with the components, and the constraints, that specify or limit these alternative actions".

The synthesis of these two definitions provided the basis for the definition of organisational structure adopted in the present study:

(i) a relatively stable pattern of behaviour, and

(ii) the constraints that specify or limit these behaviours.

Both dimensions of the definition are multifaceted (Katz and Kahn 1966, Scott 1967, Perrow 1972, Azumi and Hage 1972, Scott 1975), and can be subsumed under the study of:

(i) the work patterns of the employees of the organisation, and(ii) those collective entities which research administrators

form and/or maintain, and which constrain the work patterns.

A theoretical framework for the study of work patterns implied under (i) above was discussed in Chapter 3. For the purposes of this investigation, the work patterns of problem solvers were represented by the patterns of oral communication.

The collective entities implied by (ii) above can be defined in terms of a typology of the properties of collectivities which was devised by Lazarsfeld and Menzel (1961). Scott (1975) has argued that this typology can also be used for the analysis of organisations. These properties of collectivities are in the present study, therefore, defined as organisational properties.

In the present study, the investigation of the effects of research organisations on the work patterns of their employees was undertaken by exploring the relationships between some of the properties of organisations suggested by Lazarsfeld and Menzel (1961), and the communication networks.

The properties of organisations and those variables which constituted these properties in the present study are as follows:

- (i) analytic properties (autonomy, work related orientations, and socially recognised work competence),
- (iii) global properties (use of facilities) [4].

Nominal definitions for the subcategories of each of these properties are given below.

Autonomy means the degree to which a person has power with respect to his/her environment (Selznick 1953) and entails such things as the freedom of choice of work problems and the methods used for their solution.

Work related orientations were defined as the sets of attitudes toward the work related environment which provided the underlying ideas of the organisational members, their dispositions to act toward others and to define and evaluate these others in various ways (Riley 1963:185).

Socially recognised work competence was defined as the evaluation of the person's performance in terms of the criteria of the professional community and the organisation (Whitley and Frost 1971).

Formal structure is defined by the network of relationships involved in determining "who is administratively responsible to whom" in the organisation (Allen 1968, Frost and Whitley 1971, Hall 1974, Bitz et al 1975).

Informal networks were defined sociometrically in terms of who chooses whom as informal contacts within the organisation (Allen 1968, Frost and Whitley 1971, Hall 1974, Pruthi and Nagpaul 1978).

Physical distances were defined in terms of the physical location of personnel within the organisation.

Colleague networks were defined in terms of the patterns of who works with whom as a colleague (a team member) on projects. It is a concept

similar to "task structure" which was used in previous studies (Whitley and Frost 1972, Hall 1974).

The use of facilities was defined as the degree to which problem solvers actually used certain major facilities in the organisation.

### APPLICATION OF THE THEORY TO RESEARCH ORGANISATIONS

The purpose of this section is to show precisely how research organisations affect knowledge development through influencing oral communication. A three-point summary of the theory, as applicable to research organisations [5], provides a convenient point of departure for this discussion:

- (i) Research organisations, the major employers of knowledge makers today (Price 1965b, Sklair 1973), depend on resources from a variety of sources which are inside as well as outside the scientific community. The providers of these resources have power over the research organisations. This power varies with the focal organisation's definition of how critical and scarce the resources which the external organisations provide are likely to be. The sum of power exerted by different organisations defines the environmental contingency of the focal organisation.
- (ii) On the basis of such a distribution of power, research administrators are selected.
- (iii) Once selected, the research administrators will tend to(a) shape internal organisational structures, and

(b) enact the external organisational environment by reacting to changes in the environmental contingency of their own organisation, as well as changing it to suit their interests.

Through enacting their environments, research administrators "fuse" a variety of intra- and extra- scientific interests (Scott 1967). It is through research organisations, therefore, that the symbiotic exchange between the scientific and extra-scientific communities takes place.

By shaping the internal organisational structure which impedes or facilitates work patterns, research organisations influence the "problem areas" which are investigated; moreover, research organisations affect the "associations" among problem solvers, which are formed as a consequence of the dynamics of these processes.

The theory of organisations outlined is akin to the theory of a two-way process of information transfer between environments and the research organisations which has been proposed by Allen and Cohen (1969).

However, unlike Allen and Cohen's theory, which has been criticised for its simplicity (Rogers and Shoemaker 1971:208) [6], the resource dependence theory allows examination of the extent to which the interaction between researchers and their organisational environment is facilitated (or impeded) by the research administrators. It must be recognised that the flow of information into a research organisation does not necessarily occur in a two-way process through research administrators. Instead, research administrators aid or inhibit information flows through their own actions. The adoption of this

approach to the study of organisation explicitly acknowledges, then, that communication between organisations and their environments is multifaceted [7].

The remainder of this chapter is devoted to a discussion of how research administrators:

- (i) influence the work patterns of others in research organisations, and
- (ii) "enact" their environments.

\*

PART A

### EFFECTS OF RESEARCH ORGANISATIONS ON INTERNAL ORAL COMMUNICATIONS

The problem addressed here concerns the question of how research administrators influence the work patterns of problem solvers.

The theoretical framework adopted in the present study suggests that research administrators constrain work patterns by shaping the analytic, structural and global properties of organisations.

Thus, a central task of this investigation is to test whether the three types of properties of organisations specified earlier in this chapter significantly affect the work patterns of employees of the government research organisation investigated in the present research.

Previous research had indicated that, contrary to intuition, problem solvers do not use those channels of information which provide the most rewards for problem solving. As Allen (1968:227) noted, problem solvers:

"act in a manner which is intended not to maximize gain, but rather to minimize loss".

Allen (1966, et al 1968, 1968) found that problem solvers used channels ----which they saw as more accessible or easier to use rather than channels which were evaluated highly in terms of their technical quality. Since ease of use was found to be based upon the history of the use, existing communication networks were found to play a very important part in research organisations; moreover these networks were likely to indicate who is likely to communicate with whom in the future (Allen 1968, Allen and Cohen 1969, Allen 1977, Frost and Whitley 1971, Walsh and Baker 1972, Hall 1974, Pruthi and Nagpaul 1978).

An analysis of the relevant literature suggested that four organisational variables were likely to influence the formation of internal communication patterns. The findings from these studies are summarised in Table 4.1.

Although Allen's research indicated the effects of geographical distance and the statistically independent effects of formal and informal structures, the results from studies in the United Kingdom (Whitley and Frost 1973, Walsh and Baker 1972, Hall 1974) and in India (Pruthi and Nagpaul 1978) which sought to replicate Allen's investigations suggested that the task structure is likely to override the importance of geographical distance; and that informal networks played only a marginal role. The results from studies undertaken to date appear to be, then, inconclusive. In the present investigation, an attempt was made to

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replicate and to extend the studies already cited. The theory of organisations discussed previously provided the framework for this effort.

> Table 4.1 Important variables in the study of internal oral communication networks

	Variables			
Studies	Formal Structure	Informal Network	Geographical Distance	Task Structure
Allen 1968, Allen and Cohen 1969	+	+	NI	NI
Allen 1977	NI	NI	+	NI
Whitley and Frost 1973	+	-	-	+
Walsh and Baker 1972	NI	-	-	+
Hall 1974	+	<b>+</b> 38	· -	+
Pruthi and Nagpaul 1978	+	-	+	+

+ indicates a statistically significant relationship between a communication network and the indicated variable

- indicates that the relationship was not statistically significant

NI indicates that the effects of the variable on the communication network was not investigated.

The theoretical framework advanced in an attempt to describe and explain the effects of organisations on the work patterns of members led to the formulation of a series of hypotheses. These hypotheses sought to predict the relationships between the communication networks and variables derived from the three properties of organisations, defined earlier.

# Structural and global properties

The structural and global properties of organisations used in the present investigation were: formal structure, informal networks, physical (geographical) distance and colleague networks (task structure).

All four variables which were identified from the previous studies (summarised in Table 4.1) can be justified in terms of the early management and organisational studies (Taylor 1947, Fayol 1949, March and Simon 1958, Katz and Kahn 1966) and research carried out by members of the so-called school of human relations (Mayo 1933,1949). In Lazarsfeld and Menzel's typology, all are "structural" properties of collectivities, addressing the relations among organisational members. The relations among organisational members and technology (facilities), has been added to the list because it has been emphasised by those organisational theorists who have looked at organisations as socio-technical systems (Woodward 1958, 1965, Blauner 1964, Rice 1958, Emery and Trist 1965, Ackoff and Emery 1972).

Given that the properties of organisations are likely to be interrelated (Stinchcombe 1967, Schon 1973), it seemed reasonable to argue that the structural and global properties of organisations are likely to affect the formation of communication networks.

From this perspective it can be hypothesised that the employees of

research organisations are more likely to communicate significant work related information with:

Hyp. 2.1 : members of the same section,

Hyp. 2.2 : informal contacts,

Hyp. 2.3 : persons in close physical proximity to them,

Hyp. 2.4 : colleagues, and

Hyp. 2.5 : persons who share the same facility,

than with others in the organisation.

### Analytic properties

Structural and global properties are not, however, the only factors which are likely to affect the work of problem solvers in research organisations. Previous studies of organisations have pointed out that organisations comprise social groups whose members not only have patterned and ordered relations, but also differential views about the purpose, operation, environment and the future of organisation, and of personalities, motives and attitudes as well (Weber 1947, Lawrence and Lorsch 1967, Homans 1950, Stinchcombe 1967, Schon 1973). In Lazarsfeld and Menzel's (1961) terms, these social features are defined as the analytic properties of organisations. Buckley (1967) designated them "predispositions to act" in his definition of the structure of social systems. Indeed, this dimension of organisational structure does not deal with patterned activities, but with predispositions to act; not with manifest activities but rather with the latent roles of participants. The dimension has, in other studies, been termed

"homophily" (Lazarsfeld and Merton 1964, Rogers and Shoemaker 1971), and deals with the similarity between human beings in terms of the analytic properties (Molnar 1978) [8].

In this study, three categories of the analytic properties were considered because previous studies in the sociology of science have emphasised their importance in understanding of the work patterns of problem solvers:

- (i) autonomy (Glaser 1963, Hagstrom 1965, Marquis and Allen 1966, Storer 1968),
- (iii) socially recognised work competence (Glaser 1963, Hagstrom 1965, Cole and Cole 1968, Allen and Cohen 1969).

Given the findings from previous studies, it was assumed that the higher the research competence of problem solvers, the higher the strength of their orientation and autonomy is likely to be (Festinger 1957, Homans 1961, Newcomb 1961, Glaser 1963).

Likewise, the results from previous research led to the assumption that high competence (and therefore high strength of orientation and high degree of autonomy) results in a high level of attraction between persons who possess these attributes. In turn, strong attraction is likely to lead to a greater reciprocity of work (work relations) which, in turn, is likely to contribute to the maintenance of high competence, strength of orientation and autonomy (Glaser 1963). Because work patterns were, in this study, conceptualised in terms of patterns of communication, it was hypothesised that the employees of research organisations were more likely to communicate significant work related information with:

Hyp. 2.6 : persons with a similar strength of orientation,
Hyp. 2.7 : persons with a similar degree of autonomy, and
hyp. 2.8 : persons with a similar degree of research competence,
than with others in the organisation.

PART B

### EFFECTS OF RESEARCH ORGANISATIONS ON EXTERNAL ORAL COMMUNICATIONS

The resource dependence approach to the study of organisations suggests that research administrators within research organisations both facilitate and inhibit interactions among their staff, as well as between their own and other organisations in their environments. It can, therefore, be expected that when the existing relationships between the organisational members and employees of other organisations are mapped, the patterns of inhibition and facilitation by the research administrators should be revealed. The results of such an investigation should also reveal the environmental contingency enacted by the research administrators.

The importance of such analyses for the understanding of the work of problem solvers is obvious when their work patterns are considered. Information gained from external sources is likely to be important in the Work Programme Development stage of work because information gained from such sources provides, as it were, a "window to reality". On the basis of information gained through that "window", problem solvers select problems for investigation.

Johnson's (1972) theory of occupational control, as applied by Johnston and Robbins (1977), can be used to explore the structure of environmental contingencies for different types of research organisations. A number of possibilities can be suggested.

Two limitations of the present case study must, however, be noted:

- (i) The fit of Johnson's theory is not tested.
- (ii) It is concerned only with the environment of a New Zealand government reseach organisation engaged in biological and agricultural research.

From Johnson's (1972) theory, it can be expected that four classes of organisations will be likely to constitute the environmental contingency of the organisation examined in the present research:

- (i) the scientific community (both international and national),
- (ii) clients in the economy (in this study, these are persons in agricultural extension and the farming community [9]),
- (iii) the political system (institutional and non-institutional
   [10]), and
  - (iv) the bureaucracy (represented by the Head Office of the organisation).

While these four classes of organisations constitute the environmental contingency of the organisation investigated in the present study, it was expected that the problem solvers in the organisation would communicate differently with personnel in the four classes of organisations. In the present case, it is argued that communication between the members of the focal organisation and personnel in the four classes of organisation can be ranked, quantitatively.

Members of research organisations are likely to communicate mainly with members of other research organisations (Price 1969, Allen 1968, Toulmin 1969), and these are, therefore, likely to be the most frequently used partners in external communication. Because the organisation studied is a part of the Public Service, it is plausible to expect that the next class of actors ranked with respect to the quantity of external communication will be the bureaucracy, which not only services the organisation in terms of decisions and regulations concerning the acquisition of resources, but also interprets the political demands of the government of the day.

The clients in the economy are likely to rank next, because all research carried out in government laboratories should be "in the national interest" (Scientific and Industrial Research Act 1974).

The political system comprises a category of actors who are least likely to be sources of external, work related communication. Thus, it can be hypothesised:

Hyp. 2.9 : The quantity of work related communication from external sources is likely to be rank ordered, from most to least, as follows: other research organisations, the bureaucracy, clients in the economy, and the political system.

In an attempt to investigate further how research administrators order the environment of the organisation studied, the present study also investigated the effects of physical distance [11]. It was expected that the rate of communication with external organisations would be likely to vary significantly according to the physical distances between the sources of the information and the focal organisation (Allen and Fustfeld 1975, Allen 1977). Because the most significant organisations in the political system and the bureaucracy are located in Wellington, the hypotheses formulated concern only the first two classes of organisations.

It was hypothesised that:

Hyp. 2.10 : The greater the physical distance between research

organisations and the focal research organisation, the lower the rate of communication between them is likely to be. Hyp. 2.11 : The greater the physical distance between client organisations in the economy and the focal research organisation, the lower the rate of communication between

them is likely to be.

### SUMMARY AND CONCLUSION

This chapter focused attention on some of the organisational factors which were deemed likely to influence the networks of oral communication.

Unlike previous studies, the present study employed an organisational theory to try and delineate which factors were likely to affect these communications. The resource dependence perspective on organisations was selected as the most appropriate theoretical framework. Within this framework, three interrelated steps were used to summarise the processes in organisations, as well as to delineate the nature of exchanges between organisations and their environments.

The shaping of organisations by their environments, which was termed "enacting" the organisational environment, results in social processes which shift the balance of power within the organisation over time and according to circumstances. As far as research organisations are concerned it was argued that these processes affect the process of knowledge development.

An understanding of these processes is crucial to an understanding of the effects of administrative actions. The theoretical framework proposed suggested that unless administrators were able to bring about changes in all three steps, their attempts to influence knowledge production purposefully, were unlikely to succeed.

Coupled with related theories of organisations and their environments, the resource dependence perspective led to the delineation of analytic and structural factors which, it was suggested, would be likely to influence communication. The relationships of these variables and communication networks were described by eight hypotheses. Finally, the pattern of external communication as influenced by the variable of physical distance was discussed.

The next chapter elaborates the methodological issues involved in the present investigation.

NOTES

- [1] From the organisational rather than individual point of view, Pfeffer and Salancik (1978) suggest that there is a "loose coupling" between organisations. This term has been used to denote the relationships between organisations which are based on the filtered and imperfect effects of one organisation on another.
- [2] The coalition participants provide behaviours, resources and capabilities that are most needed or desired by other organisational participants. As a consequence, its members come to have more influence and control over the organisation, because one of the rewards for contributing the most critical resources is the ability to control and direct organisational action (Pfeffer and Salancik 1978:27).
- [3] The resource dependence perspective defines the key concepts in terms of relationships of one "object" to another.

Organisations are defined as cliques of people in relation to others.

Environments do not exist "independently" of the focal organisation, but only in relation to it. For example, as organisation A in the environment of the focal organisation B loses its power over organisation B because of the loss of control over resources required by organisation B, the importance of the organisation A diminishes relative to organisation B. Organisation A may, indeed, cease to be a part of the environment of B, even though in itself, its power over other organisations (say C and D) may be greater. Environments are not "objective realities" (Pfeffer and Salancik 1978:260).

The boundaries of organisations are not defined exclusively either by their walls or the personnel on their payroll. Rather, if a person's activity X (say research) is controlled by organisation A then, the activity X is a part of organisation A (not the person). However, for the purpose of the present study, the payroll was considered as a sufficient indicator of a person's membership in an organisation.

[4] Lazarsfeld and Menzel set out three major groups of properties of collectivities. These are:

analytic properties (based upon data about each member of the organisation),

structural properties (based upon data about the relations among organisational members), and

the global properties (not based on information about the properties of individual members but on non-member characteristics of the collectivities, such as technology).

Thus although the "use of facilities" addresses a relation and can be thus located among the structural properties of collectivities, the variable is not based upon data about the relations among organisational members, but on the data about the relations between organisational members and one of the global properties of collectivities, namely the technology. It was thus located in the third category of the properties.

- [5] For generalised statements see Pfeffer and Salancik (1978), Pfeffer (1978) and Stern (1979).
- [6] As Rogers and Shoemaker (1971:208) noted:

"The overall criticism of the two-step theory ... is mainly that it does not tell us enough. The flow of communication ... is far more complicated than two steps. What is known about the ... communication process is too detailed to be expressed in one sentence or in two steps."

[7] It is considered unreasonable to suggest that knowledge makers communicate with other knowledge makers through dominant coalitions whom Allen and Cohen (1969) termed "gatekeepers" and who were found indistinguishable from administrators (Frost and Whitley 1971). However, it is reasonable to argue that communications are facilitated or inhibited by the dominant coalitions, which may include administrators.

The term "gatekeeper" has been proposed by Allen and Cohen (1969) to denote high communicators (communication stars) who "keep the gates" by channelling external information into research organisations. In view of the earlier definition of the dominant coalition and Frost and Whitley's (1971) research findings, it can be suggested that the "gatekeepers" form, at least in part, the dominant coalition in research organisations. In this context, the term "gatekeeper" appears superfluous.

- [8] The existence of homophilic behaviour is now well established in the literature (Homans 1950, Blau 1955, Campbell and Alexander 1965, Rogers and Shoemaker 1971:210).
- [9] Studies in the transfer of technology indicate the importance of the class of actors who mediates between scientific research and industrial users. In the engineering industry, this class of actors can be defined as technologists, and the channel of activity associated with them, technology (Gruber and Marquis 1969, Davidson et al 1974, Cetron and Davidson 1977). In agriculture, agricultural extension is likely to play this role.
- [10] Two theories from political science were adopted in this study.

First, Dahl's (1961) description of the capitalist system of government as consisting of interest groups was accepted. Various organisations such as trade unions and other voluntary organisations form these interest groups and together they attempt to influence the government's actions concerning the allocation of resources. In this study, interest groups and the government were termed the "institutional" political system.

Second, the seventies saw the emergence of social movements which became non-institutionalised pressure groups (Cleveland 1971). Unlike the traditional interest groups, these social movements formed around an idea, value, or a definite policy and normally disbanded after the achievement of their goals (Cleveland 1971, Jackson 1973). On the basis of the central value, their organisers were able to mobilise people from all walks of life, including research organisations. In this study, the social movements were termed the "non-institutional" political system.

[11] The effects of similarity (Bierfelder 1974) were not investigated. The inclusion of this variable would have required the measurement of the relevant attributes of both communication partners. In the case of external communication, this condition could not be met in the present study.

### CHAPTER 5

### METHODOLOGY

This chapter sets out the methodological aspects of the present research. Following a statement of the major research design decisions adopted, the chapter deals with the following particular topics:

- (i) operationalisation of variables;
- (ii) selection and construction of instruments;
- (iii) indices construction (where appropriate);
  - (iv) data collection;
  - (v) validation of the instruments;
  - (vi) methods of data analysis.

As has been indicated in Chapter 1 of this report, the objectives of the study can be divided into two major groups. The first group dealt with a theory of the work patterns of problem solvers. The second group addressed the relationships between certain characteristics of the research organisation and these work patterns. The methodological discussion is, likewise, divided into two parts. Both parts are introduced by a summary of the variables involved in the analysis and a statement of the areas where hypotheses were formulated.

With the exception of the discussion of the construction of indices

which is not applicable in this part, the issues outlined above are the major headings in Part I, around which the analysis is ordered.

In Part II of the present chapter on methodology, these issues are reorganised to avoid unnecessary repetition.

#### RESEARCH DESIGN

To test the hypotheses presented in Chapter 3, two fundamental methodological decisions were made:

- (i) the data concerning the patterns of communication were obtained by aggregating 12 samples of communication behaviour, weighted for absences;
- (ii) the data were analysed by means of the hierarchical log-linear modelling technique.

To test the hypotheses presented in Chapter 4, three fundamental methodological decisions were made:

- (i) the flows of internal communication were analysed by the means of Harary's (et al 1965) theory of graphs (a theory which was used in previous research by Allen 1968, Allen and Cohen 1969, Allen and Cooney 1974, Allen 1977, Hall 1974, Frost and Whitley 1971, Pruthi and Nagpaul 1978),
- (ii) the effects of the organisation on the flows of internal communication were analysed by means of a locally optimal test. This technique was considered more sensitive and more appropriate than the Kolmogorov-Smirnov test used in

previous studies (Allen 1968, Allen and Cohen 1969, Allen and Cooney 1974, Allen 1977, Hall 1974). The locally optimal test not only enabled testing for independence, but also allowed the strength of the relationship between the variables under investigation to be estimated.

#### PART I

#### WORK PATTERNS OF PROBLEM SOLVERS

The theory of work patterns presented in Chapter 3 focused on seven variables. Stages of work were considered as the dependent variable, and the five dimensions of communication (sources, types, modes, circumstances and effects) were designated as independent variables. To test whether this theoretical framework can be applicable to all problem solvers, the hypotheses were investigated whilst "controlling" for the seventh variable: the occupational groups.

The theory of work patterns involved specifying the expected structure of communication characteristic of each stage of work.

### OPERATIONALISATION OF VARIABLES

For the present study, the information matrix was constructed on the basis of aggregating 12 samples of the communication behaviour of problem solvers in the government research organisation selected for investigation. As will be described fully in later sections of this chapter, the respondents were asked to record and describe, on 12 separate occasions, each significant item of information they received during a specified time period. Significant information was defined as an information which was likely to affect the content or context of work.

The diary entries, each of which represented an item of information, were the units of analysis. The dependent and independent variables were obtained from the description of these information items. Thus, all variables considered in this part were measured by means of the Information Flow Questionnaires (Appendix A).

## Sources of information

In the Information Flow Questionnaires, the respondents were asked to record and describe each significant item of information they received from persons and from written material, separately (Questions 4a, 4b). The source "written material" was assigned to the entries in Question 4b. (Consistent with the theoretical framework discussed in Chapter 3, responses denoting internal memos and letters were discarded from the analysis.)

The classification of information items into internal and external (oral) sources was carried out on the basis of respondents' naming the persons from whom they received the information, and the organisation they represented. Any person from the organisation studied was considered as an internal (oral) source; any other person was defined as an external (oral) source of information.

## Types of information

In one subquestion common to Questions 4a and 4b, the respondents were asked to classify the content of the information items. Originally, eight categories were set out. These are defined in Appendix B. Five basic types were constructed from responses to this subquestion:

- (i) scientific (denoted by the "scientific" category in the questionnaire);
- (ii) client (by aggregating information denoted "extension" and "industry");
- (iii) technical (denoted by "other technical" in the questionnaire);

  - (v) administrative (by aggregating information denoted "resources", "time" and "manpower" in the questionnaire).

### Modes of information transfer

The mode of information transfer was measured by asking the respondents to specify whether the information was "volunteered" to them (and thus received passively) or "sought" by them (and thus acquired actively).

A passive mode of information acquisition from written material occurred if the information was obtained at "random" or through "regular reading"; an active mode occurred if the information was obtained through "purposeful search".

# Circumstances of information transfer

The circumstances of information transfer in oral exchanges were measured by a direct question: whether the information was obtained "informally", or "formally".

An item of information from written material was "pointed out" to the respondents if they entered the name of the person who drew written material to their attention. Otherwise, the item of information was classified as "not pointed out".

## Effects of information

The effects of the information on the respondents were measured by the means of three-step Likert-type statements which required the respondents to indicate how strongly the information was likely to affect their work.

## Stages of work

If the information entered by the respondents on the questionnaire forms related to a single project, then the characteristics of the projects indicated whether the information item related to the Idea Generation or Problem Solving stages of the projects. All entries relating to other stages, as well as all entries relating to projects which were in both the Idea Generation and the Problem Solving stages simultaneously, were excluded from analysis. If an item of information related to more than one project, an "area" (defined in Question 1) or "work in general", then this item of information was deemed to be related to the Work Programme Development stage of work.

## Occupational groups

The respondents were divided into three occupational groups (scientists, science technicians, administrative staff) depending upon their classification in the Public Service Occupational Classes (science, science technicians, and clerical/executive). An exception was the Director who, although listed in the "science" occupational class, was for the purposes of the present research classified as administrative staff member.

# Other dimensions of communication

In the subquestion relating to the "types" of information, the respondents were also required to indicate whether the organisational and administrative information had positive or negative effects on their work. For the sake of simplicity, this distinction was ignored.

In the questionnaire, the respondents were also asked to indicate when the information was likely to be useful. This variable originated in the pilot tests which indicated a need to provide room for the classification of information along this dimension, largely because some received information was not considered to be of immediate applicability by respondents. The point was conceded also because Orr (1970) called for such a classification, and Hall (1974) used it in his research.

Unfortunately, interviews throughout the study showed that the classification of information according to the timing of its usefulness was not clearly understood by the respondents, irrespective of numerous attempts which were made by the researcher to define it in letters accompanying the questionnaires and in subsequent discussions. The major confusion rested in the distinction between information which "will" or "might" affect work. The respondents were asked to tick the category "might in the future" only in the latter events. However, some respondents did not distinguish between "might" and "will" precisely.

This 'dimension' of communication was, therefore, excluded from subsequent analysis.

### SELECTION AND CONSTRUCTION OF THE INSTRUMENT

### Instrument selection

In past studies, three methods of data collection have been used to collect information on communication behaviour:

- (i) Single Questionnaire (Pelz and Andrews 1966, Rosenbloom and Wolek 1970, Allen and Cooney 1973),
- (ii) Solution Development Record (Allen at al 1966, Gerstberger et al 1968, Allen 1969), and
- (iii) Time-sample series of questionnaires (Frost and Whitley
  1973, Whitley and Frost 1972, Hall 1974, Allen and Cohen
  1969, Bitz et al 1975).

In this study, the time-sample series of questionnaires was used, though some modifications were necessary in the light of the theoretical framework developed for this study, and because of findings from pilot tests conducted prior to the actual collection of information. Because of the need to gather data similar to those obtained by the second method, the Solution Development Record, the adapted time-sample series of questionnaires utilised some aspects of that methodology.

The single questionnaire methodology was not used because the responses collected by such means are likely to reflect the respondents' beliefs about their work rather than the actual communication behaviour.

The Solution Development Record (SDR) was considered limited to the circumstances where there are major, clearly defined projects that have a definite beginning and end, and which also constitute the major workload of problem solvers investigated. In the present research setting, this was not the case, and the SDR was, therefore, not used. However, this study, like those employing the SDR approach, related information items to projects and used a similar definition of information items recorded.

Researchers who have used the time-sample series of questionnaires did not, until recently, define what item of information was to be recorded (Hall 1974). Generally, those studies which have employed the time-sample questionnaires asked the respondents to record with whom they engaged in a technical discussion.

Unlike the previous studies, respondents in the present study were asked to record only the significant information they received. They were also asked to describe it and to indicate the process of its transfer and its effect. Finally, they were required to relate it to a particular project.

# Instrument construction

The Information Flow Questionnaire which was used to gather the relevant data is shown in Appendix A. Questions 1, 2, and 3 were designed to elicit information pertinent to the projects. Questions 4 - 6 were designed to generate data on the information matrix, and the linking of the two areas.

After consultations with section leaders and two independent experts, 15 work areas were delineated. Nine of these defined specific research areas, and the remaining six categories addressed the biological and technical aspects of service, extension, and development types of activity. In Question 1 of the Questionnaire, the respondents were asked to tick any of the work areas in which they were involved at the time of the study. In order to simplify the analysis, the responses from this question were not analysed. Instead of classifying responses into areas of work, the responses were classified into occupational groups.

Question 2 asked the respondents to list all projects they were involved at the time the questionnaire was issued. In the same question, the respondents were asked to relate these projects to their work areas and to state the stage in which these projects were at when the information for the present study was collected. In Question 3, the respondents were asked to describe the facilities they used in each project. The analysis of this variable will be shown in Part II of this chapter. The responses to Questions 1 - 3 were copied from old to new forms prior to the next issue; and the respondents were asked to record any changes.

Questions 4 - 6 were laid out in a manner which was designed to facilitate quick and clear responses.

### DATA COLLECTION

This section is divided into two subsections: the time-sampling, and the administration of the questionnaires.

### Time-sampling

Previous studies which have used time-sample questionnaires issued the instruments 10-12 times over a period of 10-12 weeks (Whitley and Frost 1972, Frost and Whitley 1971, Hall 1974). Theoretically, Ritchie (1976) argues that the questionnaires be administered 10-12 times over the period of 6-8 weeks.

Because some past researchers encountered problems with the small number of information items recorded on the forms (Bitz et al 1975), it was assumed for the purposes of the research that the greater the number of times the questionnaires could be administered, the more valid and reliable the ensuing information matrices were likely to be. However, there is a limit to which an organisation would permit the use of its employees' time for the purpose of a social science research project. Also, decision on the time span of a study which utilises this methodology must be made with a reference to the broad cyclical patterns of work which occur in organisations such as the one studied in the present research. Because the organisation studied is involved in agricultural research and is, therefore, dependent on seasonal cycles, the period of 6-8 weeks suggested by Ritchie (1976) was considered . unsuitable.

The above dilemmas were discussed at a meeting with section leaders prior to the study, and it was agreed to issue the questionnaires 12 times over a period of five consecutive months..

As in the previous studies, the selection of the actual days on which the questionnaires were issued followed the rules for systematic random sampling. The time period of five months was divided into 12 two-weekly intervals. A day was randomly selected in each period but in such a way that the total sample contained at least two samples from each day of the week.

Unlike previous studies where "day" was not defined, the present study covered all hours of the period. To do this, a week was divided into four blocks of 24 hours and one block of 72 hours. The "day" was then defined as a time period beginning on 5pm of the previous day (for Tuesdays, Wednesdays, Thursdays and Fridays), or Friday (for Mondays), and ending at 5pm on the day the questionnaire was issued. This approach was adopted because results from pilot studies indicated that problem solvers read journals or attend work-related meetings in evenings, or over weekends.

Unlike previous studies, the respondents were also requested to fill in the questionnaires if they were away on a business trip on the day the

questionnaire was issued. The aim of the study was to ascertain the work patterns, wherever they occur, not just communication behaviour when the respondents were working within the organisation.

# Administration of the questionnaires

The questionnaires and their administration were considered complex from the outset. A strategy was, therefore, devised to stimulate interest in the study, to ensure, as far as possible, uniformity in understanding the various questions and definitions used, and to sustain the respondents' interest in the study throughout its duration. This was done through a series of informal and formal meetings, a practice run accompanied by a list of definitions (see Appendix B), letters enclosed with each issue of the questionnaire (Appendix C), and follow up interviews. By using these measures, full cooperation was secured.

The questionnaire forms together with the covering letter and an envelope were distributed to the respondents between 5 pm and 8 am of the period covered by the questionnaires. The completed forms were collected at 5 pm, that is, at the end of the period covered. All completed forms were checked and followed up in cases of obviously wrong or questionable entries.

The Information Flow Questionnaires were administered between 28.4.1977 and 28.9.1977.

### VALIDATION OF THE INSTRUMENT

### Reliability

Reliability measures show the precision of the instruments (Kerlinger 1973:443). Three sets of tests were carried out. These focused on the stability of the instruments, Kerlinger's coefficient of reliability, and the dependability of the instruments.

# Stability of the questionnaires

The mean responses per sample (weighted and unweighted for absences) are shown in Diagram 5.I. Tests were carried out to establish whether or not the variations that existed could be explained by considering:

- (i) the issuing of the questionnaires on different days of the week;
- (ii) high and low response rates; and
- (iii) high and low rates of absenteeism.

To investigate the effects of the days of the week, the Kruskall-Wallis non-parametric test, which compares the sums of ranks of individuals according to their number of entries per sample, was used to test the hypothesis that days of the week did not affect the relative number of entries by the respondents. (The same test was carried out by Hall 1974.) The details of the analysis are shown in Appendix D. The low statistic H (.138) indicates that there were no significant differences between the responses to the questionnaires issued on different days of the week.



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In past research, communication networks were constructed on the basis of weighting questionnaire entries for absences (Hall 1974). The analyses undertaken in the present research adopted the same procedure, provided that absenteeism did not effect the structure of the responses. The same test was used to study the effects of different response rates. To carry out this test, the days on which were reported (i) the lowest and highest communication entries (Questionnaires 9 and 11 respectively) and (ii) the lowest and highest absenteeism (Questionnaires 9 and 4,6 respectively) were taken, and the rank ordering of the respondents were compared by means of the Kendall Tau rank correlation coefficient. (The same test was done by Hall 1974.) Details of these analyses are shown in Appendix E. The high coefficents in all tests indicate that neither absenteeism nor different rates of responses affected the structure of the responses.

Thus, results from all tests discussed to this point indicated that the questionnaires were stable: neither days of the week, absenteeism, nor response rates affected the structure of the responses. (As will also be shown in the analysis of variance discussed below, there was no significant difference between the samples of communication behaviour.) Thus, in constructing the work patterns and the communication networks, the data were weighted for absences.

# Kerlinger's coefficient of reliability

The coefficient of reliability used in the present investigation was as defined by Kerlinger (1973:446):
"...proportion of error variance to the total obtained variance yielded by a measuring instrument, subtracted from 1.0, the index 1.0 indicating perfect reliability."

The details of the analysis are shown in Table 5.1. In carrying out the analysis, missing data were substituted by values for which the residuals were effectively zero. This step was necessary to make the analysis valid. A study of residuals indicated only a moderate departure from normality. Thus, having met the assumptions underlying the test, the results can be accepted as valid. The high coefficient of reliability, r = .90, shows that the instrument was highly reliable.

Table 5.1 Reliability of Information Flow Questionnaires using two-way analysis of variance\* and Kerlinger's formula

Source	d.f.	SS	MS	F
Between Samples Between Individuals Residual	11 52 506	93.03 2542.58 2406.69	8.46 48.90 4.76	1.78 NS 10.28 ***
Total	569	5042.30	8.86	

Coefficient of reliability (r):

r = 1 - V(e)/V(ind) = 1 - 4.76/48.90 = 0.90

\* The analysis was carried out on B6700 using program TEDDYBEAR written by J.B.Wilson of Otago University.

# Dependability of the questionnaires

Two checks were carried out to measure the dependability of the questionnaires. First, all entries which recorded a public servant as a

source of information were checked against an official list of persons employed in the Public Service. From the 476 entries which were checked, only 2 (.01%) persons were not identified, and these individuals may have been employed on special work contracts which were not recorded in the official list.

Second, the respondents were asked in interviews to evaluate how consistent they considered their responses throughout the study. With the exception of one person, all indicated a satisfactory level of consistency.

# Validity

A correlation test was carried out to establish whether or not the instrument used measured "significant" information.

Significant information, it will be recalled, was defined as information which is likely to affect the content or context of work. It was anticipated that the more information was received in a project, the higher would be the rate of change in the project.

All coded projects were divided into five groups, according to the number of information items received by them (information ties). This was correlated with the extent to which changes occurred in project stages. The results are summarised in Diagram 5.II. As the diagram shows, there was an increase in the proportions of stages which changed into any of the ensuing stages (from 14.5% for projects with no ties to 31.8% for projects with 10 or more ties). Thus, the greater the quantity of information received for a given project, the greater was the rate of

Diagram 5.II Test of the Information Flow Questionnaire validity: Relationship between changes in projects and the number of communications associated with the projects



change in the project. This result shows that not only did the questionnaires measure "significant" information as defined, but the argument that the quantity of communication is proportionately related to the efficiency of problem solvers' work was also substantiated. In terms of project throughput, a greater amount of information meant higher efficiency in work.

The results from the statistical test outlined above were corroborated by information given in interviews. Over 80% of the respondents who specified the criteria used in their decisions to enter information into the questionnaires (60% of all respondents) indicated in the interviews that they entered information items which had a "subjective" significance for their work.

#### METHODS USED IN INVESTIGATING THE HYPOTHESES

One of the major aims of the study was to show the relationship between particular stages of work and the communication patterns associated with them. These relationships were studied by means of the hierarchical log-linear modelling technique of contingency table analysis.

Broadly speaking, the hypotheses specified the expected relationships between dimensions of communication and stages of work. However, it was considered necessary to investigate these for the different occupational groups within the organisation studied. Thus, the analytical task was thought to be twofold, and comprised the examination of:

(i) the relations between dimensions of communication and

stages of work; and

(ii) the linkages between the two-way relationships and the occupational groups.

Because with one exception (effects of information), the variables considered in this study were categorical, the hypotheses required the examination of two-way and three-way contingency tables. However, because the hierarchical log-linear modelling technique was employed, tasks (i) and (ii) could be combined into a single analysis. In the language of the log-linear method, task (i) can be regarded as a part of a recursive system of all considered variables (Goodman 1973, 1979).

### Log-linear modelling technique

The log-linear technique is a modern method for the analysis of contingency tables. This technique was employed because it offers a mathematically coherent and structured procedure which enables the identification of simple and complex relationships between variables in a multi-variable situation. Further, it is now regarded as a statistical technique which supercedes the traditional methods of contingency tables analyses based on the Chi square (Upton 1978:46, Reynolds 1977). Indeed, a survey of studies shown in the Sociological Abstracts since 1975 indicated that about two-thirds of the studies which examined the relationships between categorical variables employed the log-linear method of analysis.

In the context of the social sciences, the technique was developed by Goodman (1970, 1971a, 1971b, 1972a, 1972b, 1973, 1979), and among others, popularised by Davis (1974), elaborated by Duncan (1975), Lever

(1979), Allison (1980), and summarised by Everitt (1977), Reynolds (1977) and Upton (1978).

The log-linear modelling technique enables a systematic description of the relationships among variables (Fienberg 1978:3). In general, the method involves two analyses:

- (i) finding a model for relationships which best fits the data, and
- (ii) examining each relationship.

To outline how this technique was used in this study to substantiate the hypotheses presented in Chapter 3, each part of the analysis will be examined sequentially. A summary of the procedure used in the study will conclude this section.

# Fitting of models to the data

In general, the fitting of models to the data means the finding of relationships which can be considered sufficient for explaining all the relationships considered. It is therefore a method which attempts to simplify a complex situation by depicting only significant relationships. These relationships can denote two-way associations, as well as higher-order interactions. The technique is termed "hierarchical", because the higher-order relationships derive, hierarchically, from the lower-order analyses.

In studying which relationships are significant, the log-linear

modelling technique also enables the examination of causal relations (Goodman 1973, 1979, Everitt 1977, Upton 1978, Fienberg 1978). Whilst causal relationships can be specified prior to the "fitting of models" and then only the hypothesised relationships are included in the analysis (Goodman 1979), causal relationships can also be inferred from the over-all analysis (Lever 1979). In this study, the latter approach was adopted. This is because the computer provides the capacity for fitting all models in a three-way table automatically; and because the study of the relationships between the occupational groups and their pattern of work was, as has already been suggested, exploratory.

Thus, the first part of the log-linear technique was employed to indicate which relationships sufficiently explained all possible relationships in the three-way tables considered, and, as well, to indicate the causal links.

### Examining each relationship

While the log-linear technique is regarded as appropriate primarily in situations involving dichotomous variables (Thornton 1978), this is only because polytomous variables present special problems in interpreting the figures indicating relationships between variables (Upton 1978:102). Because in this study, the variables considered were mostly polytomous, this situation was of a particular interest. The method used to analyse the data in the present research is elaborated below.

In log-linear models, an association between two variables is defined by a significant likelihood-ratio Chi square; and by figures representing multiplicative odds ratios (or additive log-odds ratios) between cells

in contingency tables. These figures, termed parameter estimates, thus substitute the traditional differences between the expected and observed frequencies. Unlike the traditional measures, however, the standardised values of the parameter estimates will be approximately normally distributed with a zero mean and a variance equal to one. Two figures, the parameter estimates, and their standardised values, thus indicate the extent to which each cell contributed to the likelihood-ratio Chi square. The standardised value denotes the significance of the cell's frequency and the parameter estimate denotes the relative strength of the observed relationship between categories.

In the case of dichotomous variables A and B, the interpretation is simple because the models constrain the relationships by assuming that the parameter estimate in the cell 1,1 is the same as for cell 2,2 and bears the same but negative value as cells 2,1 and 1,2. Thus, a parameter estimate summarises the strength of the relationship between dichotomous variables.

\_\_\_\_\_

In the case of polytomies, however, no single figure can be used to point out the relationship between the variables. Rather, an examination of the relationships between each pair of categories is required. Goodman (1979) suggests that Duncan's (1975) method of replacing polytomous variables with a set of dummy dichotomies is appropriate here [1]. The method involves the partitioning of variables. However, Upton (1978) documented that a study of each cell parameter estimate in a table of polytomous variables leads to the same conclusions without resorting to the complex computation involved in Duncan's method. In the present research, Duncan's method would have

involved the analysis of up to 45-way tables. Therefore, Upton's (1978) suggestion of examining the cells in the table was adopted in the present research because of its relative simplicity and acceptability. An examination of the parameter estimates and their standardised values will clearly reveal not only the cells which significantly contribute to the significance of the overall association, but also at least the relative extent of the association.

In sum, each relationship was investigated by examining those parameter estimates which significantly contributed to a significant likelihood-ratio Chi square, and by comparing the results with the hypotheses presented in Chapter 3.

### Summary of the procedure adopted

The examination of the relationships discussed in Chapter 3 was carried out in a series of three steps using the log-linear modelling technique. The three steps were as follows:

- (i) The three-way table was studied to reveal the complexity of the relationships which needed to be examined, and to throw some light on the causalities which may be involved. This step consisted of simultaneous tests showing the level (or order) of complexity which must be considered to fit the data, and the actual fitting of log-linear models.
- (ii) Each of the significant two-way relationships was explored by "collapsing" the three-way table, that is, summing over the categories of the "other" variable (Goodman 1979,

Allison 1980). These explorations revealed trends in the \_\_\_\_\_\_ two-way relationships (Upton 1978).

The computation was carried out on the IBM 370/168 using BMDP programs. The advantages and dissadvantages of these programs have been discussed by Dale and Maindonald (1980).

SUMMARY OF PART I

Part I addressed the methodological issues involved in attempts to empirically test the theoretical framework outlined in Chapter 3. The findings from these analyses will be discussed in Chapter 6.

The data were obtained through aggregating, and weighting for absences, samples of the communication behaviour of 54 respondents in one government research organisation. The data collection was carried out over a period of five months in 1977 using a series of Information Flow Questionnaires.

Tests showed that the instrument used was reliable and valid.

The reasons for using, and the application of, the hierarchical log-linear method for analysing contingency tables to test the

hypotheses presented in Chapter 3 were also discussed.

PART II

THE RESEARCH ORGANISATION, ITS ENVIRONMENT AND THE WORK PATTERNS OF ITS EMPLOYEES

The theory of the effects of research organisations on the work patterns of problem solvers advanced in Chapter 4 explored two subproblems:

- (i) the effects of research organisations on internal communication, and
- (ii) the effects of research organisations on external communication.

The organisation of the present chapter on methodology reflects this distinction in that it is divided into two parts. Part A deals with the methodological issues involved in investigating subproblem (i). Part B deals with the methodological issues arising from the empirical study of subproblem (ii).

PART A

ORGANISATIONAL EFFECTS ON INTERNAL COMMUNICATION

The theoretical framework advanced in Chapter 4 to analyse the internal communication patterns highlighted two complex concepts (the variables

which were actually investigated are in brackets):

- (i) Work patterns (internal communication), and
- (ii) Collective entities which constrain the work patterns, especially:

  - (b) structural properties of organisations (formal structure, informal networks, physical distances, and colleague networks); and
  - (c) Global properties (the use of facilities).

Each variable is discussed, in turn, in terms of the methodological issues referred to at the beginning of the present chapter.

#### INTERNAL COMMUNICATION

### Operationalisation

As in previous studies, the communication networks were constructed on the basis of aggregating data, weighted for absences, from all 12 issues of the Information Flow Questionnaires. Sociometric matrices were used to manipulate the data.

Eight networks of internal communication were constructed, using the type of information exchanged. Five of these networks involved the ---basic types of information: scientific, client, technical, organisational, and administrative; three were aggregates: scientific/technical (aggregates scientific, client, and technical types of information), organisational/administrative (aggregates organisational and administrative types of information), and total received (aggregates all basic types of information).

In the matrices constructed for each network, each cell indicated the number of relevant information exchanges between any two persons in the organisation. However, for some analyses, it was necessary to focus on only the paths between people, not the number of exchanges.

# Non-trivial communication paths

As in previous studies (Allen and Cohen 1969, Frost and Whitley 1971, Shotwell 1971, Hall 1974, Pruthi and Nagpaul 1978), the present study used sociometric techniques to construct the internal communication patterns as originally described by Harary, Norman and Cartwright (1965).

This method suggests that if B obtains an item of information from A, A transmitted a message to B via the path AB. If C obtains information from B, B transmitted a message to C via the path BC. It is then argued that there is a potential for the transmission of message from A to C via the path ABC.

However, if, for example, person A gave information to person B only once during the period of the study, the path AB can be said to more trivial (less effective) than a path AC which was used say 3 - 5 times. The frequency with which a path was used was the basis for distinguishing non-trivial from trivial paths.

### Table 5.2 Frequencies of communicating different types of information, and the determination of "non-trivial" paths

												NON-	TRIVIAL P	ATHS
TYPE OF INFORMATION	FREQUENCIES OF COMMUNICATIONS										CUT-OFF INDEX	STAT	ISTICS	
	1	2	3	4	5	6	7	8-10	11-14	34-36	Total	N	N	Of Total
Total/Rec	186	106	33	21	15	10	7	11	7	1	397	4	72 58	18
SC	80	35	9	10	2	2	2	1	2	-	143	2	63	44
Tech	72	32	9	4	5	1	1	1	2	-	128	2	55	44
Client	12	2	1	-	-	-	-	-	-	-	15	1	15	100
Org/Adm	103	60	14	9	5	6	1	1	1	-	200	2	97	49
Admin	87	46	10	2	2	2	-	-	-	-	149	2	62	42
Org	51	22	2	3	3	3	-	-	-	-	146	1	146	100

Table 5.2 summarises the distribution of the frequencies according to the paths established for all types of information considered. These data show that most paths were used only a few times. These findings are consistent with those reported in previous studies (Frost and Whitley 1971, Hall 1974).

An analysis of the data, using Harary's (et al 1965) method of networks ----transformation, generated the index which separated trivial from non-trivial paths. This index, as well as some relevant statistics of the non-trivial paths, are also shown in Table 5.2.

The networks of internal communication were constructed from responses obtained to the Information Flow Questionnaires. This instrument was described in Part I of the present chapter.

The validation of the Information Flow Questionnaires was also discussed in Part I of the present chapter.

#### AUTONOMY

### Operationalisation

Autonomy was defined, nominally, as the degree to which people have power with respect to their environment (see Chapter 4). Operationally, autonomy can be measured in terms of the degree to which people can make effective decisions on the following work related matters:

(i) what they do,

.

- (ii) how they do it,
- (iii) when they do it,
  - (iv) with whom they do it, and
  - (v) what will be done with the outcome of their work.

# Selection and construction of instruments

Price (1972) suggested that Inkson's (et al 1970) scale best measures autonomy as defined above, since this scale measures the degree to which respondents can make decisions about various actions. For the purpose of the present study, three modifications were made to the scale. First, the words "can make effective decisions" were substituted for the words "authority to decide". original Second, instead of the Guttman-like statements used by Inkson, the respondents were asked to evaluate each domain item in terms of Likert-type statements. This was done to make all instruments measuring attitudes consistent. Third, on the basis of Price (1972) who suggested that Inkson's scale could be shortened, 13 domain items were used instead of the 23 included in the original scale. The domain items included were determined through an elaboration of the operational definition shown above. These items, together with the titles of the relevant statistics, are shown in Table 5.3. The items were printed in the questionnaire randomly.

The domain items included were determined through an elaboration of the operational definition shown above. These items, together with the titles of the relevant dimensions and statistics, are shown in Table 5.3. The items were printed in the questionnaire, randomly.

IT. DIM.	DESCRIPTION	MEAN TOP 25%	MEAN BOT. 25%	T VALUE
A1 IV A2 IV A3 I A4 V A5 I A6 IV A7 V A8 III A9 I A10 II A11 I A12 V	Determine a team member Interview new employees Terminate project Determine journal for pub. Initiate new project Select new employee Determine client Determine priorities in work Determine work problem Determine methods in work Determine content of work Determine what is published	4.67 3.42 4.75 4.92 4.58 3.50 2.08 4.83 4.83 4.83 4.92 4.17 4.75	1.10 0.90 1.50 0.30 1.20 0.80 0.70 1.50 1.90 2.20 2.70 0.60	10.11 *** 4.52 *** 9.51 *** 27.76 *** 12.11 *** 5.27 *** 1.82 N.S. 9.98 *** 7.53 *** 6.26 *** 3.63 ** 16.81 ***

Table 5.3 Autonomy scale and its evaluation

Indices construction

To compute the indices required, the interrelationships between items were analysed in order to determine the unidimensionality of the scales and to establish the items which measured the concept best (Nunnally 1967, Grimes and Berger 1970, Flango and Brumbaugh 1974). Mayntz's (et al 1976:55-57) method was selected to do this for all the scales used in the present study. This method consists of dividing respondents into four groups on the basis of a "temporary" total score, and using the t-test to compare the mean responses of the two extreme groups on each item. When values given by the two groups are not significantly different for an item, that item is judged to be measuring another dimension and is, therefore, rejected from the computation of the total score.

The results of the test carried out to determine the autonomy scores were also shown in Table 5.3.

Because item A7 was not evaluated as significantly different by the top and bottom 25% of the respondents, it was not included in the computation of the autonomy scores. The autonomy score for each respondent was computed by summing up their scores on all other items.

The frequency distribution of the autonomy scores of all respondents is shown in Diagram 5.III. The score 35 was chosen as the cut off for dichotomising this variable, or, in other words, for distinguishing "autonomous" from "non-autonomous" respondents. This point was chosen because the median score was 34.3; moreover, the largest gap between any two adjacent scores occurred between the scores of 34 and 38.

#### Reliability and validity of the instrument

Two coefficients of reliability were computed using the 12 items selected for the final scale. A coefficient alpha was .961. A \_\_\_\_\_\_ Spearman-Brown's coefficient of reliability based on split-half model was .954. [2]

The instrument was assumed to be valid on the basis of a content analysis of the items, and because of their similarity to the items

Diagram 5.III Respondents' autonomy scores



included in the scale which had been devised by Inkson (et al 1970), and which itself has been shown to be valid (Price 1972).

On the basis of the results obtained from these computations, the scale was judged to be both valid and reliable.

#### WORK RELATED ORIENTATIONS

### Operationalisation

Work related orientations, which have already been defined as sets of attitudes toward the work related environment (see Chapter 3) were measured on the basis of the professional/local scale devised by Gouldner (1957, 1958).

Three modifications were made to Gouldner's scale. These modifications were based on the theoretical framework developed for the present study, and the literature which has been published since Gouldner's original studies:

- (i) Work related orientations were assumed to be multidimensional rather than unidimensional as originally argued by Gouldner (Goldberg et al 1964, Glaser 1963, Grimes and Berger 1970).
- (ii) Unlike Gouldner's and also unlike many other studies (Goldberg et al 1964, Berger and Grimes 1973, Grimes and Berger 1970, Flango and Brumbaugh 1974, Friedlander 1971), orientations were considered in terms of the four dimensions

delineated in the theoretical framework employed in the present research (see Chapter 4).

- (iii) Two parameters rather than the three used by Gouldner were assumed to be underlying each dimension:
  - (a) loyalty/reference group orientation, and
  - (b) commitment to specialised skills.

This decision was based on the fact that Grimes and Berger (1970) indicated that the difference between loyalty and reference group orientation was not entirely clear.

# Selection and construction of the instrument

Various techniques have been developed for measuring work related orientations (Gouldner 1958, Goldberg et al 1964, Pelz and Andrews 1966, Friedlander 1971). On the basis of arguments advanced by Grimes and Berger (1970), Goldberg's (et al 1964) format was used in this study.

In constructing the instrument, at least three "marker" items should be selected per dimension, although it has been suggested that eight items per dimension is more desirable (Flango and Brumbaugh 1974) to ensure that an attitude is appraised in a sufficient number of different ways (Scott 1968:211). Table 5.4 summarises the items which were selected to measure the four dimensions of work related orientations. The table shows the randomly assigned item numbers, the description of the item, the parameter of the item, and where applicable, the loadings which were obtained on that item in previous studies. The loadings on the appropriate factor achieved in the present study are also included in the table.

#### Table 5.4

Orientations toward the scientific community, the organisation, the client communities and the political system

ITEM	DIM	DESCRIPTION	G'G	G&B	HES
AT28 AT17 AT 5 AT 6 AT18 AT22 AT30	II II I I I I I	Theoretical relevance Breakthrough in theoretical knowledge Research originated from sc. literature Reputation in professional community Opinion of colleague Challenge of the idea Enjoyment of working on the idea	58 56 ** 73 76 69	•56 •69 ** •46 - •68 •62	.60 .35 *** .68 .62 .68 .64
AT 3 AT 7 AT 8 AT11 AT19 AT23 AT24 AT29 AT32	II I II I II I I I I I	Obtaining respectable results DSIR policies Preferences of the Director Usefulness to other DSIR divisions Opinion of supervisor Goals of the organisation Promotion Government policies Reputation in the organisation	- - 48 21 *	- •53 •56 •71 •61 *	•45 •63 •65 •68 •29# •39# •04# •64 •11#
AT 2 AT12 AT13 AT14 AT15 AT16 AT21 AT26 AT27 AT 4 AT27 AT 4 AT10 AT31 AT20	II I II II II II II II II II II	Breakthrough in practical knowledge Maintenance of profit of farmers Ad hoc trouble-shooting Problems in Agr. Extension Farmers' level of technical skill Farmer support Desirable goals of the farming community Client acceptance of findings Potential developments of agriculture Opinion of persons in Agr. Extension Problems derived from Agr. Extension Opportunity to write in client journals Enhance status in the farming community			*** •53 •71 •83 •47 •59 •69 •80 •79 •65 •60 •69 •79
AT 1 AT 9 AT25 AT33	I I I I	Current public issues Ideas originated from moral issues Ideas originated from voluntary organisati Ideas originated from social movements	ions		•09# •62 •58 •62

Notes to the table are shown overleaf ....

G'G - Goldberg (et al 1974)
B&G - Grimes and Berger (1973)
HES - the present study
\* See related items, for example AT23 and AT6
\*\*\* The source of the item is in Pelz and Andrews (1966)
\*\*\* The item did not measure this dimension and was
 excluded from the computation of the score.
# Because of the low loading achieved in the study, these
 items were excluded from the computation of the
 orientation scores.

The four dimensions of work related orientations (or simply orientations) are elaborated below:

Respondents' orientations toward the professional community were measured by seven items; six of these can be regarded as marker items which were addressed to either awareness of developments in scientific fields or "professional self-gratification" (Goldberg et al 1964). In constructing this scale of items, item AT5 was added as this was considered to be an appropriate elaboration of this dimension of orientations (Pelz and Andrews 1966).

The orientations of respondents toward the organisation were measured by nine items. Four of these were marker items. The items concerning the goals of the organisation were extended to cover the goals of the DSIR and government policies as well.

The items which denoted the orientations toward the client communities were constructed by deduction from the parameters underlying the dimensions of the orientations. As was already suggested, previous studies which examined the construct did not include this particular dimension of orientations.

The items which were chosen to describe the orientations toward the

political system were inferred from Wilensky (1964), who pointed out that orientations may also be toward particular programmes and policies which are rooted in various social movements and moral issues.

# Indices construction

As in the construction of the autonomy scale, Mayntz's (et al 1976) method of testing the interrelationships between items was used to test the unidimensionality of each orientations scale. As a result, items AT2 and AT5 were discarded from further analysis.

In subsequent analysis, the structure of the dimensions was studied by means of factor analysis. Following Berger and Grimes (1973), the principal-axis solution and Varimax rotation were applied to analyse the structure of responses to items measuring all four dimensions of orientations. Since only four dimensions were expected, the Varimax rotation was computed using a four factor solution [3]. The rotated factor matrix clearly showed the four dimensions which had been anticipated theoretically.

The computation of the orientations score for each respondent was based only on those items, which "measured" the relevant dimension of each of the orientations. The formulae shown below were used to calculate these scores for each respondent:

A = (AT6 + AT22 + AT28 + AT18 + AT30)/5 B = (AT7 + AT8 + AT11 + AT29)/4 C = (AT14 + AT26 + AT27 + AT20 + AT21 + AT13 + AT4 + AT31 + AT16)/9D = (AT9 + AT33 + AT25)/3

where A - orientations toward professional community,

- B orientations toward the organisation,
- C orientations toward the client communities,
- D orientations toward the political system.

The frequency distributions of all four scales is shown in Diagram 5.IV. The information shown in this diagram indicates that with the exception of the scale measuring the orientations toward the prefessional community, the majority of respondents scored below "3" on all other dimensions. On average, the respondents were, therefore, not highly oriented toward the organisation, the client communities or the political system.

Each of the scale was dichotomised. The median of 3.2 was used as the cutting off point for the professional orientations scale. A score value of 3.01 was used to dichotomise the other three scales. This was done to ensure that "highly oriented" respondents had a score which was at least above the average score "3".

# Reliability and validity of the instrument

The validity of each of the scales used was established on the basis of content analysis, and in terms of the numerous marker items which were included from previous studies.

Two coefficients of reliability, alpha, and Spearman-Brown, were ----computed. The results for these calculations are shown in Table 5.5.

It was noteworthy that these coefficients of reliability were higher than those reported by Berger and Grimes (1973); and it was concluded that the instruments used to measure the orientations of respondents were reliable and valid.

Diagram 5.IV Respondents' orientations scores



ORIENTATIONS	ALPHA	SPEARMAN- BROWN
Professional	•844	.803
Organisational	•884	.868
Client	•929	.900
Political system	•800	.711

Table 5.5 Reliability of orientations scales

#### SOCIALLY RECOGNISED WORK COMPETENCE

### Operationalisation

In the previous studies on research organisations that have included this variable, two major forms of socially recognised work competence were normally put forward: evaluations of the researcher's performance in terms of organisational criteria; and the judgements of the professional community (Glaser 1963, Cole and Cole 1968, Whitley and Frost 1973). Consequently, the term "socially recognised work competence" will be used, synonymously, with the term "performance".

Both dimensions of performance outlined above have been employed in the present investigation. However, because as has already been noted (Chapter 4), the environmental contingency of the organisation which was the subject of the present research comprised four, rather than two, classes of actors, it was also necessary to analyse the performances of respondents in terms of both the client community and the political system.

### Selection and construction of instruments

The evaluation of individuals' performances in terms of organisational criteria was measured in terms of the ranks assigned to each person on an official "merit list", which is assembled by the organisation bi-annually for the purposes of determining the salary levels of scientists and science technicians. The existence of the merit lists overcame the need to set up a committee of senior scientists to evaluate the performance of the organisation's members (as was done in Whitley and Frost 1973, Frost and Whitley 1971, Hall 1974).

Two categories of respondents were constructed from the merit lists for 1976 and 1978. Those scientists and science technicians who were above the middle rank were defined as high performers. Low performers were defined as those scientists and science technicians who were below the middle rank. The three administrative persons were, for the purpose of the present investigation, defined as high performers, although they are not included in the official merit list.

Previous research suggests that the best methods for evaluating people's performances in terms of professional criteria were measures of the quality of work as indicated by publications, citations, honorific awards and the prestige of the employing organisation (Merton 1938, Hagstrom 1965, Storer 1966, Cole and Cole 1968). However, as a survey of the Science Citation Index revealed, there were very few citations of the work done by the respondents; moreover, investigation of honorific awards and the prestige of the organisation did not prove fruitful in

the present study. In fact, only the number of publications per respondent could be used to measure this variable.

Table 5.6							
Publication	record	of	all	respondents	in	professional	literature

COUNT	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	CUM FREQ (PCT)
0.	18	35.3	35.3
1.	6	11.8	47.1
2.	5	9.8	56.9
3.	3	5.9	62.7
4.	5	9.8	72.5
5.	6	11.8	84.3
6.	2	3.9	88.2
7.	1	2.0	90.2
8.	1	2.0	92.2
10.	1	2.0	94.1
12.	1	2.0	96.1
16.	1	2.0	98.0
17.	1	2.0	100.0
TOTAL	51	100.0	

Table 5.7 Publication record of all respondents in farm and extension journals

COUNT	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	CUM FREQ (PCT)
0	45	00 0	00.0
0.	45	00.2	00.2
1.	4	7.9	96.1
3.	2	3.9	100.0
1			
TOTAL	51	100.0	

Table 5.6 reports the frequency distribution of publications of the

respondents in the professional literature (proceedings, New Zealand and overseas scientific journals, articles in books and engineering literature). On the basis of this distribution, respondents with four or more publications were considered high performers, and those with three or less were defined as low performers, in terms of the professional criteria.

An attempt was made to evaluate the respondents' performances in terms of the client communities. However, as the data shown in Table 5.7 make clear, the number of publications of this kind was very small. Further analysis of this dimension was abandoned. Because there was only limited explicit contact with the political system (see Chapter 6) and participation in that system was also limited (Chapter 2), the evaluation of the respondents' performance in terms of the political system was also abandoned.

#### FORMAL STRUCTURE

As in previous studies, the formal structure of the focal organisation was defined as "who is administratively responsible to whom in the organisation" (Allen 1968, Frost and Whitley 1971, Hall 1974, Bitz et al 1975). The formal structure chart of the organisation in focus is shown in Diagram 5.V. This information was used to divide respondents into eight groups.



Diagram 5.V Formal structure of the organisation investigated

The informal networks of the focal organisation were defined, as in previous studies, using sociometric techniques: who choses whom as an informal contact (Allen 1968, Frost and Whitley 1971, Hall 1974, Pruthi and Nagpaul 1978). Three circumstances were considered:

- (i) regular lunch contacts,
- (ii) regular after work contacts, and
- (iii) informal contacts which combined (i) and (ii).

#### PHYSICAL (GEOGRAPHICAL) DISTANCE

Allen (1975:154) defined this variable in terms of the actual walking distance separating the office desks of any pair of individuals. Allen's technique was abandoned in favour of a clustering technique for two reasons. First, the data collection procedure in Allen's method was considered too time-consuming in relation to the benefits obtained. Second, the distances between desks (as measured by Allen), had to be supplemented by the calculation of the distances between work benches. It was not possible to determine which of the measurements would be more accurate because not all persons were either at their desks or in laboratories at any given time.

Instead of using Allen's method, it was decided to use a technique similar to that used in the operationalisation of the formal structure: the determination of clusters. Eight groups were considered, each of which occupied distinct block of offices in the buildings used by the organisation. A map showing the distribution of the respondents in these buildings is shown in Diagram 5.VI.

#### COLLEAGUE NETWORKS

The colleague networks were defined in terms of "who works with whom as a colleague (a team member) on projects". Although the organisation kept a formal register of projects which showed such details, observations during the study led to the conclusion that the register was inadequate, because not all of the projects respondents entered in the Information Flow Questionnaires were shown in the formal register.

The relevant data were obtained by asking the respondents to name all the team members involved in each of the projects they had named in the Information Flow Questionnaires. As anticipated, the responses did not mutually agree. However, as in the treatment of the data used in

Diagram 5.VI Physical location of respondents on the organisational premises



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Respondents -

delineating communication patterns, colleague networks were constructed on the basis of each respondent's identification of his/her team member.

USE OF FACILITIES

The use of facilities was defined by the degree to which respondents actually used any one of five pre-determined facilities which were in the research organisation which was the focus of the present study. All respondents were asked to report the extent to which they used each facility.

# Indices construction

When the respondents entered the receipt of significant information pertaining to a particular project, that project was also characterised in terms of facilities used for undertaking work relevant to that project. The scores for each facility were then computed for each respondent by averaging the relevant values of their entries.

The frequency distribution of all scores is shown in Table 5.8.

The use of facilities, shown in Table 5.8, which was already summarised in Diagram 2.V (Chapter 2), indicates that the in-house specialised equipment was the most frequently used facility. The next most frequently used facility was the Climate Rooms. The other three major facilities (glasshouses, farm plots owned by research organisations, and farm plots owned by farmers), were, on average, hardly used at all. However, since one of the aims of this study was to map the relationship between the research organisation and the client communities (farmers, horticulturalists, etc.), it was decided to also measure the use of farm plots as a common denominator for communication.

Rates of use *	Climate rooms	In-housed E & I	Glasshouses	Research owned fields	Farmer owned field
0- 5 6-10 11-15 16-20 21-24 25-30 31-35 36-40	30 2 1 3 2 4 10	13 2 4 2 5 9 4 15	36 5 4 1 0 1	30 10 1 2 5 1 1 4	50 1 0 1 0 1 0
Total	54	54	54	54	54
Mean S.D. Median	13.5 16.3 4.5	22.1 15.1 25.8	6.0 8.6 4.0	8.8 12.4 4.5	1.6 5.7 1.6

Table 5.8 Use of facilities

\* With reference to the original scale used, the rates of use are expressed in the multiples of 10.

It was, then, decided to retain three categories of facilities used by the respondents: Climate Rooms, in-house equipment, and fields (irrespective of ownership).

The dichotomisation of the three scales was carried out in two ways. For the Climate Rooms and in-house equipment, it was decided to separate from others those people who used the facilities more than to "a greater extent". The cut off point was 30.0. For the use of fields, the score of 20.0 was used to separate from others those people who used the facility more than to a "limited extent". As the data shown in Table 5.8 indicate the selection of a higher index value would have resulted in very few relationships between facility users.

METHODS OF ANALYSIS USED IN INVESTIGATING HYPOTHESES SHOWN IN CHAPTER 4, PART A

The hypotheses presented in Part A of Chapter 4 called for tests which would measure whether or not internal communications occur within groups with certain characteristics, and would measure the strengths of such associations. The properties analysed were analytic, structural and global. Analytic variables and the single global variable considered had ordinal qualities. These variables were dichotomised. The structural characteristics were dichotomised in that a respondent was either a member of, say, section A, or not.

The transformation of all independent variables into dichotomies enabled the selection of a single type of test to investigate the hypotheses. While the advantage of this approach was the uniformity of results and, therefore, an overview of the relationships, the disadvantage was that much of the information inherent in ordinal variables was lost. However, as the present study was exploratory in nature, the uniformity of tests (even at the expense of loss of some information) was considered preferable.
One method of analysis has, for investigating the relationships between communication networks and organisational structures, dominated previous research in the field. The method, devised by Allen (1968, Allen and Cohen 1969, Allen 1977) and which was used by Frost and Whitley (1971), Conrath (1973) and Hall (1974), used the Kolmogorov-Smirnov, one sample, test of significance.

Nevertheless, the Kolmogorov-Smirnov test was not used in this study for reasons discussed below:

- (i) A measure of the strength of the relationship was considered desirable. The Kolmogorov-Smirnov test does not provide it.
- (ii) The Kolmogorov-Smirnov test is not considered very sensitive. As Noether (in Hall 1974) showed, when discontinuous distributions are used in the Kolmogorov-Smirnov test, a conservative value will be obtained. A more sensitive test was desired.
- (iii) Some preliminary tests showed that the use of the Kolmogorov-Smirnov test to examine the relationship between organisational structures and communications, can lead to highly misleading results. In circumstances when the observed frequency distribution approaches the theoretical binomial or hypergeometric distribution, the test statistic D will be insignificant even in a case of, statistically speaking, a "perfect" association.

In the present investigation, a test which was derived from maximum

likelihood estimation techniques as the locally optimal test was used to examine the hypotheses shown in Part A of Chapter 4. This test is described below [4].

# The locally optimal test

To illustrate the application of this statistical test, the following hypotheses are considered. Work related communication is more likely to occur with:

2.1 members of the same section, and 2.2 informal contacts,

than with others in the organisation.

In each test of an hypothesis, the respondents, N, were divided into groups depending upon their membership of the same section, or informal contacts. Each individual could have contacted M = N - 1 people. For each individual, i, a number of other respondents, m(i), were regarded as "special" targets. These "special" targets were other members of his/her section, or his/her informal contacts. All other respondents, M - m(i), were "non-specials".

In testing the significance and extent of communicating with the "special" targets, as opposed to communicating at random, two situations arise (Hall 1974):

(i) Binomial case: It was assumed that contacts are made independently; repeated contacts with the same targets are counted as separate contacts. In this case it was assumed that the occurence of a previous contact with a certain target makes no difference to the probability of a future contact with this target. It is also supposed that different individuals behave independently; in particular the fact that individual, i, contacts a target person, j, makes no difference to the probability that person j contacts target person i.

(ii) Hypergeometric case: This is the situation where multiple contacts are counted only once; that is, no distinction is made between single and multiple contacts. In this situation it is still necessary to assume that individuals act independently, but a tendency towards multiple contacts is of no importance.

In the example quoted above, hypothesis 2.1 is akin to the binomial situation, and hypothesis 2.2 is akin to the hypergeometric situation. The examination of the hypotheses in both situations followed the same method, but different computational formulae were utilised.

The examination of each hypothesis involved setting up a simple model, which depended on a test statistic S, such that S = 1 corresponded to the assumption that there was a "perfect" preference for "special" targets, and that S was near zero if there was no preference for "special" targets. Under the null hypothesis that the "specials" have no special attraction, the statistic S would be roughly normally distributed with a zero mean and a variance equal to one. Thus, the statistic S provides an approximate measure of the strength of the relationship under investigation, and its standard deviation would indicate the statistical significance of the relationship. The method of computation of the statistic and its variance differed for the two situations used in the present example.

In examining hypotheses akin to the binomial situation, the test aimed to determine whether people communicated randomly with other members of the organisation (that is, the null hypothesis), or whether their choices were influenced by their membership in manifest group structures (formal structure, geographical grouping), or latent group structures (autonomy, orientations, competence, and use of facilities). The number of actual communications was analysed [5].

In examining hypotheses akin to the hypergeometric situation, the test aimed to determine the probability that a choice of communication partners was not made randomly (that is, the null hypothesis), but was influenced by the choice of other people for different purposes (informal contacts and colleagues). Consequently, the analyses involved the number of non-trivial communication paths, rather than the number of actual communications [6].

The statistics were computed on the B6700 computer using a FORTRAN program written by the researcher.

### PART B

EFFECTS OF RESEARCH ORGANISATIONS ON EXTERNAL COMMUNICATION

In examining the relationships between the research organisation and its environment, the present study focused on external communication, and

two variables which were defined as structural properties of the organisational environment: environmental contingency, and the physical distances of the sources of information which were external to the focal organisation.

Each of these variables is considered, in turn, in terms of the methodological issues which were outlined at the beginning of the present chapter.

### PATTERNS OF EXTERNAL COMMUNICATIONS

# Operationalisation

Patterns of external communication were defined operationally in terms of the strength of communication ties between external organisations and the focal organisation. The strength of a tie was computed by summing up information received from, and given to, persons from external organisations, and dividing the sum by two.

### Selection, construction and validation of instruments

The patterns of external communication were constructed from responses to Questions 4 and 6 in the Information Flow Questionnaires.

ENVIRONMENTAL CONTINGENCY

In Chapter 4, environmental contingency was defined as the sum of

"power" exerted by different organisations over the focal organisation. This "power" can be defined as the ability to influence organisational decisions in ways that produced outcomes favoured by the influencing body (Pfeffer and Salancik 1978:230). As a first approximation of this environmental contingency, this "power" can be assessed in terms of the strength of communication between the focal organisation and the organisations in its environments. This is because the influence process is likely to be reflected in the structure of communications. As Dill (1962:97, in Pfeffer and Salancik 1978:74) noted:

"To link organisational actions to environmental inputs, it is necessary to analyze an organisation's exposure to information ...".

Operationally, environmental contingency was, then, defined in terms of the strength of communication ties between the external organisations and the focal organisation as outlined above in the discussion of external communication.

### PHYSICAL DISTANCES (EXTERNAL ORGANISATIONS)

The physical distances between the external and focal organisations were measured in terms of the direct line distance (in miles) between them (as in Allen and Cooney 1973).

These data were obtained from the Information Flow Questionnaires. In Questions 4 and 6, the respondents were asked to name the organisation which was the source (or destination) of the information they received. The addresses of these organisations were determined and the distance

involved was measured on a map.

METHODS OF ANALYSIS USED IN INVESTIGATING HYPOTHESIS SHOWN IN CHAPTER 4, PART B

As shown in Part B of Chapter 4, the hypotheses which concerned the effects of research organisations on external communications called for the "mapping" of external communications, and then a comparison of the frequencies of some external communications with the physical distances of the sources of these communications.

The "mapping" of these external communication used frequency counts. Techniques of graphical representation were used to study the relationship between the external communication and physical distances.

### DATA COLLECTION

The data on the variables involved in the present investigation were obtained through various means:

- (i) Communication networks, both internal and external communications, were constructed on the basis of responses to the Information Flow Questionnaires. This instrument, which was discussed in Part I of this chapter, also provided information on:
- (ii) colleague networks,
- (iii) use of facilities, and

- (iv) the physical distances of external sources of information.
- (v) Socially recognised work competence, defined in terms of organisational criteria, was obtained from the official merit lists used by the Department of Scientific and Industrial Research.
- (vi) Socially recognised work competence in terms of professional criteria (publication record),
- (vii) autonomy,
- (viii) informal contacts, and
  - (ix) work related orientations were constructed from data gathered by means of Questionnaire II (see below).
  - (x) Formal structure was obtained from the administrative chart of the organisation, and
  - (xi) physical distances between the respondents were established from examination of the building plans of the organisation.

Let me now address the other two questionnaires which were issued to the respondents. These questionnaires, among other things, sought data on the variables central to the purposes of the present study: Socially recognised competence in terms of professional criteria (Question 4, Questionnaire II), Autonomy (Question 10, Questionnaire II), Work related orientations (Question 11, Questionnaire II), and Informal networks (Question 1, Questionnaire II). Responses to the remaining questions in these questionnaires were outlined in Chapter 2 of this report.

# Selection and construction of the questionnaires

For two reasons, a self-administered questionnaire format was selected despite its disadvantages (see e.g. Kerlinger 1973:487):

- (i) The Information Flow Questionnaires and the interviews conducted during their issues did interrupt the work of the respondents. Further interviews would have resulted in an unacceptable level of interruption of the work in the organisation.
- (ii) Measurement of the attitudes of respondents required zero overflow of bias. This condition could occur as a result of communication between those respondents who were tested and those who were not tested. In the organisation studied, the close physical proximity of all respondents would have made this circumstance a real problem.

All scales and other demographic and attitudinal questions were initially organised in one questionnaire and a pilot test was carried out in an organisation similar to the focal organisation. As a result of this test, some questions were re-worded and the questionnaire was split into two parts: Questionnaire II and Questionnaire III (shown in Appendices G and H, respectively).

### Administration of the questionnaires

The forms were issued on a Friday following the completion of the Information Flow Questionnaires run, and collected the following Monday. During five month period in which the data were collected, two scientists and two science technicians left the organisation. Completed Questionnaires II and III were received by mail from one of the scientists, but only partially completed forms were returned from the other scientist. Although the questionnaires were sent to a science technician who retired, no reply was received. The other science technician who left during the study could not be contacted. Because one clerk in the administrative section did not wish to participate in this study, the pool of information for the analyses reported was derived from 51 questionnaires.

SUMMARY OF PART II

Part II of this chapter addressed the methodological issues involved in the attempts to empirically test the hypotheses outlined in Chapter 4.

The operationalisation of each of the variables investigated, the instruments which were used to measure them, and the method of analysis used in examining the relevant hypotheses were discussed.

Analyses of data from several instruments indicated that these instruments were reliable and valid.

To investigate the relationships between the research organisation and internal communication, the relevant variables were set out to enable the use of a locally optimal test. In general, the analyses involved the computing of indices which made it possible to decide whether each

respondent belonged to a manifest or latent group. The locally optimal test was then used to establish whether internal communication occurred at random, or whether this kind of communication was influenced by such groupings.

The investigations of hypotheses concerning the effects of research organisations on external communication relied on simple frequency counts and graphical representations of relationships.

The next two chapters discuss the findings from examinations of hypotheses presented in Chapters 3 and 4.

\*

NOTES

- [1] Other methods of reducing polytomies to dichotomies include the study of their orthogonal transforms. This method was not used in the present study because the categories of the variables were not ordinal.
- [2] The coefficient alpha is akin to Kerlinger's formula for calculating the coefficient of reliability which is discussed in Part I of the present chapter.

The Spearman-Brown coefficient divides the variable into two subsets which are then correlated. This correlation measures the extent to which the two halves measure the same thing.

Both the above coefficients of reliability are frequently featured in social science reports. It was only after the analysis of reliability shown in Part I was completed, that these coefficients became available through the SPSS on the B6700.

- [3] The use of factor analysis may not be considered valid in the present application. However, it was used here merely as a check on unusual results, and to establish those items which inter-correlated and thus measured one and the same thing. The analysis was not carried out to make any claims of theoretical importance. Nevertheless, the findings were in the predicted direction. If they are considered as results from a "pilot" study, they may justify further investigation of the dimensions of orientations which have been largely ignored in previous studies.
- [4] I wish to express my gratitude to Dr R.Davies of AMD Division of the DSIR for his analysis of the problem of the present investigation, and the derivation of the locally optimal tests.
- [5] The statistic, S, and its variance, V, were computed by the following formulae:

$$S = \frac{\sum_{i=1}^{N} (x_i - n_i m_i / M)}{\sum_{i=1}^{N} (1 - m_i / M)} \qquad V = \frac{\sum_{i=1}^{N} (n_i m_i / M) (1 - m_i / M)}{\left[\sum_{i=1}^{N} n_i (1 - m_i / M)\right]^2}$$

where: N = number of respondents, M = number of all possible targets (N - 1), m(i) = number of "special" targets,

- n(i) = number of all contacts, and x(i) = number of contacts with "special" targets.
- [6] The statistic, S, and its variance, V, in the hypergeometric situation were computed by the following formulae:

$$S = \frac{\sum_{i=1}^{N} (x_i - m_i n_i / M)}{\sum_{i=1}^{N} \min(m_i n_i) - m_i n_i / M} \qquad V = \frac{\frac{1/M - 1\sum_{i=1}^{N} n_i m_i (1 - m_i / M)}{\sum_{i=1}^{N} \min(m_i, n_i) - m_i n_i / M}}$$

where: N = number of respondents, M = number of all possible choices (N - 1), m(i) = number of choices in one network, n(i) = number of choices in another network, x(i) = number of choices common to m(i) and n(i).

18.1

### CHAPTER 6

### WORK PATTERNS OF PROBLEM SOLVERS: FINDINGS

This chapter reports findings based upon the empirical investigation of hypotheses presented in Chapter 3.

Each of the hypotheses addressed an aspect of communication of problem solvers; considered together the hypotheses formed an attempt to formulate a theory of the work patterns of problem solvers.

The theory focused on three stages of work and anticipated the patterns of communication associated with each stage.

Hypotheses 1.1.1-1.1.3 dealt with sources of information,

**	1.2.1-1.2.3	"	"	types of information,
"	1.3.1-1.3.3	11	11	modes of information transfer,
"	1.4.1-1.4.3	11	11	circumstances of information
				transfer, and
Hypothesis	2.5.1	"	"	effects of information.

In Chapters 1 and 3, Table 1.1 provided the following overview of the hypotheses:

Dimensions of Communication	WD	Stages of Work IG	PS
Sources	External	Written Mat.	Internal
Types	'ALL'	SC + TEC	SC,TEC + ADMIN
Modes	Passive	Passive	Active
Circumstances	Formal	Discussion	Informal
Effects	-	-	-

# Summary of hypotheses concerning work patterns of problem solvers

To test the theoretical framework, the hypotheses were investigated for each category of occupational groups. The relationships among the stages of work, the dimensions of communication, and the occupational groups were studied by means of log-linear models. It should, however, be noted that because one dimension of communication had categories which differed for oral and written communication and another excluded some data, the log-linear modelling technique was not used to find the associations which best explain the relationships amongst all seven variables. Rather, the log-linear technique was used to study the relationships among each dimension of communication, stages of work and occupational groups. This sort of application permitted examination of the hypothesised relationships in three-way tables.

The investigations involved three general steps:

(i) The three-way table was studied to determine the complexity of the relationships and to explore the "causalities" involved. This step consisted of simultaneous tests showing the level (or order) of complexity which should be considered to "fit" the data; and the actual fitting of log-linear models.

- (iii) If the three-way interaction was significant, the third step was carried out. This step involved the analysis of the three-way interaction (in the same manner as the analysis of a two-way association); and the study of the difference between the trends indicated by the two-way associations, \_\_\_\_\_\_\_\_\_and the three-way interaction.

In this chapter, the following terminology, which was suggested by Davis (1974), has been used: "item skew" means the distribution of cases in the categories of variables shown in the marginals of two-way tables; the term "association" addresses the relationship between two variables; the term "interaction" was reserved for the relationships among the three variables in question.

The responses of 51 persons were included in the data set studied. The responses of three persons were excluded because the nature of their work did not involve problem solving in the sense it has been used in the present study. All responses were weighted for absences.

The results of investigations indicated that all variables were highly

skewed. Also, the association between the stages of work and occupational groups was significant. For simplicity of presentation, all item skews and the association between the stages of work and occupational groups which permeated the investigations of all hypotheses, are discussed first. Then, the findings concerning each group of hypotheses will be discussed in turn.

### ITEM SKEWS - FREQUENCIES OF VARIABLES

All variables considered in this part of the study had frequencies which were significantly unevenly distributed among the variables' categories. Such item skews are described and, where appropriate, interpreted in terms of previous studies.

# Sources of information

Communication from internal sources accounted for about 50% of all information received; the categories of external oral sources and written material accounted for 25% of information items each.

The proportion found in this study is quite similar to proportions of sources utilisation found in previous studies. Project SAPPHO, for example, found that 53.7% of ideas leading to significant innovation originated in-house; the rest from external sources (Rothwell and Robertson 1973:211). Similarly, Allen (1966) in a study of 17 development programmes found that out of a total of 706 messages which resulted in technical ideas considered during the course of the projects, exactly half originated internally and half externally (Rothwell and Robertson 1973:215). Both the above studies employed a similar method of data collection and emphasis on "significant" information as the present study. Using a different methodology, Allen (1968) found the ratio of use of internal and external sources to be 35:65. In other studies, if information from "personal experience" was excluded from consideration, then Johnston and Gibbons (1975) and Langrish (et al 1972) also found a proportion of 50:50 between the use

### Stages of work

#### ------

The Problem Solving and Work Programme Development stages each had approximately 45% of the information entries; however, the respondents used only 10% of information entries in the Idea Generation stage.

The ratio of information received at each stage of a project is consistent with the distribution of stages in all the projects. About 80% of all projects were at the Problem Solving stage and, indeed, 80% of the information input to projects related to that stage.

The high level of information input into the Work Programme Development stage indicates that the respondents were seriously considering a variety of information inputs which was not directly relevant to the projects, but which might bear on the selection of future topics. The Work Programme Development was, then, shown to be a significant "stage" in work.

### Types of information

Communication of scientific/technical types of information accounted for about 68% of information received; the remaining 32% was the communication of information of an organisational/administrative nature.

A look at the basic types of communication shows that the communication of scientific information accounted for 40% of all information received, technical information for 26%, and client information for only 2%. The communication of organisational and administrative types of information were 13% and 19% respectively.

The communication of administrative information was about a fifth of all exchanges and therefore proportionate to the number of categories; the communication of client and organisational information was significantly smaller whereas the communication of scientific and technical information was significantly higher. The high level of communication for scientific information and the very low level for communication of client information were the extremes.

The ratio of 7:3 found between scientific/technical information and organisation/administrative information in the present study is similar to that reported by Pruthi and Nagpaul (1978), who used similar a methodology of data collection. The results are, however, different from the ratio of 2:3 reported by Walsh and Baker (1972). The differences may, however, be explained by the different methodologies employed. Unlike this study, Walsh and Baker (1972) gathered their data through observations at meetings, a situation where organisational/administrative information might be expected to predominate.

# Modes of information transfer

Analysis of all the information received by respondents indicated that 56% of the information was received passively and, obviously, 44% was received actively.

This proportion is similar to the one reported by Hall (1974).

# Circumstances of information transfer

Nearly 85% of all oral information was received by respondents informally, and 15% of oral information was received formally. Findings like these perhaps led Burns (1969) to his famous quote that information transfer is a matter of agents and not agencies.

Only about 20% of information from written material was "pointed out" by others to the respondents; about 80% of information from these sources was "not pointed out" by anyone. Past studies did not offer findings with which this result could be compared.

# Effects of information

Whereas effect "1" ("not very strongly") accounted for about 50% of all information items, and effect "2" ("strongly") for 40%, only about 10% of information was rated by the respondents as effect "3" ("very strongly"). Previous studies in the field do not provide findings with which these results could be compared. Nevertheless, the lower frequencies reported for each ordinal category defining the degree of impact of the information conformed to what might be expected, intuitively.

### Occupational groups

Scientists received 53% of all information in the data studied, science technicians 34% and administrative staff the remaining 13%.

However, the three groups were unequal in size. When the communications of the groups were divided by the number of people which constituted each group, these differences in information input between each occupational category were found to be insignificant. This finding appears to be contrary to the findings of previous studies which indicated that scientists are likely to require a greater information input than engineers (Ackoff and Halbert 1958, McLaughlin et al 1965, Allen 1966, Katz and Tushman 1979). Two factors may account for this contradictory finding. First, neither of the groups was homogenous. Second, in an organisation employing both scientists and science technicians, the latter may adopt the attitudes and work habits of the former (Hagstrom 1965). Nevertheless, the findings from the present research suggest that neither of these possibilities constitute a completely satisfactory explanation, especially since the results indicated that the quantity of communication did not differ for respondents in different occupational groups, but the quality of their communication did differ.

# Section summary and conclusion

While the frequency distributions for all variables included in the present study were uneven, these distributions generally did not differ from those found in previous studies. The exception to this pattern was the variable involving the classification of occupational groups. The results here indicated that all problem solvers in the focal organisation received approximately equal amounts of information in their work. Where there were no findings from previous studies, the observed distributions conformed to what had been expected, intuitively.

### STAGES OF WORK AND OCCUPATIONAL GROUPS

Numbers showing the frequencies, log parameter estimates and their standardised values which depict the association between the two variables, are shown in Table 6.1.

A standard method, commonly used in presenting findings generated by log-linear techniques, has been adopted in the present research. The salient points of this method are as follows:

- (i) Instead of presenting three tables indicating observed frequencies, parameter estimates and their standardised values, this information has been summarised in one table.
- (ii) In the standard format adopted, Column 1 indicates the cells used in the given analysis, Column 2 reports the observed frequencies, Column 3 shows the log parameter

estimates (or parameter estimates for short), and Column 4 reports the standardised values of the relevant parameter estimates. Column 5 indicates the standardised values that were greater than the standard "z" scores.

(iii) The statistical significance of each analysis is shown in standard form beneath the table.

Cells	Freq.	Param. Estim.	Stand. Value	Sig.
GA(11) GA(12) GA(13) GA(21) GA(22) GA(23) GA(31) GA(32) GA(33)	422 79 333 117 47 369 173 10 20	10 .03 .07 81 .07 .74 .91 10 81	-1.56 .26 1.00 -11.26 .71 9.57 9.48 64 -6.55	(***) *** (***)

Table 6.1 Association between Occupational groups (Groups, G), and Stages of work (Stages, A)

Levels of Significance: \*\*\* p < .001 Parentheses point out negative relationships

The cells in the table were identified by letters denoting the variables (G stood for Occupational groups, A for Stages of work). Numbers denoted the categories of each variable. In the Table 6.1, the cell GA(11) addressed the relationship between scientists and the Work Programme Development stage, cell GA(22) between science technicians and the Idea Generation stage, and cell GA(33) addressed the relationship between administrative staff and the Problem Solving stage. A guide to the

numbers and their respective categories is provided at the beginning of all relevant sections of this chapter.

The information reported in Table 6.1 indicates the statistical significance of the association examined. Four of the relationships were statistically significant.

From the information presented in Table 6.1, it can be seen that scientists received the expected number of items of information in all three stages of work.

Respondents in the occupational group science technicians received significantly more information in the Problem Solving stage (.74), and significantly less information in the Work Programme Development stage (-.81), than did the other two occupational groups. The parameter estimates (shown in brackets) indicate that these relationships were strong.

For administrative staff, the observed relationships were the reverse of those indicated for science technicians. Administrative staff received significantly more information in the Work Programme Development stage (.91), and significantly less information in the Problem Solving stage (-.81), than did the other two occupational groups.

Because the association between occupational groups and stages of work occurs in all subsequent analyses, the pattern of findings was reported first. The association was obviously statistically significant in the examination of all subsequent three-way tables reported in the present chapter and should, therefore, be borne in mind in examining the results which follow.

SOURCES OF INFORMATION, STAGES OF WORK AND OCCUPATIONAL GROUPS

The findings to be reported result from empirical tests of the following hypotheses:

- 1.1.1 : In the Work Development stage, information from external oral sources is likely to be more influential than information from internal oral sources and written materials.
- 1.1.2 : In the Idea Generation stage, information from written materials is likely to be more influential than information from internal and external oral sources.
- 1.1.3 : In the Problem Solving stage, information from internal oral sources is likely to be more influential than information from external oral sources and written materials.

In this section, the interpretation of the results has been described more fully than in other sections which show only substantive findings. This approach was adopted in order to familiarise the reader with the use, meaning and interpretation of the various tests carried out in the present research.

The table of raw data which was analysed in this section is shown in Table 6.2. The numbers associated with the categories of the variables involved in the analysis identify the cells in all other tables in this section.

The number attached to each category identifies that category in other tables shown in this section.

Groups G	Stages A	Sources (S) Internal External Written 1 2 3
Scient 1	WD 1 IG 2 PS 3	193 108 120 20 29 30 154 72 107
SC.Tech 2	WD 1 IG 2 PS 3	612927175252277964
Admin 3	WD 1 IG 2 PS 3	74 71 28   4 4 2   17 1 2

Table 6.2 Cross-tabulation of Occupational groups (Groups, G), Stages of work (Stages, A), and Sources of Information (Sources, S)

Simultaneous tests showing the level (or order) of complexity which must be considered to fit the data, revealed that only the three-factor model was adequate. The results of these tests are shown in Table 6.3.

Table 6.3 The results of fitting all K-factor marginals

K-FACTOR	D. F.	LR CHISQ	PROB.
1	6	1097.06	0.0
2	12	362.52	0.0
3	8	28.22	0.0004
Cite of the second			

Following Davis (1974:213-214), the statistics mean that:

- (i) the lone three-factor interaction is significant (p < .001), and
- (ii) there may or may not be item skews and non zero partial associations amongst the variables.

To find which item skews and associations are significant, all possible log-linear models were fitted to the data. The results, shown in Table 6.4, indicated that all item skews and associations considered were statistically significant. None of the effects considered can be eliminated from the analyses as insignificant. This means that the data can be explained only by the means of the saturated model.

			Table 6	.4				
Models	fitted	to	explain	the	data	in	Table	6.1

Model	DF	Likelihood- Ratio Chisq	Prob.
S	24	1328.26	0.0
G	24 24	1080.47	0.0
S,A	22	798.06	0.0
S,G	22	920.94	0.0
A,G	22	550.27	0.0
S,A,G	20	390.74	0.0
SA	18	757.25	0.0
SG	18	875.70	0.0
AG	18	263.02	0.0
SA,G	16	349.92	0.0
SG,A	16	345.50	0.0
AG, S	16	103.48	0.0
SA,SG	12	304.69	0.0
AS,AG	12	62.67	0.0
GS,GA	12	58.25	0.0
SA, SG, AG	8	28.22	0.0004

The results of tests reported in Table 6.4 indicate that:

- (i) All variables were significantly skewed.
- (ii) Controlling for occupational groups, there was a significant partial association between sources of information and stages of work which was essentially the same for each occupational group.
- (iii) Controlling for sources of information, there was a significant partial association between stages of work and occupational groups.
  - (iv) Controlling for stages of work, there was a significant partial association between sources of information and occupational groups; and
  - (v) when the degree of association between any two variables and the level of the third was analysed, it was clear that the interaction was statistically significant.

In other words, there were complex relationships amongst the three variables: there were two-directional causal links between each pair of the three variables, plus a significant interaction. The main relationship investigated was, therefore, not a spurious one.

To identify the sources of significance in each association, the parameters of each of the relevant two-way tables were considered. The sources of significance in the interaction were subsequently examined with reference to the three-way table.

### Sources of information and stages of work

Table 6.5 shows the frequencies, parameter estimates and their standardised values for each cell.

Table 6.5								
Association	between	Stages	of	work	and	Sources	of	information

Cells	Freq.	Param. Estim.	Stand. Value	Sig.
AS(11) AS(12) AS(13) AS(21) AS(22) AS(23) AS(23) AS(31) AS(32) AS(33)	328 208 176 41 37 58 398 151 174	.06 .12 18 37 .03 .33 .30 15 15	1.19 1.99 -3.21 -4.31 .38 4.15 5.48 -2.47 -2.60	* (***) (***) *** (**) (***)

Levels of Significance: \* p < .05 \*\* p < .01 \*\*\* p < .001 Parentheses point out negative relationships

Because the hypotheses suggested a greater use of a certain category of information source in specified work stages, only positive deviations from the random model were considered. For the sake of clarity these cells in Table 6.5 are identified by arrows.

The cell AS(12) denotes the relationship between Work Programme Development and external sources of information, AS(23) the relationship between Idea Generation and written material, and AS(31) denotes the relationship between Problem Solving and internal sources of information. These were precisely the cells which were hypothesised to be significantly and positively different from a random model based on expected cell distribution. The data reported in Table 6.5 indicate that:

- (i) The Work Programme Development stage was significantly but weakly (.12) associated with the use of information from external sources.
- (ii) The Idea Generation stage was significantly and moderately(.34) associated with the use of written material.
- (iii) The Problem Solving stage was significantly and also moderately (.30) associated with the use of internal sources of information.

Occupational groups and sources of information

The observed frequencies, cell parameters and their standardised values are shown in Table 6.6.

Cells	Freq.	Param. Estim.	Stand. Value	Sig.
GS(11) GS(12) GS(13) GS(21) GS(22) GS(2) GS(31) GS(32) GS(33)	367 209 257 305 113 116 95 76 32	15 12 .28 .18 21 .023 03 .33 30	-3.22 -2.34 4.82 3.55 -3.42 .35 44 4.57 -3.43	(**) (*) *** (***) *** (***)

Table 6.6 Occupational groups (Groups, G) by Sources of information (Sources, S)

Levels of Significance: \* p < .05 \*\* p < .01 \*\*\* p < .001 Parentheses point out negative relationships The data indicated that the association between the two variables was complex. Scientists used significantly more written material (.28) and significantly less information from internal (-.15) and external (-.12) sources than the other two occupational groups.

Science technicians used significantly more information from internal sources (.18) but, more importantly, they used significantly less information from external sources (-.21), than the other groups.

Finally, respondents in the administrative category used significantly more information from external sources (.35) and significantly less information from written material (-.30), than the other two groups.

In general, therefore, the data indicated that, in comparison with each other, scientists tended to rely more on written material, science technicians on internal sources, and administrative staff on the external sources of information.

# Interaction between the three variables

The cells of the three-way table with significant standardised values of the parameter estimates are shown in Table 6.7.

The table reveals two points which are contrary to the trends noted in previous section:

 (i) Scientists tended to use significantly more information from internal sources (.24) and significantly less from external sources (-.28) in the Work Programme Development stage than expected.

(ii) Science technicians tended to use significantly more information from external sources in the Problem Solving stage (.47) than expected.

Table 6.7							
Interaction between Occupational groups (Groups,	G),						
Stages of work (Stages, A), and Sources of informa	tion						
(Sources, S)							

Cells	Freq.	Param. Estim.	Stand. Value	Sig.
GAS(111) GAS(121) GAS(222) GAS(223) GAS(232) GAS(311) GAS(331) GAS(332)		.24 28 50 .38 .47 29 .38 54	2.63 -2.53 -2.73 2.33 2.85 -2.03 1.91 -1.90	** (**) (**) ** (*) * (*)

### Levels of Significance: \* p < .05 \*\* p < .01 Parentheses point out negative relationships

Consistent with the trends observed elsewhere in the data analysed here, science technicians used significantly more written material in the Idea Generation stage (.38) and significantly less information from external sources in that stage (-.50). Administrative staff tended to use significantly more information from internal sources in the Problem Solving stage (.38) and significantly less from external sources in that stage (-.54), than was expected.

# Section summary and conclusion

Examination of the relationships between sources of information, stages of work and occupational groups using log-linear models led to the following conclusions: there were significant item skews, partial associations between each pair of the variables analysed, and a significant interaction between the three variables.(The association between the three occupational groups and stages of work, as well as the items skews, have already been discussed in the present chapter.)

Results from the analyses of the association between stages of work and sources of information confirmed the hypotheses. The Work Programme Development stage of work was significantly associated with information from external sources; Idea Generation with information from written material, and Problem Solving with information from internal sources.

Compared with the other two occupational groups considered, scientists used significantly more written material, science technicians more internal sources, and administrative personnel more external sources of information.

Considered overall, these findings were deemed to be consistent with findings from the analysis of the association between occupational groups and stages of work. Because the findings indicated that science technicians, compared with the other two occupational groups, used more information in the Problem Solving stage then, it can be expected that internal sources will be used most extensively by this occupational group. Administrative staff, because they received most information in the Work Programme Development stage, can be expected to deal with mainly

external sources. These particular findings may be construed as accentuating the results obtained from the empirical testing of the hypothesis formulated to examine this particular set of variables.

The statistical significance of the interaction in three cells {GAS(111), GAS(121), GAS(232)} was contrary to the trends outlined above. The importance of these relationships can be set out in two points:

(i) Scientists tended to develop their work programmes significantly more on the basis of information from internal sources, and significantly less on the basis of information received from external sources than was expected.

This pattern in the sources of information is generally in line with the policy of the organisation, which suggests that putting together groups of scientists of diverse specialties is likely to result in a cross-fertilisation of ideas. This pattern of information use, however, has been largely ignored in recent studies in the sociology of science. Friedkin (1978), for example, who pointed out that the proximity of members to each other within organisations is likely to affect work programme developments, has argued that organisational influence has generally been ignored in the current sociology of science literature. The findings of this study clearly suggest that science develops not only through scientists' communication with an international scientific community, but also through the strong influences which organisations have on work patterns.

(ii) Science technicians tended to draw information in the

Problem Solving stage significantly more from external sources than was expected.

These findings are similar to those reported by Johnston and Gibbons (1975). In Chapter 3 it was argued that this pattern of communication is likely to occur when the organisation has limited resources for coping with the task at hand. Indeed, at the time of the study, science technicians were developing new culture cabinets and extending the control facilities of the Climate Rooms. Only limited expertise was available within the organisation to assist with these developments. Consequently, organisational barriers had to be overcome, even though the cost of the information gained was higher (see Chapter 4).

### TYPES OF INFORMATION, STAGES OF WORK AND OCCUPATIONAL GROUPS

In this section, the findings of the analyses undertaken were predicated on the following hypotheses:

- 1.2.1 : In the Work Programme Development (WD) stage, all types of information are likely to be influential; there will be no special emphasis on any single type of information.
- 1.2.2 : In the Idea Generation (IG) stage, scientific and technical types of information will be more influential than client, organisational and administrative types of information.
- 1.2.3 : In the Problem Solving (PS) stage, scientific, technical and administrative types of information will be most influential.

The raw data used in the analyses reported in this section are shown in Table 6.8.

GROUPS G	STA	GES A	TYPES (1 SCIEN. 1	T) CLIENT 2	TECH. 3	ORG. 4	ADMIN. 5
SCIENT 1	WD IG PS	1 2 3	204 71 240	18 7 15	43 1 26	67 0 15	90 0 37
SC.TECH 2	WD IG PS	1 2 3	18 9 59	0 0 0	48 31 219	21 0 19	30 7 71
ADMIN 3	WD IG PS	1 2 3	10 7 0	6 0 0	25 0 12	72 2 9	60 0 0

Table 6.8 Cross-tabulation of Types of information (Types, T), Stages of work (Stages, A), and Occupational groups (Groups, G)

Simultaneous tests pointed out that only the three-factor model fits the data; attempts to find a simpler model which would fit the data failed. The results indicated that all item skews, associations and the interaction were significant. Therefore, none of the effects considered can be eliminated from analysis; the data could only be explained by means of the saturated model.

The next two sections examine the associations between the types of information and the stages of work (TA), and between the types of information and the occupational groups (TG). The interaction (GAT) will be discussed last in this section.
Types of information and stages of work

Table 6.9 shows the results of the relevant analysis.

Table 6.9 Association between Stages of work (A) and Types of information (T)

Cells	Freq.	Param. Estim. (log)	Stand. Value	Sig.
TA(11) TA(12)	232 87	56	-6.73 4.77	(***) ***
TA(13) TA(21) TA(22)	299 24 7	06 25 .72	71 -1.49 3.04	**
TA(23) TA(31) TA(32)	15 116	47 64	-2.52 -6.60	(*) (***)
TA(33) TA(41)	257 160	•24 •40 1.02	4.22	*** *** (**)
TA(42) TA(43) TA(51)	43 180	98 04 .43	-2.82 20 3.42	***
TA(52) TA(53)	7 108	60 .17	-2.67 1.27	(**)

### Levels of Significance: \* p < .05 \*\* p < .01 \*\*\* p < .001 Parentheses point out negative relationships

In the Work Programme Development stage, the respondents used significantly more organisational (1.02) and administrative (.43) types of information, and significantly less scientific (-.56) and technical (-.64) types of information, than expected.

In the Idea Generation stage, the respondents used significantly more scientific (.62) and client information (.72), and significantly less

organisational (-.98) and administrative (-.60) types of information, than expected.

In the Problem Solving stage, the respondents used significantly more technical information (.40), and significantly less client information (-.47), than expected. The positive but not statistically significant use of administrative information (.17) at this stage should also be noted.

### Discussion

The high parameter estimates in the "significant" cells indicate strong relationships between the relevant categories of the two variables. These results appear to be, however, somewhat contrary to the expectations specified in the hypotheses. However, it can be argued that some of the findings extend the theory of work patterns advanced in Chapter 3, whereas others only appear to be contrary to the theoretical framework which has been proposed.

It was argued that organisational information would be used significantly more in the Work Programme Development stage than in any other stage. Nevertheless it was also expected that all other types of information would be used, significantly, at this stage, too. Unexpectedly, therefore, administrative information, which it was hypothesised would be salient in the Problem Solving stage was, instead, used significantly more in the Work Programme Development stage. The finding that scientific/technical types of information were used significantly less at this stage was also unexpected. Thus, it appears that the Work Programme Development stage was influenced more by what others intended to do, and by the availability of resources, than by what others had already done. One possible interpretation of these findings may be that the respondents formed their work programme well in advance of the actual work being done.

While the finding that client interests were considered by the respondents in the setting up of specific projects (Idea Generation stage) and not in the Work Programme Development was unexpected, the small number of items of client information involved in the analysis renders this finding somewhat dubious. Otherwise, the analysis showed a significant pattern for the use of scientific information which was consistent with hypothesis 1.2.2.

In the Problem Solving stage respondents used significantly more technical information and significantly less client information. These relationships were, however, the weakest of those analysed. From these findings it may be inferred that respondents tended to use largely technical and administrative types of information in this stage. Because the hypothesis anticipated a significant use of both these types of information, hypothesis 1.2.3 can be regarded as substantiated as well. The more substantial use of technical information and the less substantial use of scientific information in the Problem Solving stage seemed to indicate somewhat greater concern on the part of respondents about the use of particular techniques and facilities. This finding was also consistent with the considerations which lay behind the formulation of this particular hypothesis.

In sum, the data which appear contrary to the hypothesised relationships

either extended the theory of work patterns advanced in Chapter 3 (Hyp. 1.2.1), or, in general, substantiated the hypotheses (Hyp. 1.2.2 and 1.2.3).

Types of information and occupational groups

Table 6.10 shows the results of the relevant analyses.

CELLS	FREQ.	PARAM. ESTIM. (LOG)	STAND. VALUE	SIG.
TG(11) TG(12) TG(13) TG(21) TG(22) TG(23) TG(31) TG(32) TG(33) TG(41) TG(42) TG(42) TG(43) TG(51) TG(52) TG(53)	515 86 17 40 0 6 70 298 37 82 40 83 127 108 60	.90 .25 -1.16 1.26 -2.01 .75 -1.08 1.48 40 58 17 .75 51 .45 .06	7.01 1.17 -6.65 3.14 -2.63 1.72 -8.27 7.28 -2.67 -4.44 79 5.32 -4.14 2.19 .43	*** (***) (***) (***) (***) (***) (***) *** (***)

Table 6.10 Association between Types of information and Occupational groups.

Levels of Significance: \*\* p < .01 \*\*\* p < .001 Parentheses point out negative relationships

The findings are discussed in order of the three occupational groups.

Respondents in the scientist group tended to use significantly more

client (1.26) and scientific (.90) information and significantly less of all the other types of information, than did the other two groups.

Not unexpectedly, respondents in science technician group used significantly more technical (.75) information, and significantly less client information (-2.01). These associations were very strong.

Respondents in the administrative group used significantly more organisational information (.75), and significantly less of the scientific (-1.16) and technical (-.40) types of information.

Interaction between the three variables

The cells of the three way table with significant standardised values of the parameter estimates are shown in Table 6.11.

Table 6.11 Interaction between Types of information (Type, T), Stages of work (Stages, A) and Occupational groups (Groups, G)

CELLS	PARAM. ESTIM. (LOG)	STAND. VALUE	SIG.
GAT(215) GAT(221) GAT(314) GAT(321) GAT(333)	71 86 72 .82 .92	-2.33 -2.67 -2.44 2.03 2.38	(*) (**) (*) *

Levels of Significance: \* p < .05 \*\* p < .01

Parentheses point out negative relationships

The statistics reported in this table indicate the negative relationships in the use of administrative information by science

technicians in the Work Programme Development stage (-.71); in the use of scientific information by science technicians in the Idea Generation stage (-.86); and in the use of organisational information by administrative staff in the Work Programme Development stage (-.72). The relationships in the use of scientific information by administrative staff in the Work Programme Development stage (.82); and in the use of technical information by administrative staff in the Problem Solving stage (.92) were positive.

Only one cell appears to be contrary to the trends shown in the examinations of the relevant associations: although the information received by respondents in the administrative group was mostly organisational, which was most influential in the Work Programme Development stage, the results indicated that this group used this type of information significantly less in that stage than did the other two groups.

These results suggest that unlike the other two occupational groups in the organisation, administrative staff tended not to develop their work in response to the intentions of others, but in response to the others' ongoing activities "here and now". Their use of client information in the Work Programme Development stage, though commendable, was limited; its statistical significance is, therefore, somewhat dubious.

### Section summary and conclusion

Just as was found in the analysis of the effects of sources of information on the stages of work, the investigation of the effects of

information on stages of work indicated that the effects were complex. The item skews, the three associations, and the lone interaction examined were all statistically significant.

Considered overall, the findings indicated that Work Programme Development stage was not influenced by a broad range of information, but mainly by organisational information. This trend suggests that at this stage the respondents tended to respond largely to the intentions rather than to the day-to-day concerns of the others. The exception to this trend were the results for respondents in the administrative category, who tended to respond to information on events which had already taken place. As expected, the respondents used mainly scientific information in the Idea Generation stage; moreover, and in general, they used scientific, administrative, but largely technical types of information in the Problem Solving stage.

Otherwise, the findings indicated that scientists received mainly scientific and client types of information, that science technicians received mainly technical information, and that administrative staff received mainly organisational information.

MODES OF INFORMATION TRANSFER, STAGES OF WORK AND OCCUPATIONAL GROUPS

In this section, the report on the results of investigations was based upon the examination of the following hypotheses:

1.3.1 : In the Work Programme Development (WD) stage, a passive acquisition of information is likely to be more influential

than an active mode.

- 1.3.2 : In the Idea Generation (IG) stage, a passive acquisition of information is also likely to be more influential than an active mode.
- 1.3.3 : In the Problem Solving (PS) stage, an active mode of information acquisition is likely to be more influential than a passive mode.

The raw data analysed in this section are shown in Table 6.12.

#### Table 6.12

Cross-tabulation between occupational groups (Groups, G), Stages of work (Stages, A) and Modes of information transfer (Modes, M)

GROUPS STAGES G A	MODES (M) PASSIVE ACTIVE 1 2
SCIENT WD 1	272 125
1 IG 2	44 25
PS 3	146 171
SC.TECH WD 1	76 35
2 IG 2	25 15
PS 3	175 183
ADMIN WD 1	81 85
3 IG 2	5 5
PS 3	2 18

Attempts to find a simpler model which would explain the data showed that only the interaction can be discarded from the analysis. All associations were significant and are examined seriatim in this section.

Modes of information transfer and stages of work

Table 6.13 shows the results of the relevant analysis.

Table 6.13 Association between Modes of information (Modes, M) and Stages of work (Stages, A)

Cells	Param. Estim. (log)	Stand. Value	Sig.
MA(11)	•13	ż.96	**
MA(12) MA(13)	.10 22	1.44 -5.23	(***)

Levels of Significance: \*\* p < .01 \*\*\* p < .001 Parentheses point out negative relationships

The association between the modes of oral information transfer and stages of work was statistically significant but weak. The overall results supported hypotheses 1.3.1 and 1.3.3.

The data confirmed that Work Programme Development was significantly associated with a passive mode of information transfer (.13); the Problem Solving stage was significantly associated with an active mode of information transfer (-.22). The positive value of the parameter estimate for the Idea Generation stage indicates the direction of the relationship. Hypothesis 1.3.2 was, then, substantiated only partially. Modes of information transfer and occupational groups

Table 6.14 shows the results of the relevant analysis.

Table 6.14 Association between Modes of information transfer (Modes, M) and Stages of work (Stages, A)

Cells	Param. Estim. (log)	Stand. Value	Sig.
GM(11) GM(21) GM(31)	•13 •03 ••16	3.42 .74 -3.05	*** (**)

### Levels of Significance: \*\* p < .01 \*\*\* p < .001 Parentheses point out negative relationships

The analysis indicated that whereas scientists tended to receive significantly more information passively, administrative staff tended to receive significantly more information actively.

## Section summary and conclusion

In general, the findings presented in this section confirmed the hypotheses. Although the support for hypothesis 1.3.2 was not statistically significant, the data were distributed in the anticipated direction. The other two hypotheses were confirmed by the data, yet the relationships were, relative to the findings presented in other sections of this chapter, weak. CIRCUMSTANCES OF INFORMATION TRANSFER, STAGES OF WORK AND OCCUPATIONAL GROUPS

In this section of the report findings which pertain to the hypotheses shown below are presented:

- 1.4.1 : In the Work Programme Development (WD) stage, formal circumstances are likely to be more influential than informal circumstances.
- 1.4.2 : In the Idea Generation (IG) stage, "pointed out" literature is likely to be more influential than literature not "pointed out".
- 1.4.3 : In the Problem Solving (PS) stage, informal circumstances are likely to be more influential than formal circumstances.

# Circumstances of information transfer of oral information

Table 6.15 presents the relevant raw data. It shows only the circumstances of oral information transfer.

Attempts to find a simpler model which would be adequate to explain the variations reported in the data shown in Table 6.15 indicated that only two associations were significant: the one between stages of work and circumstances of information transfer (AC), and the other between stages of work and occupational groups (AG). The association between circumstances of information transfer and occupational groups was not statistically significant [1].

GROUPS G	STA	GES A	CIRC (C INFORMAL 1	) FORMAL 2
SCIENT 1	WD IG PS	1 2 3	228 43 199	74 5 27
SC.TECH 2	WD IG PS	1 2 3	69 19 278	20 2 27
ADMIN 3	WD IG PS	1 2 3	123 5 18	22 2 0

Table 6.15 Cross-tabulation between Occupational groups (Groups, G), Stages of work (Stages, A) and Circumstances of oral information transfer (Circ, C)

The results of the tests threw some light on the possible nature of the causal relationships between the three variables: the model which best fitted the data indicated that there was no spurious relationship between circumstances of insformation transfer and stages of work, and that the following causal relationship may be inferred (Lever 1979):

### GROUPS ---> STAGES ---> CIRCUMSTANCES

This sequence was precisely the causal order which was assumed to be valid in the formulation of the hypotheses specified in Chapter 3. The theory of work patterns advanced in that chapter was predicated on the notion that the stages of work would significantly influence the way information was gathered. In other words, it was expected that problem solvers would, for example, attend seminars to extend their knowledge about events in their environment; however, it was not expected that the work being done would be found to have been brought about by communications alone.

Circumstances of information transfer and stages of work

Table 6.16 shows the results of the relevant analyses. As in the previous section, the table was simplified because the variable mapping the circumstances of information transfer was dichotomised.

Table 6.16 Association between Circumstances of oral information transfer (Circ, C) and Stages of work (Stages, A)

Param. Estim. (log)	Stand. Value	Sig.
27 .07 .20	-3.79 .60 2.54	(***) *
	Param. Estim. (log) 27 .07 .20	Param. Stand. Estim. Value (log) 27 -3.79 .07 .60 .20 2.54

Levels of Significance: \* p < .05 \*\*\* p < .001 Parentheses point out negative relationships

The relationship was significant yet, as the parameter estimates indicate, weak. The indicated statistical significance can be explained by reference to two categories of stages of work.

Whereas the respondents received significantly more information, formally, in the Work Programme Development stage (.27), they received significantly more information, informally, in the Problem Solving stage (.20). Thus, the data supported the two hypotheses which concerned oral

#### communication.

## Circumstances of information transfer of written information

Investigations similar to those above revealed that the model which best fitted the data excluded the associations between stages of work and circumstances of written information transfer, and between circumstances of written information transfer and occupational groups. The only significant association indicated was the one between occupational groups and stages of work.

Therefore, analysis did not support hypothesis 1.4.2, which anticipated the relationship between Idea Generation stage and the "pointed out" circumstance of the information transfer of written material.

### Section summary and conclusion

The results of investigations presented in this section supported the hypotheses which concerned oral exchanges of information. However, the hypothesis which concerned the relationship between the Idea Generation stage and circumstances of written information exchange was not supported. Nevertheless, the results indicated that the direction of the causal links between the three variables was consistent with the direction suggested by the present theory of work patterns.

EFFECTS OF INFORMATION, STAGES OF WORK AND OCCUPATIONAL GROUPS

In this section, the following hypothesis was examined:

1.5.1 : The effects of information are not likely to vary with stages of work.

The data analysed in this section are shown in Table 6.17.

	Table 6.17			
Cross-tabulation	between Occupational	groups (Grou	ups, G),	
Stages of work (Stages	, A) and Effects of f	information (	Effects, 1	E)

GROUPS G	STA	.GES A	EFFECT	(E) 1	2	3	
SCIENT 1	WD IG PS	1 2 3	25 2 14	6 8 4	141 35 151	25 16 38	
SC.TECH 2	WD IG PS	1 2 3	6 1 17	6 8 9	38 25 153	13 4 38	
ADMIN 3	WD IG PS	1 2 3	8	6 2 2	78 6 16	8 1 2	

The fitting of the models to the data indicated that two associations: between the stages of work and effects of information (AE), and between stages of work and occupational groups (AG), were sufficient to explain the variation in Table 6.17 [2].

Thus, as in the previous section, the model which best fitted the data is the one which excluded the effects of the tested variable and the occupational group. This finding means that there was no spurious relationship between the two variables and the causal order is, then, as follows:

#### GROUPS ---> STAGES ---> EFFECTS

But, the significance of the association between stages of work and the effects of information indicated that, contrary to the relationship predicted, the different stages were found to be associated with the effects of the information.

Effects of information and stages of work

Table 6.18 shows the results of the relevant analysis.

Cells	Freq.	Param. Estim. (log)	Stand. Value	Sig.
AE(11) AE(12) AE(13) AE(21) AE(22) AE(23) AE(31) AE(32) AE(33)	408 257 46 48 66 21 325 320 78	.37 04 33 34 .03 .31 03 .01 .02	5.96 60 -3.72 -3.85 .33 2.78 48 .16 .23	*** (***) (***)

Table 6.18 Association between Effects of information (Effects, E), and Stages of work (Stages, A)

> Levels of Significance: \*\* p < .01 \*\*\* p < .001 Parentheses point out negative relationships

The association among the effects of information and stages of work can be explained by reference to moderately strong relationships between four categories of the two variables. Whereas the Work Programme Development was associated with information considered by the respondents to have the weakest impact, the Idea Generation stage was associated with information to have the strongest impact. The Problem Solving stage was not significantly associated with either of the categories of the variable.

However, the associations were not linear. The results of analyses using orthogonal transformations of the ordinal variable which mapped the effects of information, indicated that both the linear and non-linear trends in the data were highly significant.

### Discussion

The results of the tests presented in this section did not provide findings which would substantiate the hypothesis.

Although no significant relationships were anticipated, there was a moderately strong association between the use of the least important information in the Work Programme Development stage of work and the most important information in the Idea Generation stage. However, the analysis showed that there were no linear trends in the data. Whereas these results suggest that the findings were inconclusive, further tests indicated that the association between stages of work and the effects of information was spurious.

On the basis of the results which showed a strong association between the stages of work and sources of information (presented in an earlier section of this chapter), a subsidiary hypothesis - that sources of information are significantly associated with the effects of information - was investigated. However, the Chi square of 3.67 (with 4 degrees of freedom) indicated that this was not the case. The perception of the effects of information did not vary with the sources of information.

Given the above result, the validity of several similar hypotheses were explored. Findings from these investigations indicated that the more the information was actively pursued and the more the information was related to specific projects, the greater was its perceived effect. Because the Idea Generation stage of work did relate to specific projects and the Work Programme Development stage did not, the effects of information varied with different stages of work. Thus, the association between stages of work and the effects of information relationship was, thus, found spurious.

## Section summary and conclusion

Whereas the log-linear tests indicated a relationship between the stages of work and the effects of information, subsequent analyses revealed two intervening variables. The consideration of a direct relationship between the stages of work and the effects of information can thus be discarded.

#### SUMMARY AND CONCLUSION

This chapter reported data generated by empirical tests of the hypotheses presented in Chapter 3.

The item skews are summarised first.

The categories for variables had significantly skewed frequencies. Nevertheless, the item skews found in the present study were generally consistent with the findings of previous studies. The differences observed were explained through the uses of different methodologies in different studies. The statistically similar amounts of information items received by the three occupational groups was an exception. A tentative explanation was sought in the notion that problem solvers working in close physical proximity would be likely to adopt the work habits of each other; however, subsequent examination of the findings indicated differences in the quality of the work patterns and, therefore, raised doubts about the validity of this explanation.

The overall findings involving the hypothesised associations between the variables are summarised in Table 6.19.

The summary shown in Table 6.19 indicates that 10 out of the 13 hypotheses formulated were at least partially supported by the data analysed in the present study.

A summary of the directions of the associations found in the present analysis are shown in Table 6.20.

Dimensions of Communication	۲ ۵	Stages of work	PS
	Category Sig.	Category Sig.	Category Sig.
Sources	External *	Written ***	Internal ***
Types	Org + Adm. ### Sci + Tech - Client -	Scientif. *** Client ##	Technic. *** Scientif Admin
Modes	Passive <b>**</b>	Passive -	Active ***
Circumstances	Formal ***	Pointed out -	Informal ***
Effects	no significant least str. (1)	relationship antic Most str. (1)	sipated

Table 6.19 Summary of findings

\*-\*\*\* Asterisks indicate significant relationships anticipated in the hypotheses.

#-### Hashes indicate significant relationships found, but not anticipated in hypotheses.

 Dashes indicate hypothesised relationships which were not found.
 (1) Whilst these effects were significant at p < .01 level, no linear trend were established. Results inconclusive.

Overall, these findings substantiated the claims advanced in the theory of work patterns of problem solvers. There were, however, exceptions which require further comment.

The relationship between the types of information and the Work Programme Development stage of work was contrary to expectations. However, the actual findings make theoretical sense and it may be argued that they offered a useful extension of the theory. The relationships between the other stages and the types of information were, generally, substantiated. Because of the lower frequency of client information reported by the respondents, the significance of this type of information was considered moot and therefore discarded. In the Problem Solving stage, the high use of technical information but insignificant use of scientific and administrative information only partially confirmed the hypothesis.

Hypotheses	Direction of Findings
1.1.1	Supported
1.1.2	Supported
1.1.3	Supported
1.2.1	Not Supported
1.2.2	Supported
1.2.3	Supported Partially
1.3.1	Supported
1.3.2	Supported Partially
1.3.3	Supported
1.4.1	Supported
1.4.2	Not Supported
1.4.3	Supported
1.5	Not Supported; Other tests indicate Intervening variables.

Table 6.20 Summary of the directions of the findings

It was also true that there was no empirical evidence that linked modes, strongly, to the Idea Generation stage, or to the circumstances of information transfer. This was considered a major failure in the context of the present study.

The results of the major analysis of the relationship between the stages

of work and effects of information appeared contrary to expectations. However, further tests indicated two intervening variables which explained the variations in this relationship. The intervening variables did not include "stages of work" or "sources of information", but the "mode of information persual" and "information specificity".

Thus, the present results indicated the following patterns of work [findings contrary to the hypothesised relationships are bracketed]:

Work Programme Development was associated with external oral sources, mainly [organisational] type of information, a passive mode of information transfer, and formal circumstances of information transfer. [Information received at this stage was considered to have the weakest impact.]

The Idea Generation stage was associated with information from written material, and scientific and [client] types of information. [No other associations were found significant.] [Information received at this stage was considered to have the strongest impact upon the work of the respondents.]

The Problem Solving stage was associated with internal oral sources, technical [but not scientific and administrative] information, an active mode of information exchange and informal circumstances of information transfer. The effects of information were not significantly related to this stage. In two cases, the causal inference indicated that the stages of work tended to determine the pattern of communication.

In general, therefore, the findings provided evidence which was considered promising for further investigation of the proposition that

there is a particular pattern of communication which is associated with each different stage of problem solvers' work.

Contrary to the findings from previous studies, the results from the present study indicated that all occupational groups tended to receive a similar quantity of information; however, the quality of their work \_\_\_\_\_\_\_ patterns appeared to differ. This finding was the obverse of what had been predicted.

Respondents in the scientist category tended to draw significantly more information both passively, and from written material, than did either of the other two occupational groups considered. Contrary to the trends for all respondents, which indicated the significant use of external sources of information at the Work Programme Development stage, scientists tended to use significantly more information from internal sources at that stage.

Science technicians tended to receive significantly more technical information more actively, and more in the Problem Solving stage than did either of the other two occupational groups. Contrary to the trends linking the use of internal sources at the Problem Solving stage, science technicians tended to receive more information from external sources at that stage.

Administrative staff tended to receive significantly more information which affected the Work Programme Development stage than did either of the other two occupational groups. Members of this occupational group received significantly more organisational type of information, but significantly less so in the Work Programme Development stage. This was

also contrary to the trends which indicated significant use of organisational information in the Work Programme Development stage.

It can, then, be concluded that the quality of work patterns differed for different occupational groups. However, although each occupational group used a different pattern of communication, their actual use of information in the three stages of work was similar. The behaviour which was contrary to the trends for the organisation as a whole was adequately explained in the preceding sections of the present chapter. Thus, despite a number of unexpected findings, the pattern of communication associated with each stage can, generally, be regarded as similar for all groups of problem solvers.

In the next chapter, the effects of work organisations on the oral communication patterns are examined.

[1] The description was based on findings in the following table:

MODEL	DF	LIKELIHOOD- RATIO CHISQ	PROB.
C A G C, A C, G A, G C, A, G CA CG AG CA, G CG, A AG, C CA, CG AC, AG GC, GA CA, CG, AG	16 15 14 14 13 12 12 9 10 10 8 6 6 4	1005.24 1130.68 1376.43 525.18 770.94 896.37 290.88 496.10 762.95 644.74 261.79 282.89 39.25 253.81 10.17 31.27 4.71	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

Models fitted to explain data in Table 6.15

-

MODEL	DF	LIKELIHOOD- RATIO CHISQ	PROB.
E A G E,A E,G A,G E,A,G EA EG AG EA,G EG,A AG,E EA,EG AE,AG GE,GA	24 24 22 22 20 18 18 18 16 16 16 16 12 12 12	1301.19 1282.31 1403.15 768.34 889.19 870.30 356.33 729.19 880.13 583.06 317.19 347.27 69.08 308.13 29.94 60.03	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
EA, EG, AG	4	14.01	0.0073

Models fitted to explain data in Table 6.17

CHAPTER 7

EFFECTS OF THE RESEARCH ORGANISATION ON ORAL COMMUNICATION

The previous chapter focused on findings concerning dimensions of communication and the work of problem solvers. The present chapter reports findings from investigating the effects of the research organisation on oral communications.

As was the case in Chapter 4, which set out the theoretical framework for the present investigation, the presentation of results here is divided into two parts. Part A deals with the effects of the research organisation on internal flows of oral communication. Part B examines the patterns of communication from sources which are external to the focal organisation.

PART A

### NETWORKS OF INTERNAL ORAL COMMUNICATION AND RESEARCH ORGANISATIONS

This part reports findings based upon the examination of hypotheses presented in Part A of Chapter 4. Thus it concerns oral communication among persons within the organisation. Such communication accounted for about 50% of the information items reported by the respondents.

Each of the hypotheses examined here addressed the association between internal oral communication and an aspect of the organisational structure; together the hypotheses formed an attempt to test a theory of the effects of work organisations on that aspect of the work patterns of problem solvers which involved internal oral communication. The theory suggested that internal communications are likely to be constrained by certain structural, analytic and global properties of organisations. The eight hypotheses which were formulated are reproduced below:

Employees of research organisations are more likely to communicate significant work related information with:

Hyp. 2.1 : members of the same section,

Hyp. 2.2 : their informal contacts,

Hyp. 2.3 : persons in their physical proximity,

Hyp. 2.4 : colleagues,

Hyp. 2.5 : persons who share the same facility,

Hyp. 2.6 : persons with a similar strength of orientation,

Hyp. 2.7 : persons with a similar degree of autonomy, and

Hyp. 2.8 : persons with a similar degree of research competence,

than with others in the organisation.

As indicated in Chapter 5, eight networks of internal communication were constructed. These were based on the following types of information:

(i) scientific,

(ii) client,

- (iii) technical,
- (iv) organisational,
- (v) administrative,
- (vi) scientific/technical (aggregated networks i iii),
- (vii) organisational/administrative (aggregated networks iv and v), and
- (viii) total (aggregated networks i v).

A locally optimal test was used to investigate each association between the communication networks (the dependent variables) and the variables which in this study were defined as part of the "organisational structure" (the independent variables). The test used was described in Chapter 5.

Following the presentation of the findings concerning the associations between the dependent and independent variables, the associations among the dependent variables, as well as those among the independent variables, will be discussed.

# Associations between the dependent and independent variables

The results of the investigations are summarised in Table 7.1. Each figure was obtained from one locally optimal test of the association between the variables shown in the margins of the table.

Communication Networks	For	A nal sig	Info: S s	UCTUR rmal sig	AL AND Geogra S si	GLOBAL P phy Coll g S	ROPER eag. sig	TIES Use c S s	of Fac. ig
Total Received	•43	***	•14	***	•37 *	•54	***	.24	***
Scient./Technic.	•55	***	•13	***	•50 *	•59	***	.29	***
Scientific Client Technical	•56 •41 •55	*** *** ***	.24 10 .02	*** NS NS	•49 * •35 •51 *	** .60 * .27 ** .60	*** *** ***	•34 •21 •24	*** NS **
Organis./Admin.	.24	***	•14	***	•19 <b>*</b>	• 45	***	.10	NS
Organisational Administrative	.22 .25	*** ***	•13 •16	*** ***	•13 <b>*</b> •23 <b>*</b>	•** •51 •** •41	*** ***	.16 .08	NS NS
	Orie S	entat sig	B. ANA t. Auto S	ALYTI onomy sig	C PROPE Com(O S s	RTIES rg) Com( ig S	Prof) sig		
Total Received	01	NS	. 32	***	44 ¥	** 04			
					•41 *	•24	***		
Scient./Technic.	08	NS	• 31	***	•31 *	** .24 ** .26	***		
Scient./Technic. Scientific Client Technical	08 11 .07 06	NS NS NS	•31 •59 •09 •05	*** *** NS NS	•31 * •34 •21 •29	** .24 ** .26 ** .35 NS .22 * .09	*** *** NS NS		
Scient./Technic. Scientific Client Technical Organis./Admin.	08 11 .07 06 .09	NS NS NS NS	•31 •59 •09 ••05 •32	*** *** NS NS ***	•41 * •31 * •34 •21 •29 •52 *	** .24 ** .26 ** .35 NS .22 * .09 ** .22	*** *** NS NS **		

Table 7.1 Associations between organisational properties and communication networks

Levels of Significance: \* p < .05 \*\* p < .01 \*\*\* p < .001 NS p > .05

In general, most of the tested associations were found to be statistically significant. These findings were taken to substantiate the claim that research organisations do affect the flow of internal communications. The notable exception was the latent network involving work related orientations. This particular network did not relate to any of the communication networks investigated.

Formal structure was found to be significantly related to all communication networks, but especially to the communication of scientific/technical types of information (.55). The association of this variable to the communication of organisation/administrative types of information was, however, relatively weak (.24). Overall though, the hypothesised association was substantiated. The statistic S summarising the association between formal structure and all communication networks was a moderate .43.

Informal networks were significantly related to three out of the five basic communication networks. The associations were, however, weak (.14). Thus, whilst some support was given to the expected association, the overall effect of informal networks on communication was about three times weaker than the effect of the formal structure.

The association between geographical distance and the communication flows was similar to the associations found between the formal structure and the communication flows. The statistic S summarising the association between geographical distance and all communication networks was a moderate .37.

The analyses carried out indicated that the colleague networks had the greatest influence on the communication networks (.54). The associations were very strong for the networks of scientific/technical

types of information (.59), and moderately high for the networks involving organisational/administrative types of information (.45).

The variable which concerned the use of facilities tended to influence significantly only two out of the five basic types of information; moreover, this influence was rather weak (.29). Thus only limited support was given to the expected relationship between the use of facilities and internal communications.

Work related orientations were not significantly related to any of the communication networks which were analysed. Overall, the association was very close to zero. This result indicated that highly oriented people did not choose each other as communication partners. Hypothesis 2.6 which suggested such a relationship was not, then, supported.

Autonomy was found to have influenced three out of the five basic communication networks. These were the same as for the informal networks. The communication of scientific information tended to occur more significantly and strongly among respondents who were defined as autonomous than between autonomous and non-autonomous respondents (.59). The association between this variable and the networks of organisational/administrative types of information was moderate (.32).

Socially recognised work competence in terms of the organisational criteria, a term which for the sake of brevity will be used synonymously with the term organisational performance, was found to be significantly but only moderately associated with the aggregate network defined by the total received information (.41). This moderate association can, however, be explained by reference to the very high effect of this variable on the network of organisational information (.67).

Socially recognised competence defined in terms of professional criteria, a term which for the sake of brevity will be used synonymously with the term professional performance, was also found to be significantly associated with the aggregate network defined by the total received information. The association was, however, relatively weak (.24); it can be explained by reference to the moderate effects of this variable on scientific (.35) and the organisational (.30) networks of information.

Table 7.2 summarises the significant associations which were found in the analysis.

The results summarised in Table 7.2 indicate that, in general, all of the communication networks were influenced strongly by three variables: colleague networks, formal structure, and geographical distance. Nevertheless, there were variations in the strength of these associations.

The influence of the variables measuring formal structure and geographical distance on the formation of organisational/administrative networks was weaker than on the neworks involving scientific/technical types of information. The networks involving organisational/administrative types of information were influenced quite strongly by the latent networks based on organisational performance and autonomy.

Table 7.2 Summary of results showing significant associations between organisational properties and internal communication networks.

COMMUNICATION NETWORKS								
Scient. Techn. Client Var. S Var. S Var. S	Sc/Tech Var. S	Organ. Admin. Var. S Var. S	Or/Admin Var. S	Total Var. S				
1 .60 1 .60 2 .41 5 .59 2 .55 4 .35 2 .56 4 .51 1 .27 4 .49 6 .29 6 .35 7 .24 3 .34 7 .34 8 .24	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	3 .67 1 .41 1 .51 3 .38 5 .39 5 .27 6 .30 2 .25 2 .22 4 .23 4 .13 8 .16 8 .13	3 .52 1 .45 5 .32 2 .24 6 .22 4 .19 8 .14	1 .54 2 .44 3 .41 4 .35 5 .32 6 .24 7 .24 8 .14				

1. Colleague network

2. Formal structure

5. Autonomy

6. Competence (Professional)

3. Competence (Organisational) 7. Use of Facilities

4. Geographical structure

8. Informal networks

The overall pattern of these findings suggests that whereas the communication of scientific types of information tended to occur among colleagues within sections and in close physical proximity to each other, the communication of organisational/administrative types of was more likely to transcend sectional and geographical information boundaries. Communications of this latter kind were also more likely to take place among respondents who were both autonomous and high organisational performers.

A brief summary -----

Overall, the results of the analyses reported above provided at least

general support for seven out of the eight hypotheses investigated in the present research. The pattern of results obtained suggests that properties of the organisation studied did affect internal communications.

The results reported here also indicated the relative strengths of the associations which were investigated. In general, five organisational variables influenced the formation of information networks (colleague networks, autonomy, formal structure, geography, and organisational performance). The significance of the effects of these organisational variables on each of the communication networks was, however, variable. In brief, the structural variables tended to be most influential in the formation of scientific/technical networks, whereas the analytic variables were found to be important in the networks involving organisational/administrative types of information.

The next two sections of this chapter examine the associations among the dependent and independent variables respectively.

## Associations among the dependent variables

Given the pattern of findings shown in Table 7.1, it seemed reasonable to examine the supplementary hypothesis that respondents communicated different types of information with the same people within the organisation. This hypothesis was tested by examining the commonalities of "non-trivial" communication paths (see Chapter 5).

Overall, there was a high association between the aggregate networks involving scientific/technical and organisational/administrative

information (.56).

The results of the tests showing the associations among the networks for the basic types of information are shown in Table 7.3. Each figure shows the result from a single locally optimal test. All tests were carried out using formulae for the hypergeometric situation.

Table 7.3 Associations among communication networks

S	cientific	Client	Technical	Organis.	Administrat.
	S sig.	S sig.	S sig.	S sig.	S sig.
Scientific Client Technical Organisational Administrative	- 1 e	•23 ** -	•47 *** 1•0 ** -	•35 *** •08 NS •35 *** -	.32 *** .21 NS .37 *** .52 *** -

### Levels of Significance: \*\* p < .01 \*\*\* p < .001 NS p > .05

The results shown in Table 7.3 indicate that, with the exception of the network involving client information, all of the associations tested were very significant. Nevertheless, the high fluctuations observed in the test statistics for the associations involving client information indicated that this network was not "stable". This lack of stability probably arises from the fact that this particular network involved only a small number of exchanges which may well have occurred by chance.

If the findings for the network of client information are excluded from consideration, the remaining findings appear to confirm the supplementary hypothesis: within the organisation, respondents did tend
to communicate different types of information with the same people.

Associations among the independent variables

Let me briefly recapitulate the findings presented so far:

- (i) respondents tended to communicate work related information from internal sources within the hypothesised organisational constraints;
- (ii) they tended to communicate different types of orally exchanged information with the same people within the organisation.

Now, the associations among the independent variables are examined in an attempt to throw further light on the formation of communication networks.

Two clusters of interrelated independent variables were anticipated:

(i) On the one hand, it was expected that people hired and placed formally into a section of the organisation would be likely to be placed in close geographical proximity to other members of that section. Where these sections are formed on a disciplinary basis, it may also be expected that the section members will tend to use similar facilities; moreover, it can be expected that work colleagues will tend to be selected from section members because they will probably be working on similar problems and are likely to be familiar with the techniques these problems involve. Informal networks are also likely to form on the basis of sectional membership because members are more likely to be acquainted with each other than with members in other sections. For these reasons, it was anticipated that variables constituting the structural properties of the organisation would be interrelated.

(ii) On the other hand, it is unlikely that any one section will tend to monopolise the highly autonomous, highly oriented and highly competent people who are working within an organisation. This possibility suggests that people with similar analytic properties are likely to be spread throughout the organisation. Nevertheless, as has already been discussed in Chapter 4, highly competent people are also likely to be highly oriented and highly autonomous (Glaser 1963). Thus, it was anticipated that the variables constituting the analytic properties of organisations would also be interrelated.

The supplementary hypothesis which anticipated the two clusters of interrelated independent variables is examined below.

The relevant findings are shown in Table 7.4. They are also summarised in Diagram 7.I. Again, each figure represents the finding from a single locally optimal test. Each test used the formulae for a hypergeometric situation. It should be noted that a structural or latent relationship was regarded as a "non-trivial path". The commonalities of such paths were analysed (see Chapter 5).

Table 7.4 Associations among independent variables

2	3	4	5	6	7	8	9
S sig S	sig S	sig S	sig S	sig	S sig	S sig	S sig
•37 *** •73 - •28	5 *** .60 3 *** .39 59	*** .41 *** .25 *** .52 40	*** .2 *** .2 *** .0 *** .1	5 NS 6 ** 7 NS 8 NS 6 NS -	.11 NS .47 *** .14 NS .47 *** .02 NS .32 ***	.05 NS .31 ** .09 NS .39 *** .02 NS .45 *** .45 ***	.14 NS .20 * .17 * .38 *** .12 * .24 *** .60 ***
   							-
Formal struc	ture	6.	Orient	ations	3		
	S sig S .37 *** .73 28 Formal struc	2 3 S sig S sig S .37 *** .73 *** .60 28 *** .39 59 Formal structure	2 3 4 S sig S sig S sig S .37 *** .73 *** .60 *** .41 28 *** .39 *** .25 59 *** .52 40 Formal structure 6.	2 3 4 5   S sig S sig S sig S sig S sig S S sig S sig S sig S S sig S sig S   .37 *** .73 *** .60 *** .41 *** .0   - .28 *** .39 *** .25 *** .2   - .59 *** .52 *** .0   - .40 *** .1   - .40 *** .1   - - .0	2 3 4 5 6   S sig S sig S sig S sig S sig S sig   .37 *** .60 *** .41 *** .05 NS   - .28 *** .39 *** .25 *** .26 **   - .28 *** .59 *** .52 *** .07 NS   - .59 *** .52 *** .18 NS   - .40 *** .18 NS   - .06 NS - -   - .60 Orientations -   - .6. Orientations -	2 3 4 5 6 7   S sig S si	2 3 4 5 6 7 8   S sig

3. Geographical structure 8. Competence (Organisational)

9. Competence (Professional)

4. Colleague Network 5. Use of Facilities

> Levels of Significance: \* p < .05 \*\* p < .01 \*\*\* p < .001 NS p > .05

The results shown in Table 7.4 substantiated the supplementary hypothesis because they suggest that all of the structural variables tended to be interrelated. More specifically, respondents within close proximity to each other tended to be in the same section, used similar facilities, and tended to select each other as work colleagues and informal contacts. All of the analytic variables were also interrelated: high performers in terms of professional criteria tended to be highly autonomous persons, and highly oriented; these respondents were also high on the merit list of the organisation.





In addition to supporting the supplementary hypothesis, the data revealed an interesting pattern in the relationships between the analytic and structural variables insofar as there was fairly strong evidence to suggest that in the organisation studied, the link between the two properties of organisation occurred via colleague and informal networks. This finding suggests that the structural barriers between people in the organisation may be overcome by the formation of colleague and informal networks. These colleague and informal networks, in turn, tended to form among highly autonomous and highly oriented, high performers.

# Summary and conclusion

The findings of all tests reported in Part A of this chapter revealed a complex pattern of relationships among the variables which were analysed. Nevertheless, the findings substantiated the claim that research organisations affect internal patterns of communication.

With the exception of the network involving client information, all other networks were significantly interrelated. These findings indicated that, in general, respondents tended to choose the same people as the suppliers of all types of information within the organisation. This pattern is consistent with Hillier's (1960) theory which suggests that problem solvers tend to form "concentric layers of people" around them. In general, each such layer provides all types of information. Once a supplier of one type of information is perceived to be useful and trustworthy, the problem solver is unlikely to doubt the trustworthiness of the supplier when exchanges of other types of information are involved, even though there may be others in the organisation who are more qualified to give it. This interpretation is also consistent with findings of other research. A search for information from sources most qualified to give it would assume a rational and mechanical learning model of problem solvers. However, as Allen (1966) showed, this does not occur: problem solvers were found to gather information so as to minimise loss rather than to maximise gain (see Chapter 4).

The results reported here indicated that communication networks were significantly influenced by seven out of the eight variables studied. Of these variables, colleague networks, formal structure, geographical distance, autonomy and performance in terms of organisational criteria had the strongest effects on the formation of communication networks. The colleague networks were clearly the most influential. But the findings also indicated that while scientific/technical communication occurred mainly within structural constraints, the communication of organisational/administrative types of information tended to override these barriers. Finally, the results indicated that the communication of organisational/administrative information-was influenced more by the analytic than by the structural properties of the focal organisation.

Overall, then, the findings from the present study corroborate those obtained from previous studies which indicate that task structure (colleague networks) is the most important variable affecting communication networks (Frost and Whitley 1971, Walsh and Baker 1972, Evans Woods and Levene 1974, Hall 1974). The claim that the task structure can override geographical distance (Frost and Whitley 1971, Walsh and Baker 1972, Hall 1974) has also been supported. However, the suggestion that informal networks are of marginal importance (Frost and Whitley 1971, Pruthi and Nagpaul 1978) cannot be supported, because the findings from the present study suggest that informal contacts tended to strengthen the colleague networks.

Even though the colleague networks can override geographical distance, this latter variable did constrain communications, significantly and strongly. This finding corroborates those obtained by (Allen 1968, Allen and Cohen 1969, Allen 1977). The effects of physical distance must, therefore, be considered further in future studies of research organisations.

The structural variables formed one cluster of interrelated variables; the second cluster comprised analytic variables. These two clusters were found to be interconnected by colleague and informal networks. This finding suggested that these variables tended to override other structural barriers.

Finally, the present findings suggest that communications involving scientific/technical types of information initially formed within formal sections, and were, therefore, likely to be constrained by physical proximities. Nevertheless, because problem solvers do get acquainted with others in the organisation through communications involving organisational/administrative types of information and through informal networks, and as a consequence, are likely to perceive the available expertise within the organisation, they were likely to approach "similar others" to work on joint projects. Eventually, the present findings suggest that colleague networks will transcend the boundaries of the

formal sections; moreover, these colleague networks were likely to be maintained through the constant updating of information about the competence of others.

PART B

#### EFFECTS OF THE RESEARCH ORGANISATION ON EXTERNAL COMMUNICATION

This part reports findings based upon the examination of hypotheses presented in Part B of Chapter 4, where it was argued that an understanding of the communication between problem solvers within a work organisation and their organisational environment would throw light on the environmental contingency of the organisation. Because this environmental contingency is, according to the resource dependence theory of organisations (Pfeffer and Salancik 1978), "enacted" by the research administrators (dominant coalition) within the organisation, a study of the external communication is likely to reveal the pattern of relationships supported by these administrators.

The environmental contingency of the organisation studied was anticipated in the following hypothesis:

Hyp. 2.9 : The quantity of work related communication from external sources is likely to be rank ordered, from most to least, as follows: other research organisations, the bureaucracy, clients in the economy, and the political system.

The influence of research administrators on external communication was also examined in the following hypotheses:

- Hyp. 2.10 : The greater the physical distance between research organisations and the focal research organisation, the lower the rate of communication between them is likely to be.
- Hyp. 2.11 : The greater the physical distance between client organisations in the economy and the focal research organisation, the lower the rate of communication between them is likely to be.

### The environmental contingency of the organisation

The analyses reported in this part of the present chapter concern only about 25% of the information items reported by the respondents.

Table 7.5 summarises the communication pattern between the organisation studied and five "classes" of external organisations.

As anticipated, communication with organisations in the scientific community dominated external communications. About 80% of all external communications took place with organisations in that community. At the other extreme, direct communication with organisations in the political system was negligible.

The frequency of communication with organisations in the bureaucracy (the Head Office of the Department of Scientific and Industrial Research) and the client community were similar; however, twice as much information was given by respondents to the client community as was ----received from clients. These frequencies are intriguing insofar as respondents considered information input from the client community important, but they did not think that these clients were likely to be the "users" of their work (Chapter 2). The findings reported in Table 7.5 suggest that the reality of the situation is somewhat different: respondents tended to advise the clients more than they listened to them. However, this pattern of communication must be interpreted within the context of the 6% of all external communication which occurred with client communities.

			Table	e 7.5			
Frequencies o	f	communications	with	classes	of	external	organisations

Classes of External Organisations	Received N %		Given N %		Total N %	
Scientific Community	334	76.1	368	83.5	702	80.0
Bureaucracy	25	5.7	23	5.2	48	5.5
Client Communities	18	4.4	35	7.9	53	6.0
Political System	4	1.0	8	1.8	12	1.4
Other	56	12.8	7	1.6	63	7.1
Totals	437	100.0	441	100.0	878	100.0

Table 7.6 shows the proportions of the different types of information which were received from the external organisations.

In general, the information shown in Table 7.6 shows that science organisations are sources of all types of information. Referring again to Hillier's (1960) theory alluded to in Part A of the present chapter, external organisations can be said to comprise further "concentric layers of people", each of which is being used as a source of

information. Only when this general source cannot provide information, is a more specialised source sought. Using this theory we can, for example, explain the finding that the client community provided only 25% of all client information received from external sources, as well as the finding that 50% of the total client information received by the respondents in this investigation came, in fact, from internal sources.

Table 7.6 Proportions of external communication per types of information

External Sources	Types of information						
	Scien.	Client	Tech.	Organ.	Admin.		
	Col.%	Col.%	Col.%	Col.%	Col.%		
DSIR*	26.7	25.0	33.3	46.6	58.4		
Other NZ sc.orgs	37.3	0.0	29.0	20.7	9.9		
Sc.orgs overseas	26.1	16.6	1.4	0.0	3.0		
Bureaucracy**	0.7	8.4	0.0	25.9	6.0		
Client comm's	3.7	25.0	0.0	3.4	7.0		
Political system	0.0	8.4	0.0	0.0	3.0		
Other	5.5	16.6	36.3	3.4	12.7		
	100.0	100.0	100.0	100.0	100.0		

\* Excludes Head Office \*\* Head Office of the DSIR

Scientists overseas provided only about a quarter of the scientific information received by respondents from external sources. The remaining three-quarters of the scientific information received from external sources came from science organisations in New Zealand. A study of the effects of information from these external sources on the work of the respondents indicated that there was no significant association. Thus, information from science organisations overseas was no more important than information from other external sources.

The fact that external communication from bureaucratic organisations supplied about a quarter of organisational information from external sources was significant. More specifically, this finding suggests that although there was negligible direct influence from the political community, the respondents, predictably, took notice of information about planning and forecasting activities which came from the Head Office of the organisation studied.

Diagram 7.II shows the results generated by trying to map the socially constructed information environment of the focal organisation. This diagram is based on the analysis of the strength of communication ties between the organisation studied and external organisations (see Chapter 5). The focal organisation was drawn as a "centre" of its external organisational environment in a manner that was consistent with Hillier's (1960) theory. Organisations in this environment were placed around this "centre" in a way that showed how close they were to the centre in terms of communication ties. The stronger the tie was, the closer the external organisation was to the focal organisation.

Communication ties with 31 other organisations were identified and analysed. These ties included only organisations in New Zealand, because communication with overseas organisations was rather diffuse. In general, there was only one communication with any given organisation overseas.

Overall, the frequency of communication with external organisations was





similar to the frequency of communication with internal sources; that is, there were few communications with many organisations and there was extensive communication with only a few organisations.

Diagram 7.II shows clearly that closest to the organisation studied was one university (42.5). Four other divisions of the DSIR and one other A & B science organisation in New Zealand (30.0, on average) were next. Organisations in Agricultural Extension and the farming community were, generally, on the "periphery" of the environment of the focal organisation. The only other-than-science organisation with a strength of communication tie equal to or higher than the mean value was the Head Office of the DSIR (24.0).

In general, therefore, the findings substantiated the anticipated organisational environment of the organisation studied.

## Association between external communication and physical distance

Diagram 7.III shows the distribution of science organisations engaged in biological and agricultural research in New Zealand. The map shows four major centres of agricultural research and a large number of smaller organisations, which are spread throughout the country.

Diagram 7.IV shows the numbers of all organisations relative to their distance from the organisation studied and the strength of the communication ties with them. It shows clearly that the selection of external communication partners during the study appeared to occur on the basis of geographically-determined ease of access, rather than the quantitative distribution of various organisations of agricultural science in New Zealand. The findings also indicated that the rate of

Diagram 7.III Location of A & B research organisations in New Zealand





Geographical Diagram distances and 7.IV external communications

communication with external organisations was inversely related to the distance of the external organisations from the focal organisation.

The organisation studied is located in one of the centres of New Zealand's agricultural research and industry. Nevertheless, the communication patterns with the clients, who were mainly 400 miles distant, indicated that hypothesis 2.11 should be rejected without undertaking any statistical tests. Geographical distance, then, affected the patterns of communication with science organisations, but not with client communities.

#### SUMMARY AND CONCLUSIONS

This chapter attempted to provide empirical support for the hypotheses presented in Chapter 4. Part A of the present chapter examined the effects of the research organisation on internal communication. In Part B, the effects of the research organisation on external communication were investigated.

Overall, this chapter presented strong evidence to support the plausibility of the claim that research organisations influence the work patterns of their employees. Both structural proximities and respondents' similarities were found to affect the patterns of internal, as well as external, communication.

Internal communications were found to be formed within the structural proximities of the focal organisation and among people with similar attributes. The analyses also indicated that initially, structural

constraints influenced internal communication; however, the data also suggested that as problem solvers became acquainted with others in the organisation through informal networks, they were likely to approach "similar others" and to team up for joint projects. The colleague network was, then, found to be the most constraining factor in the flows of internal communication; moreover this network transcended barriers defined by other structural proximities. The data also suggested that this was likely to be maintained through reciprocal perceptions of respondents' competence. Thus, the present findings confirmed Glaser's (1963) thesis, which has, however, received little attention in recent studies in the sociology of science.

The pattern of external communication revealed by the findings was generally consistent with expectations. By far the greatest amount of external communication was with organisations which employed research scientists, in other words, with the members of other organisations in the scientific community. Communications with the client communities were very weak. Somewhat suprisingly, direct work related communications with organisations in the political system were the weakest of all. The influence of political organisations on the work of the respondents tended to be indirect and where it occurred, it appeared to be channelled through the bureaucracy of the Head Office. Not unexpectedly, the data showed that respondents took notice of communications comming from this source.

The mapping of the external communication according to physical distance between the focal organisation and other organisations in its environment showed that communication with other scientific

organisations declined as the distance increased. This was consistent with findings showed by Allen and Fustfeld (1975). External communication with the client communities was not, however, constrained by physical distance. These findings suggested that whereas the research administrators within the organisation did not exert much influence on the formation of external relationships with other scientists, they did influence communication with the client community. What little involvement there was with the farming industry had, indeed, been initiated by the focal organisation's past Director.

Overall, then, the findings substantiated the proposition that research organisations affect the formation of "associations" between problem solvers. Evidence was presented which showed that the organisation studied did so in respect of both internal and external communications. Since scientific knowledge development was said to occur through the growth of these communication associations (Chapter 1), we can conclude that research organisations do indeed affect knowledge development.

In the next and final chapter of this report, the two streams of investigation pursued in the present research, the study of the work patterns of problem solvers and the effects of the research organisation on them, are summarised and discussed.

#### CHAPTER 8

WORK PATTERNS IN A RESEARCH ORGANISATION

This thesis involved an investigation of some social aspects of scientific knowledge development.

A theory which addressed the description and explanation of this kind of knowledge development was outlined in Chapter 1. This theory was based on a survey of literature in the sociology of science which indicated that science tends to develop through the "patterned growth" of explorations. It was then argued that work organisations influence the formation of associations among researchers. The networks arising from these associations form the bases for the patterned growth of scientific explorations. Thus, work organisations influence scientific knowledge development. Further, it was argued that these work organisations attract, concentrate, and fuse a wealth of both intra- and extrascientific information. As a consequence, work organisations employing researchers can also be considered as social entities through which symbiotic relationships between the scientific and other communities in society take place.

In summary then, it was argued that work organisations and their effects on the work patterns of their employees are important phenomena which should be investigated to understand how scientific knowledge is created

and utilised.

However, as Ben-David (1971, 1978) indicated, the attention of sociologists interested in science shifted, in the sixties, to the exploration of developments within the scientific community as a whole. As a result, investigations of organisations employing scientists and engineers became absorbed into the general area of management studies. A review of these latter studies indicated the lack of an integrative perspective which would explain the contradictory findings which were found frequently in previous research.

To try and bring work organisations back to the analysis of processes of scientific knowledge development, it was necessary to draw on the literature in five major areas of research in the social sciences:

- (i) sociology of science,
- (ii) management studies of R & D organisations,
- (iii) information users studies,
- (iv) transfer of technology, and
  - (v) sociology and the management studies of organisations.

Any claim for the significance of the present study rests then on the attempt to integrate theoretical and empirical studies in the above specialties because each area contributes to the understanding of scientific knowledge development.

Basically, the problem was approached by studying the effects of work organisations on work related communications, an essential component of the work of problem solvers. In an effort to narrow the scope of the present study, the work organisation chosen for study was a specific research organisation. The thesis of the study was, then, that research organisations constrain work related communications and thereby significantly affect the process of scientific knowledge development.

In order to explore the explanatory utility of this thesis, the work patterns of problem solvers had to be described. Unfortunately, previous studies did not provide an explicit, validated theory which described and explained these work patterns adequately. The present study attempted to overcome this deficiency by dealing with two major topics:

- (i) the work patterns of problem solvers (Problem I), and
- (ii) the effects of research organisations on these work patterns (Problem II).

Following an attempt to elaborate general theoretical frameworks for each of these problems, their exploratory usefulness was tested in an empirical investigation of one government research organisation in New Zealand.

In this final chapter, the findings from the research are brought together by:

- (i) summarising the communications structure associated with each stage of work in terms of the theory advanced in Chapter 3 and the findings reported in Chapter 6,
- (ii) pointing out how research organisations affect communication structures in terms of the theory advanced in Chapter 4 and the findings presented in Chapter 7, and

(iii) drawing conclusions and implications for further research,

and for research administrators.

WORK PATTERNS OF PROBLEM SOLVERS

In the present study, the work of problem solvers (Problem I) was analysed in terms of stages of work and the pattern of communication particular to each stage. Three stages of work were delineated:

- (i) The Work Programme Development stage which involved the direction of the work and the relationships among work projects.
- (ii) The Idea Generation stage which concerned the formulation of specific projects to be investigated, and
- (iii) The Problem Solving stage, the stage in which the specific projects were actually being solved.

The Work Programme Development stage of work had not been considered in previous research, but its introduction as a stage of work which is prior to, and independent of, the processes of actual projects was an attempt to further clarify the work of problem solvers. The concept of work patterns which includes this stage assumed that there is a relationship between the projects of individual problem solvers. This approach was considered to be particularly appropriate in work situations where problem solvers worked on a number of projects simultaneously, especially since the idea appeared to contribute to the resolution of several apparently contradictory findings in the literature.

A review of studies which had investigated the communication patterns of problem solvers indicated that the stages of work evolved in response to communication and therefore it was an important part of the work of problem solvers. Each stage of work was defined in terms of a particular structure of communication. By extending the previous investigations of the roles of various dimensions of communication in the work of problem solvers, it was hypothesised that:

- (i) Work Programme Development is likely to be associated with mainly external sources, all considered types of information, a passive mode of information transfer and formal circumstances.
- (ii) The Idea Generation stage is likely to be associated with mainly written materials, scientific and technical types of information, and also with a passive mode of information transfer and those circumstances which involve a discussion of the written messages.
- (iii) The Problem Solving stage is likely to be associated with mainly internal sources, scientific, technical and administrative types of information, an active mode of information transfer and informal circumstances.

In sum, it was argued that all categories of the dimensions of communication considered in the present study were likely to be important in the work of problem solvers, but that certain kinds of information were believed to more or less important at different stages of work.

Because it was thought that the theoretical framework which informed the present study may not have been equally valid for all problem solvers, \_\_\_\_\_ the specific work patterns of the three groups (scientists, science technicians, and administrative staff) were analysed.

Because the testing of the theory involved the study of the relationships among three categorical variables (dimensions of communication, stages of work, and occupational groups), the log-linear modelling technique was the main statistical technique used to analyse these data.

Considered as a whole, the findings generally supported the hypotheses. The claim that there was a particular communication pattern associated with each stage of work was substantiated. Nevertheless, it must be remembered that the present research was undertaken in only one research organisation. As a consequence, more comprehensive theoretical and empirical studies are required before any conclusive claims for the generalisability of these findings can be made.

## The roles of communication in the work of problem solvers

In this study, it was anticipated that the quantity of communication would be proportionately associated with the transition of projects from the Idea Generation stage through to the Concluding stage. In essence, this means that as a consequence of communication, the work "problems" of respondents were defined, worked on, and solved. The important point here was the suggestion that the rate of communication contributed to the efficiency of problem-solving activity.

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It was also argued that the quality of communication contributed to the definition of the "problems" worked on by respondents, and also to the kinds of solutions generated. These linkages were the basis for judgements about the effectiveness of the work of problem solvers.

The role of research administrators in the communication patterns was crucial in influencing the efficiency and effectiveness of the problem solvers.

#### EFFECTS OF WORK ORGANISATIONS ON THE WORK PATTERNS OF THEIR EMPLOYEES

Because communications are of crucial importance in the work of problem solvers, the present study attempted to examine closely the effects of certain organisational characteristics on the communications of problem solvers. The question in this part of the present research was "what facilitates and/or inhibits work communication"? More specifically, the present analysis focused on the effects of research organisations on oral communication. This particular focus was adopted because the analyses of the effects of organisations on written communication would have entailed a comparative study of library systems. This step could not be included in the present case study.

In the present research, a theory proposed by Pfeffer and Salancik (1978) was used to investigate Problem II: the effects of research organisations on oral communication. This particular theory guided the selection of relevant variables, and provided the framework for the interpretation of results within the context of more general social processes in organisations. The adoption of a theory of organisations

enabled more systematic explorations of the relationships between research organisations and communication than had been achieved in previous studies.

The resource dependence approach to the study of organisations proposed by Pfeffer and Salancik (1978) was adopted as the theoretical framework for this phase of the present study. According to this approach, the social processes of organisation can be outlined in three cyclical steps:

- (i) Organisational environments affect the distribution of power within organisations.
- (ii) On the basis of such distribution of power, the dominant coalitions within the focal organisations are formed and administrators are selected.
- (iii) Once selected, these administrators shape organisational structure and respond to and, in turn, shape their organisational environments. These latter processes were termed "enacting" the environments.

This theory of organisations indicated the problems which may arise as changes occur in organisational practices. The intertwined processes which involve organisations, their structures and their organisational environments suggested that a change in one of the processes is likely to be accompanied by consequential change in the other processes as well. To develop this further, it can be argued, for example, that a change in the relationship between an organisation and its organisational environment is likely to result in changes in the structure and composition of the dominant coalition and in the organisational structure. This sort of change in the internal structure of the organisation is also likely to result in a change in the external relationships of the organisation.

The effects of research organisations on the work patterns of problem solvers were studied by examining the relationships between:

- (i) the organisational structure and internal oral communication, and between
- (ii) the environmental structure (environmental contingency) and the pattern of external oral communication.

Both subproblems were derived from Pfeffer and Salancik's (1978) theory as follows:

- (i) Through their shaping of the internal organisational structure, research administrators constrain internal communications;
- (ii) Through their attempts to "enact" their organisational environments, research administrators constrain external communications.

Because the present study took the form of a detailed case study, these two subproblems were approached differently:

(i) The effects of organisations on internal communications were explored by examining the associations between the three properties of "organisational structure", which were operationalised in terms of eight variables (autonomy, work -related orientations, socially recognised work competence, formal structure, informal networks, physical distance, colleague networks, and the use of facilities), and internal communication networks. Locally optimal tests were used to study the observed relationships.

- (ii) The effects of organisations on external oral communication were studied by:
  - (a) postulating the likely environmental contingency and examining whether the pattern of external communication reflected this contingency, and
  - (b) focusing on the effects of physical distance on the pattern of external communications.

This particular subproblem was investigated mainly by "mapping" the external communication, and by interpreting the significance of the "map" which was obtained.

The results generated by the analysis of data generally supported the hypotheses which had been formulated and thus substantiated the proposition that research organisations have significant effects on the work patterns of their employees. Because of these effects, organisations directly influence scientific knowledge development. In other words, the work of problem solvers is a function of the particular research organisation that employs them. Because they possess a particular constellation of properties, research organisation foster the developments of certain kinds of research, and inhibit other kinds of .esearch. EFFECTS OF RESEARCH ORGANISATIONS ON THE WORK PROGRAMME DEVELOPMENT STAGE

As expected, the Work Programme Development stage of work was found, overall, to be significantly associated with external sources of information, a passive mode of information transfer, and formal circumstances of information transfer. This particular stage of work was also found to be significantly associated with transfers of organisational and, to a lesser degree, administrative types of information. Nevertheless, the association between this stage of work and the types of information was unexpected. This finding usefully extended, it was argued, the theory of the work patterns advanced in the present research.

Contrary to these general trends, the work of scientists at this stage was also significantly affected by information from internal sources; the work of administrative staff was significantly influenced by other than organisational type of information.

Each significant finding is discussed below, seriatim.

The direction of the work programmes of problem solvers was found to be affected by information concerning the forecasting and planning activities of others, and the availability of resources.

The effect of administrative information on the work programmes of problem solvers appeared to be the result of situations involving limited resources, a condition that may well exist in many research organisations. If, for example, a piece of equipment cannot be purchased, the problem solvers are not likely to generate projects which would require such a piece of equipment. In the particular organisation investigated, the respondents were reasonably "satisfied" with information they received concerning resources. Indeed, the limitations imposed upon the problem solvers by the Department of Scientific and Industrial Research and the relative isolation of New Zealand from the rest of the world, were accepted by the respondents as facts of life. These limitations nevertheless constrained the direction of their work.

The greater observed importance of organisational information, compared with the anticipated importance of scientific, client, and technical information in the Work Programme Development stage of work, extended the formulations set out in Chapter 3. While it can be said that scientific, client, and technical information address "past" achievements, organisational information concerned activities which were forecasted or planned; that is they involved "future" developments. Thus, in the organisation investigated, it was the "social construction of the future", more than "past achievements" which affected the development of work programmes. Nevertheless, this social construction of the future contained, as was argued in Chapter 3, intra- and extrascientific influences. Several examples should make this clear.

One scientist noted, with some concern, that if he was to respond to immediate problems and to set up research to get answers to such problems, by the time he "had these answers there would have been too few of them and it would have been too late". Instead, he noted, he attempted to do research which might provide answers to problems which could become issues by the time work on the research theme was completed. In other words, in the development of his work programme, this scientist attempted to anticipate crucial issues and to have undertaken the necessary research before, as it were, the issues emerged. One of his research themes came into existence following the realisation that some of his work in lipid biosynthesis also had some application to oil seeds. This occurred before the energy situation had worsened and become important economic and political issue. Following discussions with other scientists outside the organisation and the integration of research planning activities of all parties, a new research theme which would explore the adaptability of plants with high oil concentrates to New Zealand conditions was initiated.

Another scientist developed a research theme following his prediction that there would be a need to provide a chemical analysis of plant material in physiological studies which were related to animal nutrition. During the period of the present investigation, this research theme comprised five projects but was being wound up because the required method of analysis had already been developed and the results had been described in several academic journals. Because the method of analysis had been developed and proved in the situations which he had predicted, there was little point in pursuing the proposed research.

The processes of fusing the planning activities of several people including those in the client community, and of anticipating future research and development requirements can be illustrated by the following example, which involved a research theme that attempted to

apply the research findings from investigation of forage crop systems.

At first, the theme was developed to:

"... see plant systems being used by farmers well before they are released commercially, so that we can get farmers' attitudes as to their usefulness and any problems they might face with them."

As the scientist concerned indicated, this was necessary because of the anticipated resistance of farmers to anything new, especially to that which they could not see working on farms.

This research theme was then developed when this scientist tried to tackle practical constraints in his attempts to gain a foothold in the farming community, and on the basis of his thinking about the logical consequences of introducing a new system of cropping to the farming comunity.

The practical constraints involved planning the activities of several groups:

"Before we could do any work with forage cropping systems, we needed a large size rig which could be used for cutting and fine chopping of forage. There was none (about) and the only way I could see of getting (one) was to have a farmer buy it, and be guaranteed ... a minimum acreage (for contract work) that could afford to pay for it. So my now massive involvement with (a government farm in the district) grew out of a completely different need: a need to have a private contractor, or his gear, in the district in order to do my cropping work..."

However, the introduction of a "forage crop conserved feed system" to the farming community might contribute to the goal of producing meat "out of season". Such a development would, he considered, give New Zealand an edge in the overseas market and at the same time, might assist in the decentralisation of meat works. During the period of the "fieldwork" for the present investigation, this scientist was developing this theme by investigating the "seasonal pattern for the killing of stock".

In sum, the developments of work programmes are affected by information concerning the "social construction of the future".

However, the work of administrative staff appeared to be an exception to this trend. Their work programmes tended to develop in response to day-to-day problems.

It therefore appeared, that in the organisation investigated, the "planning" role was carried out by problem solvers, not by administrators.

While these findings may suprise some administrators, the respondents unhesitantingly claim this "role" for problem solvers. As was shown in Chapter 2, the respondents considered it their role to "plan and organise" their work. The arguments developed in the course of the present research corroborate this point of view. Researchers are employed in the DSIR to do "science in the national interest". Neither "science" nor "the national interest" can, however, be determined and dictated with absolute precision. Science, I argued, involves the formation of associations which have international significance. The colleague networks analysed and described in the present investigation supported this point. As has been shown in Chapter 7, these colleague networks are likely to form among highly autonomous, and highly oriented people who are also likely to be high performers in terms of professional criteria. The colleague networks were, then, formed on the

basis of perceptions of "expertise" among people. This "expertise" is, as has already been suggested, achieved through the self-motivated pursuit of research themes, and the logical development of the work programmes of problem solvers. As one respondent, a scientist, noted:

"I started working on (x) about five years ago and got publishable results and good feedback from other scientists. Since that was more feedback than I was getting on any of my other projects at that time, this encouraged me to get more into the (x)".

The involvement in research themes can, then, be influenced by presenting problem solvers with information which will modify their "weltschauung". These modifications will, in turn, be reflected in the way their work subsequently develops.

In general, Work Programme Development was affected by information from external sources. The pattern of findings which resulted were consistent with expectations.

As was shown in Chapter 7, information from external sources was constrained by the organisation. Consistent with the anticipated environmental contingency which administrators within the organisation "enact", work related communication from external sources occurred mostly with members of other research organisations, then, in descending order of frequency with the bureaucracy, clients in the economy, and the political system. Further analysis showed that, whereas communication with other research organisations declined with physical distance, communication with clients in the economy was not affected by distance. More specifically, the findings indicated that, whereas administrators within the organisation did not facilitate any particular ties with

research organisations, they did facilitate communication with the client community. Thus, by facilitating different communication contacts, research administrators did affect the direction of their employees' work programmes.

As expected, Work Programme Developments were affected by formal circumstances of information transfer and a passive mode of such information transfer.

As one scientist put it:

"I am too busy doing research to be able to go out to look for 'problems'."

The work programmes were affected most by information which the respondents received at the meetings and seminars which they attended.

How can research administrators affect the direction of work in view of the findings summarised so far?

The present position argues that facilitating policy-related external communication is the most constructive way to influence the direction of work in research organisations. Consequently, research administrators should organise seminars between their staff and representatives of those external organisations which could be selected on the basis of some policy which addressed questions such as "in whose interests should we do research"? If the direction of work should entail, for example, more farming related problems, then the appropriate representatives from farming industry should be invited to the research organisation to present their "construction of reality" (the present and future
developments in their sector of the New Zealand society). For such presentations to be authoritative, they must be backed fully by the top administrators.

Because the top administrators in the DSIR are external to their divisions, they should also be prepared to present their interpretations of relevant developments in New Zealand society. Steps like this are important because top administrators develop their ideas and opinions in discussion with the top representatives of other science organisations, and client and political communities. The findings from the present study indicated that the top administrators were listened to by the respondents (Chapter 7).

Thus, discussions rather than a series of instructions, prohibitions and political manipulations are likely to be one of the major positive roles that NRAC, DSIR Head Office, and administrators within the divisions could play in affecting the direction of New Zealand science in the future.

The idea that discussions and seminars should be organised on a regular basis is consistent with a recommendation put forward recently by the Director of the R & D Research Unit in Manchester. He suggested (Pearson 1978), that seminars in research organisations should take:

"... the form of scenarios or alternative futures, against which the projected outputs from research projects and programmes can be tested ... such information is of value at the start-up of projects and, if regularly updated, at subsequent reviews, with project leaders and team members being more aware of the factors which must be monitored and which, if they change, could lead to significant revisions in these work programmes."

Contrary to the general trends, the work programmes of scientists were also significantly affected by information from internal sources.

As shown in Chapter 7, organisational/administrative networks of internal communications were, in the main, affected by three internal organisational structures: organisational performance, colleague networks, and autonomy. These results suggested that the work programmes of scientists were also significantly affected by information concerning planning and forecasting, which was given by autonomous work colleagues at internal seminars and meetings. It is also noteworthy that autonomous work colleagues were highly evaluated by the employing organisation.

These findings substantiated further the effects research organisations have on the work of their employees. Work colleagues within the organisations also influenced the direction of work. The findings presented in Chapter 7 also showed that colleague networks tended to transcend formal sections. This is an important point because it suggests that "experts" in different sections can set up joint projects and explore problems in research areas which are "marginal" to the mainstream of scientific discourse (the importance of this point was discussed in Chapter 1). The organisation which was the focus of the present study appears to be well aware of such possibilities insofar as it was organised into six scientific sections whose members investigated "plants" from the point of view of at least six scientific specialties. According to the Director, the reason for employing people in diverse specialties is because such people would, by their interactions, increase the likelihood that significant scientific knowledge will be

created. While a study of the projects of the respondents (not discussed in the present report) indicated that many such interactions were yet to be formed, the findings did indicate that the work programmes of scientists were affected by work colleagues located within as well as outside the formal sections. In short, within the organisation studied, useful interactions across sections were occurring.

Thus, the finding summarised above implied that next to the facilitation of external communications, research administrators should:

- (i) Continue to hire highly qualified staff whose potential interaction should result in creative approaches to relevant research areas.
- (ii) At the same time, research administrators should provide for the further education of all staff so as to stimulate the development of autonomous persons in all the formal sections of their organisations.
- (iii) They should also try to facilitate the organisation of internal seminars which would involve the discussion of the research programmes of the autonomous and highly rewarded persons in the organisation.

Research administrators should not, moreover, underestimate the need to organise "formal" meetings, because they should not assume that the junior staff will know about the research programmes of their senior members. Several respondents reported that they were dissatisfied because they did not even know the direction of the work programmes of their section leaders; others reported that they only learned about the

focus of the work programmes of their more senior colleagues at conferences and professional meetings.

#### EFFECTS OF RESEARCH ORGANISATIONS ON THE IDEA GENERATION STAGE

As expected, the Idea Generation stage of work was found to be significantly associated with external written material and scientific types of information. The association between this stage of work and the modes and circumstances of information transfer were not significant.

# The Idea Generation of specific projects was affected by written material.

This finding substantiated the claim that written material in general, and journals in particular, provided an important stimulus for ideas about specific projects. Written material was also used as a reference source (in the Problem Solving stage), but its association with the Idea Generation stage was found to be highly significant. Thus, this stage of work depended mostly on ideas from written sources of information. It should be noted at this juncture, that during the course of the fieldwork for the present study, respondents derived information from over sixty different professional journals.

The implication of these findings can be stated as follows:

(i) The variety of journals received by a research organisation should not be reduced; if cuts are necessary, these should be accompanied by a reduction in the numbers of specialisations in these organisations. Nevertheless, it should be recognised that such cuts may have undesirable consequences for the exploration of "marginal" research areas as discussed in the previous section of this chapter.

(ii) Written materials should be circulated quickly by using library stands and reading rooms. This kind of circulation would ensure that these materials were more accessible to all staff simultaneously.

#### EFFECTS OF RESEARCH ORGANISATIONS ON THE PROBLEM SOLVING STAGE

As expected, the Problem Solving stage of work was found to be generally associated with internal sources of information, "all" but client types of information, a passive mode of information transfer, and informal circumstances of information transfer.

Contrary to these general trends, science technicians also used significantly more information from the external sources at the Problem Solving stage of work than did either of the other two occupational groups.

The Problem Solving stage of work was found to be affected by "all" but client types of information.

Although it had been hypothesised that only scientific, technical and administrative types of information would be influential in the Problem Solving stage of work, the additional use of organisational information during this stage did not negate the relevant hypotheses. Respondents' concern about the use of particular techniques and research facilities, was probably reflected in their somewhat more substantial use of technical information. This kind of usage had been anticipated.

# The Problem Solving stage was, as expected, affected by information from internal sources.

In Chapter 7 it was shown that the networks of internal communications were affected by both the structural and analytic properties of organisations. More specifically, the network involving colleagues and, in descending order of statistically significant associations, the formal structure, performance in terms of organisational criteria and the autonomy of respondents had the greatest effects on these internal communications.

A more detailed analysis of the relationships among the independent variables threw some light on the formation of internal communication networks. The findings indicated that initially, scientific/technical internal communication networks were likely to be formed within formal sections, and, as a consequence, would be constrained by structural factors. As problem solvers become acquainted, through communicating organisational and administrative types of information as well as through informal networks, with the expertise and the approachability of others in the organisation, networks of communication become extended beyond the limits of formal sections.

In essence, what seemed to happen was that the colleague networks

overrode structural constraints.

The findings also indicated that, because the colleague networks were formed between coevals, these kinds of networks were maintained through the updating of information about others in the networks.

# The Problem Solving stage of work was affected, as expected, by informal circumstances and an active mode of information transfer.

As was shown in Chapter 2, the Problem Solving stage of work accounted for about 50% of all stages of work: it was the major activity of problem solvers, and one which changed least in response to information input. In essence, the stage was a kind of "bottleneck" in the "throughput" of projects. However, because normally publications can only be written following the transition of projects from the Problem Solving to the Concluding stage, and because such activity was the major source of professional and organisational recognition, respondents' active pursuit of information at this stage is quite understandable.

The search for information through informal circumstances was explained in Chapter 4. In essence it was argued that informal circumstances are likely to be necessary when the information required is "complex". This occurs at the Problem Solving stage of work.

How can research administrators affect work during the Problem Solving stage?

The findings reported in the present report suggest that administrators should try to facilitate conditions under which informal contacts

between members of the organisation can occur; moreover, these efforts should involve as many staff as possible. Because the data reported here indicated that informal networks were formed on the basis of perceived expertise and autonomy, research administrators should attempt to stimulate these by encouraging the identification of "autonomous" staff members in all sections of the organisation. The promotion of seminars and discussions along the lines suggested earlier in this chapter could provide contexts in which the expertise of others could be assessed and recognised.

Such suggestions are consistent with those advanced in the discussion of the effects of research organisations on the Work Programme Development They are also consistent with the observed attitudes of stage. respondents because, as was shown in Chapter 2, respondents believed it was their job to plan their work, resolve technical problems and to control their work related activities. The central role of administrators appears to be facilitating communication and contacts, and providing resources. Further, by facilitating internal communication through colleague networks, the likelihood of having available the kind of expertise required for the research work of the organisation is increased.

Contrary to these general trends, the Problem Solving stage of work of science technicians was also significantly affected by information from external sources.

In the theory of work patterns outlined in Chapter 3, it was hypothesised that information from internal oral sources is likely to

influence the Problem Solving stage provided the tasks are "routine". Under the conditions of "non-routine" tasks, it was suggested that problem solvers are more likely to turn to external sources. This is because although the cost of information transfer is higher, the only alternative available to problem solvers is to engage in communications across the boundaries of the research organisation.

Thus, the finding indicating that science technicians used significantly more external information in the Problem Solving stage than do the other two occupational groups suggested that science technicians were engaged in "non-routine" tasks. Indeed, during the course of the present study, science technicians were almost exclusively involved in 27 projects. Approximately one-third of these projects involved the development of new instruments and/or equipment. Of these projects, at least one involved a developmental activity which was quite different from their past experience. This particular development, the construction of a tissue culture cabinet, grew out of a suggestion that the cabinet which could be imported for about \$5,000 could be "made here with some savings" by the organisation's technicians. During the course of the study, the prototype was being constructed and this demanded consultations with technicians in other organisations. By the end of the data collection period, the prototype had been built and the organisation was just about to establish a "production line", because an order for six more such cabinets had been obtained.

This sort of experience suggests that in addition to facilitating internal communications, research administrators should recognise that where "non-routine" tasks are initiated, the need to undertake external

communication will arise and should, as far as possible, be facilitated.

Let me now conclude by drawing together the important implications for further research as well as for research administrators.

#### IMPLICATIONS OF THE STUDY FOR FURTHER RESEARCH

Undertaking a case study of the kind reported here usually generates ideas and issues involving possibilities for further research. The present research is no exception:

- (i) The present study concentrated on the role of work organisations in the processes of knowledge development. However, the case study approach adopted in the present research is limited because it centred on an investigation of the effects of a single research organisation. Further research should study the differential effects of universities, R & D laboratories, as well as other organisations employing researchers in order to check and extend the findings generated in the present reseach.
- (ii) Although the findings generated by the present research provided a useful test of the theory concerning the work patterns of problem solvers, more extensive studies are required if the utility of this framework is to be fully and

rigorously tested.

- (iii) The present case study approach did not examine the effects of information generated within the organisation on the potential users. Because the utilisation of established information is an important element in the process of scientific knowledge development, further research should attempt to couple this particular part of the process with the processes examined in the present investigation.
- (iv) The theory of organisations presented in Chapter 4 did not develop all of the major ideas which the resource dependence perspective of organisations has to offer. These ideas could be pursued in future studies. The relationship between administrators and the dominant coalition, for example, could be examined because an investigation of this power relationship could throw further light on how the internal structures of organisations are manipulated and their environments are "enacted".
  - (v) Finally, attempts should be made to design and to carry out longitudinal studies of the behaviour of administrators, because investigations carried out over time should significantly advance our understanding of the nature of the relationships between organisations and the work of their employees.

IMPLICATIONS OF THE STUDY FOR RESEARCH ADMINISTRATORS

Generally, this study suggests that the most effective way to administer

a research organisation is through facilitating communications, contacts, and the provisions of resources, rather than through instructions about what work should be done or what methods should be used. This suggestion not only summarises the general implications which follow from this study, but also the attitudes of the respondents.

The study centred on work related communications. This type of communication was found to be of fundamental importance in the work of problem solvers, because it affected both their efficiency and effectiveness. By facilitating or impeding communications, therefore, research administrators can significantly influence the work carried out in their organisations. The following three points summarise the major recommendations which were discussed in the present chapter.

- (i) Research administrators should facilitate regular seminars with representatives of external organisations, selected on the basis of answers to questions such as "in whose interests should we do research?" These should also include top New Zealand science administrators. All these "visitors" should be asked to present, authoritatively, their views ("scenarios") of the present and future developments in their specific sectors of the New Zealand society.
- (ii) Research administrators should continue to hire highly qualified staff and to stimulate the development of "self-starters" in all formal sections of the research organisation; and to ensure that information about their

availability and accessibility is known within their organisations. The latter could be done by encouraging: (a) informal networks by, for example, providing large central cafeterias and recreational facilities, and (b) internal seminars which would involve the discussions of research programmes as well as work carried out by all senior and junior staff members.

(iv) Research administrators should provide a variety of journals which should be circulated quickly, preferably in reading rooms set aside for this purpose. The primary role of journals is in stimulating ideas for projects. However, recognising that journals are also used as reference sources, these should also be made available for quick retrieval. Duplications of journals held in different libraries can be avoided, provided that the two roles of written material are facilitated efficiently otherwise.

As a final remark, I should like to point out that research administrators should also continue to encourage social science research which would provide the basis upon which more effective and efficient administration of problem solvers can be based. In the previous section, I identified five areas which are likely to extend the efforts of the present study.

This study set out to propose and to defend the thesis that organisations influence scientific knowledge development. The investigation focused on the effects of a research organisations on communications. The findings substantiated this thesis: problem solvers were found to work within "collective entities (organisations), which (significantly) impede the free flow of information and materials (Whitley 1977:23; additions are mine). Work organisations thus mediate which "new problem areas are regularly created and associated social networks formed" (Mulkay 1975:520). In short, work organisations affect scientific knowledge development.

# APPENDIX A

INFORMATION FLOW QUESTIONNAIRE

### INFORMATION FLOW QUESTIONNAIRE

Please fill in the questionnaire during the day on which you receive it – today. Please put entries into the questionnaire as many times during the day as you feel appropriate.

Questions 1-3 refer to the workload you have AT PRESENT. You are asked to fill these in only once; subsequently, your replies will be copied out and you will be asked to make only appropriate modifications, as your work pattern changes.

Questions 4-6 ask you to record and describe all significant information, which you receive or give during the DAY on which you receive the questionnaire.

For the purpose of this questionnaire, the DAY begins at 5 p.m. the previous day and ends at 5 p.m. on the day you receive and complete the questionnaire.

For reference to the categories in Questions 4-6, see separate list of references. Should you find that any one of the sets of pre-coded categories does not describe any recorded significant information sufficiently, please feel free to write on the reverse sides of the questionnaire forms.

In answering any question, it is permissible to make adjustments to your answers in any of the previous questions.

As you leave the premises, put the completed questionnaire into the attached envelope, seal it and leave it in the administration room.

ALTHOUGH EACH QUESTIONNAIRE WILL BE NUMBERED, YOUR NUMBER WILL BE KNOWN ONLY TO ME, AND ALL ANSWERS WILL BE KEPT STRICTLY CONFIDENTIAL.

THANK YOU.

The research/development/work 'projects' in your Division can be sub-divided into 15 research/development/work areas (in subsequent questions these will be quoted as 'areas').

By ticking the code letter in front of each category, please indicate those 'areas' in which you are involved AT PRESENT.

Please tick as many 'areas' as you feel necessary to record major 'areas' of your work.

- A. Plant Biochemistry
- B. Nitrogen Fixation
- C. Plant Photosynthesis and Respiration
- D. Micropropagation and High Health Plants
- E. Crop Physiology
- F. Agricultural Physics
- G. Crop and Forage Breeding and Selection
- H. Agronomy
- I. Farm Management
- J. Biological Service of Facilities\*
- K. Technical Service of Facilities\*
- L. Biological Extension of Facilities\*
- M. Technical Extension of Facilities\*
- N. Biological Development of New Facilities\*
- O. Technical Development of New Facilities\*
- P. Other: Please Specify:

......

.....

.....

Pre-coded categories A-I, and P are self-explanatory; the following are definitions for J-O.

#### J., K., Biological and Technical Service of Facilities\*

Tick this category if you are responsible for the operation of a facility\*, and/or assisting its users, and/or trouble shooting, and/or making minor adjustments to recording devices which comprise the facility\*.

#### L., M., Biological and Technical Extension of Facilities\*

Tick this category, if some of your tasks are oriented to improve the performance and/or utility, and/or application of the existing facility\*.

#### N., O., Biological and Technical Development of New Facilities\*

Tick this category, if you are at present concerned with developing a new facility\*.

\*FACILITIES include climate rooms, specialised laboratory instrumentation, glasshouses, farm plots.

- Please list all the 'projects', 'problems', or 'research possibilities', in which you are engaged AT PRESENT. Even if you are only thinking about being involved in a project, this is still your work load AT PRESENT, and should be entered.
- (ii) Relate all these 'projects' to the 'areas' using code letters derived from Question 1.
- (iii) Suggest at what stage\* these projects are by ticking appropriate category.

		Pi	roject	Stage	s*	
Research/Development/Work 'Project'	'Area'	Idea Generation	Proposal	Solving	Concluding	
1						1
2						2
3						3
4						4
5						5
6						6
7	,					7
8						8
9						9
10						10
11						11
12						12
13						13
14						14

### \*PROJECT STAGES

Idea Generation is that stage, during which you are thinking about a new 'project'. Include only those ideas, about which you think, or on which you work at least one hour a week.

**Proposal** is that stage, when the research proposal is being written, without at present being engaged in further work on the project.

Solving is that stage, where you are experimenting, analysing data, or generally carrying out the 'project'.

**Concluding** is that stage, where your 'project' has been concluded and/or you are writing up the results for a report or publication.

If you are writing up results without actually concluding the research, please tick both 3rd and 4th stages.

Please indicate to what extent each 'project' relates to the five facilities specified below. To do this, utilise the code number of each 'project' and, using a scale  $0-4^*$ , please indicate the extent to which each 'project' is dependent on each of the named facilities.

Project	Major Serviced Climate Rooms	Specialised Laboratory Instrument (includes other control, cabinets, E.M., etc.)	Glasshouses	Field plots owned by a research organisation	Field plot owned by farmers
1					
2					
3					
4					
5					
6					
7					
8					
9					
10			· · · · · · · · · · · · · · · · · · ·		
11					
12					
13					
14		3. 			

# \*SCALE OF DEPENDENCY ON TECHNICAL FACILITY

ľ

	In each 'p	project' the specified f	acility is:	
0	1	2	3	4
not used at all	used but does not have to be	used to a limited extent	used to a greater extent	used throughout; project entirely dependent on this facility

Have you received any significant information today (see Ref. 1)? If from a person, answer Section A, if from written material, answer Section B.

# SECTION A-PERSONAL CONTACTS

(i) Name the contact for each item of significant information	(iii) (ii) Name the organisation (iii) Was the information volunteered to you or sought by you? <i>Tick one category</i>			(iv) In what circumstances was the information obtained? <i>Tick one category</i>			(v) To which 'area' and 'project' does the information relate? <i>Enter the letter</i> <i>and number appropriate to the</i> <i>'area' and 'project'</i>			s	(vi) Classi <sup>+</sup> cientific/Teo	ccording to its source and cont one category Organisational/Administrati Enter plus (+) or minus (-) for negative impact of the informatic				
(see ref. 2)	he/she represents	Volun- teered	Sought	Informal	Formal Regular Meeting	Other Formal Meeting	'Area'	'Project'	'Effects work in general'	'Scientific Ref. 4 (i)	'Extension' Ref. 4 (ii)	'Industry' Ref. 4 (iii)	'Other technical' <i>Ref. 4(iv)</i>	Forecast. and Plan. <i>Ref. 5 (i)</i>	Resources <i>Ref. 5 (ii)</i>	Time Ref. 5 (i

# SECTION B-INFORMATION FROM WRITTEN MATERIAL

(i) Please name the source (e.g., name the Journal, Manazine, Newspaper: specify	(ii) How did you become aware of this written material? (See Ref. 6) Tick one category ar				(iii) To which 'area' and 'project' does the information relate? Enter the letter and number appropriate to the 'area' and 'project'			(iv) Classify the information according to its source and content <i>Tick only one category</i> Organisational/Administrative ( <i>Ref. 5</i> ) <i>Enter plus (+) or minus (-) for positive o</i> <i>negative impact of the information on your w</i>					t (Ref. 5) positive or n your work	(v) H the likely to <i>Tick o</i>	low strong informat affect you nly one ca	gly is ion ur work? ategory	(vii) When is the in formation likely to affect your work? <i>Tick one category</i>			
if letter, memo or a circular)	Pointed out by: <i>(please name the person)</i>	'regular reading'	'purposeful search'	'random'	'Area'	'Project'	'Effects work in general'	'Scientific' Ref. 4 (i)	Scientific' 'Extension' 'Industry' 'Other Ref. 4 (i) Ref. 4 (ii) Ref. 4 (iii) Ref. 4 (iii)		Forecast, and Plan. <i>Ref. 5(i)</i>	Resources <i>Ref. 5 (ii)</i>	Time Ref. 5 (iii)	Manpower <i>Re</i> f. 5 (iv)	Not very strongly	Strongly Very strongly		Now	Might in the future	
																-				

e (	Ref. 5) psitive or n your work	(vii) the likely to <i>Tick o</i>	How stron informati affect you nly one ca	(vi) When is the in- formation likely to affect your work? <i>Tick one category</i>					
i)	Manpower Ref. 5 (iv)	Not very strongly	Strongly	Very strongly	Now	Might in the future			
_									
_									

Have you given what you consider to be significant information to anyone in the Division today? To Whom? (Please list names).

# QUESTION 6

Have you given what you consider significant information to anyone OUTSIDE the Division today? To whom? (*Please list names and describe the information*). Also include information on which you worked today, and which you reasonably shortly (within 14 days) intend to pass to a specific person or a group of persons OUTSIDE the Division.

		(iii) Was the information	ŀ	low was t	(iv) he informa	tion given?	?		CI	assify the i	) nformatio	v) n according	to its natu	ıre	
(i) Name the contact	(II) Name the organisation	(II) Name the organisation	(i) (i) Name the organisation	(i) Volunteered by you (i) Name the or sought from Today the contact organisation you? in www. Oral	Oral at Formal	Oral at Other		Scientific	/Technical		Oro Enter eithe or negative work of	anisational/ r plus (+) or impact of t the person (	Administrați minus (–) f he informați OUTSIDE, it	ive or positive ion on the known.	
	he/she represents	Volun- teered Sought	prepara- tion	whiten	informal	Regular Meeting	Formal Meeting	'Scientific'	'Extension'	'Industry'	'Other Technical'	Forecasting and Planning	Resources	Time	Man- power

# APPENDIX B

LIST OF REFERENCES TO QUESTIONS 4-6

INFORMATION FLOW QUESTIONHAIRE LIST OF REFERENCES TO QUESTIONS 4 - 6 In the questionnaire, you are asked to record and describe all <u>significant information</u>, whether scientific/technical or organisational/administrative in nature, which you <u>receive</u> (Question 4) or <u>give</u> (Questions 5 and 6) during the DAY on which you receive the questionnaire.

The notes below attempt to clarify what you are requested to do, and what information I need for the successful completion of my thesis.

- I need to obtain a <u>true and honest</u> picture of every significant item of information which you receive and give to persons within the Division and outside the Division during the DAY on which you receive the questionnaire. For the purpose of this questionnaire, the <u>DAY</u> begins at 5 p.m. the previous day and ends at 5 p.m. on the day you receive and complete the questionnaire.
- The unit of analysis is '<u>significant information</u>' and not 'discussion'. Therefore if you receive and/or give two or more 'significant items of information' during one discussion, please enter all these separately.
- 3. In essence, <u>significant information</u> is any information which you feel is likely to affect your work, either positively or negatively. Its mode of communication is irrelevant. All significant information whether verbal by phone, or by memo should be recorded.
- 4. <u>Significant Scientific/Technical Information</u> is information of a scientific/technical nature which
- EITHER concerns an on-going research/development/work project at any stage of its course (see Question 2) and in that case leads to a change in opinion about the approach (approaches) considered in the solution of that project. This means that if one approach is at present slightly favoured over other approaches, then any scientific/ technical information that will cause a change in this balance is considered as significant scientific/technical information;
- OR concerns a research/development/work area. In this case information is significant if it is regarded as important for its present or potential use.

The content of scientific/technical information sub-divides into four categories - the first covers scientific information, the second information on the work of 'extension' personnel, the third information on the work in 'industry', and the fourth covers any other technical information.

An item of scientific/technical information is allocated to a category according to the field from which the information AROCE, irrespective who gave it and how.

- (i) <u>Scientific information</u> is information covering scientific findings and/or data and/or methods which derive from a scientific discourse.
- (ii) <u>Information concerning the work of 'extension'</u> <u>personnel</u> is that information which expounds the conditions and methods found and used by the persons who are thought to mediate between scientific research and industry. Therefore, information on the work of various producers associations, farm advisory personnel etc., is included.
- (iii) <u>Information on the work in 'industry</u>' is that information which expounds specific conditions and/or methods found and used by the profit and non-profit making users in solving their problems.
  - (iv) <u>Any other 'technical' information</u> is a technical information not covered by the above categories, which is however, likely to effect either an on-going 'project' or 'area', in the way stressed by the above definition of significant scientific/technical information.
- 5. <u>Significant Organisational/Administrative Information</u> is information of an organisational/administrative nature, which is likely to affect an on-going research/development/ work project, or research/development/work area or your work in general. In any of the circumstances, the information is likely to either PACILITATE, or INHIBIT your work. Therefore you are acked to evaluate the impact of this information by putting a plus (+) or minus (-) sign in the appropriate column, instead of the usual tick.

This information subdivides into four types of information:

- (i) <u>Forecasting and Planning</u> information which concerns the future development of your research/development/work areas;
- (ii) <u>Resources</u> e.g., the cost, availability and operation of raw materials, equipment, instruments, or facilities:
- (iii) <u>Time</u> to do certain parts of research/development/work project;
  - (iv) Manpover to carry out certain parts of the 'project'.

6. In answering question 4B under 'how did you become aware of this written material', "regular reading" means you found the information in a journal or mail, in the course of your regular reading. A "purposeful search" means you had initiated a literature survey, or similar search of a particular including administrative field. "Random" means you found the article, letter, or meno by accident - for instance while browsing. APPENDIX C

2

LETTER ISSUED WITH I.F.Q. NO 10



AND

DEPARTMENT OF

INDUSTRIAL

RESEARCH

Telephone: 729 979

Head Office, Private Bag, Wellington, New Zealand.

26th August 1977

INFORMATION FLOW QUESTIONNAIRE NO 10

**SCIENTIFIC** 

In this questionnaire please record and describe all significant information, which you received from a number of different sources (i.e. another person, literature, mail, an experiment), or gave, in the period beginning at 5 pm on Thursday (25th August), and ending at 5 pm today (Friday 26th August).

Please fill in the questionnaire <u>today</u> and return the completed form as you leave the premises. Should you have attended a conference, this is your work activity, and I shall help you to fill in the forms at the beginning of the following week.

A preliminary analysis of the previous questionnaires is encouraging, and I hope that the last four questionnaires (there are 13 altogether) will truly and honestly reflect your information gathering activity for each specified period.

In October you will be asked to fill in a different type of questionnaire. This will be followed by a short, tape recorded interview which shall complete the data collection stage of my research.

I look forward to your continuing cooperation.

Richard Hes

APPENDIX D

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KRUSKALL-WALLIS TEST OF SIGNIFICANCE

KRUSKALL-WALLIS TEST OF SIGNIFICANCE

Ho : That there is no difference in the average of information entries for difference questionnaire runs

 $\alpha$  : Left significance level be = .1

Computation of Kruskall-Wallis statistic H:

$$H = \frac{12 - K_1}{N (N+1)^2 j} = 1 \frac{R_j^2}{M_j} - 3(N+1) = \frac{.00018 (1514.17-759)}{1 - \frac{219690}{16003008}} = \frac{.00018 (1514.17-759)}{1 - \frac{219690}{16003008}} = \frac{0.138}{1 - \frac{0.138}{1 - \frac{10}{16003008}}}$$

Where:

N	= total number in sample (252)
Rj	= the sum of ranks for group j (scores are given in table D.1)
ΣT	= $\Sigma^{\ell}$ (t <sup>3</sup> -t) -t is the number of tied observations in a tied j = 1 group of scores.
Nj	= Number of persons in each group (21)*
K	= Number of groups (12)
٤	= Number of tied groups of scores (16)
	$t = \{2, 2, 2, 4, 5, 3, 5, 9, 15, 14, 28, 23, 24, 45, 36, 30\}$

<u>Decision</u>: Since H is distributed with  $X^2$ , with K-1 (11) degrees of freedom, a value of 17.275 is needed to reject the null hypothesis. Since computed H is smaller, the null hypothesis is accepted.

\* Only those respondents who returned all 12 samples were considered.

AMOUNT OF RECEIVED INFORMATION RANKED

						DAYS		la.				
RESPON- DENTS *	1	2	3	4	5	6	7	8	9	10	11	12
6	129.5	106	106	80.5	80.5	129.5	237.5	59.5	80.5	80.5	106	80.5
7	80.5	59.5	106	45	129.5	129.5	129.5	129.5	33	204.5	129.5	237.5
9	164	204.5	129.5	164	164	164	204.5	164	204.5	164	204,5	129.5
12	45	106	106	45	204.5	129.5	26	164	106	164	80.5	164
14	10.5	59.5	45	45	129.5	33	80.5	80.5	59.5	129.5	80.5	59.5
15	129.5	237.5	164	237.5	164	204.5	237.5	237.5	237.5	237.5	164	164
16	164	164	164	204.5	204.5	237.5	164	80.5	204.5	204.5	204.5	204.5
21	204.5	237.5	237.5	45	129.5	164	237.5	237.5	106	106	129.5	164
25	1	33	3.5	7	13.5	10.5	26	18	45.	3.5	8	80.5
26	33	45	45	106	59.5	22	22	18	45	33	33	80.5
27	80.5	59.5	80.5	204.5	204.5	45	80.5	59.5	45	164	80.5	26
33	164	164	164	204.5	237.5	237.5	106	237.5	80.5	204.5	45	33
36	204.5	204.5	237.5	164	164	237.5	164	237.5	164	204.5	204.5	204.5
38	164	80.5	129.5	80.5	106	237.5	164	18	80.5	164	237.5	164
39	80.5	204.5	59.5	59.5	80.5	106	26	45	164	129.5	80.5	33
40	106	237.5	129.5	204.5	106	204.5	204.5	204.5	237.5	204.5	106	237.5
77	80.5	106	13.5	80.5	45	9	164	106	18	22	129.5	164
47	59.5	26	33	80.5	59.5	13.5	13.5	5.5	18	33	2	237.5
49	106	164	164	106	164	237.5	164	237.5	204.5	129.5	204.5	164
54	106	204.5	106	129.5	129.5	164	59.5	129.5	164	80.5	129.5	59.5
60	237.5	204.5	164	164	204.5	204.5	204.5	164	237.5	106	164	129.5
Rj	2350.5	2908	2387.5	2457.5	2780	2920.5	2715.5	2633.5	2535	2769	2523.5	2817

\*Only those respondents who returned all 12 samples were considered

APPENDIX E

KENDALL-TAU TESTS OF SIGNIFICANCE

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#### KENDALL-TAU TESTS OF SIGNIFICANCE

- H<sub>o</sub>: That the ranks of the twenty-one respondents, who returned completed forms on all 12 occasions in samples showing A) the lowest and highest rates of response and B) the lowest and highest rates of absenteeism, are not correlated.
- $\alpha$  : Let the significance level be = .01

Computation Kendall-Tau -T

$$\tau = \frac{S}{\sqrt{(\frac{1}{2N(N-1)} - T_x)}} \sqrt{\frac{1}{2N(N-1)} - T_y}}$$

N = Sample number  $T_x$  and  $T_y$  = corrections for ties  $(T_i = \frac{1}{2} \Sigma t_i(t_i-1))$ 

S = Number of concordant pairs minus number of discordant pairs.

The significance of the  $\tau$  is then compared to a normal distribution with  $\sigma_s = \sqrt{\frac{4N + 10}{9N(N-1)}}$ 

The SPSS procedure NONPAR CORR, OPTION 5 which utilises the above formulae yielded the following result:

	Highest Response	Lowest Absence					
	(Quest.1,N <sub>R</sub> - 519)	Quest.4, $N_a = 2$	(Quest. 6 N <sub>a</sub> = 2)				
Lowest Response (Quest. 9 N <sub>R</sub> = 190)	$\tau = 0.4249$ $\beta = .006 **$	-	-				
Highest Absence Quest. 9 N <sub>a</sub> = 13 a	- *	$\tau = 0.4200$ $\beta = .007 **$	τ = 0.5573 β = .001 ***				

\*\* Significant at 0.01
\*\*\* Significant at 0.001

<u>DECISION</u> - since all values of the calculated  $\tau$  are significant at least at the set level of significance, we reject the null hypothesis and accept the alternative one. Accordingly, the ranks of the respondents in terms of their response rates in samples showing A) the lowest and highest rates of response, and B) the lowest and highest rates of absenteeism, are correlated. APPENDIX F

LETTER ISSUED WITH I.F.Q. NO 13

# DEPARTMENT OF SCIENTIFIC



AND

#### INDUSTRIAL RESEARCH

Telephone: 729 979

Head Office, Private Bag, Weilington, New Zealand.

27th September 1977

#### IMFORMATION FLOW QUESTIONNAIRE NO 13

In this, the final information flow questionnaire, please complete the following three details:

(1) In the usual manner, please <u>complete</u> questions 4 - 6 of the questionnaire for the period beginning at 5 pm on Tuesday (27th September), and ending at 5 pm on Vednesday (28th September).

(2.) In Question 2 of the first questionnaire you were asked to list all 'projects', 'problems', or 'research possibilities', in which you were engaged at that time. In Question 3 you were asked to code which facilities you used in these projects.

Subsequently, you were asked to modify your answers as your work pattern changed.

All projects you have entered and also all changes you have recorded throughout the study, are listed in the present issue. The dates on the 'Review of Trojects' form are the dates of your entry; red colour has been used to denote changes.

Please <u>review</u> these projects and <u>write in</u> the approximate dates of changes which you may have overlooked. E.g. if another stage of the project ensued, during the past 6 months, instead of the usual tick in the 'Project Stages' box, please write in an approximate date of the change. If a project has been terminated, please put an approximate date of termination in the last column (outside the box), and write in whether the project was dropped, or concluded.

(3) If any of the projects is or has been a team effort, please <u>name</u> all team members and the organisation to which they belong (A different form is attached for this purpose. Flease write in the names alongside the relevant project numbers). If appropriate, <u>underline</u> the project leader. Please name team members involved in all projects, except those in area P - administration.

Than' You.

Delunch'

lichard Hes

APPENDIX G

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QUESTIONNAIRE II
### QUESTIONNAIRE II

The purpose of this questionnaire is to determine informal networks of friendships, biographical details, and some values held by each person employed in this Division.

It consists of three different types of questions which are set cut in 4 sections. Please complete every question, unless requested otherwise.

The majority of questions are asked because of my earlier promise that I shall not consult your personal files.

The questionnaire should take you about 40-60 minutes to complete. Although it may be a long time, the value of my project depends on the completeness and honesty of your answers.

Please try to answer all questions honestly and fairly.

Please try to complete and return the questionnaire immediately after this weekend!

All information provided will be treated strictly confidentially.

Thank you.

Richard Hes

Q.la. Whom from this Division do you regularly lunch with? *Please name the person(s)*.

Q.lb. Whom from this Division do you have regular after work contact with? *Please name the person(s)*.

Q.lc. Whom from outside scientific organisations (could be other DSIR Divisions) do you have regular after work contact with? Please name the person(s), and specify the organisation(s) this/these person(s) work in.

<u>Q.ld</u>. Whom from the farming community (or Agricultural Extension) do you have regular after work contact with? *Please name* the person(s) and <u>specify</u> the organisation(s) this/these person(s) work in.

- II. EDUCATIONAL QUALIFICATIONS, PROFESSIONAL EXPERIENCE AND ACTIVITY
- Questions in this section may be answered either by filling in a table, or by putting a <u>circle</u> around <u>one</u> code number next to one of several alternatives provided, whichever is appropriate.
- Q.2. Please list all your professional qualifications, including those gained at high school, university, and technical or trade institutes, and specify details by completing the following table. Scientists: please include in your list also any Postdoctoral scholarships, fellowships, etc.

Qualifi- cation	School, University or Awarding Body	Country of its location	Dates of attendance (in years)		Major subject, or area of speciali- sation
			From	То	

Q.3.

Ending with this Division, please list all your former employers, and specify details by completing the following table (exclude casual or vacation work).

Name of the employer	Country	Length o: employmen (in year:	Major research/work area
		From To	)
-			
-			

# Q.3a. To be completed by scientists only. Others, please turn to Q.4.

Please indicate the number of years of research experience you have in the research areas specified below (which are crosstabulated by different plant levels). Please fill in only those cells where you had one or more years of experience, rounding up to the nearest full year. The totals in rows or columns do not have to add up to the total number of years in research.

Plant Levels	Sub- cel-	Cel- lular	Tis- sue	Whole Plant	Plant gates	Aggre- in:
Research Areas	lular				Micro- env.	Macro- env.
Plant Biochemistry		1				
Nitrogen Fixation						
Plant Photo. & Resp.				9		
Micropropagation						
Crop Physiology						
Agr. Physics						
C & Forage Breeding			_			
Agronomy						
Farm Management					1	

-Q.4. How many papers, internal reports, and articles have you published in the following categories of literature over the past three years?

	Number:
Internal Reports	
N.Z. Scientific Journals	
Overseas Scientific Journals	
Articles in Scientific Books	
Technical (Engineering) Literature	<u></u>
Farming and Agricultural Extension Journals, Magazines, Newsletters, etc.	
Other (Please Specify)	

\* If you have published in Farming and Extension Journals, please name these:

Farming

Agricultural Extension

Q.5. Please name any professional society to which you belong, and specify any elected office you hold or have held in these societies in the past three years.

Society	Office	

<u>Q.6</u>. Please name any voluntary organisations (i.e., political, recreational, educational, and farming organisations, societies, or clubs), to which you belong and <u>specify</u> any elected office you hold or have held in these societies in the past three years.

Societies/Clubs	Office

Q.7. How frequently did you attend public meetings called by local interested groups in your neighbourhood or city, in the past three years? Please circle the code number next to the answer which most closely approximates your attendance at these meetings.

Never	(1)
Seldom	(2)
Sometimes	(3)
Often	(4)
Very frequently	(5)

Q.8. How many of the following categories of conferences or meetings did you attend in the last three years?

		Number
		1 1
Scientifi	c conferences in N.Z.	
Scientifi	c conferences overseas:	
	in Australia	
	in the South Pacific	
	in the UK	
	in the USA	<u> </u>
	in any other country (Please specify)	
Conferenc Agricultu	es or Meetings of Tral Extension Personnel	
Farmers C	onferences or Meetings	
Technical	(Engineering)	

Q.9. Have you ever lived or worked on a farm? Please specify details by completing the following table:

Type of the farm (Dairy, sheep, etc.)	Location	Length of your stay	Purpose of your stay

### II. ABOUT YOUR WORK IN THE DIVISION

Appearing in this section are several sets of questions, which require you to examine a number of statements, and to <u>circle</u> a code number, which will most closely approximate your position located on a five point scale. On this scale (1) represents the most negative answer (never, not at all, etc.), and (5) the most positive answer (always, to a great extent etc.). Equal weight is put on each point between 1 and 5. *Please find* your own position on this scale, and circle only one number next to each statement.

Point (Not Applicable) is offered for circumstances where your specific situation precludes your own position on any of the statements. *Please circle this point only if absolutely* necessary.

Q.10. How frequently can you make effective decisions on the actions shown below, without waiting for approval from your controlling officer or Head Office Administration? Please circle one code number next to each statement, corresponding to this scale:

Never				Alwavs	Not Applicable
1	2	3	4	5	9

1.	Determine who will work on projects with you	1	2	3	4	5	9
2.	Interview a potential employee	1	2	3	4	5	9
3.	Terminate a project	1	2	3	4	5	9
4.	Determine in which journal you will publish	1	2	3	4	5	9
5.	Initiate a new research/development project	1	2	3	4	5	9
6.	Select a new employee	1	2	.3	4	5	9
7.	Determine a client for your project	1	2	3	4	5	9
8.	Determine the priority in which different projects will be completed	1	2	3	4	5	9
9.	Determine the research/development 'problem'	1	2	3	4	5	9
10.	Determine what methods are used in the solution of the 'problem'	1	2	3	4	5	9
11.	Determine the content of your job	1	2	3	4	5	9
12.	Determine what will be published.	1	2	3	4	5	9
13.	Enter a new research/development area	1	2	3	4	5	9

<u>Q.11</u> When you evaluate your own ideas, how much importance do you usually give the following considerations in deciding whether or not the idea is a good one? (If you are a person whose job does not usually involve originating ideas, answer the items below in terms of the amount of importance you give them when evaluating other people's ideas). Please circle one code number, next to each statement, corresponding to this scale:

completely				of maximum	Not
unimportant	1			importance	Applicable
1	2	3	4	5	9

1.	Current public issues of a widespread concern in N.Z. society	1	2	3	4	5	9
2.	New breakthrough in practical knowledge	1	2	3	4	5	9
3.	Staying in areas where one can be fairly sure of some acceptable results, even though not spectacular	1	2	3	4	5	9
4.	Opinion of Agricultural Extension Personnel	1	2	3	4	5	9
5.	Ideas originated from scientific and technical literature	1	2	3	4	5	9
6.	Your reputation in the professional community	1	2	3	4	5	9
7.	Fitting in with the DSIR policies	1	2	3	4	5	9
8.	Preference of your Director	1	2	3	4	5	9
9.	Ideas originated from moral issues	1	2	3	4	5	9
10.	Ideas originated from problems arising from the work of Agricultural Extension	1	2	3	4	5	9
11.	Usefulness for other Divisions of DSIR	1	2	3	4	5	9
12.	Maintenance or increase of the net profit of the farming community	1	2	3	4	5	9
13.	Ad hoc calls for trouble shooting assistance to farmers	1	2	3	4	5	9
14.	Your perceptions of immediate problems in current agricultural practice	1	2	3	4	5	9
15.	Farmer's level of technical skills and technology	1	2	3	4	5	9
16.	Support and recognition from farmers	1	2	3	4	5	9
17.	Likelihood of a breakthrough in theoretical knowledge	1	2	3	4	5	9
18.	Opinion of your colleagues and coworkers	].	2	3	4	5	9
19.	Opinion of your immediate supervisor	1	2	3	4	5	9
20.	Enhancement of your own status in the farming community	1	2	3	4	5	9
	continued on next page						

Continued....

				· · ·			
21.	Achievement of desirable social goals of the farming community	1	2	3	4	5	9
22.	Challenge of the idea	1	2	3	4	5	9
23.	Achievement of the goals of your Division	1	2	3	4	5	9
24.	Increase of your chances for promotion	1	2	3	4	5	9
25.	Ideas originating from voluntary organisations to which you belong	1	2	3	4	5	9
26.	Likelihood of client's (farmer, or a person in Agr. Extension) acceptance of your findings	1	2	3	4	5	9
27.	Ideas originated from your thinking about the potential development of N.Z. agricultural systems	1	2	3	4	5	9
28.	Theoretical relevance for existing knowledge	1	2	3	4	5	9
29.	Government policies	1	2	3	4	5	9
30.	Enjoyment you have in working on the idea	1	2	3	4	5	9
31.	Opportunity to write an article in any Agr. Extension or farming journal, etc.	1.	2	3	4	5	9
32.	Maintenance or enhancement of your reputation in the Division	1	2	3	4	5	9
33.	Ideas from any social movement you regard as important	1	2	3	4	5	9

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Below are categories of persons, who could be the users of your Research/Development/Work results. Please indicate if these persons were likely to be the users of your results within one year of their release (or the completion of your work). Circle one code number next to each category, corresponding to this scale:

highly uplikely				highly likely	N/A
1	2	3	4	5	9

Technicians in the Division	1	2	3	4	5	9
Farmers	1	2	3	4	5	-9
Scientists in the Division	1	2	3	4	5	9
Personnel in Agricultural Extension	1	2	3	4	5	9
Scientists Overseas	1	2	3	4	5	9
Scientists in other DSIR Divisions	1	2	3	4	5	9
Other scientists or technicians in N.Z.	1	2	3	4	5	9
Others (Please specify)	1.	2	3	4	5	9
	1	2	3	4	5	9
	1	2	3	4	5	9

<u>Q.13</u>.What circumstances do you prefer to work in? Please circle one code number next to the appropriate statement and follow the instructions that follow the code number.

Alone \_\_\_\_\_\_ (1) - Please turn to Q.74 In a team \_\_\_\_\_\_ (2) Either alone or in a (3) team \_\_\_\_\_\_ (3) Don't know - never had (4) a team experience \_\_\_\_\_ (4)

<u>Q.13a.</u>If you had the opportunity to choose a work team, who would you prefer to work with from the following categories? *Please circle one code number, next to each category, corresponding to this scale:* 

				to a very	
not at				great	
all.	r			extent	N/A
1	2	3	4	5	9

Colleagues of similar degree of competence	1	2	3	4	5	9	
Colleagues of higher degree of competence	1	2	3	4	5	9	
Colleagues trained in the same discipline	1	2	3	4	5	9	
Colleagues trained in different disciplines	1	2	3	4	5	9	
Agricultural Extension personnel	1	2	3	4	5	9	
Farmers, horticulturalists, etc.	1	2	3	4	5	9	
Other (Please specify)							

<u>Q.13b</u>.Please indicate your preferences, showing how the team <u>should</u> be set up. Circle one code number, next to each selected answer corresponding to this scale.

not at				to a very	N/A
all .				great extend	
1	2	3	4	5	9

permanently, to solve scientific problems	1	2	3	4	5	9
permanently, to solve practical problems	].	2	3	4	5	9
ad hoc, set up by an administrator, to solve a scientific problem	1	2	3	4	5	9
ad hoc, set up by an administrator, to solve a practical problem	1	2	3	4	5	9

..... continued on next page

	continued						
	ad hoc, set up by a contributing team member, to solve a scientific problem	1	2	3	4	5	9
÷	ad hoc, set up by a contributing team member, to solve a practical problem	1	2	3	4	5	9
	Other (Please specify)						

<u>Q.14</u> Different levels of Research Development Administration may have fulfilled different responsibilities with respect to the typical projects you had, over the past 6 months.

> Examine the list of responsibilities, shown below, and indicate the extent to which these were met by (i) the Director, (ii) your section leader, (iii) your team/project leader, and (iv) yourself. Please circle one code number, next to each statement, corresponding to this code:

not at				to a	a great	N/A
all				exte	ent	
1	2	3	4	5		9

N.B. If you are a section leader, or a team/project leader the categories "your section leader", or your "team/project leader" respectively, <u>do not apply</u>. (Circle (9)).

						*	
а.	Assisting in the provision of space, equipment, funds, and personnel						
	(i) the Director	1	2	3	4	5	9
	(ii) your section leader	1	2	3	4	5	9
	(iii) your team/project leader	1	2	3	4	5	9
	(iv) yourself	1	2	3	4	5	9
b.	Providing technical advice based on his/her/my experience in the field.						
	(i) the Director	1	2	3	4	5	9
	(ii) your section leader	1	2	3	4	5	9
	(iii) your team/project leader	1	2	3	4	5	9
	(iv) yourself	1	2	3	4	5	9
с.	Planning, organising, directing, and controlling work related activities	g					
	(i) the Director	1	2	3	4	5	9
	(ii) your section leader	1	2	3	4	5	9
	(iii) your team/project leader	1	2	3	4	5	9
	(iv) yourself	1	2	3	4	5	9

#### continued ..... d. Resolving conflicts and disputes (i) the Director ] (ii) your section leader (iii) your team/project leader (iv) yourself e. Communicating with other administrators in order to pave the way for research/development projects to proceed with minimum delay (i) the Director 9. (ii) your section leader (iii) your team/project leader (iv) yourself f. Communicating with other agencies in order to pave the way for the most effective and efficient diffusion of the results of research work. (i) the Director (ii) your section leader (iii) your team/project leader (iv) yourself

g. Other Are there any other responsibilities any of the persons have fulfilled? Please detail these as fully as possible.

(i) Director

(ii) your section leader

(iii) your team/project leader

(iv) yourself

Q.14a. Please examine the list of responsibilities shown again, and indicate the extent to which, in your opinion, (i) a director, (ii) a section head, (iii) a team/project leader, (iv) a scientist/technician should be fulfilling these responsibilities. Circle a code number next to each person and in each area of responsibility. <u>N.B.</u> If you are a section leader, please indicate what areas of responsibilities a section leader should have, irrespective of whether you have fulfilled them or not. Use this scale:

		at all 1 2 3 4 5 should to a great extent 5	N/A 9					
a.	Assisti funds,	ng in the provision of space, equipment, and personnel						
	(i)	a Director	1	2	3	4	5	9
	(ii)	a section leader	1	2	3	4	5	9
	(iii)	a team/project leader	1	2	3	4	5	9
	(iv)	a scientist/technician	1	2	3	4	5	9
b.	Providi experi	ng technical advice based on his/her ence in the field						
	(i)	a Director	1	2	3	4	5	9
	(ii)	a section leader	1	2	3	4	5	9
	(iii)	a team/project leader	1	2	3	4	5	9
	(iv)	a scientist/technician	1	2	3	4	5	9
с.	Plannin work r	g, organising, directing, and controlling elated activities						
	(i)	a Director	1	2	3	4	5	. 9
	(ii)	a section leader	1	2	3	4	5	9
	(iii)	a team/project leader	1	2	3	4	5	9
	(iv)	a scientist/technician	1	2	3	4	5	9
d.	Resolvi	ng conflicts and disputes						
	(i)	a Director	1	2	3	4	5	9
	(ii)	a section leader	1	2	3	4	5	9
	(iii)	a team/project leader	1	2	3	4	5	9

..... continued

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continued ....

e.	Communicating with other administrators in o to pave the way for research/development pr to proceed with minimum delay	order cojects					
	(i) a Director	1	2	3	4	5	9
	(ii) a section leader	1	2	3	4	5	9
	(iii) a team/project leader	1	2	3	4	5	9
	(iv) a scientist/technician	1	2	3	4	5	9
f.	Communicating with other agencies in order t pave the way for the most effective and efficient diffusion of the results of research work	0					
	(i) a Director	1	2	3	4	5	9
	(ii) a section leader	1	.5	3	4	5	9
	(iii) a team/project leader	1	2	3	4	5	9
	(iv) a scientists/technician	1	2	3	4	5	9
-			_	_			

g. Other Are there any other responsibilities any of the persons should have? Please detail these as fully as possible.

(i) a Director

(ii) a section leader

(iii) a team/project leader

(iv) a scientist/technician

IV. PERSONAL DETAILS FORM

Q.15 What is your age (in years)? Q.16 What is your marital status? Never married (1)Married (including de facto) (2)Separated or divorced (3)Widowed (4)Q.17 How many dependent children do you have? Q 18 Does your spouse work? Yes (1)No (2) Q.18a If your answer to the previous question was yes, please tick whether he/she works full time or part time, and specify his/her occupation. full time (1)part time (2)his/her occupation is: In which country were you born? Q.19 Q.20 In what type of community did you live for the longest period during your childhood (until the age of 15)? Farm (1)Rural Town (Population often below 1000) (2)Borough (Population 1000 - 19 000) (3)

City (Population 20 000 - 100 000) (4)

In a large City (Population over 100 000) (5)

<u>Q.21</u> While you were growing up (until the age of 15), what were the occupations of your parents?

	Father	(a)
	Mother	(b)
Please spe parents.	ecify the le	evel of education attained by your
	Father	(a)
	Mother	(b)
-		

Q.23 If there were a General Election tomorrow, for which of the following parties would you vote? (Assuming you were allowed to vote, and that a candidate for each party was standing). How strongly do you subscribe to the principles for which this party stands? Please circle the party you would vote for and answer the strength of your subscription to that party's principles by using the following scale:



		Strength of sub.				
(a)	National Party	1	2	3	4	5
(b)	Labour Party	1	2	3	4	5
(c)	Social Credit	1	2	3	4	5
(d)	Values	1	2	3	4	5
(e)	Other	1	2	3	4	5

Q.22

- 2.24 Finally, I would appreciate your suggestions or comments on what should be the interrelationship between New Zealand Agricultural Research (especially your Division) and
  - (i) the New Zealand Government
  - (ii) the international scientific community
  - (iii) the scientific community in New Zealand
  - (iv) the Agricultural Extension, and
  - (v) the farming community

Please write as fully as possible, and if necessary, continue on a separate sheet.

Thank you for your co-operation. Please seal the completed questionnaire in the envelope provided and place it in the basket in the administration room.

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APPENDIX H

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## QUESTIONNAIRE III

### QUESTIONNAIRE III

In this questionnaire are listed 34 organisational conditions which may help or hinder you in the performance of your job. Your are requested to answer two questions related to each condition.

- Q.1 Please examine each item and indicate, in column A, how <u>important</u> a contribution you think each condition makes to the performance of your job.
- <u>Q.2</u> Having completed Q.1, please examine each item again, and indicate, in column B, how <u>satisfied you</u> are with the adequacy of the present state of that condition in your Division, or DSIR, as appropriate.

In both columns, please write in a code number [-5], or [-5],

Very unimportant Highly dissatisfied				Very important Highly satisfied	Not Appl	icable
1	2	3	4	5	9	<i>p</i>

(Code number | represents the most negative answer; 5 the most positive answer. Equal weight is put on each point between 1 and 5. Point 9 (Not Applicable) is offered for circumstances where your specific situation precludes your own position on any other point of the scale.

Please write in 9 only if absolutely necessary.

Find your own position on this scale, and write in only one code number next to each condition, and in each column.

Thank You Richard Hes

Very High	vunimportant Very important Highly sa 1 2 3 4 5	ortant latisfied	Not Applicable 9
л.		Column A Importance to work	Column B Satis- faction
1.	Recruitment Policy		
2.	Salaries		· · · · · · · · · · · · · · · · · · ·
3.	The system of promotions and rewards		
4.	The amount and quality of DSIR administrative procedures		
5.	Head Office forward planning and direction of scientific research		
6.	Head Office policies on research applications		
7.	The interpersonal relations (ability to listen, communicate, and understand people) between the staff of the Division and the ADG's and the DG		
8.	The working relations between the staff of the Division and HO Administration		
9.	The working relations between the staff of the Division and the Centre Office		
10.	The working relations between the staff of the Division and other DSIR Divisions		
11.	The amount and quality of the official liaison between the Division and organisations of Agricultural Extension		0
12.	The amount and quality of the official liaison between the Division and the farming community		
13.	The amount and quality of the Division's receptiveness to public issues		
14.	The size of your Division		
15.	The arrangement of positions in your Division		

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• • • • •	contd.				
Very Highl	unimportant Very import y dissatisfied Highly sati	ant sfied	Not Applicable		
	1 2 3 4 5		9		
		Column A Importance to work	Column B Satis- faction		
16.	The arrangement of your Division into sections				
17.	The interpersonal relations between scientists and technicians in your Division				
18.	Buildings: heating, ventilation, etc				
19.	Buildings: the interior design, arrangement of desks, benches, etc				
20.	Internal library system				
21.	Internal publication policy				
22.	The amount of autonomy you have	· · · · · · · · · ·			
23.	The quality and quantity of supporting personnel		· · ·		
24.	The quantity and quality of material resources				
25.	The level of work output of others in the Division				
26.	Ease of contacts with your colleagues in New Zealand				
27.	Ease of contacts with your colleagues overseas				
28.	Ease of contacts with persons in Agricultural Extension				
29.	Ease of contacts with persons from the farming community				
30.	Opportunity to further formal education				
31.	Opportunity to attend scientific conferences				
32.	Opportunity to extent your research/Development experience				
33.	The quality and frequency of information you receive about your own performance				

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34. Other: Are there any other important organisational conditions about which you feel strongly? Please detail these as fully as possible.

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